Volume 24, Issue 3/2024 PRINT ISSN 2284-7995

E-ISSN 2285-3952

SCIENTIFIC PAPERS

SERIES "MANAGEMENT, ECONOMIC ENGINEERING IN AGRICULTURE AND RURAL DEVELOPMENT"

Scientific Papers Series “Management, Economic Engineering in Agriculture and Rural Development“
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Volume 24, Issue 3/2024

To be cited: Scientific Papers Series “Management, Economic Engineering in Agriculture and Rural Development“, Volume 24, Issue 3/2024.

Publishers:
University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania. Address: 59 Marasti Blvd., District 1, 011464 Bucharest, Romania, Phone: + 40213182564, Fax: +40213182888**,** www.managusamv.ro
Ceres Publishing House, Address: 29 Oastei Street, District 1, Bucharest, 013701, Phone/Fax: +40213179023, E-mail: edituraceres@yahoo.com

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C O N T E N T

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

VEGETABLE FARMERS' PERCEPTION OF HYDROPONICS FARMING TECHNOLOGIES IN OGUN STATE, NIGERIA

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Abstract

This study examined vegetable farmers' perception towards hydroponic technologies in Ogun State, Nigeria. The study employed the use of a two-stage sampling technique to employ 320 vegetable farmers as respondents. Primary data was gathered through organized interviews and a structured questionnaire. Descriptive and inferential statistics were used to analyze data collected. Findings showed that only 31.3% were involved primarily in farming, livelihood diversification was 49.4% in favour of trading/business. Also, 35% of the respondents belonged to cooperatives and 90% had a favorable perception of hydroponics. The study examined the constraints to the practice of hydroponics where increase in the tariff of power supply ranked first position. Results of Chi-square test of relationship between socioeconomic characteristics of respondents and their perceptions of hydroponics farming technology showed that only level of education and membership of cooperatives indicated significant relationship. The study recommends that empowerment programmes and knowledge acquisition programmes on hydroponic technology farming should be targeted at vegetable farmers who are members of farmers' cooperatives and this is to ensure successful knowledge impact and positive effects of the programme.

Key words: *hydroponic, vegetable farming, perception, constraints, co-operative, education*

INTRODUCTION

Agriculture is an important sector of the economy and a way of life for many Nigerians, contributing almost 25% of the country's GDP and employing 70% of the labour force [11]. Despite its economic importance, Nigeria's agricultural sector suffers several difficulties that have an impact on its output [18]. Poor land tenure systems, insufficient irrigation for agriculture, climate change, and land degradation are a few of these challenges. Other factors include inadequate funding, significant post-harvest losses, minimal access to markets, low technology, high production costs, and poor input distribution [18].

Hydroponics was derived from the Greek words hydro, meaning water, and ponos, meaning work. Hydroponic farming is a division of soilless farming that involves the development of plants without the use of soil, and the plants receive all the vital nutrients from a nutrient-rich water-based solution [5]. There are varieties of hydroponic approaches in which plants can either be cultivated in a non-soil medium or directly in the solution. Hydroponic has many advantages over orthodox farming and they include; a shorter growth interval for many plants, no pesticides or herbicides, improved use of space, and increased productivity, amongst others. Conventional farming practices mainly involve such soil-bound methods and can cause a variety of antagonistic effects on the environment. Conventional farming is the practice of growing crops in the ground, outside, often with irrigation and the active application of nutrients such as fertilizers and herbicides. The deleterious impacts of conventional agriculture is not only related to the growth conditions of the crops but in particular to the effect on natural ecosystems, including high and inefficient water demand, vast land requirements, fertilizer use, soil degradation and loss of biodiversity [3].

According to [12], vegetables are common crops grown and eaten in Nigeria. The fresh parts of the plants are either eaten raw, cooked or processed in some other ways. Vegetables provide fundamental vitamins, minerals and antioxidants that provide many important health benefits to the body. [7] opined that vegetables yield per unit land areas is high when related to other arable crops, making it a good source of income generation. However, the use of chemicals in vegetable production has been well-known as a major source of health complications and a cause of several health and environmental loss to the entire population. To achieve viable food production levels in Nigeria, farmers need to alleviate the effects of climate change, insecurity, flooding, farmer-herders' clashes, inflation, and rising food prices through inventive farming technologies. To achieve this, hydroponics technology is one of such innovations for producing food all the year round. Furthermore, to meet the food requirements of the growing population, there is a need to embrace out-of-box techniques to achieve the United Nations' sustainable development (SDGs) goal 2; Zero hunger which "seeks sustainable solutions to end hunger in all its forms by 2030 and to achieve food security". Farmers' opinion is influenced and moulded, among other things by their distinct characteristics, experiences, information they receive, cultural and geographical locations in which they live.

Food security has become a major global concern as a result of the recent lack of access to sufficient and healthy foods for many people worldwide. If immediate action is not taken, almost 25 million people in Nigeria could go hungry [19]. It is more important than ever to supply food in quantities and grades that support food production. Hydroponic farming presents a viable means of accomplishing this. However, there hasn't been much study done on the value of hydroponic farming methods in improving food security, especially in poor nations like Nigeria where food insecurity is most prevalent.

It is against this background that this study intends to provide answers to the following research questions.

1. What are the socio-economic characteristics of the respondents?
2. What is the awareness level of vegetable farmers on hydroponic farming technology?
2. What is the perception of vegetable farmers to hydroponic farming technologies in the study area?
3. What are the constraints to the practice of hydroponic farming in the study area?

MATERIALS AND METHODS

Study Area

On February 3rd, 1976, the Western States were combined to form Ogun State. Lagos State borders Ogun State on the south; Oyo and Osun States border it on the north; Ondo State borders it on the east; and the Republic of Benin borders it on the west. The state is located between longitudes 3.0°0' and 5.0°0 East and latitudes 6.2°0 and 7.8° 0 North of the Greenwich Meridian.

Population, Sampling procedure and sampling size

The population of the study consisted of 1,076 vegetable farmers belonging to vegetable farmer's group registered in Ogun state, Nigeria. For this study, a two -stage sampling technique was adopted. The first stage was the purposive selection of two (2) Local Governments, Odeda and Ewekoro due to large number of vegetable and hydroponic farming activities. The second stage involved the random selection of (32%) respondents from each of the Local Governments Areas.

Table 1. Summary of sampling procedure and sampling size

Stage 1: Purposive selection of Two Local Governments Areas (LGAs)	Stage 2: proportionate Random sampling	
	Total Number of vegetable farmers	**32% of farmers**
Odeda	675	204
Ewekoro	383	116
Total	**1,058**	**320**

Source: Soilless Agriculture database in Ogun state.

Instruments for data collection

The data used for the study was primary data which was acquired via structured questionnaire. Experts from the Department of Agricultural Extension and Rural Development made modifications to the questionnaire's design to assure its validity and establish content validity. Various technologies on hydroponics technologies were outlined and respondents were asked to tick if they are aware or not aware. A score of 1 and 0 were assigned respectively. Perception statements on vegetable farmers towards hydroponic farming technologies were listed for respondents to tick. These statements were placed on a 5-point Likert type scale. The scales were strongly agree, agree, undecided, disagree and strongly disagree while scores of 5,4,3,2 and 1 were assigned respectively for positively worded statement but the reverse was the case for negatively worded statements. A list of constraints was outlined and respondents were asked to tick if the constraints are Very Severe, Severe, Not Severe and Not a constraint. A score of 3, 2, 1 and 0 were assigned to constraints respectively.

Data Analysis

The results obtained from the field were analyzed using SPSS Version 21. Descriptive and inferential statistical tools were used to analyze the data collected. Frequency counts, percentages, means and standard deviations and chi-square were descriptive tools that were used to present the findings from all objectives of the study. Inferential statistics such as Pearson Product Moment Correlation were used to test the hypothesis.

RESULTS AND DISCUSSIONS

The average age of the respondents was 36.1 years, according to the statistics presented in Table 1. Contrary to the findings of [7], who found that young men and women in a study of farm youth participation in farming disapproved of the aspirations of working as farmers, this indicates that vegetable farming is dominated by youths in the research area. In order to carry out vegetable farming tasks effectively, these young people must be nimble and economically engaged. Gender equity in the ratio of male to female teenagers cultivating vegetables in the research area is implied by the respondents' sex, which was 56.3% male and 43.8% female. The results are in line with the finding of [10],who reported that male farmers had more awareness and were more likely to adopt agricultural technology than female farmers and that women appear to be less adaptive because of financial or resource constraints. Most (78.8%) of the youths were mainly singles which may indicates that they had relatively minimal responsibilities and time to dedicated to hydroponics farming. The result corroborates with the results of [6], who looked at actual evidence supporting the claim that the majority of research participants were single. They followed Islam (46.3%), Christianity (52.5%), and Traditional (1.3%) religions, according to the research. These outcomes concur with those of [17], which found that religious and cultural customs play a significant role in determining technical efficiency. A small percentage of respondents (10.6%) did not have any formal education, but the majority (80.4%) did. The outcomes are consistent with the discoveries of [16] who observed in a research that the farmers in the study area were uneducated. This indicates that the respondents were literate. Literacy can positively influence the adoption of innovation such as hydroponic technology. The average farming experience was 3.4 years. This shows that the farmers in the study area were relatively new to farming and this is in accordance with the findings of [16], who discovered that farming experience was a determinant of adoption of agricultural technology. The main labour types used by farmers were family labour (50.0%) as well as hired labour (30.6%). This result supports the findings of [20], who suggested that a combination of family and hired sources contributed most of the labour supplied for crop production. Also, only 31.3% were mainly engaged in farming occupation while others diversified into trading/business (49.4%), artisan (10.0%) and civil service (9.4%) as their means of livelihood. This negates the findings of [15], where they discovered that the primary source of income for the respondents was agriculture. Few (35.0%) of the respondents were members of cooperatives and this result syncs with the findings of [2], who found that there were indications that joining agricultural cooperatives had a positive impact on the wellbeing of smallholder farmers. The results also showed that the farmers benefitted from loan (5.6%), and trainings (25.6%) in the cooperatives, these findings support the results of [1], who found that farmers who used cooperative societies report benefited in the form of loans and other resources.

Table 2. Socio-economic characteristics of respondents

Variables	Frequency	Percentage %	Mean (SD)
Age (years)			
≤ 25	150	46.9	
26 – 35	162	50.6	36.1(5.09)
36 and above	8	2.5	
Sex			
Male	180	56.3	
Female	140	43.8	
Marital status			
Single	252	78.8	
Married	64	20.0	
Widowed/widower	4	1.2	
Religion			
Islam	148	46.3	
Christianity	168	52.5	
Traditional	4	1.2	
Educational status			
No formal education	34	10.7	
Primary education	100	31.3	
Secondary education	158	49.4	
Tertiary education	28	8.8	
Farming experience(years)			
1 – 5	280	87.5	
6 – 10	34	10.6	3.4(2.46) (years)
11 and above	6	1.9	
Main labour use			
Family members	160	50.0	
Hired labour	22	6.9	
Family and hired	98	30.6	
Communal	40	12.5	
Secondary occupation			
None	100	31.3	
Civil servant	30	9.4	
Artisan	32	10.0	
Trading/business	158	49.4	
Membership of cooperative associations			
Yes	112	35.0	
Benefits of cooperative			
Loans	18	5.6	
Subsidized inputs	10	3.1	
Training	82	25.6	

Source: Field Survey, 2023.

Vegetable farmers' level of awareness of hydroponics technologies

Results in Table 3 showed that the majority of the respondents in the study area (87.5%) were still using traditional methods (use of soil) for farming. However, all (100.0%) were aware of hydroponics farming technology (soilless agriculture). In contrast, [14] found that a large number of people were not aware of the existence of hydroponic farming. The farmers were familiar with Deep Water Culture (79.4%) and local hydroponics technology (45.0%), but only a small percentage (28.8%) was familiar with the nutrient film approach. This suggests that farmers in the research region have a thorough understanding of local hydroponics technologies and deep water culture.

Table 3. Vegetable farmers' level of awareness of hydroponics technologies

Statement	Frequency	Percentage
Are you currently using traditional methods (use of soil) for farming		
Yes	280	87.5
What is your awareness of hydroponics farming practices		
Aware	320	100.0
Which of these hydroponics systems are you aware of		
NFT (Nutrient Film Technique)	92	28.8
DWC (Deep Water Culture)	254	79.4
The Kraktky Method (Local Hydroponics Technologies)	144	45.0

Source: Field Survey, 2023.

Perception of hydroponics technologies

The ranking of farmers' responses to the perception statements is shown in Table 4. The least favorable perception of hydroponic farming technologies is that pests and diseases can spread easily with a mean score of $\bar{x}$=2.88, ranked twenty-first. You would be willing to use hydroponic farming technology if you had access to quality water, with a mean score of $\bar{x}$=4.20, ranked fourth; your farming experience influences your perception of hydroponic farming, with a mean score of $\bar{x}$=4.21 ranked third position [9]. Vegetable production through hydroponics is environmentally friendly, with a mean score of $\bar{x}$=4.21 ranked second.

Finally, you would be willing to use hydroponics farming technology if proper training was available, with a mean score of $\bar{x}$=4.24 ranked first.

Table 4. Perception of hydroponics technologies

Perception Statements	Mean±SD	Rank
You would be willing to use hydroponics farming technology if proper training was accessible.	4.24±0.75	1st
Production of vegetables through hydroponics is environmentally friendly	4.21±0.71	2nd
Your farming experience influences your perception of hydroponics farming	4.21±0.76	3rd
You would be willing to use hydroponics farming technology if you had access to quality water.	4.20±0.84	4th
I am willing to introduce hydroponics technologies to my friends and family	4.19±0.75	5th
Hydroponic farming technology is easy to use	4.13±0.77	6th
Vegetables grown in hydroponics nutrients solution have faster plant growth and improved yield	4.11±0.87	7th
The level of market demand for hydroponics farming products influences your perception of hydroponics farming	4.11±0.79	7th
The type of crop you grow affects your perception of hydroponics technology	4.08±0.80	9th
Diseases and pests can be easily controlled in Hydroponics farming	4.04±0.88	10th
Nearness to the market influences your perception of hydroponics farming	4.01±0.87	11th
Hydroponic technologies can be set up anywhere	3.93±0.87	12th
Hydroponically-grown vegetables taste better	3.93±0.87	12th
Hydroponics requires proper monitoring of the nutrient solution	3.89±0.89	14th
Kratky method is the best option for hydroponics where there is no electricity	3.73±0.96	15th
Your income level influences your perception of hydroponics technology	3.59±0.98	16th
Your farm size influences your perception of hydroponics technology	3.54±1.00	17th
Your education level influences your perception of hydroponics technology	3.51±1.13	18th
Hydroponic farming is meant for well-educated farmers	3.21±1.13	19th
You experienced the impact of climate change on your crop production	2.95±1.29	20th
Pest and disease can spread easily in hydroponics farming technologies	2.88±1.21	21st

Source: Field Survey, 2023.

Farmers' perception categories on hydroponic technologies

The perception scores of each respondent about hydroponic technologies were categorized. According to results in Table, 90.0% of the respondents had positive perceptions of hydroponic technology, compared to 5.0% who had negative perceptions and another 5.0% who had neutral perceptions. This suggests that farmers had a favorable opinion of hydroponic technologies, which is consistent with the research findings of [13], which discovered that younger farmers had a favorable opinion of hydroponic farming. Farmers in the research area may embrace hydroponic technologies more readily as a result of this.

Table 5. Farmers' perception categories on hydroponic technologies

Categories	Obtained score range	Frequency	%	Mean score
Unfavourable perception	21 – 62	16	5.0	
Neutral	63	16	5.0	80.69±8.63
Favourable perception	64 – 105	288	90.0	
	Total	320	100.0	

Possible range score: 21 – 105 points
Source: Field Survey, 2023.

Constraints to the Practice of Hydroponics Farming

Table 6 showed that increase in the tariff of power supply hydroponic farming technologies may require more electricity than traditional farming methods, according to a mean of $\bar{x}$=2.06 ranked second, inadequate power supply, at $\bar{x}$=2.02 ranked third, and access to credit, at $\bar{x}$=1.97 ranked fourth. These results are consistent with those of [8], which found that access to credit is a significant factor in hydroponic farming, and that there is limited access to training and guidance on hydroponic farming technology ($\bar{x}$=0.71) ranked fifteenth position as the least constraint regarding the practice of hydroponic farming, suggesting that the respondents' lack of access to hydroponics farming training may be a barrier to their use of the technique. This suggests that the primary barriers to the practice of hydroponic farming in the study area were an increase in the power supply tariff, higher electricity requirements, and an inadequate power supply. These findings are consistent with those of [21], who noted that hydroponic technologies require higher electricity.

Table 6. Constraints to the practice of hydroponics farming

Constraints	Mean±SD	Rank
Increase in the tariff of power supply	2.06±0.87	1st
Hydroponic farming technologies may have higher electricity requirements compared to traditional farming methods	2.06±0.86	2nd
Inadequate power supply	2.02±0.89	3rd
Access to credit	1.97±1.02	4th
High input costs	1.97±0.86	5th
High cost of investment	1.96±0.90	6th
Consumers are unwilling to pay a premium price for hydroponically-grown produce	1.94±0.80	7th
Government policies do not favor hydroponics farming practice	1.94±0.90	8th
The availability and quality of water for hydroponics farming technology are major challenges	1.87±0.95	9th
Access to market	1.79±1.10	10th
Technical know-how	1.74±0.98	11th
Scarcity of nutrient solution	1.58±0.88	12th
Literacy level	1.33±0.86	13th
High cost of training	1.00±1.03	14th
Access to training and guidance on hydroponics farming technology is limited	0.71±0.89	15th

Source: Field Survey, 2023.

Chi-square test of the relationship between socioeconomic characteristics of respondents and their perception of hydroponics farming

The results of the Chi-square test are shown in Table 7 and show how respondents' perceptions about hydroponic farming relate to their socioeconomic factors. Results revealed that level of education (24.291, $p<0.05$) exhibited a significant relationship. This is in agreement with the results of [4], who discovered that education boosts farm productivity when modern technology is embraced. Furthermore, cooperative members demonstrated a strong connection (23.022, $p<0.01$), which is in line with the findings of [22], which demonstrated that cooperative membership had a beneficial effect on the extensity of technology adoption. This suggests that further years of education and membership in farmers' cooperative groups will enable farmers to get a positive impression of hydroponics technologies and a solid comprehension of them.

Table 7. Chi-square test of the relationship between socioeconomic characteristics of respondents and their perceptions of hydroponics farming

Perception	Chi-square ($\chi 2$)	Df	Sig. (p-value)
Sex	3.414	2	0.181
Religion	1.314	4	0.859
Level of education	24.291*	15	0.019
Labour type	8.018	6	0.237
Membership of cooperative	23.022**	9	0.006
Age group	4.288	6	0.638
Farming experience group	4.976	4	0.547

**,* Significant at 0.01 and 0.05 level respectively
Source: Field Survey, 2023.

CONCLUSIONS

This study examined the vegetable farmers' perception of hydroponics technologies in Ogun State, Nigeria. Based on major findings, the study concluded that vegetable farmers in Ogun State had positive perception of hydroponic technology farming. The high rate perceptions of the farmers were their willingness to use hydroponics farming technologies if proper trainings were accessible and their knowledge that production of vegetables through hydroponics is environmentally friendly. Socioeconomic factors that supported farmers' favourable perception about hydroponic farming were additional years of schooling as well as additional years of joining farmers' cooperative group. Vegetable farmers in the research region were well-versed in native hydroponics technologies and deep water culture. The primary barriers to the implementation of hydroponic farming in the research area were an increase in power supply tariffs, an increase in the amount of electricity needed, and an inadequate power supply. The study recommends that empowerment programmes and knowledge acquisition programmes on hydroponic technology farming should be targeted at vegetable farmers who are members of farmers' group/cooperative and is to ensure successful knowledge impact and positive effects of the programme.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ASSESSMENT OF CHALLENGES AND COPING STRATEGIES OF MAJOR INPUT RESOURCES IN CATFISH FARMING

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Abstract

This study assesses the challenges catfish farmers are facing in the procurement of these input resources and coping strategies employed to control them for the farmers to remain in business. This study was carried out in Ibadan, the capital of Oyo State, Nigeria. A multistage sampling method is employed in this study. Three local government areas were purposefully selected among the eleven in Ibadan, Oyo State. The selected local governments were Oluyole, Ido, and Lagelu. Then, the snowball sampling method was employed to administer the prepared structured questionnaire. Descriptive and inferential statistics were used to analyze the data obtained. The results show that the majority (86.4%) of the catfish farmers depend on catfish breeders to source their fish seeds, with many having multiple sources to avoid disappointment in comparing costs and best fish seed. Among the challenges identified by the farmers are bad quality fish seeds that result in stunted growth, high cost of fish seed and fish feed, and poor-quality feed which usually pollutes pond water. Many farmers agreed that they breed their fish themselves to ascertain its quality, and stunted fish should be sold early. Farmers increase the cost price of their fish, use homemade feeds, and buy feeds in bulk to cushion the effect of the high cost of feed.

Key words: *fish seeds, fish feed, stunted growth, catfish farmers, resources*

INTRODUCTION

Catfish farming is no doubt a profitable enterprise, but the success and profitability of the enterprise are limited by various inherent challenges (Alawode and Ajagbe, 2020) [5]. Onyekuru *et al*. (2019) [21] and Kehinde (2022) [14] explained that some farmers may run at a loss or out of business after a few years of practicing due to insufficient planning, budgeting, and execution of the production plan, and without proper knowledge about the into business's profitability. This could be one of the reasons for the annual recurring fish deficit supply, which incapacitated aquaculture from meeting the expected demand for fish production in Nigeria (Iruo *et al*. 2018) [12]; yet aquaculture with all available resources has the potential to meet fish demand in Nigeria. This should not discourage anyone planning to venture into the business, since every profitable business has associated risks and threats that could hinder the expected profit. Successfully managing these risks and threats is a profit determinant of any adjudged profitable venture. Aphunu and Agwu (2014) [7] explained the need for catfish farmers to have competency in knowledge, skills and techniques involved in efficiently managing fish to maximize production. This is the reason why the analysis of strengths, weaknesses, opportunities, and threats (SWOTs) of any business is highly recommended to be carried out before the actual start-up of any business (Elfitasari and Albert, 2017) [9].

In aquaculture, especially in catfish farming, challenges are evenly distributed across every stage of production from the acquisition of ponds, and fish seeds (fry, fingerlings and juveniles) to the marketing of table-size catfish. The most prominent among these challenges besides water relates to the two major input resources *vis a viz* procurement of quality fish seeds and quality fish feed. Water is an essential resource in fish farming. It is required in both in good quality and in abundant quantity. Notwithstanding in Nigeria, many catfish farmers usually ignore the cost of securing quality water in the required amount and in addition, usually do not recognize it as a challenge that can limit catfish production. However, water in an actual sense is a limiting factor to the optimum productivity of fish (Mohammad and Haque, 2021) [15]. Water is to fish what air is to human beings. It is the immediate environment of fish that supports the existence of fish.

Omeje *et al*. (2020) [20] and Onyekuru *et al*. (2019) [21] reported that the use of poor-quality catfish seeds and the high cost of feeds are among the factors for the low level of catfish production in Nigeria. Likewise, Shitote *et al*. (2013) [22] reported similar challenges in Kenya that lack of certified quality seed (Fingerlings) and commercially produced feeds are among the problems facing the fish farming sector.

The quality and viability of fish seeds are essential for the survivability, optimum growth, and harvest yield of the stocked catfish. The genetic makeup of catfish contributes to the growth and feed efficiency or feed conversion ratio (Jamabo *et al*. 2015) [13]. Likewise, the quality and quantity of fish feeds contribute to the growth and harvest yield of catfish at the end of the production cycle. Many authors have adjudged its contribution to catfish production as the highest which can be up to 70% of the total input resources (Ashley-Dejo *et al*. 2017; Onyekuru *et al*. 2019) [8, 21]. Therefore, without mincing words, fish feed could be seen as a major determinant of profitability in catfish production (Eriegha and Ekokotu, 2017) [10]. For this purpose, Zlaugotne *et al.* (2022) [24] reported the need for efficient and sustainable fish feed and most importantly the feed costs must be economically justified.

Therefore, this study aims to assess the challenges associated with the acquisition of fish seeds and fish feed as well as some coping strategies adopted by the farmers to keep themselves in the business.

MATERIALS AND METHODS

The Study Area

This study was carried out in Ibadan, the capital of Oyo State located in the South Western part of Nigeria. The rainy season in Ibadan is between March and October, while the dry season is between November and February. Agricultural activities in Ibadan are characterized mostly by secondary and quaternary services, although there are still features of primary functions such as farming. Ibadan is known as a hub for catfish production. Catfish marketers source their fish from Ibadan to sell to other parts of Nigeria.

Data collection and analysis

The population of the study is catfish farmers in Ibadan. A multistage sampling method is employed in this study. Three local government areas were purposefully selected among the eleven local government areas in Ibadan, Oyo State. The selected local governments were Oluyole, Ido, and Lagelu. Then, the snowball sampling method was employed to administer the prepared structured questionnaire since the number of respondents could not be ascertained during the sampling period. The sampling relies on the introduction of different catfish farmers by their colleagues who have met and responded to the questionnaire. Some visited areas in these three local government areas are Fodacic Adeoyo, Omi Panada, and Olodo.

A structured questionnaire was used to collect data from the respondents. The questionnaire focused on issues such as the socioeconomic characteristics of catfish farmers in the study area, means of sourcing Fish seeds and culture period, challenges associated with sourcing of fish seeds and challenges associated with catfish feeding. A total of 125 copies of the questionnaire were duly attended to by the respondents in the study areas. Descriptive and inferential statistics were used to analyze the collected data.

RESULTS AND DISCUSSIONS

Socio-economics characteristics

Catfish producers in the research locations are categorized according to their socioeconomic status in Table 1. From 23 to 77 years old, the farmers range in age. Within the study locations, the average age of catfish farmers is 48.16±1.79 years, with the modal age class interval falling between 51 and 60 years old. According to Omeje *et al*. (2020) [20], the mean age of farmers in the Kainji Lake Basin of Nigeria was 36.7 years. This result is more noteworthy. A record of male domination in the catfish farming industry exists, even though both genders engage in the company (Ashley-Dejo *et al*. 2017;Onyekuru *et al*. 2019) [8, 21]. Concerns concerning male dominance and low female participation in paid initiatives in many emerging economies have been raised by the International Labour Organization (ILO) (2016) [11]. The industry's intense labor- and management-intensive character and male dominance in catfish production (Omeje *et al*., 2020) [20] are further factors contributing to this phenomenon. Farmers in the study area are entirely literate, with men making up the majority (68%) of farmers. 13.6% of them had completed at least elementary school, 34.4% had completed secondary school, and 52% had completed postsecondary education. So, unemployed graduates may find self-employment options through catfish farming.

Six to ten children make up the bulk of farmers' families (54.4%), with most of them being married (92%). Furthermore, suggested by this was that catfish farming in Nigeria provides a stable means of income for households to survive. Marital status is seen as a sign of social duty, trust, and success, according to research by Iruo *et al.* (2018) [12]. With an average experience of 11.26±0.98, the catfish farmers in the research region ranged in years from 2 to 27. It is noteworthy that many catfish farmers (32%) had experience ranging from 1 to 5 years, whilst only 4% had experience exceeding 21 years. Elfitasari and Albert (2017) [9] noted that a crucial prerequisite for the success of catfish farming operations is years of experience along with sufficient technical and administrative abilities (Olaleye *et al*. 2019) [19].

Since just 48% of the fish farmers in the research region are members of a catfish farmers association and 52% are not, the majority of fish farmers in the area are unconcerned about belonging to one.

Table 1. Socio-economic of catfish farmers

Variables	Frequency	Percentage (%)	Mean
Age			
20 - 30	17	13.6	48.16±1.79
31 - 40	23	18.4	
41 - 50	25	20	
51 60	40	32	
61 - 70	15	12	
71 - 80	5	4	
Maximum: 77	Minimum: 23		
Gender			
Male	85	68	
Female	40	32	
Education			
Tertiary	65	52	
Secondary	43	34.4	
Primary	17	13.6	
Marital status			
Married	115	92	
Single	10	8	
Family size			
1 – 5	57	45.6	
6 – 10	68	54.4	
Years of experience			
1 – 5	40	32	11.26±0.98
6 – 10	25	20	
11 – 15	20	16	
16 – 20	35	28	
>21	5	4	
Maximum: 27	Minimum: 2		
Member of catfish association		0	
No	65	52	
Yes	60	48	

Source: Data Analysis, 2023.

Fish seed and culture period

Table 2 shows how the farmers source their fish seeds and different culture periods in the study area. The majority (86.4%) of the catfish farmers depend on catfish breeders to source their fish seeds either fry, fingerlings or juveniles. This observation agrees with the findings of Iruo *et al.* (2018) [10] that a more significant proportion of the fish farmers obtained their fingerlings from hatcheries while Ashley-Dejo *et al.* (2017) [8] are of the contrary opinion that many of their respondents sourced their fish seed from personal own fish farm. Many catfish farmers (68%) have multiple sources for sourcing their fish seeds, which vary between 2 to 6 breeders while 32% have only one source of breeders.

Table 2. Means of sourcing Fish seed and culture period

Variables	Frequency	Percentage (%)	Mean±SD
Sources of fish seeds			
Self	17	13.6	
Fish breeders	108	86.4	
Number of fish sources			
1	40	32	
2	40	32	
3	40	32	
6	5	4	
Why have more sources			
Disappointment	48	38.4	
To compare the best	62	49.6	
To compare the cost	15	12	
Fish seed stocked			
Fry	5	4	
Fingerling	12	9.6	
Juvenile	108	86.4	
Suitable time to stock			
Raining season	88	70.4	
Anytime	37	29.6	
Stocking per year			
Once	18	14.4	
Twice	60	48	
Thrice	47	37.6	
Number of fish stocked			
1 – 2,000	70	56	
2,001 – 4,000	20	16	
4,001 – 6,000	10	8	
6,001 – 8,000	15	12	
8,001 – 10,000	5	4	
>10,000	5	4	
Culture period			
3 – 4 months	40	32	6.0±2.37
5 – 8 months	65	52	
9 – 12 months	20	16	

Source: Data Analysis, 2023.

The farmers justified having multiple sources for sourcing fish seeds including disappointment (38.4%), comparison of best fish seeds (49.6%) and comparison of cost of fish seed (12%). Most of the farmers preferred to stock juvenile fish seed instead of fry and fingerlings. This could be due to juvenile fish seed's high survival rate over both fry and fingerlings. The majority (70.4%) of the farmers agreed that catfish are best stocked during the rainy season.

This could be due to water availability to raise fish to maturity. However, some (29.6%) catfish farmers think that catfish can be stocked any time of the year.

Therefore, many farmers (37.6%) stocked their ponds thrice, while 48% stocked their ponds twice and 14.4% stocked their ponds once per year. This could be associated with the length of the culture period and expected harvest weight.

Table 2 shows that the length of the culture period for catfish production varied between 3 and 10 months.

This result agrees with the report of Adewumi (2015) [2] that catfish can be cultured and grow to a minimum acceptable marketable size in a reasonable growing period (between 4 and 9 months) depending on the production system.

Most (52%) catfish farmers raise their fish for a period varying between 5 to 8 months, 32% raise their fish between 3 to 4 months while 16% raise their fish between 9 to 12 months, while the average culture period is found to be 6.0±2.37.

This is consistent with the findings of Adeyemo *et al*. (2011) [3] who reported that it takes an average of eight months to produce catfish in Ibadan, Nigeria. Most (56%) catfish farmers stocked up to 2,000 juveniles in their ponds per production cycle.

Challenges of sourcing of fish seeds

The challenges of catfish growers experiencing in finding fish seed are indicated in Table 3. Most farmers (60%) felt that the most significant obstacles were the cost of fish seed, mobility, and distance. By contrast, 17.6% of farmers thought that the main problem was the stunted fish seed, while 22.4% thought sick or poor-quality fish seed was a concern. There has been minimal growth in the stocked fish seed for many (44%) catfish producers. Many (48%) cited water contamination or scarcity as the reason for the minor modifications. Some agreed that the time spent stocking the fish might be a factor. However, few people thought that over-sorting fish seed or runt, inadequate or irregular feeding, bad quality feed and water, and inexperienced farmers were to blame. The results are consistent with the study by Suwarsito *et al*. (2022) [23], which found that a decline in fish appetite is caused by deteriorating water quality.

Fish development thus slows down. However, poor seed, overstocking or overcrowding, poor water management, infection and diseases that reduce growth, poor feed management could be the major causes of stunted growth in catfish.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 3. Challenges associated with sourcing of fish seeds

Variables	Frequency	Percentage (%)
Sourcing fish seed		
Distance, mobility, and cost	75	60
Stunted growth	22	17.6
Sick/bad quality seed	28	22.4
Experience of stunted growth		
No	70	56
Yes	55	44
Causes of stunted		
Time factor	47	37.6
Water scarcity/pollution	60	48
Bad source and inexperience	8	6.4
Poor feed quality and water	5	4
Runt, over sorting	5	4
What to do with stunted fish		
Proper feeding	55	44
Dispose of it / early harvest	65	52
Change water	5	4
Control of stunted growth		
Maintain good water quality	45	36
Self-breeding	33	26.4
Proper care and feeding	47	37.6
Using a particular fish feed		
No	105	84
Yes	20	16
Reasons for changing fish feed		
Protein requirements at different growth stages	60	48
Cost and availability	60	48
Profit	5	4
Response to change of fish feed		
Slow response	68	54.4
Good response	57	45.6
Average fish weight at harvest		
0 – 1 kg	28	22.4
1 – 2 kg	45	36
>2 kg	52	41.6
Times of feeding per day		
Twice	125	100

Source: Data Analysis, 2023.

In contrast, some farmers (44%) said intensive and correct feeding regime may result in a better transformation. Many farmers (52%) felt that once such a situation is noticed on the farm, it is best to harvest the fish early and sell them off. However, many respondents (37.6%) agreed that catfish require extensive food management to prevent stunted growth, and 36% said that preserving high water quality would assist in resolving the issue. By contrast, 26.4% of respondents believe that fish farmers should develop their fish seeds to guarantee seed quality and prevent the problem of stunted growth in catfish farming. When it came to raising catfish, many farmers (84%) admitted to utilizing multiple fish feeds. The rationale behind their decision was based on three factors: the cost and accessibility of feed (48%) the varied protein requirements of catfish at different life stages (48%) and the anticipated profit (4%). It is advisable to use caution when combining other meals. According to Mramba and Kahindi (2023) [16], feed—especially non-conventional feed—is a source of pathogens, which can lower water quality and raise the danger of infections. Farmers generally (100%) said that they feed their fish twice a day, and many (54.4%) agreed that catfish react slowly to changes in diet. Many farmers (41.6%) also raised their fish to harvest weights greater than 2 kg.

Challenges associated with catfish feeding

Table 4 shows the challenges associated with catfish feeding. All the farmers agreed that the price of catfish feed is increasing. The high cost of commercial fish feeds is a major limiting factor for the profitability in aquaculture (Adeogun *et al*. 2007) [1]. Shitote *et al*. (2013) [22] emphasized that commercially produced feeds are hard to come by and when available, are expensive for most farmers to afford. The implication is that the cost of production of catfish will invariably increase. This is because the feed cost in catfish production is observed to be the single largest input resource that determines the enterprise's profitability. The majority (84%) of catfish farmers agreed that the increasing cost of fish feed hurts the business's profitability. This observation agrees with the report of Okpeke and Akarue, (2015) [18]. Therefore, catfish farmers adopted various strategies to cope with the increasing cost of fish feed. Such systems include increasing catfish selling price at harvest (37.6%); and using homemade or locally produced meals with adjusted feed composition or formulation (26.4%) while 36% of them increase their capital base by securing more loans. This shows that due to the high cost of imported feeds, many catfish farmers are forced into using locally produced meals that are not up to international standards. The use of homemade or locally made feed has negative impacts on pond water. Most (94.4%)

of the farmers agreed that those feeds pollute the pond water. Elfitasari and Albert (2017) [9] reported that internal and external factors cause pollution of pond water. Such feeds that pollute pond water according to the farmers are maggot blood meal (62.4%), locally made feeds (28%), and sinking pelleted feed (9.6%). Mohammad and Haque, (2021) [15] identified daily feed input as one of the substances contributing to pond water deterioration. Likewise, Mramba and Kahindi, (2023) [16] are of the opinion that pond management practices such as daily feed input, stocking density, and fertilization have a significant impact on water quality. All farmers agreed that once pond water is observed to is polluted, it should be changed. This is necessary because reduced water quality will weaken and reduce fish's immune systems and make them vulnerable and easily susceptible to disease, which will invariably reduce their survival rate (Suwarsito *et al.* 2022) [23].

Catfish farmers in the study area are indifferent on the mode of feeding fish, as 50.4% agreed that they do not feed their fish to satiation, while 49.6% confirmed that they do provide their fish to satiation. Feed management becomes essential in catfish farming due to the following reasons as given by the farmers: fish feed is wasted if fish is fed in excess (37.6%). This could be because fish feed cannot be retrieved after being given to fish in water like other livestock. In addition, 34.4% of the farmers agreed that feeding fish should be discouraged due to scarcity of resources or funds (34.4%) and some (28%) farmers believed that if the feed is supplied in excess, the pond water may be polluted, and fish may die. These observations agree with the report of Eriegha and Ekokotu (2017) [10] that feeding fish in excess will result in wastage of valuable feed nutrients, poor fish growth, and a high possibility of water quality deterioration, which could culminate in fish mortality and reduced profitability.

Many (54.4%) farmers agreed that there is an advantage in buying fish feed in bulk. However, catfish farmers identified some challenges that can cause discouragement of the practice. Most (68%) farmers identified rat and cockroach attacks as a challenge, some (12%) identified loss of flavor and mold infestation while few (8%) identified expiration of the feed as challenges that cause discouragement of buying catfish in bulk.

Table 4. Challenges associated with catfish feeding

Variables	Frequency	Percentage (%)
Increasing cost of fish feed		
Yes	Yes	100
Coping with high cost of feed		
Increase catfish selling price	47	37.6
Go for loan	45	36
homemade/ adjust formulation	33	26.4
Negative impact on profitability		
No	20	16
Yes	105	84
Impact on pond water		
it does pollute water	118	94.4
no impact	7	5.6
Feeds that pollute pond water		
Locally made feeds	35	28.0
Maggot and blood meal	78	62.4
Sinking pelleted feed	12	9.6
What to do		
Change pond water often	125	100
Feeding fish to satiation		
No	63	50.4
Yes	62	49.6
Reason for feed management		
Wastage	47	37.6
Lack of funds	43	34.4
They die if the food is too much	35	28
Is there any advantage in buying fish feed in bulk		
Yes	68	54.4
No	57	45.6
Challenges of storing fish feeds		
Rat and cockroach	85	68
Loss of flavor	15	12
Expiring	10	8
Mold infestation	15	12

Source: Data Analysis, 2023.

Impact of socioeconomic on challenges

The dependent variables, such as stunted development, use of single fish feed, bulk feed purchases, and the impact of high feed costs on profitability, were tested using binary logistic regression to see if they affected the demographics of catfish producers at $P < 0.05$. Age and family size were impacted by stunted growth, as Table 5a demonstrates. According to Shitote *et al*. (2013) [22], despite frequent feeding using government-supplied feed, most fish producers in Kenya complained about undersized fish. Similarly, using single fish feed affected age, marital status, and years of experience. About 20% more money is made by businesses when there is a 20% rise in marital status, particularly in very healthy marriages (Ahituv and Lerman, 2005) [4]. Experience is crucial for overcoming obstacles related to catfish farming, like the high cost of fish feed, according to Ashley-Dejo *et al*. (2017) [8]. According to Omeje *et al*. (2020) [20], farmers' experience is crucial in the sustainability, productivity, and management of catfish production.

Additionally, Table 5b demonstrates how bulk catfish feed purchases impacted age and family size. The profitability of high feed costs also impacted age, gender, education level, and family size. The present discovery aligns with the findings of Ngeywo *et al*. (2015) [17], who reported that age is an important determinant of a farmer's productivity and profitability. The degree of education significantly impacts the production and profitability of catfish farming, according to Onyekuru *et al*. (2019)[21]. More significant family sizes give catfish farming a free labor force to boost output and profitability (Amsalu and de Graaff, 2007) [6].

Table 5a. Impact of dependent variables on the catfish demographic

	Stunted growth			Use of single fish feed		
Variables	Coefficient	T-value	P-value	Coefficient	T-value	P-value
Age	1.062*	3.647	0.056	-4.197*	3.77	0.052
Gender	-0.58	0.315	0.574	-26.398	0	0.998
Education	0.499	0.382	0.537	-0.904	0.265	0.607
Marital status	-0.009	0	0.995	7.927*	4.33	0.037
Family size	8.89764*	5.472	0.019	0.014	0	0.989
Experience	-0.582	1.251	0.263	5.569*	4.198	0.04

Source: Data Analysis, 2023.

Table 5b. Impact of dependent variables on the catfish demographic

	Bulk purchase of feed			Impact of feed on profitability		
Variables	Coefficient	T-value	P-value	Coefficient	T-value	P-value
Age	1.14*	4.563	0.033	1.391*	3.864	0.049
Gender	1.074	1.099	0.294	-2.777*	3.761	0.052
Education	-0.122	0.025	0.874	2.22*	3.356	0.067
Marital status	-0.456	0.135	0.714	-1.178	0.672	0.412
Family size	-1.823*	4.493	0.034	-2.19*	3.225	0.073
Year of experience	-0.778	2.26	0.133	-0.239	0.154	0.695

Source: Data Analysis, 2023.

CONCLUSIONS

Like any other industry, catfish farming has a limited potential profit margin. Due to some inherent problems, producers may not even break even or perhaps experience a loss. The effective handling of these difficulties increases the business's potential for profitability. High-quality catfish seeds and feedstuffs are essential for a profitable catfish farming operation. Catfish with stunted growth are a common problem for farmers due to poor-quality fish seeds. This is the reason why a lot of farmers get their fish seeds from different places. Upon noticing their fish's growth is impeded or inhibited, they typically sell off their stock. If you want to learn how to breed to assure the quality of your fish seeds, it is recommended that you obtain them from government-approved hatcheries or independent farmers. Catfish growers are finding it increasingly difficult to manage and sustain the exorbitant expense of fish feed. Many catfish producers have employed homemade or local feed to grow their fish. Many people feed their fish unusual feed supplies, such as poultry excrement, which frequently contaminates pond water and occasionally has been shown to have infections that are dangerous to fish. To save their industry, catfish farmers are thus putting out intense demands for assistance from the government and other essential parties.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

REPEATABILITY ESTIMATES OF EXTERNAL AND INTERNAL EGG QUALITY TRAITS OF LOCAL MUSCOVY DUCKS

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Abstract

Repeatability is one of the genetic parameters that determines breeding values of traits. Studies on repeatability estimates of the internal and external quality traits of Nigerian Muscovy duck eggs were carried out at Poultry Unit, Teaching and Research Farm, Osun State University. Ejigbo. A total of 383 eggs collected from 50 ducks mated to 10 drakes were used for the studies. External egg quality studied includes: egg weight (EW), shell weight (SW), shell thickness (ST) egg length (EL), egg width (EWIEgg density (ED), egg shell index (ESI) and egg surface area (ESA), shell percentage (SP), shell density (SD), egg volume (EV) and shell surface area (SSA). The internal egg quality traits include: yolk colour (YC), yolk weight (YW), yolk height (YH), yolk diameter (YD), albumen height (AH), albumen diameter (AD), albumen weight (AW), yolk percentage (YP) yolk index (YI), albumen percentage (AP), and haugh unit (HU). The data collected were subjected to one way analysis of variance to determine variance components and repeatability estimates. Results showed that, repeatability estimates were ranged from low to moderately high and the repeatability values for external egg quality traits were: EW*(0.44±0.02), SW(0.11±0.01), ST (-0.01±0.01), EL (0.26±0.02), EWI (0.39±0.02), ED (-0.01±0.01), ESI (-0.02±0.01), ESA (0.44±0.02), SP (0.16±0.02), SD (-0.01±0.01), EV (0.14±0.02) and SSA (0.11±0.01) while that of the internal qualities were: YC (0.01±0.01), YW (0.41±0.02), YH (0.10±0.01), YD (0.04±0.01), AH (-0.11±0.00), AD (0.21±0.02), AW (0.42±0.02), YP (0.37±0.02), AP (0.34±0.02), while Haugh unit is (0.34±0.02) and albumen index (0.02±0.01). It was concluded that, traits with moderately high, to high estimates could be selected in the early part of the duck's lifetime while the low estimates of repeatability for some egg quality traits in this Muscovy duck indicates that improvement in these traits could be achieved through improvement of most of their non-genetic factors of Muscovy production.*

***Key words**: Muscovy duck eggs, external egg quality traits, internal quality traits, repeatability estimates.*

INTRODUCTION

Repeatability estimate is one the important genetic parameters that could be used in estimating breeding values in animal genetic improvement programmes. This can assist breeders to decide if a particular trait can be improved through selection or by the improvement of the non-genetic factors.

[8] defined repeatability as a measure of the degree of association between records on the same animal for traits expressed more than once in an animal's life and that it's estimate indicates the gain in accuracy expected from multiple measurements. Several authors had estimated repeatability for different traits in livestock and in poultry species. [18]: for milk, fat, protein yields and lactose minerals and other milk traits in dairy cattle In Jersey cattle; [23] for body weight in pure and reciprocal crosses of Nigerian goats; [22] for egg weight in Japanese quail eggs; [21] for eggs at 40 weeks for laying birds; [1] for egg weight, egg length, egg width and shell weight in Isa Brown layers. There is paucity of information on repeatability estimates on egg quality traits in local Muscovy ducks.

Egg quality traits are characteristics of an egg that affects its acceptability to users and consumers. [15], indicated that both external and internal egg quality traits in poultry hens had significant effects on the hatchability of incubated eggs, body weight and development of young chicks. [10] also noted that egg quality is indicative of the reproductive fitness of parents. [2] indicated that, weights of egg shell, albumen and yolk that form the major components of an egg as well as their ratios determine the amount and price of the product in the egg processing industry. The improvement of egg production parameters is desirable because of their economic importance and this can be achieved by improvement of both genetic and non-genetic factors influencing egg production. Repeatability estimates will guide animal breeders in designing appropriate breeding plans for genetic improvement of traits in livestock and poultry species. Therefore, the objective of this study was to estimate repeatability for both external and internal egg quality traits of the muscovy ducks which could serve as basis for the development of improvement programmes for this species in south-western Nigeria.

MATERIALS AND METHODS

Study location

This study was carried out at the Poultry Unit of the Teaching and Research Farm, Department of Animal Science, Osun State University, Ejigbo Campus. Ejigbo is prominent town in Yoruba land, and the headquarters of Ejigbo Local Government Area of Osun State on latitude 7^0, 54ʹ 0.00ʺ N and longitude 4^0 18ʹ 54.00ʹ[13]. E. The town is strategically located in the middle of the region as 35 kilometers (Km) north-east of Iwo, 30 Km from Ogbomoso in the north and 24 Km from Ede in the south-east. It is about 40 Km north-west of Osogbo the capital of Osun State.

Experimental units

A total of 60 Muscovy ducks was sourced from reliable farms across Osun state. Ten sire families consisting of five females (ducks) and one male (drake) per each family were used. The birds were winged banded for proper identification and randomly allocated to each family. Each family was placed in deep litter pens. The pens were cleaned, disinfected and littered with wood shavings which were changed once a week to prevent bad odour and wet litter which could lead to disease causing organisms build-up within the pens. Clean water was provided both in the morning and evening. Experimental birds were fed *ad-libitum* with layers' mash containing 18% crude protein and 2,500Kcal metabolisable energy at the rate of 170g per bird per day as recommended by [14].

Data collection and laboratory analysis

Eggs were collected daily in the morning and both the internal and external qualities of the eggs were analysed within 24 hours of lay. Eggs were weighed after collection before quality characteristics measurement. A minimum of three eggs were collected from each sire family continuously for ten days making a total of 383 eggs that were sampled. Using the procedures of [17], data were collected on the external and internal quality traits of the Muscovy duck eggs. External quality eggs were weighed using a 0.01g sensitive digital weighing scale, the length and width of egg were measured with digital vernier caliper. while the Internal egg quality data were taken by breaking the sharp end of the eggs. In order to carefully measure albumen and yolk parameters, the contents were emptied into a container and the yolks were carefully separated from the albumen and weighed using a sensitive balance. The egg yolk color score was determined using Roche yolk color fan having tabs from 1 to 15. The container was wiped dry after each weighing. The shell weight with membrane was determined by carefully placing the material on the sensitivity scale. However, to measure the shell weight only, the membrane of the shell was first removed and the shell thickness measured using micrometer screw guage. Other egg quality traits were obtained by mathematical calculations.

Albumen weight = egg weight- (yolk weight + shell weight)

Albumen percentage= (albumen weight/egg weight) x 100

Yolk percentage= (yolk weight/egg weight) x 100

Shell percentage= (shell weight/egg weight) x 100

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Haugh unit (HU= 100log (h+7.57)-(1.7*W 0.37)
where:
h = albumen height and
W= weight of egg were weighed in cm and g respectively.
(Haugh unit determines the relationship of the height of the thick white to the weight of the egg and it is usually used to determine albumen quality).

The data obtained with respect to each trait were subjected to one-way analysis of variance using the following model described by [5].

$Y_{ij} = \mu + T_i + e_{ij}$

where:
Y_{ij}= individual observation on the i^{th} eggs belonging to the i^{th} sire family
μ= Overall mean
T_i= Fixed effect of ith sire family
e_{ij}= Residual random error

The variance components were determined from the mean square expectation of the ANOVA using the [19] and repeatability estimated using the following expression:

$R = \frac{\delta_B^2}{\delta_B^2+\delta_E^2}$………….. …Equation 1
δ_E^2=MSE

$\delta_B^2 = \frac{MSB-MSE}{K}$……………Equation 2

where:
R = repeatability estimate [5]
MSB= mean square between individuals
MSE= mean square error
K= number of records
δ_B^2 =Variance between individuals in the population
δ_E^2 =Variance component (error) = the differences within individual bird measurement.

The standard error of the repeatability (SER) estimate was calculated using the procedure of [5].

$SER = \frac{\sqrt{2(1-R)2(1+(-1)R)2}}{K(K-1)(N-1)}$………Equation 3

where:
SER= Standard Error of Repeatability
R=repeatability estimate
K = number of eggs per bird; N = number of birds involved.

RESULTS AND DISCUSSIONS

Repeatability estimates of egg quality traits of Muscovy ducks

Repeatability (R) estimates in different egg quality traits in poultry species by several authors ranged between very low value of 0.03 and as high as 0.902±0.13 (Table 1).

Some of the repeatability estimates for some traits could not be estimated and they are indicated as inestimable. The values in this study fall within the range reported by different studies in poultry species.

The R estimates for the external and internal egg quality traits in the present study are shown in Tables 2 and 3 respectively.

The estimates for some of the external qualities are moderately high: egg weight (0.44±0.02), egg length (0.26±0.02), egg width (0.39±0.02) and egg surface area (0.44±0.02) while that of the internal qualities are: yolk weight (0.41±0.02), albumen weight (0.42±0.02), yolk percentage (0.37±0.02), albumen percentage (0.34±0.02), while Haugh unit is (0.34±0.02). This indicates that, these traits can be selected early in the life of Muscovy ducks. The repeatability estimate for egg weight in this study was lower than 0.76 what was reported by [22] in Japanese quail eggs. It is however similar with 0.44±0.24 reported by [21] for eggs at 40 weeks for layer chicken. R estimates for width and length of egg, shell and yolk weight, albumen diameter and weight were all higher than what [22] reported for quail eggs which might be as a result of differences the poultry species used.

[1] reported repeatability estimates for egg weight, length and width and shell weight to be 0.23±0.065, 0.42±0.18, 0.65±0.071 and 0.59±0.033, respectively while 0.86±0.108, 0.11±0.072, 0.54±0.034, 0.43±0.088, 0.12±0.072 and 0.81±0.117 for shell thickness, yolk weight, diameter and height, albumen height, and Haugh unit respectively, for chicken eggs.

The moderate estimates observed for egg weights were in agreement with the reports of [21] who reported a range of 0.12 to 0.85 and 0.05 to 0.62 in two strains of layer chicken studied. and [12] in local quail lines who reported a range of 0.081 to 0.088 indicating that repeatability estimates for egg numbers and egg weights in chicken were low.

It is pertinent to note that repeatability estimates for reproductive traits as reported by some authors [3]; [20]; [6] were generally low. This was attributed to the huge influence of differences in environment and age of the birds under study [8]. However, some authors had reported moderate values which include: [16] who reported a range of 0.22 and 0.36 for some egg quality traits in chicken.

These differences in values might be as a result of differences in species and location of studies.

In order to improve the accuracy of the breeding values of the Muscovy ducks, it would be important to collect more relevant records, improve rearing and management conditions and other non-genetic factors influencing egg production.

Traits with moderately high to high estimates could be selected for early in life, since few number of records will be needed to take decision on selection early in the ducks' lifetime.

The low estimates observed in this show that, non-genetic factors have major influence on the traits. R estimates for shell thickness, egg density, shape and index, shell density and albumen height could not be estimated because of negative variance components which could be because of small sample size or the negligible contributions of additive genetic variance component.

Low R estimates obtained for some external egg quality traits in this study indicate that there is need for an improvement in the non-genetic factors of production.

Table 1. Repeatability estimates of egg quality traits of poultry egg from the literature

S/N	Author	Species/Breed	Traits	R± SE
1	[1]	Chicken (Isa Brown Layers)	Egg weight Egg length Egg width Shell weight Shell thickness Yolk weight Yolk height Albumen height Haugh Unit	0.23± 0.065 0.42±0.18 0.65±0.07 0.59±0.033 0.86±0.108 0.11±0.07 0.54±0.034 0.43±0.088 0.81±0.12
2	[12]	Local quail lines Desert	Egg number Egg weight	0.088 0.087
		Brown	Egg number Egg weight	0.087 0.084
		White	Egg number Egg weight	0.088 0.081
3	[22]	Japanese quail	Egg weight Egg width, Egg length, Shell weight Shell thickness Yolk height Yolk diameter Yolk weight Albumen height Albumen diameter Albumen weight	0.76 0.04 0.09 0.002 0.15 Inestimable Inestimable 0.03 Inestimable 0.008 0.05
4	[16]	Chicken	Egg weight at 42 weeks Shell thickness Haugh unit	0.22 0.24 0.36
5	[21]	Quail	Egg number Weight of first egg Egg weight at 30 weeks Egg weight at 40 weeks	0.36 0.04 0.07 0.44
6	[11]	Chicken (Bovan Nera Black layers)	Egg weight Shell weight Egg weight at 25 weeks Egg weight at 51 weeks Egg weight at 72 weeks Yolk weight 25 weeks Yolk weight 51 weeks Yolk weight 72 weeks Albumen weight at 25 weeks Albumen weight at 51 weeks Albumen weight at 72 weeks	0.45±0.03 0.55±0.003 0.843±0.18 0.902±0.13 0.880±0.09 0.838±0.07 0.666±0.09 0.666±0.17 0.846±0.13 0.712±0.14 0.887±0.11
7	[9]	Chicken (Onagoidori) White Leghorn	Egg weight Shell weight Egg weight Shell weight	0.47 0.50 0.42 0.26

8	[7]	White Lohmann egg line	Egg weight Breaking strenght Dynamic stiffness Shell thickness Shape index Albumen height	0.75 0.33 0.71 0.36 0.65 0.23
		Brown egg line Lohmann	Egg weight reaking strenght Dynamic stiffness Shell thickness Shape index Albumen height	0.74 0.32 0.68 0.51 0.42 0.36
9	[9]	Onagoidori (Japanese chicken)	Egg weight Egg length Egg width Eggshell strength Shell weight Shell thickness Albumen weight Albumen height Yolk weight Yolk height Yolk colour	0.47 0.42 0.40 0.23 0.50 0.23 0.51 0.35 0.48 0.56 0.51
		White Leghorn	Egg weight Egg length Egg width Eggshell strength Shell weight Shell thickness Albumen weight Albumen height Yolk weight Yolk height Yolk colour	0.42 0.58 0.24 0.39 0.26 0.23 0.45 0.25 0.40 0.35 0.44
10	[4]	Chicken (Hubbard Layers)	Egg production Egg weight Egg index	0.40±0.14 0.58±0.05 0.60±0.05

Source: from the literature. R is the repeatability estimate and SE is standard error.

Table 2. Variance component and repeatability estimates of external egg quality traits of Muscovy ducks

Variables	MS_B	MS_E	δ^2_E	δ^2_B	R	S.E (R)
Egg weight (g)	297.99	33.71	33.71	26.43	0.44	0.02
Shell weight (g)	2.25	1.00	1.00	0.13	0.11	0.01
Shell thickness(cm)	20.75	22.71	22.71	-0.20	-0.01	0.01
Egg length(cm)	0.23	0.05	0.0	0.02	0.26	0.02
Egg width(cm)	0.15	0.02	0.02	0.01	0.39	0.02
Egg density (g/cm^3)	3.93	4.27	4.27	-0.03	-0.01	0.01
Egg shell index	215.93	262.45	262.45	-4.65	-0.02	0.01
Egg surface (cm^2)	172.93	19.42	19.42	15.35	0.44	0.02
Shell percentage (%)	3.16	1.11	1.11	0.21	0.16	0.02
Shell density (g/cm)	2.14	2.34	2.34	-0.02	-0.01	0.01
Egg volume (cm^3)	4,698.27	1,747.29	1,747.29	295.10	0.14	0.02
Shell surface (cm^2)	21.86	9.78	9.78	1.21	0.11	0.01

MS_B = Mean square within individuals, MSE = mean square between individuals, δ^2_B= variance component within individuals (estimating total genetic variance and portion of the environmental variance peculiar to individual birds); δ^2_E = variance component error (differences among measurements within the individual bird; R = repeatability estimate; S.E(R) = standard error of repeatability

Source: Own results.

Table 3. Variance component and repeatability estimates of internal egg quality traits of Muscovy duck

Variables	MS_B	MS_E	δ^2_E	δ^2_B	R	SE (R)
Yolk colour	2.43	2.17	2.17	0.03	0.01	0.01
Yolk weight (g)	68.49	8.69	8.69	5.98	0.41	0.02
Yolk height(cm)	0.17	0.08	0.08	0.01	0.10	0.01
Yolk diameter(cm)	6.23	4.32	4.32	0.19	0.04	0.01
Albumen height(cm)	0.03	13.97	13.97	-1.39	-0.11	Inestimable
Albumen diameter(cm)	1.25	0.35	0.35	0.09	0.21	0.02
Albumen weight(g)	159.12	19.22	19.22	13.99	0.42	0.02
Yolk percentage (%)	73.36	10.84	10.84	6.25	0.37	0.02
Yolk index	108.75	55.98	55.98	5.28	0.09	0.01
Albumen percentage%	89.10	12.75	12.75	7.64	0.37	0.02
Haugh unit	0.04	0.01	0.01	0.01	0.34	0.02
Albumen index	0.54	0.46	0.46	0.01	0.02	0.01

MS_B = Mean square within individuals, MSE = mean square between individuals, δ^2_B = variance component within individuals (estimating total genetic variance and portion of the environmental variance peculiar to individual birds); δ^2_E = variance component error (differences among measurements within the individual bird; R = repeatability estimate; S.E(R) = standard error of repeatability.
Source: Own results.

CONCLUSIONS

Repeatability estimates of both external and internal quality traits ranged from low to high. Traits with moderately high to high estimates could be selected for early in life, since few number of records will be needed to take decision on selection early in the ducks' lifetime. The low estimates of repeatability for other egg quality traits in the Muscovy duck indicate that improvement for these traits could be achieved through efficient rearing management and improvement of most of their non-genetic factors.

ACKNOWLEDGEMENTS

The authors are grateful for the cooperation and efforts of the Senior Farm Officer: Mr A. B. Adesanya and other farm worker during the period of this study at the Poultry Unit of Osun State University Teaching and Research Farm, Ejigbo, Osun State, Nigeria.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

TOMATO PRODUCTION QUANTITY ESTIMATES FOR 2023-2027 WITH ARIMA MODEL: EVIDENCE FROM LEADING PRODUCING COUNTRIES INCLUDING TURKEY

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Abstract

A study was conducted to analyze the changes in tomato production, which holds significant global importance, from 1961 to 2022 and to provide forward-looking predictions. The primary data for this study were derived from statistics obtained from the Food and Agriculture Organization (FAO) spanning the years 1961 to 2022. Utilizing the ARIMA model, the study aimed to forecast trends in tomato production from 2023 to 2027. The most suitable ARIMA models selected for China, India, Turkey, the United States, and Egypt were (1,1,3), (4,1,3), (2,1,0), (5,1,1), and (4,1,3), respectively. Upon comparing the actual production figures from the period 2018-2022 with the forecasted results for the period 2023-2027, a 4.09% increase in global tomato production is anticipated. Analysis of production forecasts for leading countries during the 2023-2027 period suggests that China, India, and Turkey are expected to experience production growth. Notably, a 7.38% decrease in production is forecasted for the United States during these years. The analytical findings indicate a strengthening influence of China and India in the tomato production sector in the forthcoming years. To enhance competitiveness in the tomato industry, countries like Turkey must focus on reducing production costs while ensuring the production of high-quality goods.

Key words: *tomato industry, ARIMA model, competitiveness in tomato production*

INTRODUCTION

Tomato is one of the most produced and consumed vegetables worldwide. According to 2022 statistics, global tomato production reached 186.1 million tons [11]. China leads the world in tomato production with an annual output of 68.3 million tons, followed by India and Turkey. Tomato production is not only significant in terms of quantity but also economically and nutritionally valuable.

The consumption of tomatoes has been associated with various health benefits and medicinal properties. Due to its low calorie content and essential nutrients such as amino acids, fiber, monounsaturated fatty acids, and carotenoids, tomatoes are considered ideal for weight control [6, 16]. Rich in vitamins A and C, potassium, and lycopene, a potent antioxidant linked to reduced risk of certain cancers and heart disease, tomatoes are considered a cornerstone of a healthy and balanced diet [5, 13, 15].

Given its numerous health benefits, tomatoes hold a prominent position as one of the most produced, consumed, and traded vegetable crops globally. Its versatility in various forms such as fresh, frozen, canned, paste, sauce, ketchup, pickled, pureed, peeled, sliced, diced, and dried expands its significance in the food industry [2, 3, 10]. Therefore, tomato production makes substantial contributions to the economies of various countries worldwide, including those in Europe, the Balkans, and Asia [2, 9].

With the world's population steadily increasing, the demand for food continues to rise. In this context, it becomes crucial to determine people's dietary needs and anticipate future production levels. Various models, including the “Autoregressive Integrated Moving Average” (ARIMA) model, are commonly used in agriculture to forecast future production based on historical data. The ARIMA model has been successfully applied to predict the production of various fruits and vegetables, such as strawberries [4], figs [8], hazelnuts [18], and apricots [19, 20].

Despite its importance in vegetable production, the use of the ARIMA model for predicting

tomato production has been limited. Forecasting tomato production among the leading tomato-producing countries for the years 2022-2027 will provide insights into future supply and the role of tomatoes in international trade. This study aims to forecast future tomato production and determine the dynamics among leading countries in the tomato sector. Predicting the changes in tomato production in Turkey, one of the leading tomato-producing countries, as well as in other significant tomato-producing nations, will contribute to gaining a competitive advantage in the international market and developing sustainable agricultural policies.
Therefore, this study was conducted to predict the changes in tomato production in Turkey and other leading producer countries in the foreseeable future using the ARIMA model.

MATERIALS AND METHODS

To ensure sustainability in tomato production, which holds significant importance in human nutrition and is affected by climate change, it is crucial to estimate the production amounts of countries with substantial shares in production for the forthcoming years. The primary data source for this study is the Food and Agriculture Organization (FAO) data. In this context, tomato production data from 1961 to 2022 in major tomato-producing countries were analyzed.
Tomato production quantity data spanning 1961-2022 were obtained from the FAO. Future production quantity estimates were derived using the ARIMA model. Stationarity of the data was assessed through root tests, and if non-stationarity was observed, adjustments were made to ensure stationarity at lags of 1, 2, or 3 years. In instances where the data did not exhibit a normal distribution, adjustments were made to achieve normality, and predictions for the years 2023-2027 were generated using the ARIMA model based on 62 years of data.
For enhanced accuracy and consistency in predictions, the p and q values were determined based on Bayesian Information Criterion (BIC) values obtained through SCAN and ESACF in the SAS 9.4 program. The selection criteria prioritized the smallest Schwarz Bayesian Criterion (SBC), Mean Squared Error (MSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Root Mean Square Error (RMSE), Durbin-Watson statistic closest to 2, and the highest R-squared value.
The most suitable ARIMA model was identified based on the p and q values that best fulfilled these criteria.
The formulation of the difference operation is as follows [21]:

d=0: $y_t = Y_t$ (1)

d=1: $y_t = Y_t - Y_{t-1}$ (2)

d=2: $y_t = (Y_t - Y_{t-1}) - (Y_{t-1} - Y_{t-2}) = Y_t - 2Y_{t-1} + Y_{t-2}$ ....(3)

The ARIMA model was expressed as in the formula 4 [21].

$$(1 - a_1B^1 - a_2B^2 \dots - a_PB^P) * (1 - B)^d y_t = (1 - \theta_1B^1 - \theta_2B^2 - \dots - \theta_qB^q)\varepsilon_t \quad \text{..........(4)}$$

The term $(1 - B)^d$ is difference process from the d[nd] degree, $(1 - B)^d y_t$ can be written for d=1 as B$y_t = y_{t-1}$. Also, it can be written for d=2 as $B\ ^2y_t = y_{t-2}$ or $B\ ^1y_{t-1} = y_{t-2}$.

RESULTS AND DISCUSSIONS

The past-to-present production values of the world's leading tomato-producing countries and the predictions generated by the ARIMA model were examined. Table 1 presents the discrepancies between actual and estimated tomato production for the top 5 countries, as well as other producing nations, and global tomato production from 1962 to 2022.
As the methodology section outlines, the ARIMA model provides the most suitable prediction results by considering various criteria. In Table 1, the optimal model for China was identified as ARIMA (1,1,3). In contrast, for other countries, the preferred models were ARIMA (4,1,3) for India, ARIMA (2,1,0) for Turkey, ARIMA (5,1,1) for America, and ARIMA (4,1,3) for Egypt.
Upon reviewing the literature, it was found that [7] and [14] used ARIMA (0,1,1) and ARIMA (1,0,1) models respectively for predicting

tomato prices, while [17]employed SARIMA (2,0,0) and ARIMA (1,1,0) models for forecasting monthly tomato prices in India.

China, India, Turkey, America, and Egypt collectively contribute 52.8% of global tomato production [11]. Comparison of actual values with ARIMA model predictions for the top 5 tomato-producing countries revealed near-perfect forecasts across all leading nations, with the highest deviation observed globally at -0.1 percent. Overall, the predicted values are closely aligned with actual figures, demonstrating the effectiveness of the models.

Table 1. Deviations between the realized and the ARIMA model estimation of average tomato production for the 1962-2022 period

Country	Model	Realized (thousand tons) (A)	Estimation (thousand tons) (B)	Deviation (%) (100*(B-A)/A)
China	1.1.3	21,765.44	21,765.44	0.00
India	4.1.3	6,929.11	6,929.3	0.00
Turkey	2.1.0	6,647.84	6,649.17	0.02
USA	5.1.1	9,843.1	9,839.24	-0.04
Egypt	4.1.3	4,761.16	4,761.45	0.01
Other	2.1.4	44,024.21	44,038.12	0.03
World	5.1.0	93,993.45	93,900.54	-0.10

Source: Calculated by author.

The differences between the actual production values from 1961 to 2022 and the predictions obtained from the ARIMA model from 2023 to 2027 for the leading countries in global tomato production are presented in Table 2. While the total share of the top 5 countries in tomato production increased from 53.14% from 1961 through 2022 to 64.56% in the years 2023-2027, China experienced the highest increase rate of 14.36%, followed by India with 3.90%. The greatest decrease, estimated at 5.18%, is expected to occur in the United States, indicating a decrease in the total production shares of America and Egypt. Moreover, during the same period, it is anticipated that there will be an increase of 11.42% in the total production share of the top five countries.

Table 2. Countries Leading in Tomato Production: Their Shares of Global Tomato Production and the Differences Among Them (%)

Country	A (1961-2022)	B (2023-2027)	Difference (B-A)
China	23.16	37.51	14.36
India	7.37	11.27	3.90
Turkey	7.07	7.14	0.07
USA	10.47	5.30	-5.18
Egypt	5.07	3.34	-1.72
Total share %	53.14	64.56	11.42

Source: Calculated by author.

According to these findings, it is evident that China and India will emerge as dominant players in global tomato production. Considering this, current leading tomato-producing countries must take pre-emptive measures to counteract this trend and rectify any shortcomings in their production goals.

Table 3 illustrates the changes between the actual production quantities observed in leading tomato-producing countries from 1961 to 2022, 2018 to 2022, and the estimated quantities to be produced between 2023 and 2027. When comparing the production quantities realized during the 2018-2022 period with the forecasted results from the model for the 2023-2027 period, a 4.09% increase in global tomato production is expected. Upon examining the production predictions for the leading countries during the 2023-2027 period, it is anticipated that China, India, and Turkey will increase their production. Specifically, a 7.38% decrease in production is expected for the USA during the forecasted years. Based on these findings, diverse developments can be expected both in tomato production and in international trade.

Alongside Turkey, a competitive player in tomato production [2], China and India may play a more influential role in tomato international trade compared to other countries.

Furthermore, anticipated changes in tomato production and trade should also be considered for other fruits and vegetable species [1].

Table 3. Comparison of Tomato Production of the Five Countries Between the Periods (1,000 tons

Country	A (1961-2022)	B (2018-2022)	C (2023-2027)	Change 100*(C-A)/A	Change 100*(C-B)/B
China	21,514.44	64,744.92	72,211.15	235.64	11.53
India	6,824.83	20,238.2	21,691.57	217.83	7.18
Turkey	6,558.68	12,858.25	13,752.05	109.68	6.95
USA	9,762.09	11,009.08	10,196.83	4.45	-7.38
Egypt	4,698.38	6,550.18	6,433.16	36.92	-1.79
Others	43,564.43	69,540.01	73,231.02	68.10	5.31
World	92,922.87	184,940.64	192,503.83	107.17	4.09

Source: Calculated by author.

The relationship between the actual production values of leading countries in global tomato production (excluding China) from 1961 to 2027 and the predictions obtained from the ARIMA model is depicted in Figure 1. When Figure 1 is examined, it is noteworthy that the predictions are quite consistent. The changes presented in Table 3 are further clarified in Figure 1. It is noteworthy that while India and Turkey have consistently increased their production over the years, a decline in production quantity is observed in Egypt after 2009 and in the United States after 2015. Similar predictions have been made for countries in small-scale studies focusing on tomato production and demand estimation. For instance, [12] noted an increase in tomato production within Bangladesh over the years but highlighted the inability to meet domestic demand, with production falling significantly short of demand.

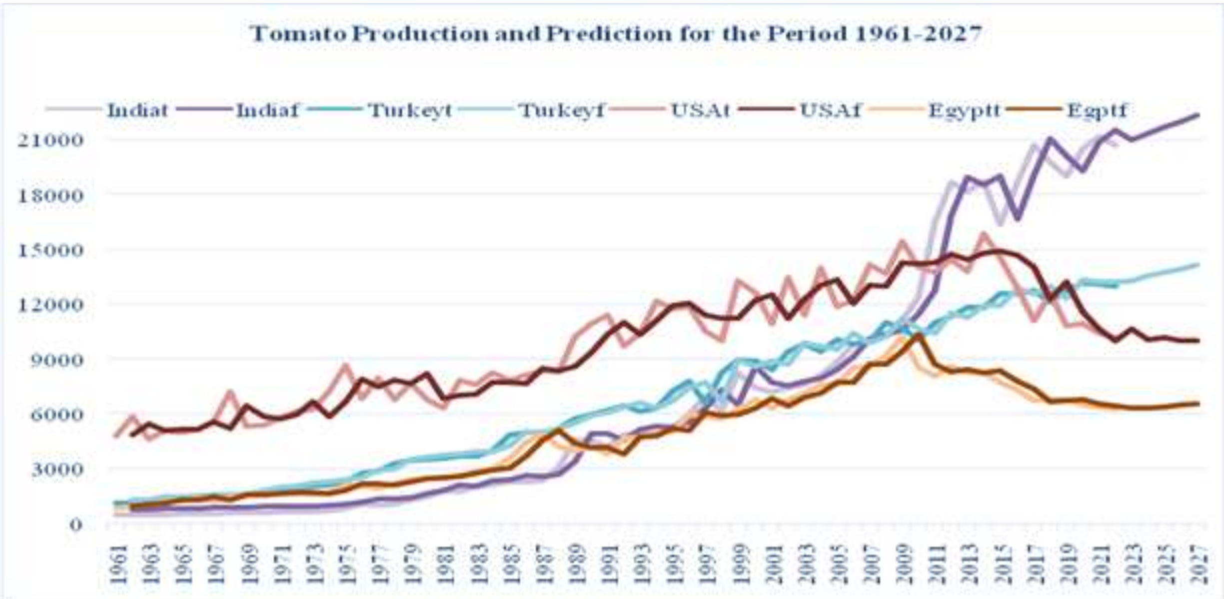

Fig. 1. Tomato production ın India, Turkey, USA and Egypt in1961-2022 and forecast chart for 1962-2027
Source: Calculated by author.
Note: t= production, f = prediction

The production quantities and forecast values of China and world tomato production are examined in Figure 2. A perfect alignment between the production values of China, the leading country in global tomato production, and the ARIMA model estimates from 1961 to 2022 is observed. It is also evident from Figure 2 that there is no deviation in the obtained predictions. Particularly after the 1990s, significant increases in tomato production have been observed in China. A remarkably low deviation of 0.1% has been observed between the actual world tomato production and the predictions during the study years. This can be considered as evidence that the ARIMA model, which has been successfully applied in hazelnut, apricot, fig, and strawberry production forecasts, can also be reliably used for tomatoes [4, 8, 18, 19, 20].

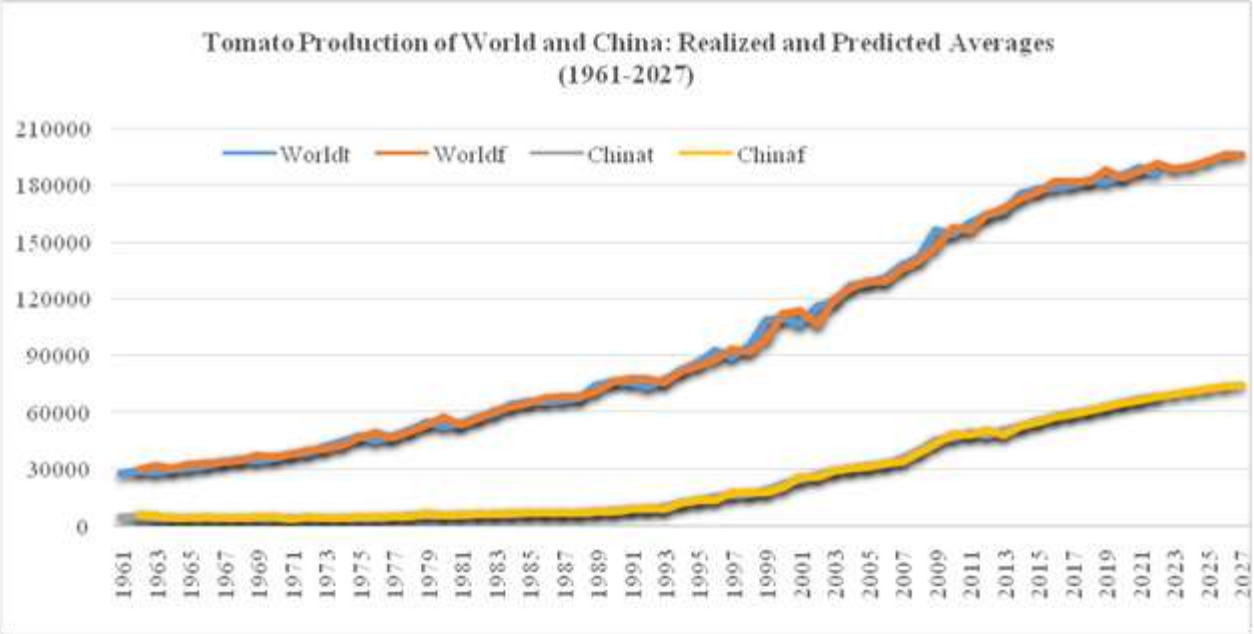

Fig. 2. Tomato production in China and the world in 1961-2022, and prediction graph of 1962-2027
Source: Calculated by author.

CONCLUSIONS

In this work, changes in tomato production between 2023 and 2027 for the leading tomato-producing countries were estimated using the ARIMA model, based on FAO data from 1961 to 2022. According to FAO data, China is the largest tomato producer, followed by India, Turkey, and the United States. Findings from the study suggest that the annual growth rate in world tomato production was 9.41% during the 1961-2022 period, but it is expected to decrease to 0.75% between 2023 and 2027. Significant increases are anticipated in China and India, the top two tomato-producing countries, which could raise the total production share of the top 5 countries in the global market from 53.14% to 64.56% during 2023-2027. However, the production of the USA, among the top tomato- producing countries, is estimated to decrease by 7.38%. With the increasing world population,
there will also be significant growth in demand for tomatoes and tomato-based food products. The analysis results indicate that the influence of China and India in the sector is expected to grow in the next years. Countries like Turkey need to reduce production costs and ensure quality production to compete in tomato production and related sectors. As a result, it can be said that the risk of China and India dominating tomato production and related sectors in the coming years should be taken into consideration, and other significant tomato-producing countries need to take necessary precautions against this situation.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE EVOLUTION OF THE ROMANIAN VEGETABLE INDUSTRY AND SOME PROSPECTS FOR THE FUTURE

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Abstract

The purpose of this paper is to analyse the evolution of the fruit and vegetable processing industry in Romania, using several specific indicators that allowed placing the Romanian industry in a European context based on Eurostat data. Based on these developments, another important indicator was calculated with the help of which the degree of food security can be appreciated, namely the degree of self-sufficiency for the main group of vegetables, and forecasts were made regarding its evolution in the medium and long term. The results show that the prognosis remains pessimistic in the sense that Romania will not be able to attain self-sufficiency in the short and medium term, unless the sector is prioritised for important investments in vegetable processing and sector organisation, although some signs of growth opportunities were identified in the analysis.

Key words**:** *self-sufficiency, vegetable production, short- and medium-term prognosis*

INTRODUCTION

This study investigates the potential of the vegetable and fruit processing industry to contribute to the development of the local economy based on some economic indicators, which at the same time allow the positioning of the Romanian vegetable processing industry in the European context. In this sense, it was tailored a conceptual analytical model which is based on Porter's diamond used for evaluating and ranking companies, to position the Romanian vegetable processing industry in a national and European context, with the aim of observing the best development prospects of this sector but also making some comparisons with the main competitors in the EU. The main indicators considered in this study were: number of employees, turnover, degree of industry concentration, production value, gross value added, gross investment in tangible goods and investment rate. With the help of these indicators, a comparative analysis was also carried out with Poland, Hungary, Italy and France for the period 2011-2020, in order to position the Romanian processing industry in a European competitive context.
A synthetic picture of the main problems faced by the Romanian fruit and vegetable sector through the lens of trade deficit and dependence on imports is presented. Based on these developments, in the paper another important indicator was calculated with the help of which the degree of food security can be appreciated, namely the degree of self-sufficiency for total vegetables (fresh vegetables equivalent), and forecasts were made regarding its evolution in the medium and long term.

MATERIALS AND METHODS

The creation of added value for agricultural products is known as one of the most important activities that can contribute to sustainable rural and local economic development. This is why, it is important for the local agricultural products to generate added value in order to attain the objectives of rural economic development by creating a solid foundation for new job creation and local economy (Barbier, 2007) [2]. Among the most representative and successful impacts of sustainable local economic development could be named: 1) ensuring food security, 2) increasing the contribution of exports to GDP, and 3) improving sustainable job creation) [13]. It is worth noting that the development of agro-industries is known as one of the most important means of local economic development. Consequently, the creation of added value can effectively help sustainable development in economic and social dimensions.

The specialised literature shows, for example, that Spain holds a significant share of the international saffron market through the development of the domestic packaging industry for this product [9]. Another example is the case of Germany, which is a major exporter of natural extracts from horticultural crops through the development of processing industries. However, this country produces no more than about 0.27% of the world's horticultural crops domestically. These economic achievements resulted from the development of local processing industries for local production of raw materials.

The work is based on several data sources from Eurostat, the National Institute of Statistics, but also on the conclusions of several research companies from Romania and EU [13]. The main indicators used are the production value, number of enterprises, average number of employees per enterprise, gross added value per employee, gross operating surplus, apparent labour productivity, gross investments in tangible goods. These indicators were calculated to see where Romania's processing industry is positioned in relation to several other EU member states that represent an important competition for the national vegetable and fruit processing industry. Data from the period 2011-2021 were used to calculate these indicators. Some prognosis regarding the production, imports and exports and self-sufficiency were calculated on short and long term.

RESULTS AND DISCUSSIONS

Local processing can represent an important source of income and development for the local community and this can be achieved by investing in local processing. In addition, the lack or insufficiency of modern processing and packaging facilities limits the potential for value added creation to vegetable production in the already established vegetable basins. Some of the barriers that prevent local economic development in the fruit and vegetable processing sector in Romania include: 1) insufficient infrastructure and supply chain contracting; 2) insufficient investment in the processing industry to create added value and 3) low development of the necessary infrastructures for export.

To solve these problems, many countries have developed medium and long-term initiatives for financing, establishing the necessary infrastructures for industrial development, creating jobs, expanding exports, reducing taxes and building educational infrastructures, most of which have focused on developing agricultural product processing industries [3].

The value of EU processed fruit and vegetables represents almost 51 billion euros, i.e. 6.5% of total production value of the food industry. In the EU, fruit and vegetables are processed in all countries, but five Member States were accountable for over two-thirds (69.1 %) of the total production value in 2021; these were Italy (22.3%), Spain (15.1%), Germany (11.8%), France (10.2%) and the United Kingdom (9.8%), showing quite a high concentration percent.

In addition to being consumed directly and traded as raw commodities, fruit and vegetables are also processed into a large variety of processed food. These can be grouped into frozen, dried and preserved fruit and vegetables (vegetable preserves, jams, marmalades and dried fruits) (72.5% of the sold production), juices (19.6%), tomato ketchup (3.2 %), preparations (4.1 %) and the grouping of dried fruits and homogenised vegetables and fruits (1.3 %) [12].

As regards Romania, according to an analysis carried out by KeysFin [6] in 2020, the turnover of the fruit and vegetable processing industry increased by 17.4% compared to 2019 and reached the highest level in history of about 24 billion RON. Looking at sub-sectors, trade recorded the highest growing rate of 19%, with a turnover of about 21 billion RON, while the processing activity enlarged by 12% achieving a turnover of 1.4 billion RON), and the turnover of fruit and vegetable producers increased by 5% compared to 2019 reaching almost 2.1 billion RON in 2020.

For the following years, the above-mentioned study estimated the continuation of the growth tendency which started in 2014 and it was forecasted to attain a record level of 28 billion RON in 2022 and almost 30 billion in 2023 as a result of increased consumption, but also inflationary pressures of approximately 10% in 2020 and 2021.

Production value

The production value of the fruit and vegetable processing industry had an increasing evolution from the year 2011 to 2020, with a growth rate of +37% compared to 2011 and annual growth rates of approximately +4% compared to 2015. Compared to the other countries with which the comparison was made, however, Romania had the lowest production value, i.e. half of the level of Hungary and 10 times lower than the production value recorded by fruit and vegetable processing factories in Poland.

Table 1. Production value in the fruit and vegetable industry 2011-2020 and comparison with other EU member states, million euros

	2011	**2015**	**2020**	**Dynamics** 2020/2011	**Dynamics** 2020/2015
Italy	9,928	10,529	12,579	27	20
Hungary	713	750	921	29	23
Poland	3,468	3,980	4,598	33	16
Romania	**333**	**437**	**455**	**+37**	**+4**
France	7,076	7,188	7,928	12	10

Source: personal computation based on data extracted from Eurostat [4].

The vertical integration might be another measure with direct impact on the output and productivity of the processing company that initiates vertical contracting and of its suppliers involved in vertical coordination schemes. Supplying farmers have experienced beneficial effects on output, productivity, and product quality – and ultimately on incomes – through better access to inputs, timely payments, and improved productivity with new investments [11].

According to Eurostat data, in 2021 there were 818 enterprises registered with 1,794 employees, obtaining a profit of 16.7 million euros.

This places Romania at half the number of enterprises registered in Italy, Poland and France, but above that registered in Hungary. The evolution of the number of fruit and vegetable enterprises is presented in Table 2.

Table 2. Number of enterprises in the fruit and vegetable processing industry

	2011	2015	2020	**Dynamics** 2020/2011	**Dynamics** 2020/2015
Italy	1,788	1,726	1,749	-2.2	1.3
Hungary	534	544	537	0.6	-1.3
Poland	952	1,085	1,416	48.7	30.5
Romania	249	365	818	**228.5**	**124.1**
France	1,176	1,282	1,689	43.6	31.7

Source: personal computation based on data extracted from Eurostat [4].

The first five enterprises accumulated 40% of the sub-sector's turnover and held a share of 32% of the employed staff, making 52% of the profit. In other words, the first five enterprises covered almost half of the fruit and vegetable processing sector.

The division of the supply chain by sub-sectors confirms a fairly balanced market: accordingly, 43% of the companies were involved in trade and in primary production, while the rest were involved in fruit and vegetable processing. The number of enterprises in the fruit and vegetable processing and preservation has increased every year in the analysed period, including units that manufacture perishable food from fruit and vegetables (such as salads, cleaned or cut vegetables). On the other hand, the average number of employees per enterprise has decreased, suggesting that many of the newly established enterprises are smaller in size.

In 2020, compared to the analysed countries, Romania had the lowest number of employees, 7.5 employees per enterprise, a downward trend compared to 2011 (-67%), as shown in Table 3.

Table 3. Number of employees per processing company

	2011	**2015**	**2020**	**Dynamics 2020/2011**	**Dynamics 2020/2015**
Italy	16.5	17.3	20.8	26.1	20.2
Hungary	14.6	15	15.7	7.5	4.7
Poland	34.3	30.3	28.2	-17.8	-6.9
Romania	22.7	15.8	7.5	**-67**	**-52.5**
France	21.4	19.7	16.6	-22.4	-15.7

Source: personal computation based on data extracted from Eurostat [4].

The number of employees per enterprise in the vegetable and fruit processing industry registered a negative trend in the period 2011-2020, recording the largest decrease compared to the other analysed countries (-67% compared to 2011 and -52% compared to 2015). The processing industry in Romania also has the lowest number of employees per enterprise, which indicates that most of these enterprises are small in size according to the number of employees.

The added value per employee

Tomato sauces, vegetable pots, vegetables for soups and frozen vegetables hold the most important share in the processed vegetables.

Romania is a net importer of processed products, and the Romanian processing plants only partially cover their need for raw materials from domestic production. In 2019, the processing and preservation of vegetables and fruit represented a small percentage of the added value of the food sector, approximately 3%, next to sectors such as meat and the manufacture of meat, flour and dairy products. The distribution of fruit and vegetables also represents a very small percentage of the added value of the food sector, namely 5%. Consumer services account for around 1%. This denotes a sector where the formation of added value on the food chain is very low and unbalanced, which highlights the need to reorganise the chain. Therefore, the supply of fresh and processed fruit and vegetables has a rather low added value, mainly due to the poor organisation of producers (below 1% degree of association, compared to the EU average of 45%, or over 100% in the Netherlands, which have producer organizations, associations of producer organizations and cross-border cooperatives). On the other hand, Poland annually produces more than 4.1 million tonnes of vegetables and 4.6 million tonnes of fruit, out of which only 15% of vegetables and 50% of fruit are used for processing. Concomitantly, in the last years processors tried to influence the growing consumers preferences for vegetables which are processed freshly, respectively already cleaned, precut, packed or presented in the form of a meal ready to eat or cook [10]. There has been a consumer trend towards a healthy lifestyle for many years. Consumers are buying food products more consciously by reading product labels and are increasingly choosing natural foods. In the study conducted by Kuboń et al. (2019) [7], about 50% of a group of 100 people preferred lightly processed foods without artificial colour additives and preservatives.

Table 4. The gross added value per employee in the fruit and vegetable processing industry, thousand euros

	2011	2015	2020	Dynamics 2020/11	Dynamics 2020/15
Italy	59.6	62.5	63.9	7.2	2.2
Hungary	20.2	20.8	29	43.6	39.4
Poland	23.7	27.6	34	43.5	23.2
Romania	13.1	14.3	18.3	**39.7**	**28**
France	58	65.7	69.6	20	5.9

Source: personal computation based on data extracted from Eurostat [4].

By sub-sectors, the net profit of fruit and vegetable processors increased by almost 33%, while that of traders grew by 42%; at the same time, the primary production sector increased by 50% in 2020 compared to the years before the close down pandemic.

On the other hand, although the sector has apparently registered significant increases in the last 5-6 years, the labour productivity in the fruit and vegetable processing industry is three times lower in Romania than in France and almost two times lower than in Poland, but the gross investments have similar values or even higher, which shows the willingness of the industry to make investments.

Table 5. Gross investments in tangible goods, million euros

	2011	**2015**	**2020**	**2020/ 2011 growth**	**2020/ 2015 growth**
Italy	435.0	407.8	490.1	12.7	20.2
Hungary	32.5	47.8	70.5	116.9	47.5
Poland	166.3	223.1	279.5	68.1	25.3
Romania	**26.6**	**19.8**	**52.0**	**95.5**	**162.6**
France	392.4	367.6	425.7	8.5	15.8

Source: author's calculations based on Eurostat, 2022 [4].

Gross investments in tangible goods had a positive dynamic, Romanian companies registering the highest growth rate in the period 2020/2015 (+162%), approaching the level of investments made in Hungary, but still remain at the lowest level compared to the other states, which proves that it is still necessary to re-engineer their business and increase their level of investment.

The degree of self-sufficiency (fresh vegetables equivalent)

The self-sufficiency indicator shows the level of food security for this sector. The degree of self-sufficiency in vegetables (fresh vegetables equivalent) in 2021 was calculated at 82%, down from 2015 when it reached 88%, and the proposed short-term target, the horizon of the 2030s, is 87% (Table 6).

Table 6. Forecasts regarding the degree of self-sufficiency in vegetables (fresh vegetable equivalent)

	UM	Base year (2021)	Short term	Medium term	Long term
Production used	Thou. tonnes	3,669	3,797	3,910	4,023
Import	Thou. tonnes	954	698	642	612
Export	Thou. tonnes	109	123	172	198
Consumption availability	Thou. tonnes	4,474	4,372	4,380	4,437
Self-sufficiency	%	82%	87%	89%	91%

Source: author's calculations and forecasts based on Population Consumption Availabilities, NIS, 2022 [8].

Thus, the results forecast that the production of vegetables will increase, the import will decrease, and the export will register an increase. Also the results show that the degree of self-sufficiency will continue to increase in the medium and long term as a result of the increase in productions obtained in greenhouses and plastic tunnels, better organisation of the supply chain and adaptation to consumer demands. The assumptions considered for setting the targets are based on the following aspects observed: the continuation of the increase in the areas cultivated in greenhouses and plastic tunnels (+220% compared to 2007), the growth in investments in logistics as a result of the measures supported by the National Strategic Plan and the Sectoral Operational Programs, the rise in population’s consumption due to higher incomes and the importance given to health and food diet [1]. At the same time, it is forecasted an increase of the coverage degree for the raw production needs of processing factories as a positive effect of the coupled support for certain types of vegetables.

Better policies should also target the small farmers involved in the vegetable cultivation so that to increase their role in the supply chain [5]

In order to achieve these targets, the policy of this sector must respond to market demands by reducing price fluctuations and the imbalance between supply and demand and encourage the consumption of fruit and vegetables, while ensuring a high rate of investments in the sector.

CONCLUSIONS

The gross added value per employee in the fruit and vegetable processing industry records relatively good growth rates in relation to the countries with which the comparison was made (Italy and France) but slightly below that recorded in Hungary.

Also, the investment rate has recorded significant increases in recent years, which shows the industry's potential for growth and adaptation to the market.

However, the production value remains at a low level compared to all the other four countries analysed, with values up to 10 times lower in 2020 compared, for example, to Poland. This denotes the need to improve the marketing of production in Romania and the use of the growth potential offered both by the production of raw materials and by the growing demand of the population.

To address these challenges, a number of policies and measures are needed to support the cultivation and processing of fruit and vegetables. These include providing subsidies to farmers, investing in modern processing and packaging facilities, and promoting processed products in local and international markets.

In conclusion, in order to achieve the objective of this industry contributing to local development and for a better exploitation of local raw materials, important investments are needed. The National Strategic Plan (NSP) offers such opportunities, and investments in the conditioning, storage and processing of agricultural and fruit products outside the farm is one of the measures of the NSP, which will contribute to the consolidation of enterprises in the food industry, by providing non-reimbursable public support for projects to support investments in modernisation of up to 3 million euros per project (a value that can increase up to 7 million euros for projects establishing processing enterprises and even 10 million euros for new investments in the processing of fruit and vegetables. Thus, the NSP provides an amount of 101 million euros for investments in the vegetable and/or potato sector, respectively 1.7% of the total financial allocation of the Programme. This adds to investments for the processing and marketing of agricultural products in order to obtain food products and processed products, other than those provided for in Annex 1 of the Treaty on the Functioning of the EU, for which 164.9 million euros, respectively 2.8%, were allocated, part of which could also be accessed by the vegetable processing industry if the measure sheet will prioritize this sector.

The new regulation of the Common Agricultural Policy (CAP) will bring higher direct payments per hectare for Romania. Coupled aid from Pillar I (direct payments) will keep the current list of products benefiting from coupled support: potatoes, vegetables grown in greenhouses and plastic tunnels, field tomatoes and cucumbers for industrialisation, plums, apples, apricots. All these measures will allow both the development of the short supply chain and the greater processing capacities. Overall, better targeted measures can contribute to the creation of added value and local development.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

COMPLEX NETWORK PROPOSAL FOR THE ANALYSIS OF TERRITORIAL EDUCATIONAL COVERAGE IN RURAL AREAS OF SPAIN

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Abstract

In this article we will use the approach and methodology of complex networks to analyze the territorial distribution of the public offer of secondary education in Asturias, based on the different population centers, which are the different nodes of the network, and the educational services that can connect them. Through the analysis of its structure and network topology, we will extract information that can be part of and incorporated into a complex socio-technological system that helps us understand the dynamics of Asturian territorial development. We will pay a special attention to the urban or rural nature of the nodes of the network and the implications in this regard that we can observe, due to the condition that the availability of the educational offer supposes for the development of the towns and their inhabitants. The results show a network with a scale-free topology that gives rise to consider possible alternatives that are more balanced from a territorial point of view.

Key words: *complex network, public offer of secondary education, network structure measures, topological analysis*

INTRODUCTION

We will define a complex network structure based on the territorial distribution of population units for a specific territory (Principality of Asturias, in Spain), in which the underlying network-shaped structure allows us to describe the interactions between the elementary units that we are going to consider as its support. This will help us to try to determine in turn which are the emergent properties, inherent to any complex system, that we can use, to verify, from a sustainability approach, whether certain land management guidelines are efficient and necessary. We will focus on public educational resources, of a universal and almost free nature, that the corresponding administrations, endowed with the necessary skills and financial resources, use to cover the educational needs of a specific territory.

We will start with a brief review of the literature in which the complex approach is used both to study the relationships or connections between towns and cities, and to study different aspects of the educational system. Next, the methodology used and our proposal for a complex network are described, to later present the results obtained by analyzing its structure and topology. Finally, we will present the conclusions and a brief discussion about the implications and potential of future lines of research that are based on the proposed approach and the results obtained.

Brief literature review

There are several authors who have used the complex network approach to analyze the territorial structure of aspects or variables that make it possible to establish connections between different towns or cities distributed spatially in specific territories. In logistics or transportation areas, we can highlight [11] that detect characteristics of a small world network and not free scale in the Chinese air transport network, with a degree distribution that better fits an exponential function, or [2] who have proposed a complex approach to collect the transport system of the islands of Sicily and Sardinia, which has also shown characteristics of a small world network. About telecommunications, [10] have studied the differences between the telecommunications networks of the United States and Europe, analyzing their topology to see if they conform or not to scale free networks, being distributed or not with a power law. The differences found, the authors understand that should be understood by technological, economic, cultural and political factors that explain the dynamics of these networks. [7] have studied the daily migratory flows of urban China, to determine the existing urban regions based on the connectivity of cities, beyond physical or administrative borders.

On the other hand, the analysis of the validity of the complexity approach to study different aspects of the educational system has also been addressed by different authors.

[6] consider it essential to take advantage of complexity science to understand the properties of educational systems in changing contexts. Also, [4], who concludes that it is necessary to advance in the development of methodological tools in the field of complexity for their applicability to the study of educational systems. Along the same lines, [5] determine the importance of the complex approach, both at a conceptual and methodological level, to advance in the study and understanding of both the educational system and the different educational policies implemented or to be implemented. [8] also shows the adequacy of complexity theory to the field of social sciences and specifically to the field of education.

Our proposal uses an approach based on a combination of the lines of research described, defining a complex network whose nodes are spatially distributed towns and cities and considering some aspects of the educational system as a complex system to try to understand its properties, characteristics, and functioning.

MATERIALS AND METHODS

Construction of the network structure

The nodes are determined by the population units, that is, the population centers defined by the gazetteer in the official statistics databases (National Institute of Statistics). Towns and cities configure population accumulations with a clearly defined historical and socioeconomic structure.

Number of population units (N)=6,942.

We will consider that there is a link when there is a situation between two populations in which one of them offers an educational service of secondary education and any potential student residing in another and meeting the necessary administrative requirements could choose to enroll and study at the corresponding center if desired, as long as the distance allows.

Once we have proposed the network, we will analyze its structural properties and topology, for its analysis, including a statistical contrast to verify if there is similarity with a topology adjusted to a power law, typical of scale free networks, which allows us to approximate its operation.

The source of statistical information from which the data have been obtained is the National Institute of Statistics of Spain (INE) [9]. For the construction and analysis of the proposed complex network, R has been used.

RESULTS AND DISCUSSIONS

Structural properties of the network

To analyze the structure of the network we will study, together with the number of edges and nodes, the degree of the nodes and the degree distribution, the average degree, the density of edges, the average length of the paths, the diameter and the clustering coefficient.

The number of vertices is 6,942 and the number of edges is 43,630. The network density in a complex network is the number of edges made between possible edges. In our network it is very low, specifically 0.001810959, since only 39 nodes provide the educational service to the rest. It is the clear result of the centralization in the largest population centers of educational services towards the rest, which allows us to consider education as a public service provided to rural areas from the most urban ones. There are also exceptions, as in the case of Luces, located in a small village, but it is an agrarian training center that needs to have appropriate facilities and farms. In addition, it has a boarding school, so it is an educational service offered to any other nucleus, no matter how distant it is from the center. In this case, the rural-urban relationship would be the opposite, and would derive from an alternative model to the usual one.

Given G = (V, E), we will define the degree of a node, vi, as the number of links or edges it has with other nodes

$$\deg v_i = \left|\{e_{ij} \in E: j \neq i\}\right|$$

where | · | denotes cardinality.

We will also define the degree distribution as a percentage, specifically the percentage of network nodes with a given degree, k. This definition allows it to be interpreted as the probability that a randomly selected network node has k links.

$$P(k) = \frac{|\{v_i \in V: \deg v_i = k\}|}{|V|} \text{.................................(1)}$$

where k ∈ {0, 1, ..., ∞}.

The average degree of the network, which we denote by $\bar{k}$, is defined as the average of the degrees of all nodes in the network.

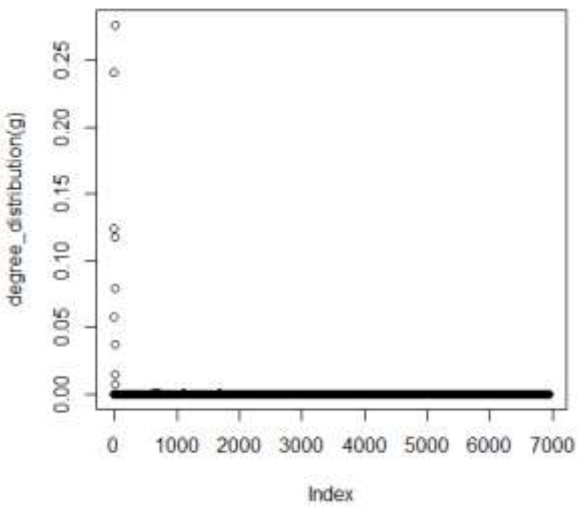

Fig. 1. Degree distribution
Source: Own elaboration.

The degree distribution is represented in Figure 1 and is typical of a network with a few highly connected nodes and the rest with few connections, like those known as scale free.

These networks also present high heterogeneity and follow a power law in the distribution of degrees [1], compared to other networks that follow exponential laws and are more homogeneous.

The mean degree of the nodes is 12.56986. We define the local clustering coefficient. According to [13] it is the number of links that a node has among the maximum number of possible links of that node. If the network is undirected, its expression is:

$$C_i = \frac{E_i}{\frac{k_i(k_i-1)}{2}} \text{..(2)}$$

If we consider it in global terms, that is, for the entire network, the average of the individual clustering coefficients of all the nodes in the network would be the global clustering coefficient.

$$C = \frac{1}{N}\sum_{i=1}^{N} C_i \text{...(3)}$$

An equivalent alternative for the calculation of the coefficient of clustering or transitivity would be the one that uses the concept of triplets.

Global clustering coefficient [12], also known as transitivity of the network, indicates the tendency to join between nodes forming groups. It is based on the concept of triplets, which are three nodes connected by two or three edges. If there are two bonds the triplet is open and if there are three the triplet is closed and is called a triangle.

$$C = \frac{N^{\underline{o}}\ of\ closed\ triplets}{N^{\underline{o}}\ of\ closed\ triplets + N^{\underline{o}}\ of\ open\ triplets} \text{...(4)}$$

For local the expression based on triplets would be

$$C_i = \frac{N^{\underline{o}}\ of\ closed\ triplets\ containing\ node\ i}{N^{\underline{o}}\ of\ triplets\ centered\ on\ node\ i} \text{..(5)}$$

In our case, the global coefficient is very low, specifically 0.007193096, because the tendency of nodes to group together is low, since only a few acts as head and are those that provide educational services to the rest.

In the local coefficients, the transitivity of the nodes that do not provide educational service is very high, but very low in those that do, that is, in those that have a secondary school. In the latter, the degree of transitivity is less than 0.03, while in the rest it is mostly 1, and in any case always greater than 0.46. Something that happens because the nodes that have a secondary school have many neighbors and therefore a high degree, unlike the rest.

Average Path Length:

$A_{length} = \frac{1}{N(N-1)} \sum_{i,j} d(v_i, v_j)$............(6)

For any two nodes we can determine the shortest path connecting them. The number of links in said shortest path is the distance $d(v_i, v_j)$ between two nodes (v_i and v_j). In our network, the average path length is 1.998204, practically equal to the diameter (maximum of the shortest roads) of the network, which is 2.

$$diam(G) = max\,\{d(v_i, v_j)\}\ \forall\ v_i, v_j \in V$$

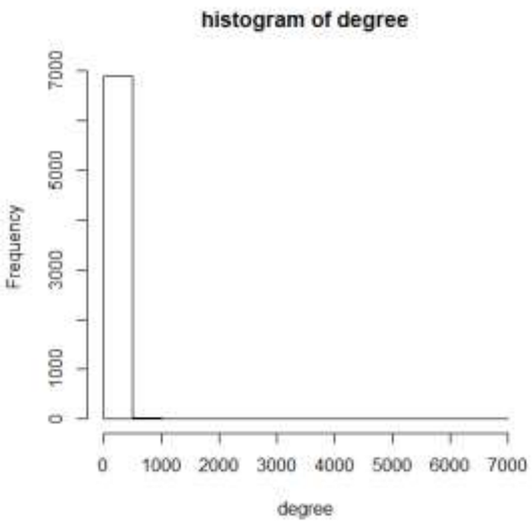

Fig 2. Histogram of degree
Source: Own elaboration.

Table 1. Topology of network

Number of nodes	**6,942**
Number of edges	43,630
Density	0.001810959
Mean Degree	12.56986
Global clustering coefficient	0.007193096
Average path length	1.998204
Diameter	2

Source: Own elaboration.

Analysis of the network topology

Statistical comparison between the observed network and random networks

In principle, our network has a few nodes with many links and most nodes with very few links, so we expect similarities with a scale-free network. These networks have a topology with a degree distribution that conforms to a power law, instead of an exponential law, more typical of Small World type networks, or a Poisson's law, typical of Erdös-Renyi networks [3].

Power Law Topology: $P(k) = Ck^{-\gamma}$............(7)

Exponential Topology: $P(k) = Ce^{-\alpha k}$.........(8)

Poisson Topology: $P(k) = e^{-z} \frac{z^k}{k!}$.................(9)

For our analysis, we will carry out a fit of the data set to simulate a scale free network and we will compare the original data with said adjustment, to verify, by means of a statistical contrast, whether they follow a power law.

The fit is carried out by the method of maximum likelihood.

The Kolmogorov-Smirnov test comparing the fitted distribution with the input vector has a test statistic of 0.005755396. Low values of the same denote better fit, as in this case.

The null hypothesis raised in the test considers that the original data could have been extracted from the distribution adjusted to the power law. In our case, a p-value of 0.9753968 is obtained, when it would need to be less than 0.05 in order to reject the null hypothesis.

The results obtained seem to indicate that the structure and topology of our complex network, which includes the provision of public educational services in the territory of action, contains a few “hubs”, that is, nodes with high connections and a behavior typical of a scale free network. This may raise the possibility of considering the convenience or not, of other alternative distributions, in which the public educational offer of secondary schools contemplates a more equitable development in the territory and with a lower incidence in the more urban centers in favor of rural areas, acting in a complementary way to existing centers, taking advantage of the possible advantages of online training, not face-to-face and the creation of more centers with internships in cases where the subjects require compulsory attendance.

CONCLUSIONS

The spatial distribution of basic services, given the possibilities offered by new technologies and educational innovation, could be the object of evolution to a more balanced territorial planning system that requires multidisciplinary study and research for its development. The network distribution, with more distributed connections, without the concentration in a few nodes, would mean in our proposal a territorial rebalancing of a basic and fundamental service such as education, especially when it comes to fixing population in rural areas, thus avoiding the flight of young talent, and encouraging greater involvement of students in their hometowns. There is currently no relevant literature on this initiative, which we believe should be approached from fields related to public economics, pedagogy, operational research, geography or sociology, among others, to lead to a specific proposal for rural and local development, but applicable to any territory that has been granted educational policy competencies, which makes this proposal an initiative of general interest.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

SELF-SUFFICIENCY FOR FOOD SECURITY ANALYSIS IN THE SAXON HOME GARDENS OF AȚELCOMMUNE, SIBIU COUNTY, ROMANIA

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Abstract

Climate change effects are more and more dramatic in the last years all over the world, and in the Eastern European countries too. In this regard, the self-sufficiency concept use for future rural strategies development should become more than relevant for ensuring food security. Such rural communities should take rapid measures for developing a new strategy for adapting to and mitigating the climate change effects. The more complex a rural landscape, the better responses against climate change effects should be. However, it seems that the best chances for the future may have heterogenous agricultural lands. In Romania, such rural areas can be easily found in Central Romania such as in Sibiu, and Brașov Counties. The scope of this article was to survey 19 properties known as Saxon home gardens in Ațel Village, Sibiu County, Romania, for self-sufficiency in case of vegetable crop production for one year. Also, the survey of wild plant species found in these home gardens is relevant to understand the need to ensure connectivity with the forests and the grasslands. At least 32 wild species and 26 crop species were identified. The self-sufficiency at the community level is ensured 100% based on the circular economy principles. The major limitation factor for agriculture in this locality is the bedrock that under severe drought periods may negatively impact food security for the future. However, the maintenance of wild or domesticated species but autochthonous, would further improve the response against climate change for rural communities in Central Romania as well as in the Easter European countries.

Key words: *agricultural land use, circular-economy, crops, food security, self-sufficiency, weed species, Saxon origin home-gardens*

INTRODUCTION

Food security became a stringent subject globally in the past 30 years, mainly due to the dramatic effects of climate change [36] and not only for the countries with weak agriculture system [33] but also for countries where agriculture is an important pillar into their national economy [31, 49]. Starting more than 20 years ago, different scientific articles, reports and publications underlined different ways and means for developing sustainable agriculture strategies for the future [47, 50]. Today the global agri-food market became more and more vulnerable and poses some more risks for countries from Africa [2, 5], Latin America and Pacific [4] as well as for the European countries [17] from an economic point of view. The volatility characteristics of the global market are well documented nowadays in one official report published some more than ten years ago by the United Nations Food and Agriculture Organization (FAO) [35] and continue today to pose the same real problems.

For more than 20 years, food-security was also discussed at the global level in close connectivity to self-sufficiency in agri-food systems [30]. Under this umbrella, it was also raised the problems generated by the colonialism that completely changed the native agricultural landscape, and today local communities are struggling to restore to ancient landscapes [15,16, 53]. Such cases are inspirational subjects for understanding how we can further develop the best strategies for a sustainable agriculture in close connectivity to landscape protection by accessing nature-based solutions [42, 43, 44].

Upon the above discussions it became more relevant that the preservation of heterogeneity of the agricultural landscaping should become part of future land-use planning [37], especially when nature-based solutions are implemented [45]. In this regard, a more heterogeneous rural landscape is most resilient against climate change and crises [46].

Based on all these discussions, self-sufficiency became more than important as research subject to be defined which, according to Jean Pierre Enriques from Zamorano University Honduras, after 2007 *it is the ability of a household or a region to cover their own agri-food requirements* [20]. However, self-sufficiency, was also defined by Cassio Luiselli Fernandez earlier in 1985 in his attempt to explain the food chain from Mexico towards the United States of America [21]. A deep search in the scientific literature reveals that Sir Alferd Daniel Hall was the initiator of this concept. Thus, he defined self-sufficiency, starting with 1920 when he was able to couple the crop production sufficiency to the income of the holder or farmer (page 64) [25].

Later, Christopher Ritson developed further the concept of self-sufficiency and raised attention to the risks of insulation and detachment of the regional and national economies [39]. Lately, human rights for food sovereignty became more vocal at the global level, especially for countries that are not able to cover self-sufficiency in agri-food systems at the national level [30]. As a consequence, it can be considered that it is relevant to understand the main characteristics of an agricultural ecosystem to cover the local needs for food and, further, to contribute to the circular economy as well as to integrate this local income into the circular economy up to the national level [26]. An appropriate analysis of such agricultural ecosystems may further support the best land-use planning for the future [48].In the past 20 years, as a baseline study in developing agricultural strategies for more sustainable economies, it became obvious that the future conceptual frameworks for sustainable agriculture development in any region should take into consideration the agricultural landscaping, nature-based solutions, pedological and climatic characteristics of the place, and self-sufficiency covering of the population needs in the European countries [48, 54], Africa [13], Asia [38] or America [40].

The scope of this article is to describe certain characteristics of self-sufficiency related to vegetables cultivation and provided by Saxon home gardens in Romania in the traditional village of Ațel, Sibiu County. The same heterogeneity of agricultural landscape can be observed as it was defined for Moșna [10]. We expect that our results will become relevant for future land-use planning, especially for heterogenous agricultural landscapes.

Also, in this article, some original nature-based solutions integration for the future rural areas' development will be emphasized. Such a conceptual framework may be further use for developing a more resilient and sustainable agricultural strategy in the countryside by considering the balance that should exist between the self-sufficiency of agri-food systems and further integration of local incomes into the regional economy to avoid the economic insulation of rural populations and to ensure food security for the future.

MATERIALS AND METHODS

The analysis of vegetable self-sufficiency is based on the household's land use inside home-gardens and adult persons relaying on the food products for one year, or 365 days. In this study we applied the same principles like in our research before [10]: (1) investigate only households as landowners and not change for more than 50 years; (2) protect from an ethical point of view the owner's identity; and (3) local endorsed landowners for local and traditional knowledge related to agricultural practices.

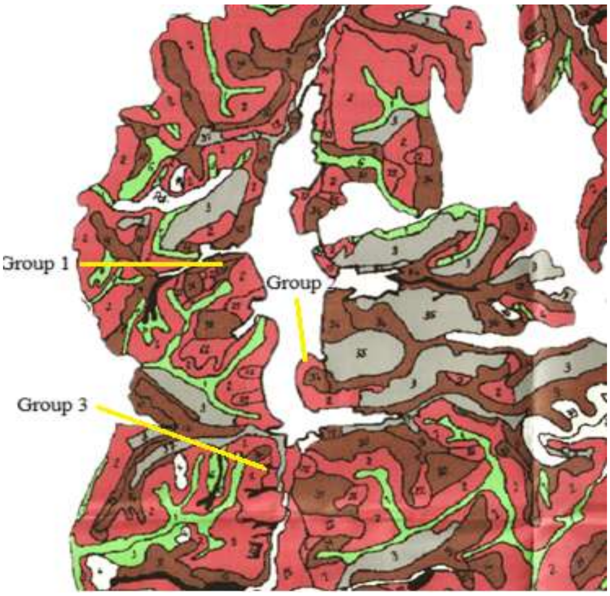
Place of study. All data collection was realized in Ațel locality, Sibiu County Romania, between 2010-2023 (GPS: 46.1572222, 24.46777) (Map 1).

Land-use mapping of home-gardens inside households was realized with the support of Google Map [23] and a Bosch GLM 50-22 laser telemeter. All obtained data with the telemeter were compared to the results obtained when Google Map provided the map. For the scope of this article, the surfaces of home-gardens were investigated as well as the need for food for the adults inhabiting the household. All in field investigations were conducted during March and September 2010,

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

2015, and 2022. The free GPS software 3.3.1.2. of Virtual Maze was used for maps creation.

Map 1. Aerial view of Ațel locality, Sibiu County, Romania map realized with Google Map
Source: Google Maps, https://www.google.com/maps, Accessed on 6 Sept. 2024[23].



Map 2. The map of arable land limitations due to bedrock for Ațel locality, Sibiu County Romania. Scale: 125 000.
Legend:
severe land limitations
extremely severe limitations
reduced land limitations.
Source: Modified map in 2024 based on the original according to Acelenescu (2007) [1].

Land Limitations mapping towards the bedrock was provided in 2010 by the Chief Officer of the Soil Studies office working under the Agriculture Direction of Sibiu County, namely Eng. Septimiu Acelenescu [1]. The map was modified with the support of the 3D Painting software to overlap the Google Map of the village and data collection areas. The original colors were used also for the final map (Map 2).

Questionnaire applied. A scientific based questionnaire developed in our laboratory based on our experience starting in 2010 was applied through direct interviews with local authorities and householders [9]. The householders are interviewed for the crops species as vegetables cultivated in their gardens as well as the self-sufficiency as production that should respond to the needs of all adult members family for one year long. The land-use in the household properties is similar towards that already published for Mosna [10].

Householder's owners survey. In 2010, 2015, and 2022, 12 full days were dedicated to field missions for 19 household owners that have been endorsed by local authorities. All owners provided information related to household surface, home-garden surface, land use history of the household, vegetable cultivated species, and the needs and gaps in their needs covering.

Scientific data bases. The official scientific names of plant species are documented based on the information provided by the International Plant Name Index [28].

Data analysis. All scientific data, based on specific criteria, were introduced and processed in Excel.

RESULTS AND DISCUSSIONS

The village of Ațel was settled by the Saxon population in 1283 and has different names under different dialects (Saxon: Hätselderf, Hâtseldref, German: Hetzeldorf, Hungarian: Ecel). If in the beginning it was populated with 14 families in a group of houses surrounding the church, during the time the population grew and slowly integrated into the natural forest and pastures a heterogenous agricultural landscape [3]. Today the locality has 565 houses or buildings, and 3 of them are still not inhabited with a population of 1,395, or 3.03 people per household. This locality is positioned at 16 km distance towards the closest city: Mediaș, and 68 km towards the capital of the Sibiu County. The village is also positioned in the protected area Sighisoara - Târnava Mare ROSCI0227 based on Natura 2000 classification system for European Union countries. Since 2015, this village is also part, of an integrated management plan for SPA Podişul Hârtibaciului, SCI Sighisoara - Târnava Mare and SCI Oltul Mijlociu – Cibin – Hârtibaciu, and it is designated as a museum open village too for eco-tourism too.

The locality is positioned in a hilly area, crossed by a small but permanent crick, with the average annual precipitations ranging between 700 and 600 mm. The year 2024 is coming with the highest shortage in precipitations for July and August [14]. We mention also a 230 m variation on vertical altitude due to hills (i.e., 540 m highest altitude) valleys, crick, and meadows (i.e., 310 m lowest altitude). The fertility of the soil is considered moderated, and the limitations of the soil dept due to bedrock are severe to extreme severe (i.e., the medium soil profile is 1 m). Due to climate conditions, the presence of forests, orchards, and vineyards, is highly important [6].These facts paved the reasons why this village was chosen as a case - study in 2010: (1) remote distance to Sibiu, (2) placed in a protected area, (3) not changed the ratio between forest/grassland, and agricultural land for more than 2 centuries, (4) and having a permanent crick water supply. Based on these, the real needs and gaps for conserving plant genetic resources for food and agriculture (PGRFA) including landraces for Romania were analyzed and finally the first red listing methodology of crops varieties was published [7]. Based on this experience, we understand further that the same type of localities may help us to understand how to define new terms for the European Union countries facing today the dramatic effects of climate change. Such terms should be self-sufficiency described above and the need to understand the relevance of wood networking for this area in case of extreme drought conditions.

Historical background. The land use is almost unchanged for more than 2 centuries when speaking of forests, grasslands, and agricultural lands based on Fiscal Conscription of Transylvania from 1750 [24]. In this regard, today we can speak of a balanced ratio for land use shared between forest (i.e., 1,239 ha), arable land (i.e., 1,250 ha) and grassland (i.e., 1,411 ha) that was almost unchanged in the past 2 centuries and also defining it as a heterogenous agricultural landscape. From an agricultural point of view, the communism did not touch this ration but only the land use inside the agricultural land (i.e., it unifies the plots in major plot areas for the intensive cultivation of large surfaces of different field cereals [27, 29]. The second attribute relevant for agriculture is that this region is highly humid during the year and due to the microclimate and summertime’s fog stagnation. Also, it can be recognized as a hot spot for wheat leaf rust (*Puccinia recondita* f.sp. *tritici*) starting with the Fiscal Conscription of Transylvania and excellent resources for wheat breeding program [41, 52]. The third attribute relevant for the scope of this article is that the agricultural land provides good conditions for maize cultivation, early season legumes, legumes generally, potatoes, orchards, and vineyards.

Householder property description. The total number of properties is 568, and 37 of these are public properties and three are not inhabited.

A decreasing trend of living population in Ațel Commune was registered immediately after 1990, when 1,277 persons were recorded. However, today the population is stabilized at around 1,300, with a proportion of 46.88% active persons and 18.57% retired persons [11].

Considering the average number of persons per household as 3.11%, it can be considered that the village can be considered among the best oriented for sustainable development if the future landscape planning is preserving the same historical structure.

The structure of population ethnicities is as follows: 84% Romanian, 8.86% Rhoma, 4.58% Saxons, 2.37% Hungarian, 0.46% Slovaks and other ethnicities 0.08% (Fig. 1) and emphasizes the multicultural values of the place also [34].

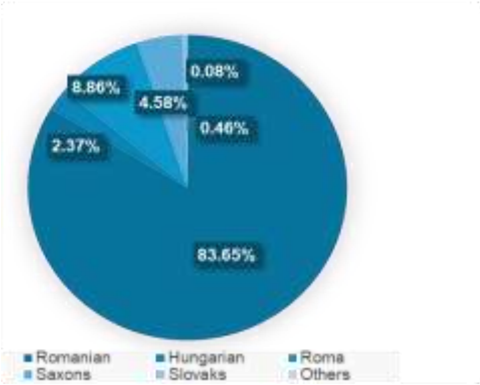


Fig. 1. The ethnic structure of Ațel locality, Sibiu County, Romania. It can be observed that the Saxon ethnics are only 4.58%.
Source: Graphic based on official reports [11].

Limitations analysis of the householders' properties.

All 19 properties have been surveyed and organized in three groups for three different positions of the villages. The main argument to be analysed is due to the position inside the village: (1) close to the forest and remote distance from the centre downstream the crick, (2) close to the crick and central and (3) close to the forest and central. This argument is also supported by the heterogenous landscape of the village, following a main central road that is parallel with the crick. The general description of the properties is below.

Map 3. First group of investigated Saxon home-gardens belongs to householders close to the forest of Ațel, Sibiu County, Romania. It comprises 5 properties, wooden fenced.
Source: Google Maps, https://www.google.com/maps, Accessed on 6 Sept. 2024 [23].

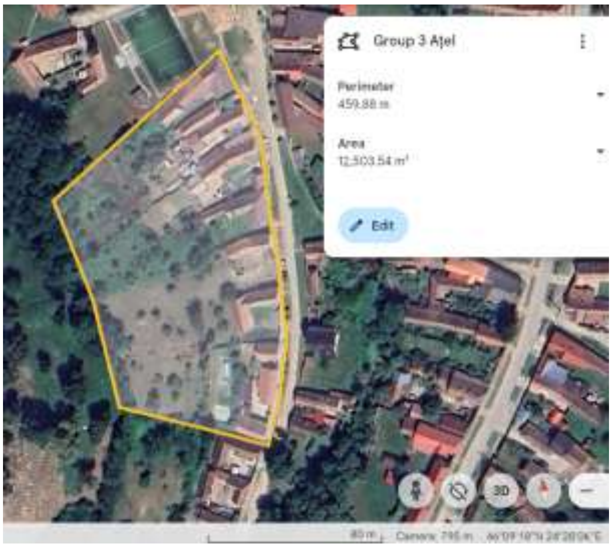
First group of householders.Five neighboring properties towards the exit of locality, to Mediaș have been chosen, and covering a total area of around 1 ha (i.e., 9,938.82 m^2, 46°09'45"N 24°27'49"E) (Map 3).

The analysis of the arable land map reveals that all five gardens present extremely severe land limitations due to the bedrock (i.e., an average of 1 m depth) (Map 2). However, the climate conditions overcome all negative effects of land limitations analysis (i.e., precipitation, annual average temperature) based on the local and traditional management of the agricultural land for more than eight centuries. All home-gardens are at the limit of the forest, wooden fenced, and a slope of 1% [1].

Group 2 comprises 6 properties and covers an area of around 12,500 m^2 (Map 4, GPS coordinates: 46°09'34"N 24°27'52"E). The analysis of the arable land map also reveals that all six gardens present severe land limitations due to the bedrock (i.e., the average depth of the soil profile goes down to 1.5 m) (Map 4). These properties are close to the church group, and better conditions for gardening are also ensured by the climate conditions and local/ traditional management of the agricultural land [1]. All gardens are at the end limit of the crick of the village, with an excellent water supply during the summertime. We mention that the crick is permanent and only for severe droughts can it disappear.

Map 4. Second group of investigated Saxon home-gardens belongs to householders close to the crick in the central area of Ațel, Sibiu County, Romania. It comprises 6 properties, wooden fenced.
Source: Google Maps, https://www.google.com/maps, Accessed on 6 Sept. 2024 [23].

Group 3 comprises 8 properties and covers an area of 12,500 m^2 (Map 5, GPS coordinates: 46°09'20"N 24°27'57"E). The analysis of the arable land map reveals that all eight gardens present severe land limitations due to bedrock (i.e., 1.5. m depth as an average) (Map 2). However, due to forest limitations the climate conditions overcome all negative effects also based on the local and traditional management of the agricultural land. All gardens are at the limit of the forest, wooden fenced, and a slope of 1.5% [1]. This group of houses is surrounding the Evangelic Church and best positioned from a defending point of view for the XIII century.



Map 5. The third group of investigated Saxon home-gardens belongs to householders, central and close to the forest of Ațel, Sibiu County, Romania. It comprises 8 properties, wooden fenced.
Source: Google Maps, https://www.google.com/maps, Accessed on 6 Sept. 2024 [23].

Self-sufficiency analysis. The main goal of this article is to investigate the vegetable needs self-sufficiency for 19 families and one year long. Usually, families owning greenhouses are the major stakeholders for the circular economy in the village. They are well integrated at the local level for selling seedlings and vegetables and in the surrounding villages and Mediaș city. Self-sufficiency also depends on the favourites species for the householders to broaden the diversity of the cultivated species. In this regard, the householders are dividing into the cultivation cycle for the spring, summer, and autumn periods of time.

Table 1 presents the results of the survey. As major discussion subjects are as following: home-garden areas, family adult members, integration in the circular economy, and covering self-sufficiency in vegetables.

Table 1. Self-sufficiency analysis for vegetable needs and covering 19 families in Ațel locality, Sibiu County, Romania. The data are collected on anonymous base and emphasizing the needs for one year long starting with 2010, 2018, 2023.

Households	Household (m^2)	Home garden (m^2)	Solar garden	Family members no	Merket selling	Self -sufficiency covering in vegetables
1.1. Forest border	1,700	1,000	No	4	Buying	80%
1.2. Forest border	1,800	1,100	No	5	Buying	80%
1.3. Forest border	1,600	800	100 m^2	4	Yes	120%
1.4. Forest border	1,300	500	No	2	Buying	100%
1.5. Forest border	2,600	1,000	No	3	Yes	120%
2.1. Crick border	1,700	1,060	150 m^2	4	Yes	120%
2.2. Crick border	2,600	1,200	No	5	Yes	130%
2.3. Crick border	3,000	2,000	No	4	Yes	130%
2.4. Crick border	1,600	1,100	100 m^2	4	Yes	110%
2.5. Crick border	2,000	1,250	No	4	Yes	135%
2.6. Crick border	1,600	1,000	No	2	Yes	210%
3.1. Evangelical Church	1,400	700	No	2	Yes	150%
3.2. Evangelical Church	1,400	600	100 m^2	3	Yes	100%
3.3. Evangelical Church	1,000	500	No	2	Yes	110%
3.4. Evangelical Church	1,800	800	No	4	Yes	100%
3.5. Evangelical Church	1,600	900	No	4	Yes	100%
3.6. Evangelical Church	1,800	1,000	No	4	Yes	120%
3.7. Evangelical Church	1,700	1,100	No	3	Yes	140%
3.8. Evangelical Church	1,800	1,100	80 m^2	2	Yes	150%

Source: based on original data from 2010, 2015, 2022.

The survey is made based on respecting the privacy of the involved persons. It can be observed from Fig. 1, that the main poll of home-gardens is covering between 200 and 400 m^2/adult persons and officially recorded for the village. Only three householders, marked in red, are depending on other vegetable production and are also integrated into the circular economy at the local level based on their statements. The rest of the householders are producing more vegetables to be included in the circular economy or as raw food materials either as home processed food (i.e., pickles, gems, compotes) or as greenhouse products (seedlings and other mature vegetables such as spinach, lettuce, green onion, and garlic).

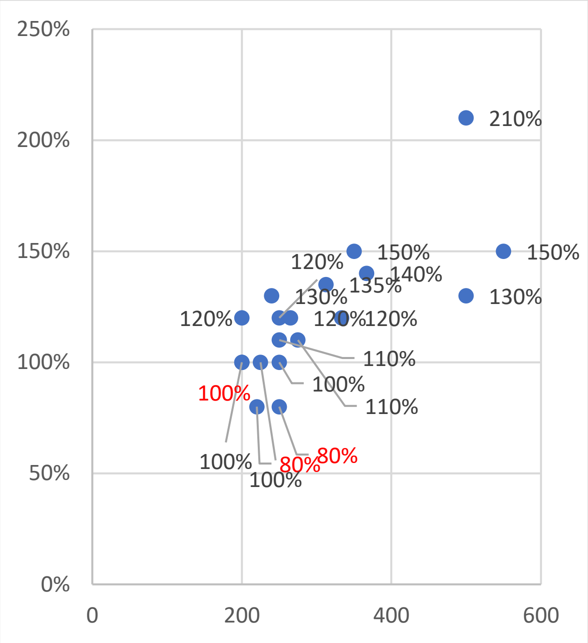


Fig. 2. Self-sufficiency analysis for cultivated vegetable in home-gardens of Ațel, Sibiu County, Romania. Three householders marked in red cannot afford to cover their needs but are part of the local circular economy.
Source: based on original data: 2010, 2015, 2022.

Photo 1. Household landscaping, orchard, vineyard and home-garden prepared for springtime Ațel, Sibiu County, Romania.
Source: Original photo taken in 2010.

The list of vegetables cultivated is presented in Table 2. The food needs of a household in the rural area are relevant to be taken into consideration when self-sufficiency is studied to enable developers to understand the future land planning consequences on food security.
An image of the landscaping of home-gardens can be analysed in Photo 1. The householder has already the knowledge for associating different vegetables for their cultivation as well as different types of technologies that are integrated already into the local knowledge (i.e., cultivating crops in solar and greenhouses) (Photo 2 and Photo 3).

Photo 2. Capsicum sp. Seedlings from garden solar in Ațel, Sibiu County, Romania
Source: Original photo taken in 2018.

Photo 3. Spinach cultivation in garden solar, Ațel, Sibiu County, Romania.
Source: Original photo taken in 2023.

A complete list of vegetable species cultivated in the surveyed home-gardens is listed in Table 2. Some of the seeds or seedlings are local, as is the example of onion seeds which are a mixture of white and red onion varieties used by the locals. They consider that this mixture is more adapted to their needs and taste (Photo 5).

Photo 4. Local onion, red and white mixed on purpose, Ațel, Sibiu County, Romania
Source: Original photo taken in 2018

Photo 5. Maize as commodity for the household feed use in Ațel, Sibiu County, Romania
Source: Original photo taken in 2023.

The same situation is for yellow maize seeds when used as a commodity for feeding animals (Photo 5). They are not using current maize varieties and prefer to cultivate local landraces [8].

The analysis of Fig. 3 revealed that pea (*Pisum sativum* L.) is not very popular, even the crop species is archaic and cultivated for more than 6,000 years in South-East Transylvania [18]. Also, other crop species, such as rosemary and fennel, very popular in traditional Saxon home-gardens are cultivated only by 5 householders of 19. This is also a subject of social choice related to crops cultivation, that should be relevant when considering food security. Multiculturality in the rural area becomes important to support further the conservation of more crop species in home-gardens of Romania.

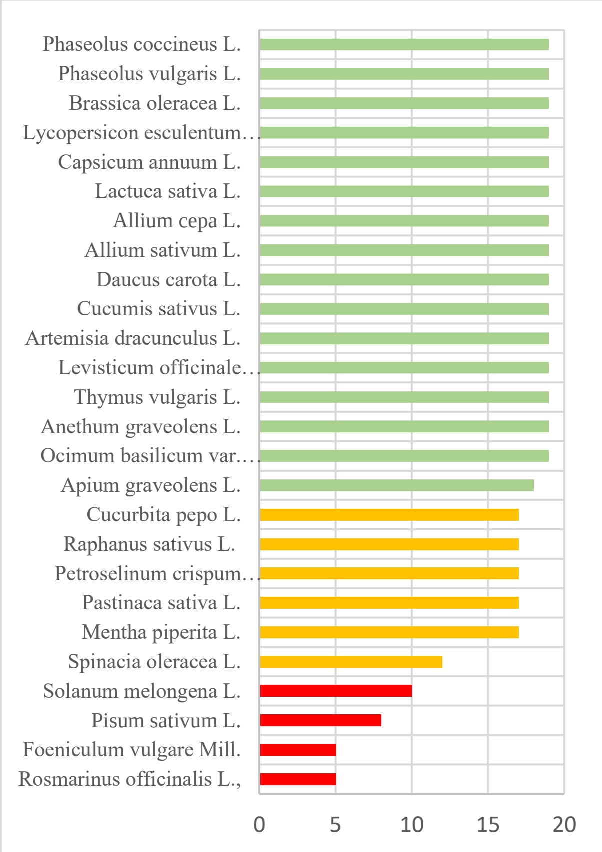


Fig. 3. The distribution of more common vegetables cultivated in home-gardens, It can be seen that at least 4 crops species are not very common such as Rosemary, fennel, pea and solanum melongena. Atel, Sibiu County, Romania
Source: based on original data: 2010, 2015, 2022

Table 2. The most common vegetables surveyed in Ațel locality, Sibiu County Romania. Their integration into the circular economy is based on the local merchandizes exchanges as raw or processed food

Crop latin name	Origin	Home-gardens
Ocimumbasilicum var. album (L.) Benth., Pl. Asiat. Rar. 2: 13 (1830)	Local	19
Rosmarinus officinalis L.,	Local	5
Anethum graveolens L.	Local	19
Mentha piperita L.	Local	17
Thymus vulgaris L.	Local	19
Levisticum officinale W.D.J.Koch	Local	19
Artemisia dracunculus L.	Local	19
Apium graveolens L.	Local	18
Pastinaca sativa L.	Local	17
Petroselinum crispum (Mill.) Fuss	Local	17
Foeniculum vulgare Mill.	Local	5
Cucumis sativus L.	Local/ trade	19

Daucus carota L.	Local/ trade	19
Raphanus sativus L.	Local/ trade	17
Allium sativum L.	Local	19
Allium cepa L.	Local	19
Pisum sativum L.	Local/ trade	8
Lactuca sativa L.	Local/ trade	19
Capsicum annuum L.	Local/ trade	19
Lycopersicon esculentum Mill.	Local/ trade	19
Solanum melongena L.	Local/ trade	10
Brassica oleracea L.	Local/ trade	19
Spinacia oleracea L.	Local/ trade	12
Phaseolus vulgaris L.	Local/ trade	19
Phaseolus coccineus L.	Local/ trade	19
Cucurbita pepo L.	Local/ trade	17

Source: based on original data: 2010, 2015, 2022.

Among the weeds 30 plant species were identified (Table 3).

Rural areas from Sibiu County, that were established by the Saxons, more than 8 centuries ago preserve the characteristics of an unchanged functional rural landscape for more than 100 years.

The main characteristics of these villages today in terms of agriculture is that most of the landowners, or householders, are interested in self-sufficiency for food production.

Considering only vegetable cultivation it can be considered that self -sufficiency is covered at the community level; even 3 of 19 owners cannot afford to cultivate vegetables as their needs for one year.

The circular economy in Ațel is functioning at the community level based on these 19 householders' surveys, only considering the raw food or feed materials covering the needs for one year.

Moreover, some of the householders are producing more vegetables to be sold as such or as primary food products (i.e., 5 of the 19) in the neighboring localities.

The investigation in the wild flora is relevant to understand the need to promote this type of rural area for biodiversity conservation and maintaining the soil fertility for long term.

Table 3. The wild herb species present in the Saxon and local home-gardens of Ațel, Sibiu County, Romania.

No.	Scientific name
1.	*Achillea millefolium* L.
2.	*Agropyron repens* (L.) P.Beauv.
3.	*Agrostis stolonifera* L.
4.	*Agrostis tenuis* Sibth.
5.	*Bothriochloa ischaemum* (L.) Keng
6.	*Danthonia provincialis* DC.
7.	*Equisetum arvense* L.,
8.	*Festuca glauca* var. rupicola Schur
9.	*Festuca pratensis* Huds.
10.	*Geranium robertianum* L.
11.	*Glyceria maxima* (Hartm.) Holmb.
12.	*Hypericum perforatum* L.
13.	*Juncus acutus* (L.) subsp. Acutus
14.	*Matricaria chamomilla* L.
15.	*Melissa officinalis* L.,
16.	*Molinia caerulea* (L.) Moench
17.	*Nardus stricta* L.
18.	*Onobrychis viciifolia* Scop.
19.	*Papaver somniferum* L.
20.	*Phragmites australis* (Cav.) Trin. ex Steud.
21.	*Plantago lanceolata* L.
22.	*Plantago major* L.
23.	*Polygonum aviculare* L.
24.	*Polygonum aviculare* L.
25.	*Portulaca oleracea* L.
26.	*Portulaca oleracea* L.
27.	*Symphytum officinale* L.
28.	*Taraxacum officinale* F.H.Wigg.
29.	*Trifolium repens* L.
30.	*Trifolium pratense* L.

Source: based on original data: 2010, 2015, 2022.

Therefore, for future it will be relevant that the Margalef index should be explored for future rural areas development [10]. In this regard it will be essential for the future rural area development strategies to include the need for the preservation of all native species no matter their role in agricultural productivity, due to their more important ecological role [19].

It is relevant that the native tree species, including domesticated tree species, be integrated into the rural area landscaping for continuing the maintenance of species communication at the root level, extremely important for land restauration [22].

This will become more relevant for Ațel, as the bedrock is a limiting factor for agriculture as well as the water access for long periods of droughts due to climate change.
In this regard, it is essential to go further and to understand the negative potential of completely removing native species from rural areas by analyzing the different examples all over the world on land restoration for rural areas [12, 32, 51].

CONCLUSIONS

Self-sufficiency studies are important for ensuring food security for the long term in rural areas, especially now when we are facing the dramatic effects of climate change. The self-sufficiency study's results are also paving the way for our research to understand the mechanisms of the circular economy functioning at the householder as well as at the rural community level. Once known very well, self-sufficiency as a concept that includes all peculiarities of agricultural landscapes in rural areas may open a new way of thinking about landscape planning at the village level by considering the resilience of local communities too, facing climate change and political crises, and ensuring food security for future generations. As we can understand from these studies the preservation of these heterogenous agricultural landscapes from the former province of Transylvania, present in Sibiu and Brașov counties of Romania [3], they may provide us different clues to understand how the rural communities can develop best and may be used as best practices in this regard. They are also essential for biodiversity conservations well as for the maintenance of original landscaping in close communication with wild nature, with a special focus also on native wild species conservation.

ACKNOWLEDGEMENTS

The authors express their gratitude to authorities and stakeholders from Ațel, as well as to Eng. Filip Drăgușanu, from the Agriculture Register of Ațel communefor making possible the communication with authorities and local householders. The paper was realized in the Research Center for Agricultural Sciences and Environmental Protection of the University Lucian Blaga of Sibiu, Romania.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY ON ROMANIA'S MEAT IMPORT FLOWS FROM 2014 TO 2023

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Abstract

This paper aimed to analyse the evolution of the Romanian`s meat imports within the last decade and to identify the main flows and trade partners who supplied from abroad Romanian meat market. The research method is based on a quantitative approach, based on international time data series related with meat imports in Romania. We quantified the Romanian imports by year and by large geographical areas, and determined the trends and growth rates for Romanian imports. The results indicated that Romania remained a huge meat importer and most part of the import flows with meat in Romania are from Europe, especially from the EU countries.

Key words**:** *trade, meat, import, Romania*

INTRODUCTION

Imports are important in a country economy as they could "have a significant positive effect on productivity growth but exports do not. Also, import liberalization could have a positive and significant contribution to growth and development" as affirmed [9].
They key determinants of import demand are "income and relative import price, but their impact differs from a country to another" as sustained [12].
As any other commodity, meat worth more money in a country with deficit than in a country with surplus and if the traders can gain a profit margin [3] from selling abroad, some enterprises will manage to make the trade happen.
The world meat trade has an essential role for balancing the meat sectors of individual countries, such as Romania. Each year there are changes in international supply chains and trade flows that can significantly impact domestic markets, necessitating a careful evaluation, to both production and imports. Romania's meat sector follows these global influences, as the country depends heavily on imported meat products to meet its consumption demand. Tracking into the past, one important moment was related with Romanian integration in EU, when the meat imports started to be predominant from this market. [5]. Romania is recognized as a net importer for meat, and particularly for pork and chicken [1]. The low competitiveness of the Romanian meat sector was related by some authors with the overall meat trade negative balance [4]. Popescu [7] mentioned that after Romania joined the EU, its dependence on imports increased, at the beginning for live pigs and then for pork carcasses and meat and also emphasizes the critical role of meat trade in Romania, detailing import and export dynamics [8]. Stanciu et al. [10] also assess the competitiveness of the Romanian meat processing industry, stressing the dependency on meat imports. A special attention to the evolution of livestock, to the main suppliers for the meat market can be also considered by authorities, who have to find solution in reducing the meat imports [6]. Recent studies indicated that meat consumption in Romania increased while domestic production can`t support enough the internal market, so the imports became crucial [11].
In this context, the aim of this study is to analyse the dynamics of the Romania`s meat imports within the last decade 2014-2023 and to identify the main flows and trade partners who supplied the internal meat market.

MATERIALS AND METHODS

For this paper the statistic and trade indicators were used. The evolution of imports in Romania during the period 2014-2023 was studied by country and large geographical areas of origin, determining the trends and yearly growth. The date regarding trade imports, in terms of value were collected from International Trade Centre – ITC through its official web site [2].

RESULTS AND DISCUSSIONS

The total meat imports in Romania have significantly changed in the studied interval, increasing from 545,575 thousand euro in 2014 to 1,534,539 thousand euro in 2023. A significant part of this growth can be observed from countries that belongs to Europe, which has recorded a constant and significant increase by approximately 181% from 2014 to 2023.

Starting from 2023, there is a distinguishable presence of meat imports in Romania from North America, amounting to 1,337 thousand euro, which is approximately 0.087% of the total imports for that year (Table 1).

Table 1. Evolution of Romania's meat imports between 2014 and 2023 (thousand euro)

Year	World	Europe	North America	Oceania	South America
2014	545,575	514,143	0	64	3,981
2015	568,661	537,506	0	135	1,767
2016	643,710	605,740	0	190	1,185
2017	766,528	730,168	0	0	1,286
2018	817,588	766,787	0	108	322
2019	940,316	883,670	0	172	286
2020	912,484	861,626	0	228	96
2021	973,613	925,012	0	312	342
2022	1,300,729	1,230,623	0	308	420
2023	1,534,539	1,445,295	1,337	940	1,935

Source: ITC [2].

Oceania and South America are the other geographical areas from which meat imports in Romania are coming from.

Australia has consistently been the largest exporter of meat to Romania from Oceania, dominating the market in all years with values ranging from 64 thousand euro to 701 thousand euro.

Imports from New Zealand have been minimal or non-existent in most years, with some increase in recent years, indicating a limited but growing trade relationship in meat imports (Figure 1).

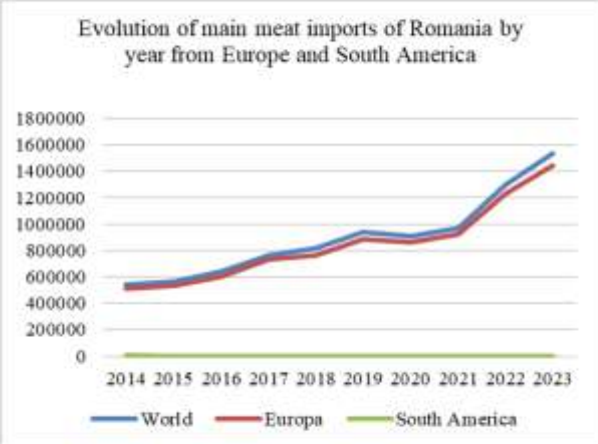

Fig.1. Evolution of the main meat imports of Romania by year from Europe and South America (thousand euro)
Source: ITC [2].

Germany was the main exporter of meat to Romania in 2014 with 145,503 thousand euro (26.7% of total imports), followed by Hungary with 114,615 thousand euro (21%), and the Netherlands with 70,737 thousand euro (13%). Imports from Spain were 50,103 thousand euro (9.2%) and Poland were 121,551 thousand euro (22.3%) (Figure 2).

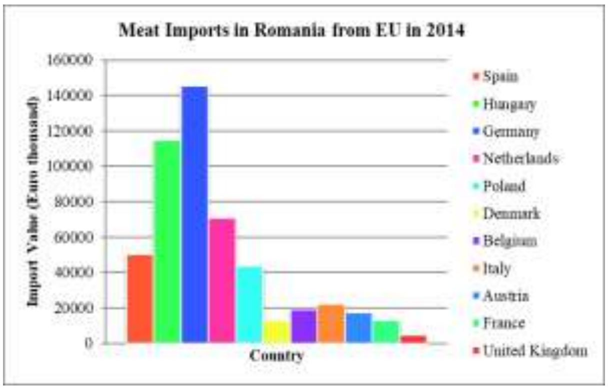

Fig. 2. The meat imports in Romania from EU in 2014 (thousand euro)
Source: ITC [2].

Germany maintained its leading position with 158,091 thousand euro in 2015 (27.8% increase from 2014) (Figure 3).

Imports from Spain increased to 60,989 thousand euro in 2015 (21.7% increase from 2014), surpassing Poland and the Netherlands.

Hungary remained in second place in 2015 with 113,819 thousand euro (a slight decrease of 0.7% from 2014) (Figure 3).

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

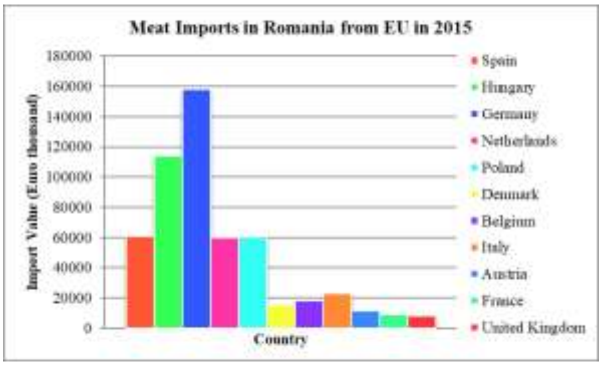

Fig. 3. The meat imports in Romania from EU in 2015 (thousand euro)
Source: ITC [2].

Also in 2016, Germany maintained its leading position in the meat exports to Romania with 151,817 thousand euro (4% decrease from 2015), followed by Hungary and Spain with 126,791 thousand euro (11.3% increase from 2015) and 101,231 thousand euro (65.9% increase from 2015) respectively. Imports from the Netherlands continued to decline to 58,847 thousand euro (11.2% decrease from 2015), and Poland`s exports valuated 129,179 thousand euro (5.9% increase from 2015) (Figure 4).

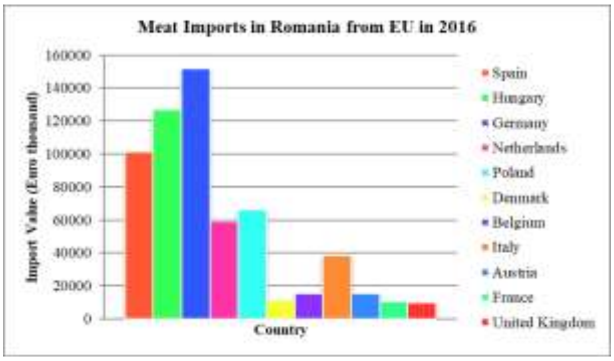

Fig. 4. The meat imports in Romania from EU in 2016 (thousand euro)
Source: ITC [2].

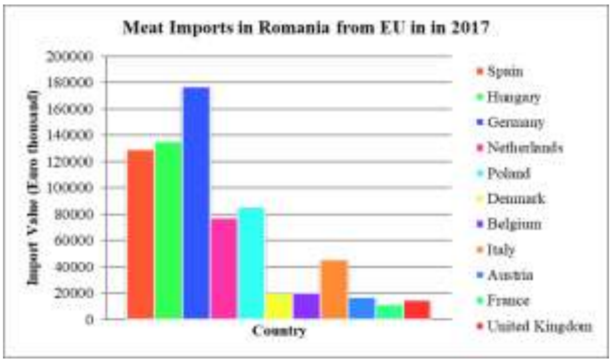

Fig. 5. The meat imports in Romania from EU in 2017 (thousand euro)
Source: ITC [2].

Germany continued to be the leader in 2017 of meat exports in Romania with 176,706 thousand euro (16.4% increase from 2016) (Figure 5).
Hungary came on the 2nd position with 135,071 thousand euro (6.5% increase from 2016) and Spain with 129,000 thousand euro (27.5% increase from 2016).Imports from Poland and the Netherlands were 129,179 thousand euro and 77,131 thousand euro (31.1% increase from 2016) (Figure 5).
In 2018, Germany maintained its top position with 174,225 thousand euro in the meat export to Romania (1.4% decrease from 2017), followed by Spain with 164,720 thousand euro (27.7% increase from 2017) and Hungary with 149,656 thousand euro (10.8% increase from 2017). Imports from Poland and the Netherlands were 129,179 thousand euro and 73,228 thousand euro (5% decrease from 2017) (Figure 6).

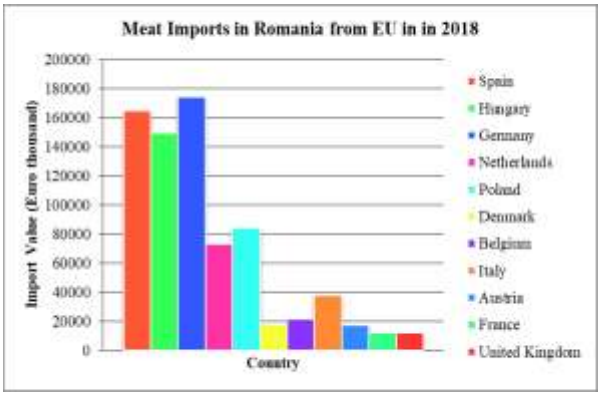

Fig. 6. The meat imports in Romania from EU in 2018 (thousand euro)
Source: ITC [2].

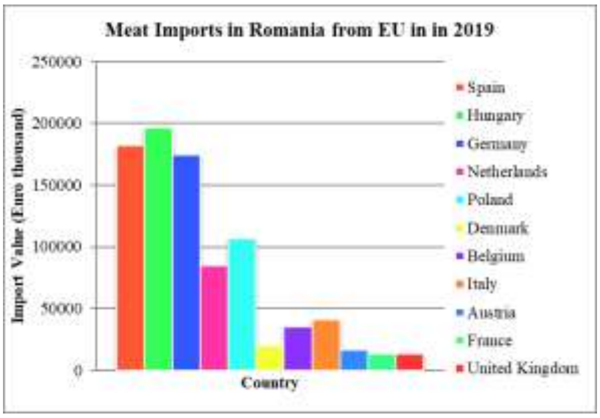

Fig. 7. The meat imports in Romania from EU in 2019 (thousand euro)
Source: ITC [2].

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Hungary surpassed Germany, becoming the main exporter of meat to Romania with 196,535 thousand euro in 2019 (31.3% increase from 2018) (Figure 7).

Spain was in second place with 182,017 thousand euro (10.5% increase from 2018), and Germany in third with 174,586 thousand euro (0.2% increase from 2018). Imports from Poland and the Netherlands were 129,179 thousand euro and 84,848 thousand euro (15.8% increase from 2018) (Figure 7).

Spain became the leader in meat imports to Romania with 176,176 thousand euro in 2020 (3.2% decrease from 2019), surpassing Germany with 174,943 thousand euro (0.4% decrease from 2019) and Hungary with 170,092 thousand euro (13.5% decrease from 2019). Imports from Poland and the Netherlands were 121,551 thousand euro (5.9% decrease from 2019) and 82,130 thousand euro (3.2% decrease from 2019) (Figure 8).

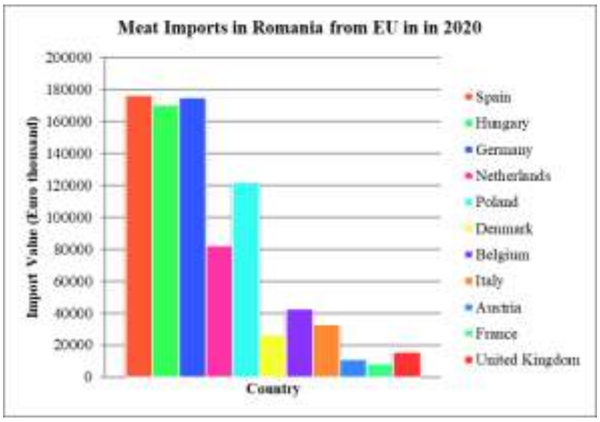

Fig. 8. The meat imports in Romania from EU in 2020 (thousand euro)
Source: ITC [2].

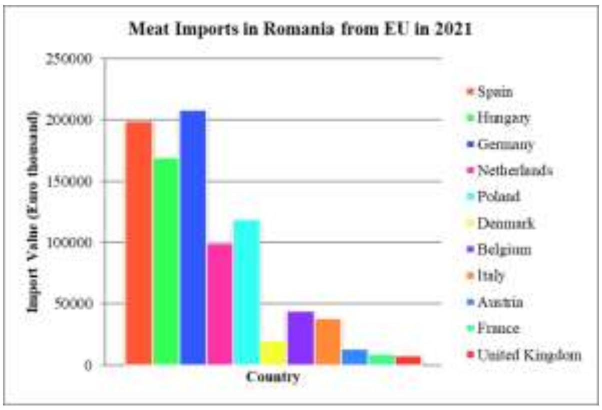

Fig. 9. The meat imports in Romania from EU in 2021 (thousand euro)
Source: ITC [2].

Germany returned to the top position with 208,249 thousand euro in 2021 (19% increase from 2020) (Figure 9).

Spain came on the second position with 198,823 thousand euro (12.9% increase from 2020) and Hungary with 169,047 thousand euro (0.6% decrease from 2020). Imports from Poland and the Netherlands were 129,179 thousand euro (6.3% increase from 2020) and 99,112 thousand euro (20.7% increase from 2020) (Figure 9).

Spain shifted again and became leader in the meat exports to Romania in 2022 with 310,167 thousand euro (55.9% increase from 2021), followed by Germany with 257,933 thousand euro (23.8% increase from 2021) and Hungary with 220,503 thousand euro (30.4% increase from 2021). Imports from Poland and the Netherlands were 129,179 thousand euro (same as 2021) and 134,254 thousand euro (35.5% increase from 2021) (Figure 10).

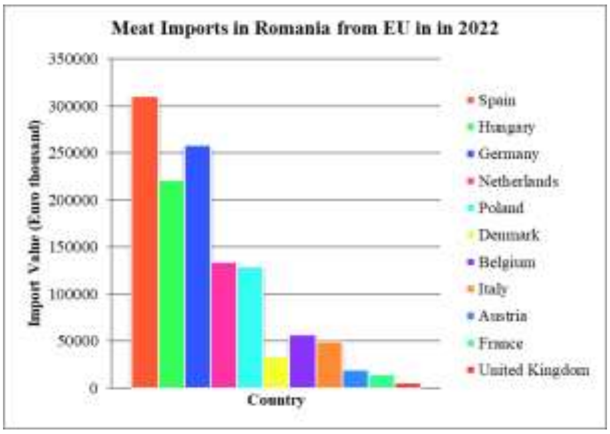

Fig.10. The meat imports in Romania from EU in 2022 (thousand euro)
Source: ITC [2].

Spain maintained its leading position in 2023 with 424,144 thousand euro (36.8% increase from 2022), followed by Hungary with 270,367 thousand euro (22.6% increase from 2022) and Germany with 255,125 thousand euro (1.1% decrease from 2022).

Imports from Poland and the Netherlands were 138,923 thousand euro (7.5% increase from 2022) and 153,422 thousand euro (14.3% increase from 2022) (Figure 11).

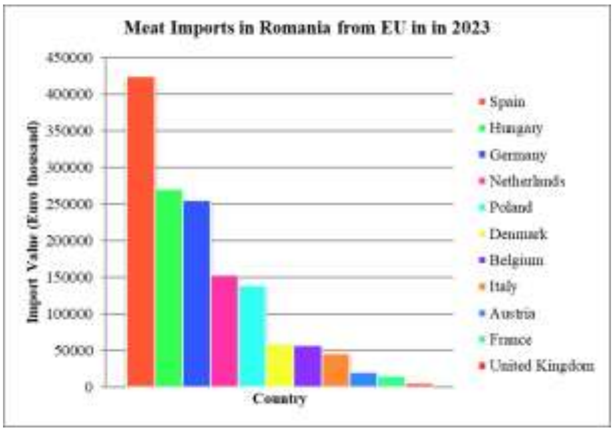

Fig.11. The meat imports in Romania from EU in 2023 (thousand euro)
Source: ITC [2].

The chart that shows the annual growth rate of meat imports in Romania indicates that only the imports from Europe have a predictable trend (Figure 12).

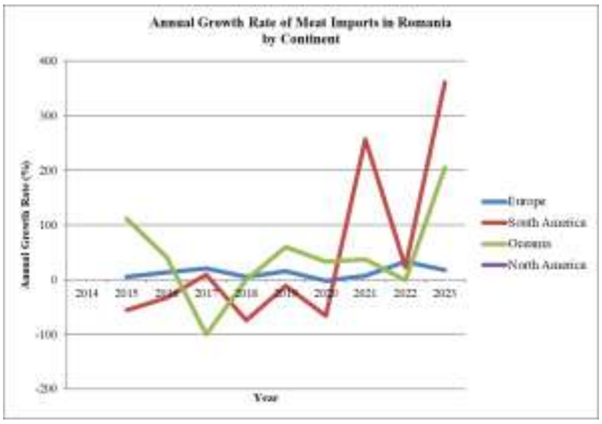

Fig.12. The Annual Growth Rate of Meat imports in Romania between 2014 and 2023
Source: ITC [2].

CONCLUSIONS

Germany has consistently been one of the largest exporters of meat to Romania, dominating the market in most years with values ranging from 145,503 thousand euro to 208,249 thousand euro. Hungary and Spain have had significant impacts, alternating in the top three exporter positions, with values ranging from 114,615 thousand euro to 310,167 thousand euro. Imports from the Netherlands and Poland have been steady but significantly lower compared to Germany, Hungary, and Spain, with values ranging from 58,847 thousand euro to 153,422 thousand euro. The year 2020 marked a significant change, with Spain becoming the leader with 176,176 thousand euro, reflecting possible changes in trade relations or import preferences of Romania. In the long term, there is a trend of diversifying import sources, although Germany, Hungary, and Spain remain the main meat exporters. The overall trend shows Australia as the primary and significant supplier of meat from Oceania to Romania, with New Zealand starting to contribute more in recent years.

Canada and the United States of America have had minimal or no recorded meat exports to Romania in most years. The overall trend shows a very limited trade relationship in meat imports from North America to Romania, with a notable exception for Canada in 2023. Meat imports from South America in Romania had a variable evolution between 2014 and 2023. Although the figures are lower compared to Europe, there is an increasing trend in the recent years.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

HOW COMPETITIVE ARE THE BUSINESS INVOLVED IN THE PROCESSING AND PRESERVATION OF POULTRY MEAT IN ROMANIA?

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Abstract

This paper aimed to analyse the situation on the market of the main enterprises from Romania involved in the processing and preservation of the poultry meat. The research method is based on a quantitative approach, and it is made at county and national level. We grouped the specialized enterprises in processing and preservation of poultry meat by county and analysed their dimensions, related with their number of employees, the turnover and the profit they made. The results indicated that the number of active businesses in this field is not large enough and their economic results can be in most cases highly improved in the next years.

Key words**:** *poultry meat, processing and preservation, business, Romania*

INTRODUCTION

After several years of decline of Romanian poultry livestock [9, 10], some signs of recovering were seen in the recent years when the entire poultry livestock increase up to 7.82 million heads in 2022 from a last decade minim of 7.11 million heads, recorded in 2020 [8]. Around 47% from the all-poultry livestock was dedicated to the meat processing.
As any other business, the one involved in the processing and preservation of poultry meat aimed to increase their turnover and profit, based on their high-quality poultry meat products, their integration in the poultry meat chain [5], also on their investments and innovative approaches, targeted on increasing safety and quality of their production operation. The consume of poultry is usual compared with the other meat option for consumption, based on nutritional aspects [3, 9]. While the poultry meat is leading over the meat market in relation with the production period and costs, feed efficiency, and opening on the large urban cities, the world poultry consumption is anticipated to grow, by 15% until 2032 when will account over 2/5 from the all-protein consumption from meat [1]. In Romania, local researches indicated that most part of the population consume poultry meat and over 2/3 of buyers use to shop this type of meat each week [2]. Despite some changing in buying and cooking behaviour, registered on the important international markets [2] the poultry industry is adapting to the market even if some certain events as avian influenza [12] and Covid 19 [4, 6, 11] affected this sector.
In this context, the purpose of this study is to analyze the situation of the main Romanian enterprises involved in the processing and preservation of the poultry meat.

MATERIALS AND METHODS

For this paper we used data provided by the Romanian Ministry of Finance, through its official web site [7]. The data were analysed at the county level. We used the economic indicators as number of employees, the turnover and the profit, in order to evaluate the situation in the sector. We also made an analyse in relation with the recent evolution of the top enterprises that activated on the market.

RESULTS AND DISCUSSIONS

In the fiscal year 2021 in Romania activated 69 enterprises, having the main activity poultry processing of meat and its preservation. Since around 40% of them didn't have any employees, is not surprising that for the fiscal year 2022 their number decreased at 31 and their overall situation anticipate even a higher reduction in the next years if no other enterprises will replace them on the market. If in 2021 the main enterprises that activated on this market were situated in Alba County, Bacău County and Vaslui County, having a total market share of over 64%, in 2022 the main enterprises were found in Alba County, Vâlcea County and Bacău County, with a share of market of over 59%. Bucharest is the Romanian location for most of the enterprises [6] that have activated in the field of poultry processing of meat and its preservation, followed by Brașov County and Constanța County with 5 enterprises (Fig.1).

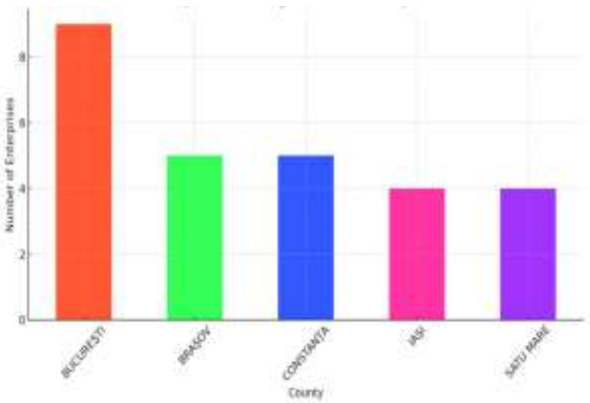

Fig.1. Total counties with the highest number of enterprises in the field of poultry processing of meat and its preservation in 2022
Source: Ministry of Finance from Romania, Official website [7].

In 2022, Alba County (2,276 employees), Bacău County (1,985 employees), Vâlcea County (855 employees) and Vaslui County (843 employees) were the counties with the biggest number of employees in the enterprises that activated in the processing of meat and its preservation sector (Fig. 2). They account over 45% from the all number of workers in the enterprises specialized in processing of meat and its preservation. Over 22% from the enterprises involved in this sector didn't have in 2022 any employees recorded in the official reports. Comparative, in 2021, Bacău County (1,862 employees), Alba County (1,713) employees) and Brașov County (796 employees) cumulated over 70% from the all number of employees in the enterprises specialized in the poultry processing of meat and its preservation.

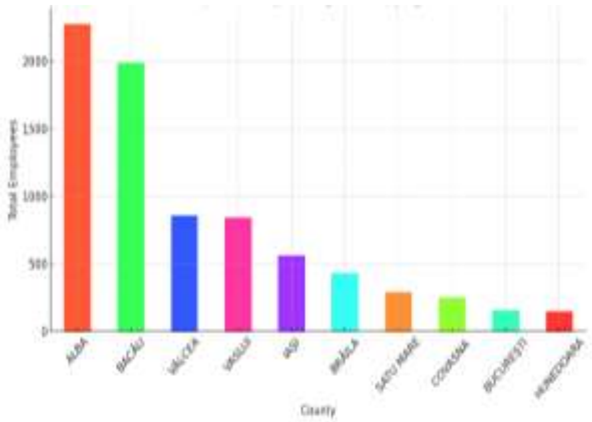

Fig. 2. Top counties with the highest number of employees that are activating in enterprises in the field of poultry processing of meat and its preservation in 2022.
Source: Ministry of Finance from Romania, Official website [7].

Only one enterprise from the top 3 had a significative increase of the workers between 2019 and 2023 (Fig. 3).

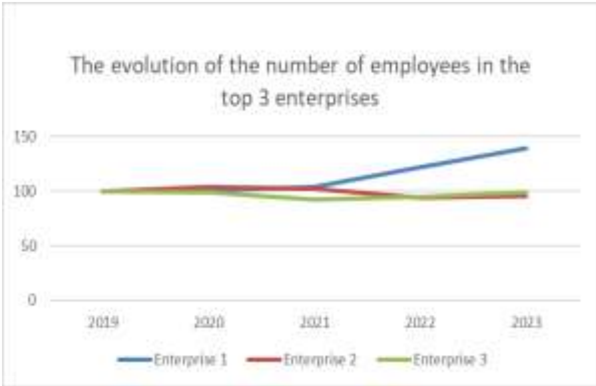

Fig. 3. The evolution of the number of workers between 2019 and 2023 in the top enterprises in the field of poultry processing of meat and its preservation in Romania
Source: Ministry of Finance from Romania, Official website [7].

The first enterprise from the sector had an increase of the employees with 39.11% in 2023, compared with 2019. The second classified enterprise in the poultry processing of meat and its preservation sector in Romania had a decrease of employees with 6.24% in 2022 comparative with 2019, while in 2023 the number of workers slightly increased, but was

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

still 4.68% less than in 2019. Compared to 2019, the number of workers in the 3rd business from the sector decreased with 7.46% in 2021, and with 1.34% in 2023 (Table 1).

Table 1. The evolution of the number of workers, between 2019 and 2023 in the top enterprises in the field of poultry processing of meat and its preservation in Romania

Year	Enterprise 1	Enterprise 2	Enterprise 3
2019	100	100	100
2020	100.12	103.57	98.76
2021	104.19	102.34	92.54
2022	122.09	93.76	95.13
2023	139.11	95.32	98.66

Source: Own calculation after the data provided by the Ministry of Finance from Romania, Official website [7].

The group of the three enterprises from Alba County had in 2022 a net turnover of over 231 million euro, followed by Vâlcea County with over 185 million euro, represented by only one enterprise, and Bacău County with over 176 million euro, through three enterprises (Fig. 4).

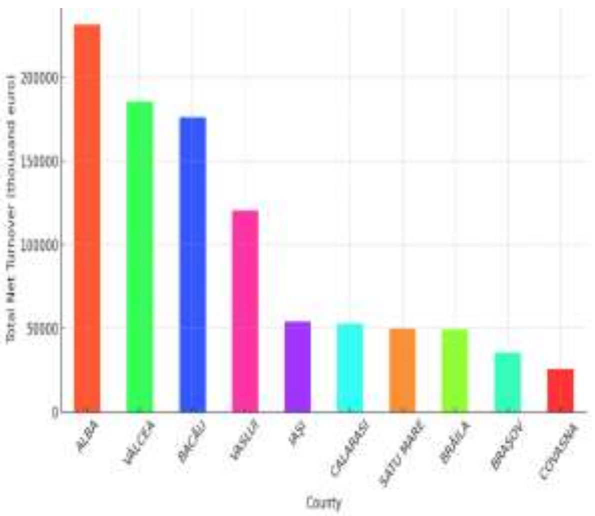

Fig. 4. Top counties with enterprises in the field of poultry processing of meat and its preservation in 2022 that recorded significant net turnover
Source: Ministry of Finance from Romania, Official website [7].

An analyse of the evolution of the net turnover in the top 3 enterprises that activated in the processing and preservation of poultry meat sector indicated that in the last 5 years the increase of the net turnover had a positive trend for all of them (Fig.5).

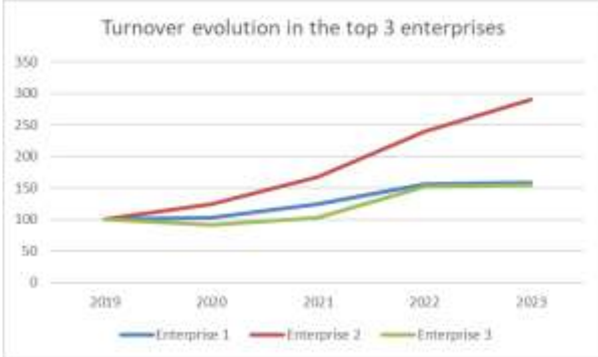

Fig. 5. The evolution of turnover in the top 3 enterprises in the field of poultry processing of meat and its preservation between 2019 and 2023 (2019 – the reference year, %)
Source: Ministry of Finance from Romania, Official website [7].

The first enterprise from the sector had an increase of the turnover with 58.88% in 2023, compared with 2019. The second classified enterprise in the poultry processing of meat and its preservation sector in Romania had an increase of turnover with 139.05% in 2022 comparative with 2019, while in 2023 the turnover increased with 189.86% more than in 2019. Compared to 2019, the turnover in the 3rd enterprise from the sector increased with 52.77% in 2022, and with 54.67% in 2023 (Table 2).

Table 2. The evolution of turnover in the top 3 enterprises in the field of poultry processing of meat and its preservation (2019 – reference year, %)

Year	Enterprise 1	Enterprise 2	Enterprise 3
2019	100	100	100
2020	102.25	124.23	92.02
2021	124.48	167.23	102.54
2022	155.80	239.05	152.77
2023	158.88	289.86	154.67

Source: Own calculation after the data provided by the Ministry of Finance from Romania, Official website [7].

Alba County with over 47 million euro, besides Bacău County with over 14 million euro and Iași County with almost 9 million euro, were the counties with the largest net profit recorded in 2022 in the processing of meat and its preservation sector. The same analyse made for the evolution of the net profit in the top 3 enterprises that activated in the processing and preservation of meat indicated also that after a year 2020 when the enterprises face difficulties, the profit had a positive trend for all of them (Fig. 6).

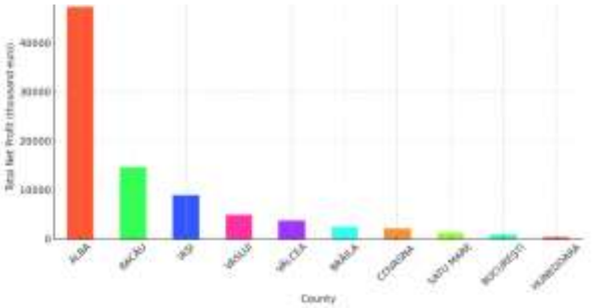

Fig. 6. Top counties with enterprises in the field of processing of meat and its preservation in 2022 that recorded significant net profit
Source: Ministry of Finance from Romania, Official website [7].

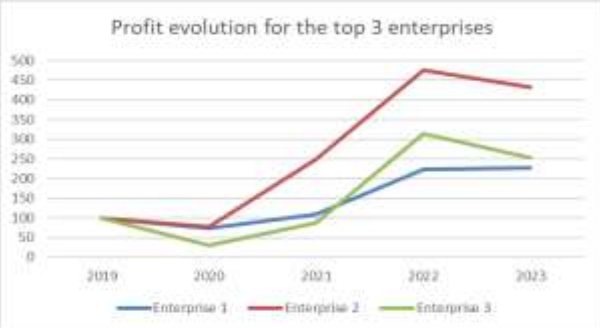

Fig.7. The evolution of profit in the top 3 business in the field of poultry processing of meat and its preservation between 2019 and 2023 (2019 – the reference year, %)
Source: Ministry of Finance from Romania, Official website [7].

Table 3. The evolution of the net profit in the top 3 enterprises in the field of processing of meat and its preservation (2019 – reference year, %)

Year	Enterprise 1	Enterprise 2	Enterprise 3
2019	100	100	100
2020	73.08	77.70	30.09
2021	110.12	249.09	87.70
2022	223.90	475.74	314.11
2023	227.20	431.40	253.71

Source: Own calculation after the data provided by the Ministry of Finance from Romania, Official website [7].

The first business from the sector had an increase of the net profit with 127.2% in 2023, related with 2019. The second classified enterprise in the poultry processing of meat and its preservation sector in Romania had an increase of profit with 375.74% more in 2022 comparative with 2019, while in 2023 the net profit increased with 331.4% more than in 2019. Compared to 2019, the turnover in the 3rd enterprise from the sector increased with 214.11% in 2022, and with 153.71% in 2023. In 2020 all the enterprise from the top 3 recorded a profit net under the values from 2019. The 3rd enterprise recorded in 2020 a decrease of almost 70% of its profit, compared with 2019 (Fig. 7, Table 3).

CONCLUSIONS

The poultry processing of meat and its preservation industry has faced major challenges, including avian influenza and the COVID-19 pandemic, but has needs to adapt to market conditions. Since the number of active enterprises in this field decrease in the last years and is not large enough, Romania needs to develop and support enterprises in the poultry processing of meat and its preservation sector to fully exploit market potential and to ensure sustainable economic growth and consumers protection. Because it is expected a higher poultry meat consumption in the next decade, the integrated companies producing broilers will be tempted to diversify the sorts of poultry meat and also to extend the preservation sector.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

FACTORS INFLUENCING MARKETED SURPLUS OF TOMATOES IN PUNJAB, PAKISTAN

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Abstract

Many vegetables are grown throughout Pakistan's provinces, but tomatoes, potatoes, cauliflower and onions are among the most common ones. Pakistan has a 150 thousand acres of tomato farming, producing 57094 tonnes of tomatoes per year, making it the world's 35th largest producer. Due to importance of tomatoes in our daily routine, there is need to explore marketing system of tunnel grown tomatoes, analyze current marketing margins, as well as to quantify the impact of significant variables affecting marketed surplus of tomatoes. The study was confined to areas of the district Lodhran because there is an increasing trend to produce tomatoes by using tunnel system in the region. Then Lodhran tehsil was chosen purposively. After selecting region then 100 tomato farmers (50 tunnel growers and 50 non tunnel growers), 20 commission agents, 20 wholesalers, 20 retailers, and 100 tomato consumers were chosen as sampled respondents. Convenient sampling technique was used to select the sample. The frequencies and percentage of sampled respondents was calculated by using descriptive statistics. The impact of factors affecting tunnel tomato growers' marketed surplus was determined by using multiple regression analysis. The regression results showed that the selected traits (experience, area, marketing cost, sale price, and distance from the output market) are influencing significantly on the marketed surplus. So, both public and private sectors should engage to organize and rain the tomato farmers regarding tunnel farming in the region.

Key words: *tunnel grown tomatoes, marketing system, tunnel growers, output market, marketed surplus*

INTRODUCTION

All necessary nutrients, such as vitamins, minerals, and fibers, are found in the food we eat daily. Most of the food we eat nowadays is not suitable for our bodies. Vegetables have long been thought to be a source of nutrients and good immunity. A person who consumes the recommended number of fruits and vegetables is disease-free. Vegetables are an all-important part of a diet because they keep our stomachs satisfied for a longer time (Government of Pakistan, 2022) [12].

Tomatoes are an important part of a kitchen dairies. Important minerals, vital amino acids, carbohydrates, dietary fibers and vitamins are present in them. Tomatoes have high levels of vitamins (B and C) as well as minerals (phosphorus and iron). Tomatoes might be used raw in salads or cooked in sauces, dishes and soups. Purées, juices, and ketchup may be made from them. Tomatoes, both canned and dried, are important processed food items. Though yellow tomatoes have higher the quantity of vitamin A rather than red tomatoes, red tomatoes include lycopene, an antioxidant that may protect against carcinogens (Government of Pakistan, 2020) [13]. In all the provinces of Pakistan production of tomatoes is twice a year. Once it is cultivated in the spring and second it is cultivated in autumn. From 2017 through 2018 total production of tomato crops over an area of 41,731 hectares was 414,645 tons. Cultivation of tomatoes during 2017-2018 in Punjab, Khyber Pakhtunkhwa (KPK), Sindh, and Baluchistan over an area of 2,874, 3,135, 24,968, 5,354 hectares with 109,445, 85,446, 182,198, 37,556 tons' production respectively (Hassan et al., 2018) [17].

Tomato cultivation is mostly done in small farming areas in Pakistan. Tomato cultivation in the small fields produces the most benefit to the producers and provides job opportunities to the people of rural areas but its yield is lower in Pakistan (Mari et al., 2007) [22].

The portion of production that actually makes it onto the market is known as the "marketed surplus." Marketed surplus is the money that remains with the farmer after covering family expenses, gifts, payments in kind, and on-farm waste (Gupta and Arora, 2015) [15]. In certain definitions of marketed surplus, distressed sales—in which grain is sold soon after harvesting to meet debt commitments and later replenished or repurchased—are included; nevertheless, they are deducted from marketable excess. In this situation, marketable surplus is the net amount following repurchases, whereas marketed excess would be a gross phrase. Farmers' reactions to price fluctuations can guide appropriate agricultural price policy, which in turn may serve as a catalyst for growing agricultural output (Goyal and Berg, 2017; Rifin, 2022) [14, 28].

The establishment of appropriate policies with respect to prices, exports, imports and marketing and overall rural and national development goals can greatly benefit from an understanding of the behavior and variables driving marketed surplus (Chatha and Singh, 2013; Dhindsa and Singh, 2013) [8, 11]. In non-market subsistence agriculture, surplus produce can be given away or transferred in kind, and any remaining goods can be sold in the market (Hariss, 2011; Dhindsa and Singh, 2013) [18, 11]. Small and medium farmers held a significant portion of their production of food for household needs, according to research on the pattern of marketable surplus of food grains by farm size. Compared to small farmers, major farmers sold a disproportionately high quotient of their marketed surplus of wheat during the post-harvest period. Later, the (Krishna, 2015) [21] model-generated feasible ranges of market pricing for wheat in Punjab were compared by (Behrman, 2017) [7]. It was discovered that although the models converged when the majority of production was sold, they might actually diverge in magnitude and sign when less than half of the output was sold. Furthermore, when marketed surplus was expressed as a percentage of output, some empirical data suggested that medium-sized farms marketed a smaller percentage of their surplus than very small and very big farms did (Aslam et al., 2013) [3]. Therefore, by keeping in view the importance of research topic the study in hand is designed to explore factors influencing marketed surplus of tomatoes in district Lodhran.

Literature Review

The literature regarding marketing system of tomatoes more specifically marketed surplus has been scanned from developed and developing nations.

Aminu (2009) [2] observed that experience and a good rapport with the commission agents and farmers matters a lot in a normal vegetable marketing system. According to Olukosi et al. (2005) [25], the marketing task entailed the movement of goods from producers to consumers. The marketing function guaranteed that customers received the product in the form, location, and time that they prefer. Marketing increased the productivity of all sectors of the economy by stimulating output, business, and specialization. As a country's economy increases, the divide between farmers and consumers widens, making marketing more difficult to operate (Badar et al., 2021) [5]. Tomato had a significant ability to increase profitability of associated stakeholders and reduce poverty. Undoubtedly, a large number of people would be employed in its production, handling, shipping, distribution, and marketing. Tomatoes could be sold domestically or processed and exported to other West African nations. The marketability of agricultural products played a big role in increasing production. An effective market not only connected sellers and buyers in adjusting to current supply and demand situations, but also played a dynamic role in encouraging output consumption, which was critical to economic development (Haruna et al., 2012) [19]. Among the several vegetables cultivated in Pakistan, the tomato was definitely the most significant, both in terms of production and consumption (Adejobi et al., 2011) [1]. Consumer preferences for consumption and purchase, as well as consumer priority ratings for key tomato quality criteria, collected. Descriptive statistics, analysis of variance, and post-hoc testing used to analyze the collected data. The findings revealed both parallels and differences in fresh tomato consumption and purchase preferences in three cities. In most of the experience, safety, and marketing criteria, the survey found no statistically significant variations in consumer preferences (Bashir, 2003; Cholan, 2007) [4, 10]. When it came to search attributes, consumers had a wide range of preferences. According to the findings, tomato value chain actors should deliver their products in accordance with the needs of their target markets. They must enhance their production, harvesting, and marketing procedures, as well as their collaboration, to produce fresh, undamaged, and immaculate tomatoes. The report also recommended linked public-sector entities to address consumer needs when planning their support operations, because the profitability of tomato value chain stakeholders, particularly growers, could not be increased until these needs are met. The marketed surplus also predicted and found that many variables were influencing the marketed surplus (Bhatia, 2002; Gupta and Arora, 2000; Chauhan and Chhabra, 2005; Joshi, 2012; Maske et al., 2012; Rahim et al., 2007) [6, 15, 9, 20, 23, 26]. Tomato quality (*Solanum lycopersicum* L. syn name *Lycopersicon esculentum*) is mostly revealed by discussing suitable handling practices during post-harvest activities such as harvest, grading, packaging, and shipping. The current study was designed to examine tomato crop in the markets of Lahore district. During the investigation, it discovered that the goods had degraded by 25% due to the packing material, 10% due to transportation, 5% due to distribution, and particularly high post-harvest losses of up to 30% and sometimes the entire lots were lost (Saeed and Khan, 2019) [29]. Rehman and Jan (2020) [27] in their study calculated the post-harvest losses in the tomato crop grown in the Peshawar valley during Kharif 2016. Data gathered at random from 68 tomato growers in the area. Tomato crop post-harvest losses in the Peshawar estimated to be 20% of overall production. Most of the losses happened during crop harvesting, handling, and transportation to markets, among other things. Farmers in the area need to be educated on the latest packing techniques, tomato crop processing procedures, and innovative techniques and methods of post-harvest handling to minimize these losses.

The purpose of the paper

Therefore, by keeping in view the importance of research topic the study in hand is designed to explore factors influencing marketed surplus of tomatoes in district Lodhran, Punjab, Pakistan.

MATERIALS AND METHODS

It is important to undertake research to investigate current marketing margins and the involvement of various players in the supply chain, as well as to quantify the influence of main variables affecting marketed surplus of tomatoes. The nature of the problem calls for a much larger scale, such as that of a province or a country, however due to apparent time and budget constraints; the study will be limited to regions of the Lodhran district because there is an increasing trend to produce tomatoes by using tunnel system in the region. Then the tehsil of Lodhran was chosen. So, 100 tomato farmers (50 tunnel growers and 50 non tunnel growers) were chosen as a representative sample of farmers, commission agents, wholesalers, retailers, and consumers. Convenience sampling technique was employed to select the sample. The frequencies and percentages of sample responses calculated using descriptive statistics. The influence of main factors affecting tomato farmers' marketed surplus was determined by using multiple regression analysis.

To analyze the result of present study the descriptive statistics used to find out the percentage and frequencies of different stakeholders in the marketing chain of the tomatoes."

The following is how the dependent and independent variables are related:

"$Y = f(Xi)$……………………...(1)

where: "

Y = Marketed surplus (Maunds)"

X_i = Vector of quantitative variables i = 6"

Equation 2 can be expressed in more detail as

"$Y_i = \beta o\ X_i^{\beta i} e^{\mu}$ …………………(2)

The equation 3 can be explained further as;

"$Y = \beta o\ X_1^{\beta 1}\ X_2^{\beta 2}\ X_3^{\beta 3}\ X_4^{\beta 4}\ X_5^{\beta 5}\ X_6^{\beta 6} e^{\mu}$ ……………………………..........(3)

Equation 4 can be expressed as by taking the natural log on both sides

$lnY = \beta o + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \beta_6 lnX_{6+}\ \beta_7 D + \mu$….(4)

where:

X_1= Education of farmers (Years of schooling)

X_2= Farming experience of farmers (Years)

X_3= Area under tomatoes cultivation (Acres)

X_4 = Marketing cost (Rupees per kgs)

X_5 = Sale price (Rupees per kgs)

X_6 = Distance from wholesale market (Km)

D=0, if not employing tunnel farming

D=1, if employing tunnel farming

βs are the elasticity's, βo is the intercept, and μ is the random error

NL = Natural log

RESULTS AND DISCUSSIONS

As per our findings, out of 50 tunnel tomatoes grown people, 50 (representing 100%) of people are those who said that our initial investment for tomato cultivation is high, out of 50 tunnel tomato grown people, 50 (representing 100%) of people are those who say that the temperature control for growing tunnel tomatoes, out of 50 tunnel tomato grown people, 47 (representing 94%) of people are those who said that production is high in tunnel forming. out of 50 tunnel tomato grown people, 37 (representing 74%) of people are those who said that the tunnel grown tomatoes is more profitable. out of 50 tunnel tomato grown people, 46 (representing 92%) of people are those who said that tunnel grown tomatoes weight more than conventional grown tomatoes out of 50 tunnel tomato grown people, 42 (representing 84%) of people are those who said that the tunnel farming tomatoes shelf life is better than as compared to conventional grown tomatoes. out of 50 tunnel tomato grown people, 49 (representing 98%) of people are those who said that in tunnel grown tomatoes less usages of pesticides as compared to conventional grown tomatoes. out of 50 tunnel tomato grown people, 50 (representing 100%) of people are those who said that they have sow our crop early. out of 50 tunnel tomato grown people, 45 (representing 90%) of people are those who said that they must send our crops to the market early to sell them. out of 50 tunnel tomato grown people, 41 (representing 82%) of people are those who said that a tomato planted in a tunnel sells for a good price out of 50 conventional tomatoes grown people, 20 (representing 40%) of people are those who said that our initial investment for tomato cultivation is high, out of 50 conventional tomato grown people, 0 (representing 0%) of people are those who say that the temperature control for growing tunnel tomatoes, out of 50 conventional tomato grown people, 25 (representing 50%) of people are those who said that production is high in conventional forming. out of 50 conventional tomato grown people, 30 (representing 60%) of people are those who said that the conventional grown tomatoes is more profitable. out of 50 conventional tomato grown people, 22 (representing 44%) of people are those who said that conventional grown tomatoes weight more than tunnel grown tomatoes. out of 50 conventional tomato grown people, 27 (representing 54%) of people are those who said that the conventional farming tomatoes shelf life is better than as compared to tunnel grown tomatoes. out of 50 conventional tomato grown people, 10 (representing 20%) of people are those who said that in conventional grown tomatoes less usages of pesticides as compared to tunnel grown tomatoes. out of 50 conventional tomato grown people, 28 (representing 56%) of people are those who said that they have sow our crop early. out of 50 conventional tomato grown people, 28 (representing 56%) of people are those who said that they must send our crops to the market early to sell them. out of 50 conventional tomato grown people, 25 (representing 50%) of people are those who said that a tomato planted in a conventional sell for a good price.

Table 1. Detail Comparison between Tunnel Grown Tomatoes and Conventional Grown Tomatoes

Factors	Tunnel Grown Tomatoes	Conventional Grown Tomatoes
High initial investment	50 (100%)	0 (0%)
Controlled Temperature	50 (100%)	0 (0%)
High Production	47 (94%)	25 (50%)
More Profitable	37 (74%)	30 (60%)
Tomatoes Weight	46 (92%)	22 (44%)
Shelf life	42 (84%)	27 (54%)
Lesser use of pesticides	49 (98%)	10 (20%)
Early sowing	50 (100%)	28 (56%)
Early availability in the market for sale	45 (90%)	28 (56%)
Premium Prices	41 (82%)	25 (50%)

Source: Authors' own calculations

The double log form of regression model was applied to evaluate the connection between the dependent variable (marketed surplus) and the independent variables (education, experience, family size, area under tomato crops, marketing cost, sale price and distance from the output market). This relationship was suggested by the scattered plot between the dependent and independent variables. To describe the data of the dependent variable (marketed surplus) and independent variables, descriptive statistics (minimum, maximum, mean, and standard deviation) were utilized (education, experience, family, size, area under tomato crops, marketing cost, sale price and distance from the output market). Table 2 includes the information in summary form.

Table 2. Descriptive Statistics of the Data Used for Model Estimation in Brief

Factors	Max.	Min.	Std. Dev.	Mean Value
Education of tomato farmers (Years of Schooling)	16	0	4.893	7.83
Experience of farmers (Years)	60	4	15.133	22.35
Area under tomato crop (acres)	60	2	13.728	12.09
Marketing cost (Rs./ Maund)	20	10	3.334	14.10
Sale price (Rs. / Maund)	2,000	1,200	161.325	1675.00
Distance from market (Km)	12	1	2.699	5.50
Marketed surplus (Maund)	2,685	20	493.217	330.88

Source: Author's own calculations.

Strong correlations between the independent variables are called collinearity (or multi collinearity), and they are an undesirable circumstance.

Tolerance is a statistic used to quantify the degree of linear relationship between the independent variables (multi collinear).

The tolerance is equal to the variance inflation factor, or VIF. The variance of the regression coefficient rises with the VIF, making the estimate unstable.

Multi collinearity is indicated by high VIF scores. Multi collinearity is a concern if the value of VIF is more than 10. All VIF values in our analysis were less than 10, which demonstrated that the data set had no multi collinearity.

The coefficient of determination is also known as R^2. We learn how much of the variation in the dependent variable is explained by the independent factors taken together. R^2 has a range of 0 and 1, and the closer it is to 1, the better the model fits (Gujrati and Porter, 2008) [16]. Our study' R^2 value was 0.558, meaning that all of the independent variables together were able to account for 55% of the change in the dependent variable, which was the marketed surplus of tomatoes. This figure also indicated that the remaining 45% of the dependent variable's change was due to some other factors, the effects of which the model was unable to account for it.

Table 3. Collinearity Statistics

Variables	Tolerance Level	VIF Factor
Qualification of farmer (years of schooling)	.477	2.095
Farming experience (No. of years)	.504	1.982
Family Size (No.)	.958	1.044
Cultivation area under tomato crop (acreage)	.445	2.247
Marketing expenses (Rs./ Maund)	.958	1.044
Sale price (Rs./ Maund)	.435	2.300
Distance from the market (kilometers)	.714	1.401

Source: Authors' own calculation.

Adjusted R^2 denotes degree of freedom adjustment. For cross-sectional data, it is employed.

adjustment. For cross-sectional data, it is employed.

In our investigation, the adjusted R^2 value was 0.515, which is significant. The adjusted R^2 score indicates that, when all other variables were held constant, all independent variables explained 51% of the variation in the dependent variable. According to the F-ratio, all independent variables may or may not be significant contributors to variation in the dependent variable. Our analysis' extremely significant F-value of 30.330 (p 0.05) demonstrated why the model was generally appropriate.

Considering the findings, it may be assumed that the tomato growers' sold surplus, in the absence of an impact from independent factors, could be 8.790 hundred maunds. Education is seen as an important socioeconomic factor since it improves farmers' capacity to sell more produce. The positive sign of the education coefficient was 0.187 (p >0.05). According to the coefficient of variation, if all other variables remained constant, there could be a 0.187 Percent rise in the marketed surplus of tomato producers for every one percent increase in education (Years of Schooling).

Table 4. Summary of Results of Regression Analysis

“Factors	**“Coefficient”**	**Standard-Error”**	**“T-Value”**	**“Significance (P-value)”**
(Constant)	-8.790	3.354	-2.621	.010
Education of farmer (years of schooling)	.187	.127	1.478	.143^{NS}
Experience of farmers (years)	.338	.154	2.198	.030**
Family Size	.098	.138	.708	.480^{NS}
Area under tomato crop (acres)	.309	.159	1.940	.512^{NS}
Marketing costs (Rs./ Maund)	-.326	.147	-2.213	.029**
Sale price (Rs./ Maund)	2.183	.466	4.686	.001***
Distance from the Output market (km)	-.287	0.101	-2.854	.005***
Dummy Variable	.100	.122	1.370	.001***
R Square	.558			
Adjusted R Square	.515			
F- Value	30.330			

Source: Authors' own calculations.

The price a farmer receives depends on their level of farming experience. Farmers with more experience can sell the tomato (marketed excess) in huge quantities for a reasonable price. The agricultural experience coefficient was significant and had a positive sign of 0.338 (p 0.05). According to the coefficient of variation, with all other parameters remaining constant, there may be a 0.338 Percent rise in the marketed surplus of tomato producers for every one percent increase in farming experience (Years).

Family size is an important demographic factor since it improves farmers' capacity to sell more produce. The positive sign of the education coefficient was 0.098 ($p > 0.05$). According to the coefficient of variation, if all other variables remained constant, there could be a 0.098 percent rise in the marketed surplus of tomato producers for every one Percent increase in family size (No).

Given that it enables farmers to produce more tomatoes, the area beneath tomatoes is regarded as a crucial factor. The area coefficient of 0.309 ($p < 0.05$) had a non-significant sign. According to the coefficient of variation, if all other variables remained constant, there could be a 0.309 percent rise in the marketed surplus of tomato growers for every one percent increase in the area under tomato production (acres). The marketing cost coefficient, which was negligible at -.326 ($p > 0.05$), had a negative sign. According to the coefficient of variation, if all other variables remained constant, there could be a -.326 percent rise in the marketed surplus of tomato growers for every one percent decrease in marketing cost (Rs. Per maund). Sale price is a key factor in determining how much surplus tomatoes are marketed by tomato farmers. Farmers grow more and more tomatoes as a result of market price increases for tomatoes, increasing the market excess. Nosheen and Iqbal also support this finding (2008) [24]. The output price correlation coefficient was positive but negligible at 2.183 ($p > 0.05$). The coefficient of variation stated that, if all other variables remained constant, for every one Percent increase in the sale price (Rs. / maund) of tomatoes, there might be an increase of 2.183 percent in the marketed surplus of tomato growers. Farmers' chances of selling their produce in a particular market are impacted by their distance from the wholesale market.

The distance coefficient from the wholesale market was -.287 (p 0.05), which had a strong negative sign. According to the coefficient of variation, there may be an increase in the marketed surplus of tomato growers for every one percent reduction in distance from the wholesale market (Rs. / maund), if all other factors remain constant.

Dummy variable has taken to check the impact of tunnel and conventional farming practices. The value =1 is taken if farmer employs tunnel farming and value =0 if farmer uses conventional farming. The coefficient value was .10 (p 0.05), which had a strong positive sign. According to the coefficient of variation, there may be an increase in the marketed surplus of tomato growers for every one unit increase in production via tunnel farming if all other factors remain constant.

CONCLUSIONS

The present marketing system of tunnel tomato needs a lot of improvement to prove its real potential. Some recommendations to improve marketing of tunnel tomatoes as long distance from production area to market and losses due to poor condition also cause reduction in marketed surplus, production is declining due to various possible factors as reduction in area according to our results. The farmers should enhance tunnel grown tomatoes so that the marketed surplus would be high as farming community would be able to fetch premium prices. According to our research, the selected traits (experience, area, marketing cost, sale price, and distance from the output market) are influencing significantly on the marketed surplus. So, both public and private sectors should engage to organize/train the tomato farmers regarding tunnel sowing.

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MEAT TRADE DYNAMICS: MONTHLY PATTERNS IN ROMANIA'S IMPORTS (CMA AND HOLT-WINTERS METHODS)

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Abstract

This study examines the trend of meat imports from Romania using monthly data from January 2011 to May 2024. The analysis aims to project the values of meat imports until May 2025 by using various forecasting algorithms to understand import trends and seasonality. The study used the TempoOnline database for data analysis, and the forecast used two methods: a seasonally adjusted regression model and the Holt-Winters methodology. The regression model integrated seasonal indices to forecast future imports, while the Holt-Winters method, which adjusts for trends and seasonality with smoothing constants, provided a more advanced prediction. The forecast results indicate that meat imports have increased significantly, especially after 2022, influenced by factors such as the pandemic and geopolitical instability. The regression model (Model 1) predicted a decrease in imports for 2024 compared to 2023, while the Holt-Winters model (Model 2) projected a substantial increase. The Holt-Winters model showed higher accuracy with lower RMSE and MAPE values than the regression model. In conclusion, both forecasting models provided valuable information on the trends in Romanian meat imports. The Holt-Winters model proved more accurate, predicting higher future imports with more appropriate values. The findings suggest that meat imports from Romania will continue to grow, with significant fluctuations due to seasonal effects. We recommend the Holt-Winters approach for more accurate future planning due to its superior forecasting performance.

Key words: *meat imports, time series forecasting, Holt-Winters method, seasonality index, trend analysis*

INTRODUCTION

Meat is an essential food that meets the protein and fat intake requirements for adults and professionally active people [10]. Consumption has been increasing in recent decades and increased even more amid the COVID-19 pandemic crisis because active people who worked from home had to cook at home as all the restaurants in the HoReCa system were closed. The only campaigns that had already implemented the online sales system were able to continue their activity.
At the global level, the EU is the second largest producer of pork and the most important exporter of meat from pork products [17], and a European citizen consumes an average of 35 kg of pork per year, exceeding the average three times [13]. However, the EU faces many challenges in the field, such as global population growth, geopolitical conflicts, increased volatility of food prices, food insecurity, and environmental needs in the agricultural sector [5].
Thus, at the European level, it was discovered that the number of animals and meat production has decreased continuously in recent years [16]. To ensure all the meat it needs, the EU must integrate CAP reforms that focus on economic, social, environmental, and food security performance [15]. It is also necessary to support farmers if we take into account the increase in production costs and the long-term objectives of reducing meat consumption [4].
Although Romania has exceptional agricultural conditions and is considered an agricultural power among EU member states, it depends on agri-food product imports [2]. However, Romania remains an exporter of beef, especially in the category of live animals [11].
Regarding the import of meat, it continues to play the most important role in the supply chain of the meat market in Romania, especially given that meat and meat products are among the most consumed agri-food products in our country. In Romania, the most consumed meat which occupies the first

position among consumers' preferences is pork, preceded by poultry [17][9], while the consumption of beef is low because its price is too high. Domestic meat production is not sufficient to satisfy domestic demand [12][6], and this has decreased a lot in recent decades, especially due to various epizootics [20]. Also, because some live or semi-finished animals were exported, the domestic meat industry suffered a trade imbalance and lost income [18]. Romania can reduce its dependence on imports by allocating more resources and investments to the livestock sector to provide part of the meat needed for consumption [14].

MATERIALS AND METHODS

The study investigates the trends in Romania's meat imports. The Tempo Online database used in this study consists of monthly recordings from 2011. We accessed the data from January 2011 to May 2024 and projected the imports of meat products until May 2025 using the employed forecasting algorithms.
The last observed month was May 2024, and we made a forecast using MO Excel. We used a combination of time series analysis techniques to forecast the monthly meat import values for 2024 and 2025. We used a forecast that included seasonality and a forecast based on the Holt-Winters Method.
Initially, we employed Excel for forecasting seasonality and trends, which involved creating a regression function to determine the trend and calculating a seasonality index to produce a seasonal prediction that integrated the trend. We utilized the computation approach suggested by Canbolat M. (2006) [3].
The second method employed was the Holt-Winters methodology, an advanced time series forecasting approach that enhances simple exponential smoothing by integrating both trend and seasonal elements. This method is very effective for predicting monthly meat import amounts because the data displays both trends and seasonal fluctuations. The Holt-Winters approach comprises three primary components (level, trend, and seasonality) and considers three smoothing constants (α, β, and γ).
The optimum values of α, β, and γ are determined by minimizing the sum of the square of error using Solver in Excel, with the stipulation that α and β must be less than or equal to 1, and the sum of α and γ must be less than 1. We utilized the computation approach suggested by Major L. (2020) [8].
For both techniques, we conducted a forecast accuracy evaluation by calculating MAPE (the relative percentage error corresponding to the average of the absolute error) following Lee et al. (2018) [7]. These measurements provide insight into the precision of the forecasts and facilitate the comparison of the employed models.Ultimately, the results were graphed in conjunction with the original monthly data to enhance comparison and explanation of the trends.

RESULTS AND DISCUSSIONS

Background data

Meat imports increased during the analyzed period and almost doubled in the last years due to the pandemic and geopolitical instability (Table 1).

Table 1. Imported meat value (January 2011-May 2024)

	Total Thou euro	Month	Monthly average	Min (thou euros)	Max (thou euros)
2011	456,909.0	1	54,860.4	23,172.0	125,680.0
2012	479,422.0	2	58,094.9	26,643.0	122,681.0
2013	487,174.0	3	65,493.9	30,829.0	130,217.0
2014	551,691.0	4	62,573.6	33,629.0	132,699.0
2015	571,892.0	5	67,463.7	34,842.0	130,124.0
2016	645,829.0	6	66,665.9	36,697.0	132,426.0
2017	760,265.0	7	68,405.8	38,578.0	125,183.0
2018	820,597.0	8	74,238.2	42,684.0	137,032.0
2019	940,884.0	9	78,749.9	43,273.0	135,030.0
2020	910,481.0	10	77,982.3	43,394.0	150,321.0
2021	977,651.0	11	76,493.8	35,557.0	149,564.0
2022	1,300,744.0	12	76,662.5	35,145.0	150,014.0
2023	1,534,844.0				
2023/2011	336.0%				
Monthly Mean 2011- 2024				68747.8	
Monthly Min 2011-2024				23,172.0 (January 2012)	
Monthly Max 2011-2024				150,321.0 (October 2023)	
Monthly Median 2011-2024				61,868.0	
Monthly Sd Dev 2011-2024				30,679.0	

Source: Own calculation based on data from Tempo Online database 2011-2024, NIS [19].

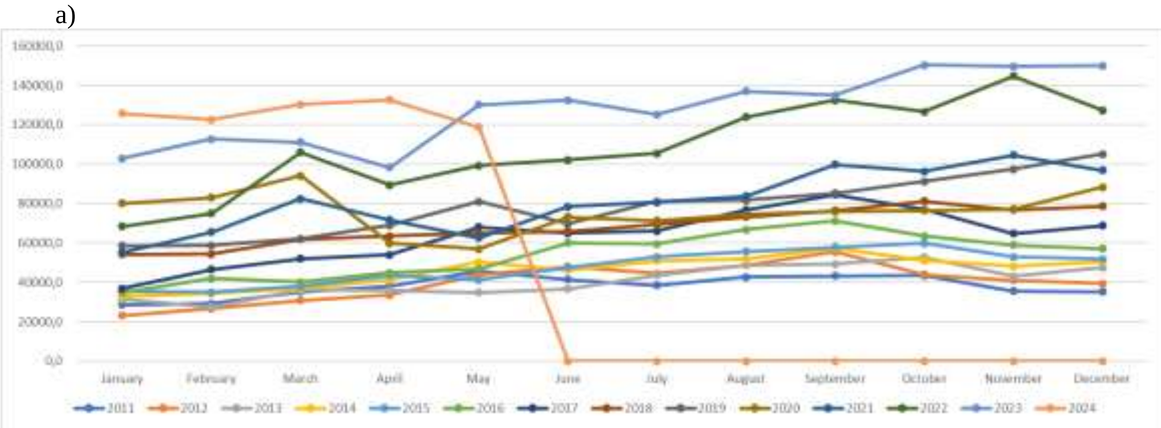
In 2023, the total value of meat imports reached 1,534.8 million euros, the largest value since 2011. Imports have a monthly average value of 68.8 million euros. The data also reveals seasonality, a factor we must take into account in our research. In March and

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

November Romania imports more meat, while in January, it imports less. Figure 1 shows the monthly meat import model in Romania for the years 2011-2024. We can observe an increase in imports since 2017, particularly after 2022. The import value diminishes in specific months, such as January, due to an oversaturation of local supplies on the domestic market during the holiday period.

Figure 2 illustrates the time series of meat import values from January 2011 to May 2024.

a)



b)

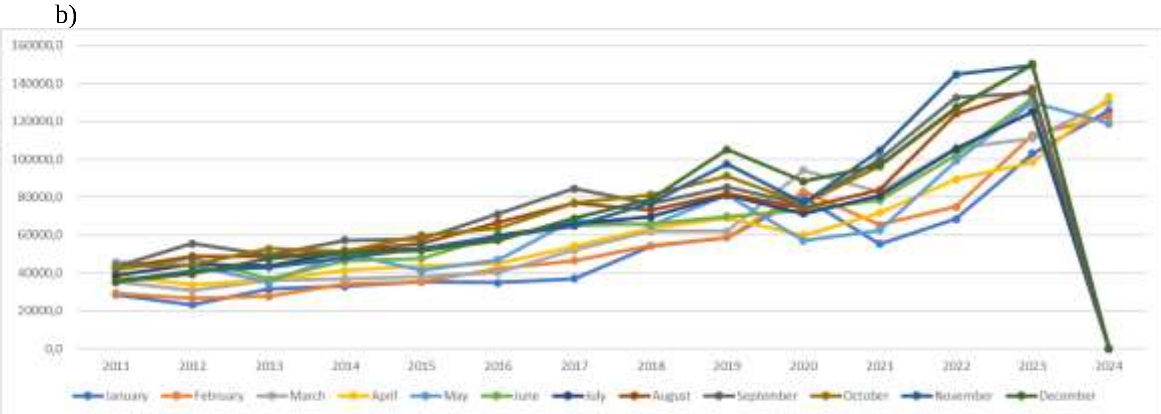


Fig.1. Meat imports (2011-2024): a) Monthly values each year; b) Annual values each month
Source: Own calculation based on data from Tempo Online database 2011-2024, NIS [19].

In 2022-2023, the meat import reached a value of 150 million euros due to the increase in prices, while its lowest point occurred in 2012 when the market remained oversaturated after the winter holidays (23.2 million euros). Starting from this trend we projected the imports until the end of 2024 and May 2025 using two methodologies of time series analysis.

Figure 3 illustrates the actual meat imports (depicted in blue) from January 2011 to May 2024, with the projected imports (shown in red) derived from the first forecasting model (regression function with seasonality index adjustment) extending to May 2025.

Although it is a simple forecasting method, it effectively predicts the pattern of the actual data, but with less variability compared to the original data. The future model projection indicates an increase in seasonality accompanied by an upward trend.

The forecasted data are lower than the original data with errors varying on average between 6 and 12 million euros (Table 2).

We obtained an RMSE value of 33,754.4. The MAPE value of 14.6% proves that we created good forecasting [7].

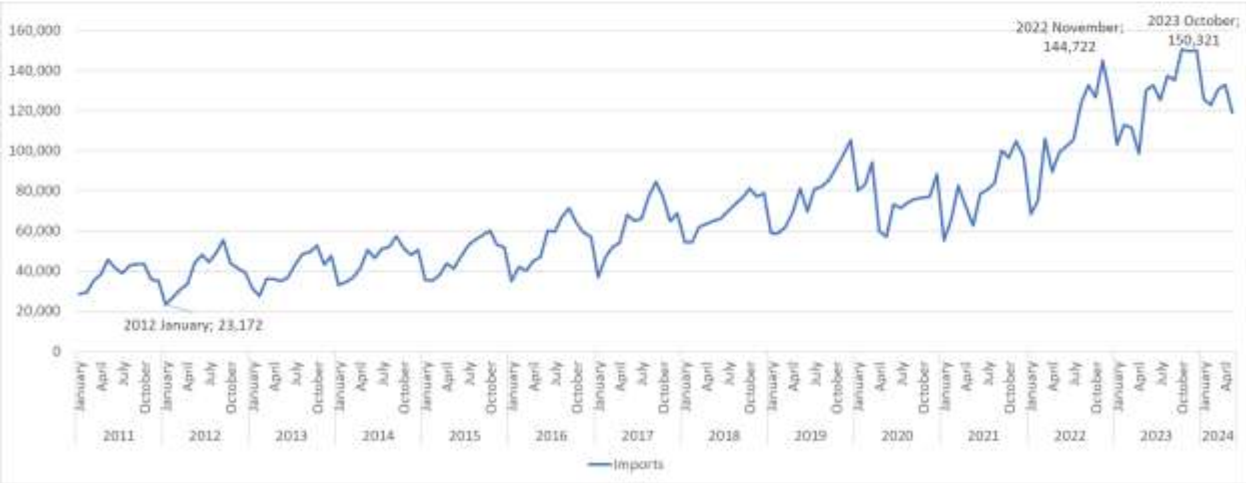


Fig. 2. Value of imports by months
Source:Own calculation based on data from Tempo Online database 2011-2024, NIS [19].

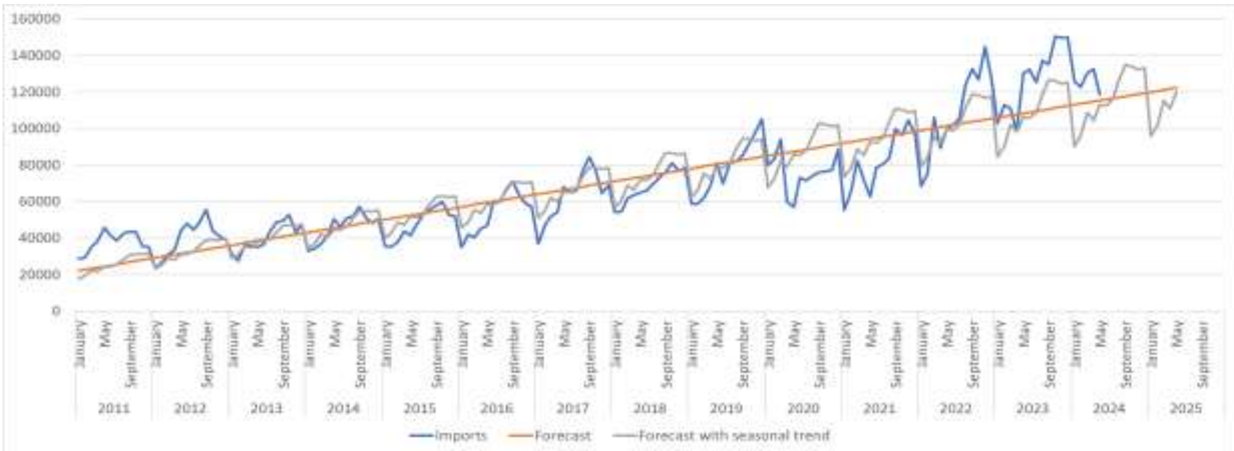


Fig. 3. Actual values of import and forecast
Source: Own calculation in Excel based on Canbolat M. (2006) [3].

Table 2. Import forecasting – average monthly data (Model 1)

Month	Imports (thou euros)	Seasonality Index (the average of the values obtained by reporting the imports of the month (1,2, ...12) to the total of months in the database)	Forecast (thou euros)	Forecast with seasonal trend (thou euros)	Errors
January	54,860.4	0.80	71,075.5	56,717.9	-5,514.9
February	58,094.9	0.85	71,657.5	60,553.7	-6,331.8
March	65,493.9	0.95	72,239.4	68,820.2	-7,692.6
April	62,573.6	0.91	72,821.4	66,281.4	-7,879.3
May	67,463.7	0.98	73,403.3	72,032.3	-9,066.1
June	66,665.9	0.97	70,493.6	68,358.9	-6,454.8
July	68,405.8	1.00	71,075.5	70,722.0	-7,202.3
August	74,238.2	1.08	71,657.5	77,380.3	-8,444.8
September	78,749.9	1.15	72,239.4	82,749.6	-9,624.6
October	77,982.3	1.13	72,821.4	82,603.1	-10,190.9
November	76,493.8	1.11	73,403.3	81,673.9	-10,643.9
December	76,662.5	1.12	73,985.2	82,503.0	-11,316.3
RMSE 33,754.4 MAPE 14.6 %					

Source: Own calculation in Excel based on Canbolat M. (2006) [3].
Note: RMSE "represents the square root of the variance of the residuals" ("distance between the observed data values and the predicted data values") [1].

The results obtained by the Holt-Winters approach are depicted in Figure 4 and Table 3. The forecast results start from January 2012, and seasonality from previous data was used to forecast grain imports from 2024-2025. The future model projection indicates a higher increase in trend. The forecasted data are generally higher than the original half of the

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

year, with errors varying on average between 0.6 and 10 million euros (Table 3). We obtained an RMSE value of 12,536.26. The MAPE value of 12.41% proves that we created good forecasting [7].

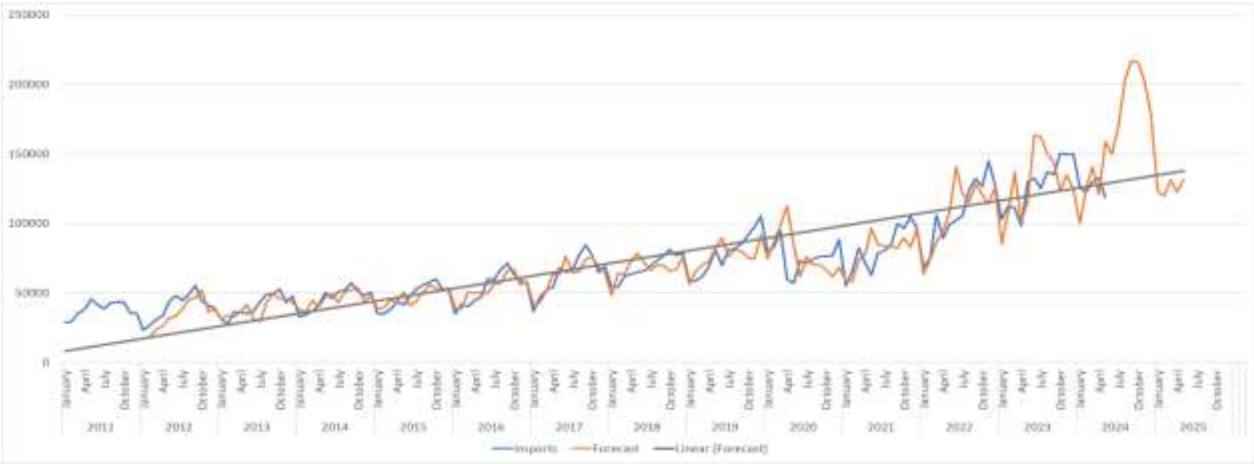


Fig. 4. Actual values of import and forecast
Source: Own calculation in Excel based on Lee et al. (2018) [7].

Table 3. Import forecasting – average monthly data (Model 2)

Month	Imports (thou euros)	Seasonality Index (month value/annual average)	Forecast with seasonal trend (thou euros)	Errors
January	37,949.4	0.72	56,202.4	3,486.4
February	47,994.5	0.76	60,886.5	-568.8
March	56,642.4	0.88	70,621.9	-2,798.6
April	46,559.9	0.92	70,206.3	-5,758.2
May	39,435.1	1.08	77,676.0	-8,527.2
June	26,875.8	1.18	80,177.5	-5,599.6
July	41,731.5	1.20	79,505.6	-1,050.1
August	50,467.2	1.27	83,499.1	3,369.2
September	41,289.5	1.29	87,372.9	5,129.8
October	39,416.7	1.20	84,967.1	6,796.9
November	46,615.5	1.05	79,890.6	10,202.9
December	42,767.6	1.00	81,942.3	6,134.8
RMSE 12,536.26 MAPE 12.41 %				

Source: Own calculation in Excel based on Lee et al. (2018) [7].

As we can see, both forecasting models are suitable for our research. For 2024, Model 1 forecasts a decrease compared with 2023 to 1,401.1 million euros, and the second model shows an increase to 1,981.6 million euros.

Fig. 5. Forecasted values for 2024 and 2025
Source: Own calculation in Excel.

The values forecasted by the Holt approach are higher but follow the same trend as in the first model (Fig.5).

Model 2, on the other hand, has the lowest RMSE and MAPE, indicating that it is better able to fit the forecast of meat imports (Table 4).

Thus, we consider that the values predicted by model 2 (by the Holt-Winters Method) can be more accurate (as Lee et al. proved [7]). Model 2 predicts the future is non-linear and has a general upward trend, with obvious decreases in April and January.

Table 4. The forecast for 2024-2025 – Model 1 and Model 2

	Model 1	Model 2
	RMSE 33,754.4 MAPE 14.6 %	RMSE 1,253,6.26 MAPE 12.41
2024 (January-December)	1,401,214,4	1,981,548.9
2025 (January-May)	543,753.9	628,182.4

Source: Own calculation in Excel.

CONCLUSIONS

The analysis of the value of Romanian meat imports reveals a strong upward trend, particularly from 2022 on, influenced by global disruptions and increased demand. The use of time series forecasting techniques, including a regression model and the Holt-Winters methodology, provided valuable projections for the future.

Model 1, which combined regression analysis with seasonal adjustments, predicted a decrease in meat imports for 2024, estimating a total of approximately 1,401.1 million euros. However, this model showed less accuracy, with an RMSE greater than 33,754.4 and a MAPE of 14.6%, indicating some discrepancies between predicted and actual values.

In contrast, Model 2, using the Holt-Winters method, predicted a significant increase in meat imports, projecting a total of approximately €1,981.6 million for 2024. The lower RMSE (12,536.26) and MAPE (12.41%) show that this model works better than others. This is because it can better account for both trend and seasonal changes in the data. The Holt-Winters approach has demonstrated a better fit for historical data and more accurate forecasts, particularly in capturing non-linear trends and seasonal fluctuations. Projected values for 2025 also indicated a continued increase in imports, with model 2 predicting around 628,182.4 thousand euros, compared to the regression model's estimate of 543,753.9 thousand euros.

In general, the results underline the need for accurate forecasting methods in the management and planning of meat import strategies in Romania. The Holt-Winters model's higher accuracy indicates its preference for future projections, providing stakeholders in the meat import industry with more reliable data. This approach not only improves forecast accuracy but also supports better decision-making in response to evolving market conditions.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

TRITICALE - AN ALTERNATIVE CEREAL FOR FOOD INDUSTRY IN THE WORLD, EU-27 AND ROMANIA

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Abstract

In the context of global food security and the intensification of sustainable agriculture, triticale has become a relevant alternative cereal in food industry. In this paper, the status of triticale crop in the world, EU-27 and Romania was analyzed based on the data provided by the FAOSTAT platform for cultivated area, production quantity and yield. The results showed that in 2022, worldwide, the area cultivated with triticale was 3,616.7 thousand ha, the production quantity was 14,157.9 thousand tons, and the yield 3,914 kg/ha. In the same year, the EU-27 held 71.5% of the world cultivated area, producing 79.6% of the world production of triticale and obtaining a yield of 4,362 kg/ha, higher by 11.4% compared to the world yield. The main producers of triticale, by production, both in the world and in the EU-27 were Poland, Germany and France. Romania occupied the 10th place in the world and the 6th place in the EU-27 in terms of cultivated area (57 thousand ha), as well as the 8th place in the EU-27 in terms of production (192.4 thousand tons). In order to increase the amount of triticale-based food products, it is necessary to develop and use high-quality varieties that meet market demands, but also the development of new processing technologies.

Key words**:** *cultivated area, production quantity, triticale, yield*

INTRODUCTION

Wheat, rice and maize are the most widely grown and consumed traditional grains in the world, providing a large part of human nutrition requirements, but when food security is considered there is a need to increase the production of alternative, non-traditional cereals. Currently, improving the compatibility between environmental management and food security is a worldwide emergency due to climate change, rapid population growth, and the current consumer preference for healthier foods.

Triticale is one of the alternative, non-traditional cereals that offer promising solutions to these challenges/problems, through its good environmental adaptability and nutritional composition. According to [24], triticale market size will grow from USD 554.22 million in 2023 to USD 640 million by 2028.

Triticale (x *Triticosecale* Witt.) from the Poaceae (Gramineae) family is an amphiploid obtained from the artificial hybridization between tetraploid wheat (*Triticum aestivum*) and rye (*Secale cereale*). The first hybrid between these two species was obtained in 1875 by the botanist Wilson (Scotland), but it was sterile. Later, in 1888, through spontaneous chromosome doubling, Rimpau (Germany) developed the first viable hybrid between these species, and in 1968, the first commercial variety was released in Hungary. Therefore, European countries can be considered the pioneers in the creation and breeding of this species [1].

In Romania, in 1927, the first wheat-rye hybrids were described by Saulescu, and the first octoploid form of triticale was obtained by Priadcencu in 1939, but a breeding program for triticale was initiated in 1971 at ICCPT Fundulea [12].

By creating this species, the researchers combined the most valuable traits of wheat (baking quality, early maturity, large number of ears in the ear, large number of grains in the ear and high grain weight) with the valuable traits of rye (resistance to drought, heat, diseases, pests, and high utilization capacity of poorly productive soils) [11, 12, 18].

According to the specialized literature, the chemical composition and nutritional properties of triticale vary significantly due to the rather large number of genotypes.

The unique nutritional value of triticale grains is due to a higher content of proteins and essential amino acids (especially lysine), total carbohydrates, macro elements (i.e. potassium and phosphorus) [2], phytoestrogen, alkylresorcinols and vitamins [7], compared to wheat and rye grains.

In terms of exchangeable energy content, on average, triticale exceeds wheat and rye by 14% and 23%, respectively, and the consumption of these fiber-rich triticale grains can reduce the risk of weight gain and, consequently, help reducing cardiovascular disease and controlling type 2 diabetes [15].

In a previous study carried out on eight Polish varieties of triticale, [7] reported the following chemical composition in triticale grains: protein 11.8% - 15.2%, lipids 1.9% - 2.4%, starch 60.8% - 67.6%, ash 1.6% - 2%, lignin 2.1% - 3.2%, dietary fibber 11.7% - 13.6%, total phenolic content 1.3 - 1.6 mg GAE/g, insoluble non-starch polysaccharides 7.7% - 9.1% and soluble non-starch polysaccharides 1.5% - 2.8%. A better mineral balance, higher lysine content and a better protein digestibility make triticale a suitable substitute or supplement for other cereals in food or feed [2]. Although the main destination of triticale grains is the use in animal nutrition, many previous studies have indicated that it can also be used in human nutrition (bakery, malt, pastry, crackers, macaroni, soups, bars of cereals, etc.) [5, 8, 16, 28].

Its use on a large scale in the production of bread is hindered by the quantitative and qualitative insufficiency of gluten, which is why triticale flour is indicated especially for the preparation of unleavened dough products, such as crackers and other similar products [10]. However, flour obtained from triticale can be used to obtain good quality bread through new technologies. For example, adding maltodextrins of potato to triticale flour [23], mixing triticale flour with 5% and 10% bran [16], or co-processing several cereals such as triticale, wheat and rye in a ratio of 40:50:10 [14], triticale and oats in a ratio of 90:10 [8], proved to be very promising in obtaining quality bread.

In another study, [7] found that it is possible to obtain quality bread from triticale alone, by using modern varieties suitable for baking. The realization of some improvements in grain plumpness and colour, quantity and quality of gluten, could make triticale more attractive as a food cereal [21].

In addition to its nutritional advantages, the triticale crop stands out compared to wheat through other agronomic traits, namely, resistance to abiotic stresses (drought, heat, cold), biotic stresses (diseases, pests), high productivity, relatively low soil requirements [4, 5, 21, 26], traits that have contributed to increasing its popularity, especially among organically farmers. According to [17], triticale produces 11% more grain yield per acre than wheat and 19% more when grown with less fertilizer. Since the triticale crop germinates and develops quickly covering the land completely, it prevents the development of weeds through the lack of light, and farmers can thus avoid herbicides [10].

In the context of the above, this paper aims to present information regarding the triticale culture as an alternative, non-traditional cereal for the food industry, globally, EU-27 and Romania, highlighting its advantages and the evolution of cultivated area, production and yield.

MATERIALS AND METHODS

This paper was carried out on the basis of data from the FAOSTAT [6] platform and research articles.

The main indicators studied were: the cultivated area, the production quantity and the yield of triticale in the world, EU-27 and Romania. The statistical parameters used, namely, average, standard deviation (STDEV), coefficient of variation (CV), regression equations (y), coefficient of determination (R^2), coefficient of correlation (r) were calculated using the EXCEL program.

RESULTS AND DISCUSSIONS

The world triticale cultivated area, production quantity and yield

In the world, in 1975, 467 ha were cultivated with triticale and the production was 1,200 tons. An impressive growth of the triticale crop was registered in the period 2001-2016, respectively 34.8 times in cultivated area (the largest producing region being Europe with 90.4%) and 79 times in production, compared to the period 1975-1983, when the largest producing region was Oceania with 70.9% [9].

For 2022, the area cultivated with triticale worldwide was 3,616.7 thousand hectares, and the production was 14,157.9 thousand tons. The first ten producers of triticale in the world, by cultivated area and their share were: Poland (34.1%), Belarus (11.2%), France (9.4%), Germany (9%), Spain (7.8%), China (5.5%), Turkey (2.8%), Lithuania (1.7%), Australia (1.7%) and Romania (1.6%).

The top ten triticale producers, by production, and their share were: Poland (38.4%), Germany (13.6%), France (11.4%), Belarus (8.4%), Spain (4.5%), China (2.7%), Turkey (2.3%), Russian Federation (2.2%), Australia (2.1%) and Czechia (1.5%).

The world average of yield was 3,914 kg/ha, the highest yields/ha being obtained by Belgium (6,897 kg/ha), Luxembourg (6,475 kg/ha), Denmark (6,475 kg/ha), Switzerland (6,016 kg/ha), Germany (5,948 kg/ha), Austria (5,686 kg/ha), Sweden (5,673 kg/ha), Netherlands (5,583 kg/ha), Chile (5,556 kg/ha), Czechia (5,117 kg/ha)(Table 1).

Table 1. Top ten triticale producers in the world, by cultivated area, production and yield, 2022

Rank	Cultivated area			Production quantity			Yield		
	Country	Thousand ha	Share in the world (%)	Country	Thousand tons	Share in the world (%)	Country	kg/ha	Share in the world (%)
	Total world	3,616.7	100	Total world	14,157.9	100	Total world	3,914	100
1	Poland	1,232.7	34.1	Poland	5,440.3	38.4	Belgium	6,897	176.2
2	Belarus	406.0	11.2	Germany	1,929.7	13.6	Luxembourg	6,475	165.4
3	France	339.7	9.4	France	1,613.7	11.4	Denmark	6,303	161.0
4	Germany	324.4	9.0	Belarus	1,192.9	8.4	Switzerland	6,016	153.7
5	Spain	280.4	7.8	Spain	634.9	4.5	Germany	5,948	152.0
6	China, Mainland	199.7	5.5	China, Mainland	386.1	2.7	Austria	5,686	145.3
7	Turkey	99.6	2.8	Turkey	320.0	2.3	Sweden	5,673	144.9
8	Lithuania	63.1	1.7	Russian Federation	306.9	2.2	Netherlands	5,583	142.6
9	Australia	61.9	1.7	Australia	292.9	2.1	Chile	5,556	141.9
10	Romania	57.0	1.6	Czechia	207.6	1.5	Czechia	5,117	130.7

Source: Own design and processing based on the data from [6].

Although triticale has several advantages compared to wheat and rye, and the demand for healthier food products has favoured the popularization of this species, the worldwide cultivated area and production are still low.

Comparing the value of the studied indicators from 2022 with the values from 2013 (3,807.1 thousand ha, 14,462.3 thousand tons and 3,799 kg/ha, respectively) a slight decrease can be observed, except for yield [6].

[27] believes that expanding the use of triticale in food products by increasing the quality of flour, could lead to an increase in the world's amount of food, especially in the scenario of climate changes and population growth. For this, plant breeders are tasked with identifying and developing new varieties with superior quality to meet market needs [25].

The EU-27 triticale cultivated area, production quantity, and yield

In 2022, the area cultivated with triticale in the EU-27 was 2,585.2 thousand hectares, representing 71.5% of the world area, and the production was 11,276.7 thousand tons, representing 79.6% of the world production. The first ten producing countries in EU-27, by cultivated area and their share were: Poland (47.7%), France (13.1), Germany (12.5%), Spain (10.8%), Lithuania (2.4%), Romania

(2.2%), Hungary (2.1%), Austria (2.1%), Czechia (1.6%) and Sweden (1.1%) (Table 2).
The first ten triticale producing countries, by production quantity and their share were: Poland (48.2%), Germany (17.1%), France (14.3%), Spain (5.6%), Austria (2.6%), Czechia (1.8%), Lithuania (1.8%), Romania (1.7%), Hungary (1.7%) and Sweden (1.4%).
The average yield of triticale in the EU-27 was 4,362 kg/ha, higher by 11.4%, compared to the global level, the highest yields being obtained in Belgium (6,897 kg/ha), Luxembourg (6,475 kg/ha), Denmark (6,303 kg/ha), Germany (5,948 kg/ha), Austria (5,686 kg/ha), Sweden (5,673 kg/ha), Netherlands (5,583 kg/ha), Czechia (5,117 kg/ha), Slovenia (4,864 kg/ha) and France (4,750 kg/ha) (Table 2).
It is surprising that although Poland ranks first both worldwide and at the EU-27 level for cultivated area and production, it is only ranked 15th in the world and 13th at the EU-27 level for yield, with 4,413 kg/ha [6].
The advantage of the expansion of triticale crops in Poland is represented by the high demand for feed cereals on the domestic market, as a result of the expansion of poultry, pig, and cattle farms [13, 25]. Furthermore, in Eastern Poland, where acidic soils and a cold climate predominate, rye has been replaced by triticale in bread production [5].

Table 2. Top ten triticale producers in the EU-27, by cultivated area, production and yield, 2022

Rank	Cultivated area			Production quantity			Yield		
	Country	Thousand ha	Share in the world (%)	Country	Thousand tons	Share in the world (%)	Country	kg/ha	Share in the world (%)
	Total EU-27	2,585.2	100	Total EU-27	11,276.7	100	Total EU-27	4,362	100
1	Poland	1,232.7	47.7	Poland	5,440.3	48.2	Belgium	6,897	158.1
2	France	339.7	13.1	Germany	1,929.7	17.1	Luxembourg	6,475	148.4
3	Germany	324.4	12.5	France	1,613.7	14.3	Denmark	6,303	144.5
4	Spain	280.4	10.8	Spain	634.9	5.6	Germany	5,948	136.3
5	Lithuania	63.1	2.4	Austria	292.9	2.6	Austria	5,686	130.3
6	Romania	57.0	2.2	Czechia	207.6	1.8	Sweden	5,673	130.1
7	Hungary	55.3	2.1	Lithuania	204.6	1.8	Netherlands	5,583	128.0
8	Austria	51.5	2.0	Romania	192.4	1.7	Czechia	5,117	117.3
9	Czechia	40.6	1.6	Hungary	186.5	1.7	Slovenia	4,864	111.5
10	Sweden	28.6	1.1	Sweden	162.5	1.4	France	4,750	108.9

Source: Own design and processing based on the data from [6].

The Romania triticale cultivated area, production quantity, and yield

In 2022, Romania occupied the 10th place in the world in the area cultivated with triticale and the 6th place in the EU-27. In the same year, Romania's contribution to world triticale production was 1.4%, and to EU-27 production it was 1.7% (Tables 1 and 2).
Analyzing the evolution of the area cultivated with triticale in the period 2013-2022, a downward trend was observed with a decrease rate of 33.1%. In 2022, the cultivated area decreased to 57 thousand ha compared to 72.5 thousand ha in 2013 (-21.4%) (Figure 1).
Regarding the evolution of triticale production in the period 2013-2022, a slightly downward trend was observed, with a decrease rate of 6.8%. The lowest production was recorded in 2022 (192.4 thousand tons), 21.5% lower than in 2013 (Figure 2).
For yield, the trend was slightly upward in the analyzed period, the growth rate being 2.3%. The highest triticale yields were recorded in 2017 and 2018 (4,139 kg/ha, respectively 4,272 kg/ha), and the lowest yields in 2020 (3,197 kg/ha) and 2022 (3,376 kg/ha) (Figure 3).
Crop yield is a complex trait influenced by both genetic and agro-ecological factors (drought, heat, agricultural practices, soil, plant protection, etc.) [3].
The first Romanian variety of triticale was released in 1984 by NARDI Fundulea [12], and currently 11 autumn varieties created by NARDI Fundulea are registered in the Official Catalogue [20], the most recently released

being the varieties Zaraza (in 2021) and FDL Ascendent (in 2022).

According to [19], the years 2020 and 2022 were years of extreme drought for Romania. In these extremely dry years in the southern part of Romania (ARDS Teleorman), the new Romanian varieties of triticale managed to exceed the yield reported at the national level (3,197 kg/ha in 2020, and 3,376 kg/ha in 2022, respectively), the variety Zaraza achieving 5,235 kg/ha in 2020 and 6,393 kg/ha in 2022, and the variety FDL Ascendent achieving 4,953 kg/ha, and 6,685 kg/ha, respectively [26]. Also, in the pedoclimatic conditions of central Moldova (ARDS Secuieni), the Zaraza variety achieved 6,689 kg/ha in 2020 and 7,119 kg/ha in 2022 [22].

Therefore, by including these modern varieties in their farms, Romanian farmers could ensure better yields in unfavourable years.

The calculated coefficients of variation were small for all the indicators studied (cultivated area, production and yield of triticale), and they did not vary too much and remained relatively homogeneous (Table 3).

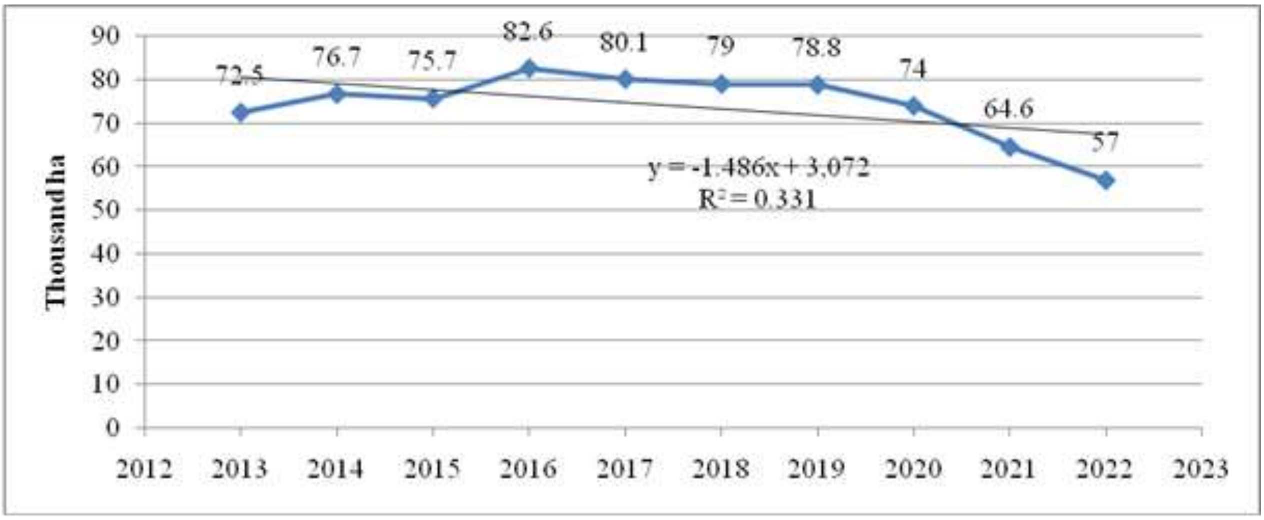

Fig. 1. The evolution of Romania's triticale cultivated area in the period 2013-2022
Source: Own design and processing based on the data from [6].

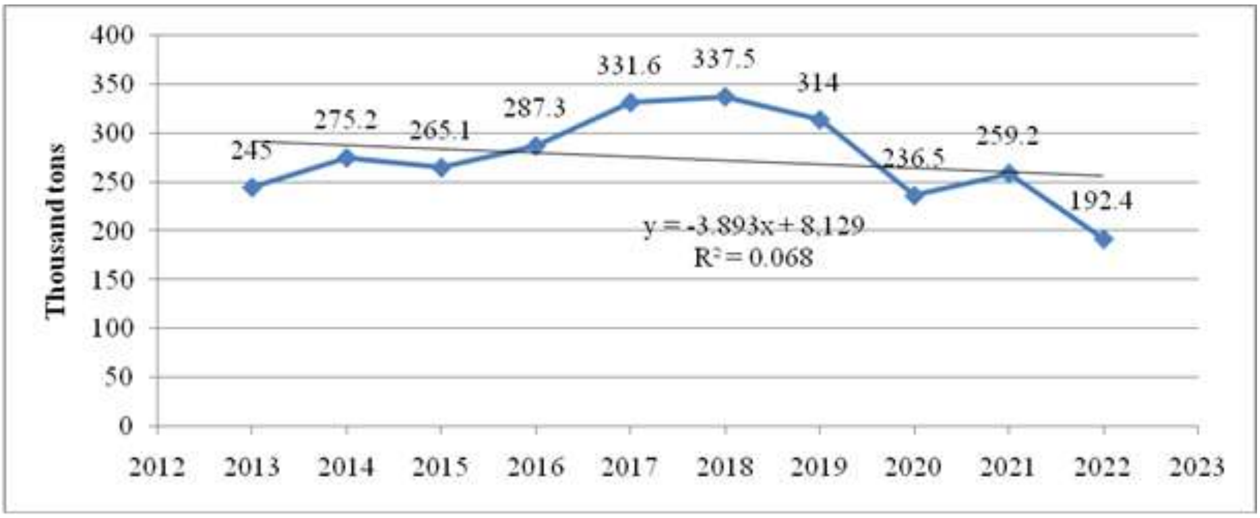

Fig. 2. The evolution of Romania's triticale production quantity in the period 2013-2022
Source: Own design and processing based on the data from [6].

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

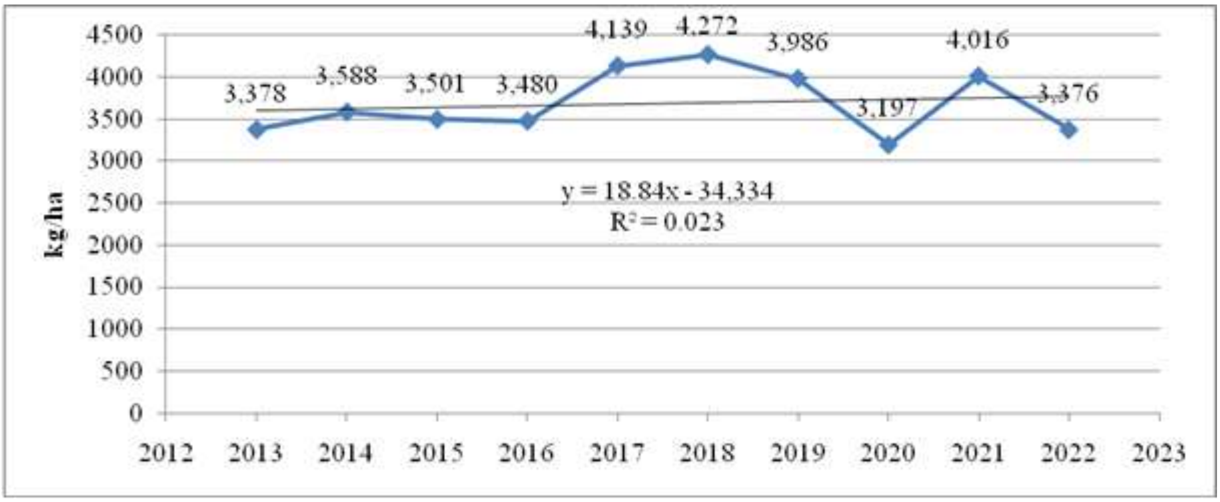

Fig. 3. The evolution of Romania's triticale yield in the period 2013-2022
Source: Own design and processing based on the data from [6].

Table 3. Average, standard deviation (STDEV) and variation coefficients (CV) for cultivated area, production and yield of triticale, Romania, 2013-2022

Indicators studied	Average	STDEV	CV (%)
Cultivated area (thousand ha)	74.1	7.8	10.5
Production quantity (thousand tons)	274.4	45.1	16.4
Yield (kg/ha)	3,693.3	374.7	10.1

Source: Own design and processing based on the data from [6].

The regression equations showed that the increase by one hectare of the area cultivated with triticale caused an increase in the production of triticale by 4.61 units, and the increase by one kg/ha in the yield caused an increase in the production of triticale by 0.09 units (Table 4).

The correlation coefficients between cultivated area and production (r = 0.798), as well as between yield and production (r = 0.800), were positive and significant, showing that triticale production was influenced by both cultivated area and yield. A positive but weak correlation coefficient was recorded between cultivated area and yield (r = 0.281), expressing an insignificant relationship.

Based on the coefficients of determination, it was established that 64% of the variation in triticale production was caused by the yield variation; also 63.7% of the variation in triticale production was determined by the variation in cultivated area (Table 4).

Table 4. Regression equations and correlation coefficients between the indicators characterizing production of triticale

Indicators studied	Regression equation (y)	Determination coefficient (R^2)	Correlation coefficient (r)
Production quantity and cultivated area	y = 4.614x – 67.54	R^2 = 0.637	r = 0.798**
Yield and cultivated area	y = 13.49x + 2,693	R^2 = 0.079	r = 0.281^{ns}
Production quantity and yield	y = 0.096x – 81,54	R^2 = 0.640	r = 0.800**

**- significant positive at 0.01 level; ns - non-significant
Source: Own design and processing based on the data from [6].

Table 5 presents the average values (2013-2022) of cultivated areas, productions and yields for the main small-grain cereals grown in Romania. Comparing the cultivated areas and productions at the national level, it can be seen that triticale occupied the 4th place among small grain cereals, after wheat, barley and oats. Even though these values are much lower than for wheat, they are significantly higher than for rice and rye. Also, the average yield obtained by triticale (3,925 kg/ha), which places it in 2nd place among small-grain cereals, reflects the good potential of this alternative cereal.

Table 5. Averages of cultivated areas, production quantities and yields for the main small-grain cereals in the period 2013-2022, Romania

Cereal	Cultivated area (thousand ha)	Production quantity (thousand tons)	Yield (kg/ha)
Wheat	2,127.8	8,726.1	4,101
Barley	460.1	1,718.4	3,750
Oats	145.9	321.6	2,205
Triticale	74.1	274.4	3,925
Rye	10. 7	28.0	2,633
Rice	8.4	37.5	4,467

Source: Own design and processing based on the data from [6].

In the analyzed period 2013-2022, Romania's potential for the export and import of triticale recorded an upward trend as a result of the increase in interest for this species, the highest values being recorded in 2020 (Figure 4).

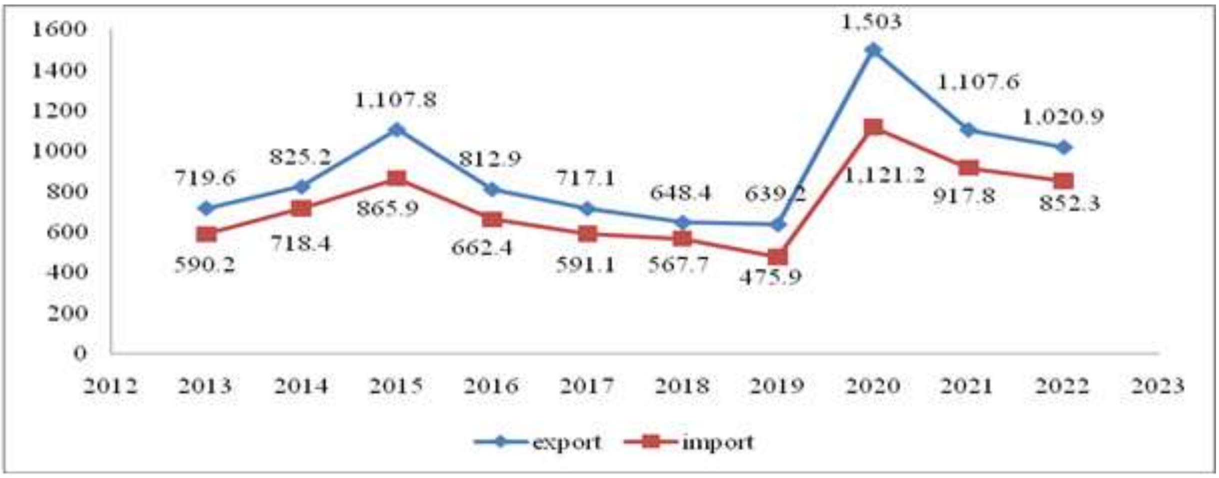

Fig. 4. The import and export of triticale (thousand tons) in Romania in the period 2013-2022
Source: Own design and processing based on the data from [6].

CONCLUSIONS

The data analysis showed that, although the demand for healthier food products has favoured the popularization of this species, the cultivated area and world production are still low.

In 2022, worldwide the area cultivated with triticale was 3,616.7 thousand ha, production quantity of 14,157.9 thousand tons, and yield of 3,914 kg/ha. In the same year, the EU-27 represented 71.5% of the world cultivated area, producing 79.6% of the world production of triticale and obtaining a yield of 4,362 kg/ha, higher by 11.4% compared to the world yield.

The main producers of triticale, by production, both in the world and in the EU-27 were Poland, Germany and France. Romania ranked 10th in the world and 6th in the EU-27 in cultivated area (57 thousand ha), as well as 8th in the EU-27 in production (192.4 thousand tons).

In the period 2013-2022, in Romania, the fluctuation of the cultivated area and the production of triticale from one year to another was small, registering, on average, 74.1 thousand ha and 274.4 thousand tons, respectively.

In order, to increase the amount of triticale-based food products, it is necessary to develop and use high-quality varieties that meet the needs of the market, as well as the development of new processing technologies.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

NEW CROPS: POTENTIAL AND OPPORTUNITIES FOR THE FUTURE OF AGRICULTURE

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Abstract

The paper studies explores the potential and application of new crops in agriculture. New crops are defined as various plants that offer alternatives to traditional grain crops and legumes. They include oilseed crops, fiber crops, biomass crops, and plants with special applications in pharmaceuticals. The article discusses various potential applications of new crops, including fiber and textile production, nutritional supplements, biodegradable materials, pharmaceuticals, and energy resources. To achieve their full potential, innovative technologies and methods are presented, such as genetically modified organisms, precise selection and biotechnologies, smart agriculture, and vertical farming. The article also emphasizes the importance of socio-economic aspects and regulatory challenges associated with the introduction of new crops in agriculture. Overall, the article highlights the importance of new crops as a key element for the future of agriculture, offering solutions to the demands of growing populations and challenges facing the agricultural industry in the context of sustainable development.

Key words**:** *new crops, agriculture, sustainable farming, innovation*

INTRODUCTION

Agriculture plays a pivotal role in providing food, fiber, energy, and other essential resources for humanity. Despite significant progress in the agricultural sector over the past decades, there is a constant need for innovation and technological advancement to address the growing needs of the global population and to tackle challenges such as climate change, depletion of natural resources, and the necessity for sustainable production models.

In this context, new crops emerge as a potentially revolutionary tool for the future of agriculture. New crops encompass a diverse range of plants distinguished by their species, properties, and application possibilities. They offer a wide array of opportunities for food production, materials, and energy, while simultaneously contributing to the sustainable development of the agricultural sector and society as a whole.

The aim of this scientific article is to explore the potential and opportunities that new crops offer for the future of agriculture. Through an analysis of existing research, technologies, and innovations, the article aims to examine the various applications of new crops in agriculture, including their role in food production, fiber, construction materials, and energy. Additionally, the article will investigate the innovations and technologies that support the development and implementation of new crops, as well as the challenges faced by the agricultural sector in this process.

By analyzing and discussing these aspects, the article aims to provide a comprehensive perspective on the significance of new crops for the future of agriculture and to propose directions for future research and development in this field.

MATERIALS AND METHODS

The assessment of the potential and opportunities of new crops as the future of agriculture is based on a study of sources such as specialized and scientific publications on innovative technologies, reports, projects, and studies at both national and EU levels. Additionally, online resources and other available sources of information and data have been utilized.

During the research, a SWOT analysis was conducted to identify the strengths and weaknesses, opportunities, and threats of implementing innovative production technologies - new crops.

RESULTS AND DISCUSSIONS

Definitions and Innovative Opportunities

New crops are defined as "a set of unconventional crops such as oilseeds, fiber crops, and biomass crops that can be grown for specific end markets such as fiber production, nutritional supplements, plastics, pharmaceutical, and energy industries"[15]. These crops can be utilized for generating heat and electricity or for producing biofuels for transportation and various other products [13].

Examples of New Crops:

Quinoa (*Chenopodium quinoa*)

Quinoa has gained popularity worldwide due to its high nutritional value, adaptability to diverse climates, and resilience to environmental stress. It serves as an excellent alternative to traditional cereal grains, offering a complete protein profile and essential micronutrients.

Hemp (*Cannabis sativa*)

Hemp is experiencing a resurgence in interest for its versatile applications in textiles, construction materials, biofuels, and health products. With its fast growth rate, low water and pesticide requirements, and minimal environmental impact, hemp holds promise as a sustainable crop for various industries.

Kernza (*Thinopyrum intermedium*)

Kernza, a perennial grain crop, has garnered attention for its deep root system, which improves soil health and reduces erosion. As a perennial crop, kernza requires less water and fertilizer inputs than annual grains like wheat, making it a promising candidate for sustainable agriculture.

Moringa (*Moringa oleifera*)

Moringa is a fast-growing tree native to tropical and subtropical regions, known for its high nutritional value and medicinal properties. Its leaves, pods, and seeds are rich in protein, vitamins, and antioxidants, making it a valuable addition to diets in developing countries and a potential cash crop for smallholder farmers.

Camelina (*Camelina sativa*)

Camelina, also known as false flax, is an oilseed crop that thrives in marginal lands with low water availability. It produces oil rich in omega-3 fatty acids, making it suitable for human consumption, biofuels, and industrial applications. Camelina's resilience to drought and its potential for crop rotation make it an attractive option for sustainable agriculture.

Seaweed (Macroalgae)

Seaweed farming is gaining traction as a sustainable source of food, feed, and bioenergy. Various species of seaweed are cultivated for their nutritional value, bioactive compounds, and ecosystem benefits such as carbon sequestration and coastal protection. Seaweed aquaculture has the potential to alleviate pressure on terrestrial resources and mitigate climate change impacts on coastal communities.

Teff (*Eragrostis* tef)

Teff is an ancient grain native to Ethiopia, prized for its resilience to drought, heat, and waterlogging. It is gluten-free and rich in essential nutrients, making it suitable for individuals with celiac disease and other dietary restrictions. Teff's adaptability to diverse agroecological conditions and its potential for value-added products like flour and beer highlight its importance as a new crop for global food security.

Jatropha (*Jatropha curcas*)

Jatropha is a drought-resistant shrub cultivated for its oil-rich seeds, which can be converted into biodiesel. Despite initial enthusiasm for its potential as a biofuel feedstock, challenges related to yield variability, land use conflicts, and market viability have tempered its widespread adoption. Nevertheless, ongoing research and breeding efforts aim to improve jatropha's agronomic performance and commercial viability.

Fonio (*Digitaria exilis* and *Digitaria iburua*)

Fonio is a resilient, drought-tolerant cereal grain grown primarily in West Africa. It has a short growing season and high nutritional value, containing essential amino acids and micronutrients such as iron and zinc. Fonio's ability to thrive in poor soils and harsh climatic conditions makes it a valuable crop for smallholder farmers in regions prone to climate variability and food insecurity.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Bambara Groundnut (*Vigna subterranea*)
Bambara groundnut is an indigenous legume crop cultivated in sub-Saharan Africa for its edible seeds and nitrogen-fixing properties. It is well-adapted to semi-arid environments and can improve soil fertility while providing a nutritious source of protein, carbohydrates, and micronutrients. Bambara groundnut's resilience to climate extremes and its potential for intercropping systems contribute to its role in sustainable agriculture.

All the examples provided above for new crops for the future agriculture are visualized in Figure 1.

Fig. 1. New crops for the future agriculture
Source: Own design and conception.

These examples [2], [5], [14] showcase the diversity of new crops and their potential contributions to agricultural sustainability, food security, and economic development on a global scale. Continued research, investment, and collaboration are essential to unlock the full potential of these crops and integrate them effectively into agricultural systems worldwide [12].

Potential and Applications

Nutritional Security

New crops offer opportunities to address malnutrition and food insecurity by providing nutritious alternatives to traditional staple crops [10]. For example, crops like quinoa, moringa, and fonio are rich in protein, essential amino acids, vitamins, and minerals, contributing to balanced diets and improved health outcomes, especially in regions where micronutrient deficiencies are prevalent.

Environmental Sustainability

New crops can promote sustainable agricultural practices by reducing environmental impact and enhancing ecosystem services. Perennial crops like kernza and jatropha improve soil health, sequester carbon, and conserve water resources compared to annual crops, mitigating soil erosion, greenhouse gas emissions, and freshwater depletion. Additionally, crops like seaweed and camelina cultivated in marine and marginal lands can alleviate pressure on terrestrial ecosystems and contribute to coastal and biodiversity conservation.

Climate Resilience

New crops with inherent tolerance to climate extremes, such as drought, heat, and salinity, offer resilience to changing environmental conditions. These crops help farmers adapt to climate variability and mitigate production risks associated with erratic weather patterns. By diversifying crop portfolios and introducing resilient species like teff and camelina, agricultural systems become more robust and less vulnerable to climate-induced disruptions, safeguarding livelihoods and food security.

Economic Development

The cultivation and commercialization of new crops present economic opportunities for farmers, agribusinesses, and rural communities. Value-added products derived from new crops, such as quinoa-based snacks, moringa supplements, and camelina biofuels, create market niches and generate income streams along the value chain. Moreover, the adoption of new crops diversifies revenue sources, reduces market dependence on commodity crops, and enhances the competitiveness of smallholder farmers in global markets.

Industrial Applications

New crops have diverse industrial applications beyond food and feed, including biofuels, bioplastics, pharmaceuticals, and cosmetics. For instance, hemp fibers are used in textiles, construction materials, and biocomposites, offering sustainable alternatives to conventional materials with lower environmental footprint.

Genetic Resources and Biodiversity Conservation

New crops represent valuable genetic resources that contribute to crop diversity and resilience. By conserving and utilizing genetic diversity within new crop species, researchers can breed improved varieties with desirable traits, such as yield, nutritional quality, and stress tolerance. Furthermore, integrating new crops into agroecosystems diversifies habitats, supports beneficial organisms, and enhances biodiversity conservation efforts, promoting ecological balance and ecosystem resilience.

Soil Health and Regeneration

New crops can play a crucial role in soil health and regeneration by improving soil structure, fertility, and microbial diversity. Perennial crops like kernza and moringa develop extensive root systems that help prevent soil erosion, enhance water infiltration, and sequester carbon in the soil, contributing to carbon farming and climate change mitigation efforts. Additionally, leguminous crops such as Bambara groundnut and lupin fix atmospheric nitrogen, enriching soil fertility and reducing the need for synthetic fertilizers, thereby mitigating nitrogen pollution and greenhouse gas emissions associated with conventional agriculture.

Water Efficiency and Conservation

New crops with low water requirements and efficient water-use strategies offer sustainable solutions for water-stressed regions and mitigate the impacts of water scarcity on agricultural productivity. Crops like quinoa, teff, and sorghum are inherently drought-tolerant and thrive in arid and semi-arid environments, where water availability is limited. By promoting the cultivation of these water-efficient crops, farmers can optimize water resources, reduce irrigation demand, and adapt to changing precipitation patterns induced by climate change, thus enhancing agricultural resilience and water security.

Pest and Disease Management

New crops with natural resistance to pests and diseases offer alternatives to chemical pesticides and reduce reliance on agrochemical inputs, promoting ecological pest management and sustainable crop protection strategies. For example, certain varieties of quinoa and amaranth exhibit resistance to common pests like aphids and thrips, reducing the need for insecticide applications. Moreover, intercropping diverse crop species, such as legumes with cereals or aromatic plants with vegetables, can disrupt pest cycles, enhance biodiversity, and improve overall crop health through natural pest control mechanisms.

Cultural and Social Significance

New crops often have cultural and social significance, especially in indigenous communities, where they are deeply rooted in traditional agricultural practices, culinary heritage, and cultural identity. By revitalizing indigenous crops like amaranth, millets, and taro, communities can preserve cultural knowledge, promote food sovereignty, and strengthen social cohesion.

Economic significance

Market Diversification: New crops offer farmers and agricultural industries opportunities to diversify their product portfolios and access niche markets with higher value-added products. By introducing new crops into cultivation, farmers can reduce dependence on traditional commodity crops, which often face price volatility and market saturation. Diversification enhances market resilience, mitigates risks associated with monoculture cropping systems, and provides avenues for farmers to capture premium prices for unique and specialty crops.

Value Chain Development: The cultivation and commercialization of new crops stimulate the development of value chains encompassing production, processing, distribution, and marketing activities. Value chain development creates employment opportunities across various sectors, including farming, agribusiness, food processing, logistics, and retail, thereby contributing to rural livelihoods, economic growth, and poverty alleviation. Moreover, value-added processing of new crops into food products, beverages, cosmetics, pharmaceuticals, and biofuels generates additional revenue streams and enhances competitiveness in domestic and international markets.

Export Potential: New crops with unique characteristics, nutritional profiles, and market appeal have significant export potential, particularly in high-income countries with discerning consumers and strong demand for health-conscious and sustainably produced products. Export-oriented cultivation of new crops generates foreign exchange earnings, supports agricultural trade balances, and strengthens the competitiveness of agricultural sectors in global markets. Export promotion initiatives, market access agreements, and branding strategies enhance the visibility and competitiveness of new crop exports, positioning them as premium products with superior quality and sustainability credentials.

Smallholder Empowerment: New crops present opportunities for smallholder farmers and marginalized communities to improve their economic status, enhance food security, and reduce poverty through inclusive value chain participation and income diversification. Many new crops, such as indigenous species and underutilized crops, thrive in agroecological conditions where conventional crops may struggle, enabling resource-poor farmers to cultivate resilient crops and access niche markets with higher returns. Empowering smallholder farmers through capacity building, access to finance, technology transfer, and market linkages strengthens their resilience to economic shocks and fosters sustainable rural development.

Rural Development: The adoption of new crops contributes to rural development by revitalizing local economies, revitalizing agricultural landscapes, and creating vibrant agri-food clusters that attract investment, tourism, and infrastructure development. New crop cultivation generates multiplier effects in rural economies, stimulating demand for inputs, services, and infrastructure, and creating non-farm employment opportunities in ancillary sectors such as hospitality, tourism, and agro-tourism. Rural development initiatives that support new crop production, processing, and marketing enhance livelihoods, reduce rural-urban migration, and promote inclusive growth in rural communities.

Innovation and Entrepreneurship: The emergence of new crops fuels innovation and entrepreneurship in the agricultural sector, fostering a culture of experimentation, adaptation, and collaboration among farmers, researchers, agribusinesses, and start-ups. Innovation hubs, incubators, and accelerators focused on new crop development provide platforms for knowledge exchange, technology transfer, and business incubation, nurturing a vibrant ecosystem of agripreneurship and agtech innovation. Entrepreneurs leverage technological advancements, market insights, and funding opportunities to develop novel products, services, and business models that capitalize on the economic potential of new crops and address emerging market needs.

Urban Agriculture and Vertical Farming

New crops offer opportunities for urban agriculture and vertical farming systems, where space constraints and resource limitations necessitate innovative approaches to food production [16]. Leafy greens, herbs, and microgreens like kale, basil, and watercress can be efficiently grown in controlled indoor environments using hydroponic or aeroponic systems, minimizing land use, water consumption, and pesticide use while maximizing crop yield and quality.

Genetic Engineering and Biotechnology

Advancements in genetic engineering and biotechnology enable the development of novel traits and applications in new crops, including enhanced nutritional profiles, stress tolerance, and disease resistance. Genetic modification techniques such as genome editing and RNA interference offer precise tools for trait manipulation without introducing foreign DNA, facilitating the development of crop varieties with improved agronomic performance and consumer traits. Biotechnological innovations also enable the production of biofortified crops with elevated levels of vitamins, minerals, and antioxidants, addressing nutrient deficiencies and improving public health outcomes, particularly in resource-limited settings.

All the examples provided above for new crops potential and applications are visualized in Figure 2.

Fig.2. New crops potential and applications
Source: Own design and conception.

In summary, the multifaceted potential and applications of new crops encompass a wide range of agricultural, environmental, social, and technological dimensions, offering transformative solutions to pressing challenges facing global food systems [6]. Harnessing the benefits of these crops requires holistic approaches that integrate scientific innovation, policy support, community engagement, and market development to ensure sustainable and equitable outcomes for present and future generations.

Innovations and Technologies

Precision Agriculture

Precision agriculture utilizes advanced technologies such as remote sensing, Geographic Information Systems (GIS), Global Positioning Systems (GPS), and unmanned aerial vehicles (UAVs) to optimize crop management practices, resource allocation, and decision-making processes [3]. For new crops, precision agriculture enables farmers to tailor cultivation practices to specific environmental conditions, monitor crop health and growth parameters, and identify areas for improvement or intervention, thereby enhancing productivity, efficiency, and sustainability.

Molecular Breeding and Marker-Assisted Selection

Molecular breeding techniques, including marker-assisted selection (MAS), genomic selection, and quantitative trait locus (QTL) mapping, accelerate the breeding process by identifying and selecting desirable traits at the molecular level. These techniques enable breeders to develop new crop varieties with improved yield, quality, disease resistance, and stress tolerance more rapidly and efficiently, thereby expanding the genetic diversity and resilience of agricultural systems.

Biotechnology and Genetic Engineering

Biotechnology and genetic engineering offer powerful tools for trait manipulation, gene editing, and genetic modification in new crops. Techniques such as CRISPR-Cas9 genome editing, RNA interference (RNAi), and gene stacking enable targeted modifications of crop genomes to introduce desirable traits, enhance nutritional content, improve agronomic performance, and confer resistance to pests, diseases, and environmental stresses. Biotechnological innovations also facilitate the development of biofortified crops with enhanced micronutrient content, addressing nutritional deficiencies and improving human health outcomes.

High-Throughput Phenotyping and Genotyping

High-throughput phenotyping and genotyping platforms leverage automation, robotics, sensors, and imaging technologies to rapidly and accurately assess plant phenotypic and genotypic traits on a large scale. These platforms enable researchers and breeders to phenotype plant populations for complex traits such as yield, drought tolerance, nutrient efficiency, and disease resistance, facilitating trait discovery, trait mapping, and genotype-phenotype associations in new crop species. High-throughput phenotyping and genotyping accelerate breeding efforts, enable genotype-based selection, and enhance the efficiency of crop improvement programs.

Vertical Farming and Controlled Environment Agriculture (CEA)

Vertical farming and controlled environment agriculture (CEA) utilize indoor farming techniques, hydroponics, aeroponics, and vertical stacking systems to cultivate crops in controlled environments with optimized growing conditions. These technologies enable year-round production, efficient resource utilization, and space-efficient cultivation of new crops, including leafy greens, herbs, and microgreens, in urban and peri-urban settings. Vertical farming and CEA systems offer opportunities to diversify crop production, increase local food resilience, and reduce environmental impact while maximizing productivity and quality.

Blockchain and Digital Traceability

Blockchain technology and digital traceability systems provide transparent and immutable records of crop production, supply chain transactions, and quality assurance processes, enhancing transparency, accountability, and trust throughout the agricultural value chain [7]. For new crops, blockchain and digital traceability enable farmers to track the origin, cultivation practices, and sustainability credentials of their products, verify compliance with certification standards, and access premium markets with higher consumer trust and willingness to pay.

Agroecological Approaches and Regenerative Agriculture

Agroecological approaches and regenerative agriculture principles integrate ecological principles, biodiversity conservation, and sustainable farming practices to enhance ecosystem services, soil health, and resilience in agricultural systems. For new crops, agroecological practices such as intercropping, agroforestry, cover cropping, and crop rotation promote biodiversity, improve soil fertility, suppress pests and diseases, and enhance ecosystem resilience, contributing to long-term sustainability, climate change mitigation, and food security.

Smart Sensors and Internet of Things (IoT)

Smart sensors and Internet of Things (IoT) devices enable real-time monitoring, data collection, and decision support in agricultural systems, facilitating precision farming, resource management, and automation of tasks. For new crops, smart sensors measure environmental parameters such as temperature, humidity, soil moisture, and nutrient levels, providing farmers with actionable insights to optimize growing conditions, irrigation scheduling, and fertilizer application, thereby improving crop performance, resource efficiency, and yield consistency.

Synthetic Biology and Metabolic Engineering

Synthetic biology and metabolic engineering technologies enable the design, construction, and optimization of biological systems for novel functions and applications in agriculture. For new crops, synthetic biology approaches enable the engineering of metabolic pathways to produce valuable compounds, such as pharmaceuticals, industrial chemicals, and biofuels, in plant-based production systems. Metabolic engineering techniques also facilitate the development of bioengineered crops with enhanced nutritional profiles, biofortified traits, and value-added products, addressing societal needs and market demands.

Robotics and Automation

Robotics and automation technologies are revolutionizing agricultural operations, including planting, harvesting, weeding, and crop monitoring. Autonomous vehicles, drones, and robotic systems equipped with cameras, sensors, and AI algorithms enable precise and efficient management of new crop cultivation, reducing labor costs, increasing productivity, and minimizing environmental impact [1]. For example, robotic weeders can selectively remove unwanted plants while sparing new crops, reducing the need for herbicides and manual labor.

Advanced Plant Breeding Techniques

In addition to traditional breeding methods, advanced plant breeding techniques such as speed breeding, haploid induction, and genomic selection accelerate the breeding process and improve the efficiency of trait introgression in new crop development. Speed breeding techniques involve controlled environments with optimized lighting, temperature, and nutrient conditions to shorten generation times and enable rapid selection of desired traits. Haploid induction techniques produce haploid plants for accelerated breeding cycles and efficient trait fixation, while genomic selection utilizes genomic information to predict breeding values and select superior genotypes for breeding programs.

Nanotechnology and Nanosensors

Nanotechnology and nanosensors offer novel solutions for crop protection, nutrient delivery, and disease diagnostics in new crop cultivation. Nanomaterials such as nanoparticles, nanofertilizers, and nanopesticides enable targeted delivery of nutrients and agrochemicals to plants, improving nutrient uptake efficiency and reducing environmental losses. Nanosensors embedded in soil or plant tissues provide real-time monitoring of nutrient status, water availability, and disease incidence, enabling proactive management strategies and precision agriculture interventions to optimize crop performance and resource use efficiency.

Climate-Resilient Crop Varieties

Climate-resilient crop varieties developed through conventional breeding, molecular breeding, and genomic selection techniques offer solutions to mitigate the impacts of climate change on agriculture. New crop varieties with enhanced heat tolerance, drought tolerance, flood tolerance, and disease resistance enable farmers to adapt to changing environmental conditions and maintain productivity under adverse weather events. For example, heat-tolerant rice varieties exhibit improved photosynthetic efficiency and yield stability under high-temperature conditions, ensuring food security in regions vulnerable to heat stress.

Mobile Applications and Decision Support Tools

Mobile applications and decision support tools provide farmers with access to real-time weather forecasts, agronomic recommendations, pest alerts, and market information, facilitating informed decision-making and risk management in new crop production. These digital tools empower farmers to optimize input use, plan planting schedules, implement integrated pest management practices, and access markets with higher price premiums for sustainably produced crops [17]. Mobile applications also enable data collection, farm record-keeping, and traceability documentation, enhancing transparency and accountability across the agricultural value chain.

Biostimulants and Microbial Inoculants

Biostimulants and microbial inoculants derived from beneficial microorganisms, plant extracts, and organic compounds enhance plant growth, nutrient uptake, and stress tolerance in new crop cultivation. Biostimulants stimulate physiological processes in plants, such as seed germination, root development, and nutrient assimilation, improving overall plant health and resilience to abiotic and biotic stresses. Microbial inoculants contain beneficial bacteria, fungi, or algae that form symbiotic relationships with plants, promoting nutrient cycling, disease suppression, and soil fertility enhancement, leading to improved crop productivity and sustainability.

Climate-Smart Farming Practices

Climate-smart farming practices integrate climate adaptation, mitigation, and resilience strategies into agricultural systems to minimize environmental impact and maximize productivity in the face of climate change. For new crops, climate-smart farming practices include agroforestry, conservation agriculture, water harvesting, and integrated crop-livestock systems, which enhance soil carbon sequestration, water use efficiency, and biodiversity conservation while improving farm profitability and resilience to climate variability. These practices contribute to sustainable intensification of agriculture and climate-resilient food systems.

All the examples provided above for new innovations and technologies for the future agriculture are visualized in Figure 3.

Fig. 3. New innovations and technologies for the future agriculture
Source: Own design and conception.

These examples illustrate the diverse range of innovations and technologies that are driving advancements in new crop cultivation, enabling sustainable, efficient, and resilient agricultural systems to meet the challenges of the 21st century.

The current situation

At present, some of the applications of non-food crops in fiber/textile production are well known, while others, such as plastics made from starch-based polymers, are less familiar. In the long run, innovation in agriculture is encouraged to improve biodiversity, reduce greenhouse gas emissions and waste, and slow down the loss of natural resources [9]. This can be achieved through collaboration between science, industry, and agriculture.

The innovative use of new non-food crops and their by-products can significantly contribute to diversifying agricultural production, enhancing industrial sustainability, and creating new jobs [11]. This includes accessing new markets and opportunities to increase income. The future use of new non-food crops largely depends on environmental concerns and government sustainability goals [4].

An example of this is the biofuel and biomass market, which is expected to grow significantly in the future, especially due to legislative changes related to environmental conservation and renewable energy production goals [8].

SWOT analysis

During the study, a SWOT analysis was conducted to identify the strengths and weaknesses, opportunities, and threats of applying innovative production technologies - new crops, as presented in Figure 4.

Fig.4. SWOT New crop
Source: Own design and conception.

From the proposed SWOT analysis, several strengths can be derived. Overall, sales of products manufactured from new crops tend to yield higher profits compared to those from traditional production. Additionally, innovative products derived from new crops carry higher added value. For example, cultivating energy crops for biofuel and biomass production diversifies farmers' production and provides access to various markets. It also enhances competition among agricultural producers, reduces energy consumption, environmental pollution, and waste generation. To improve financial opportunities and competitiveness in the sector, new markets must be secured, and opportunities to stimulate the production of products from farmers specializing in new crops must be found.

As for weaknesses, the analysis highlights that producing products from new crops requires more precise specifications, which poses risks in terms of business. Additionally, limited scientific research and a lack of communication between business and science regarding the exact impact of investing in and producing new crops on productivity, competitiveness, and business profitability are identified as weaknesses. Another weakness noted in the analysis is that a significant portion of new crop markets have low volumes, which cannot offset the high value of the product itself.

Opportunities derived from the analysis are related to new business opportunities in rural areas, contributing to their development and prosperity. It will also enhance producers' competitiveness and provide access to new markets and the production of new products.

Threats identified in the analysis are related to the unstable final price for crops, limited production potential for the global market due to global supply regulation to prevent oversupply and market saturation for pharmaceutical and cosmetic companies. Another threat is the high risk associated with producing new crops due to their specific production requirements.

CONCLUSIONS

In conclusion, new crops play a pivotal role in the future of agriculture, offering inevitable potential for innovation, sustainability, and diversity in food, materials, and energy production. Integrating new technologies and methods for plant cultivation and processing can transform agriculture into a more efficient and sustainable industry capable of meeting the growing needs of our society.

With their diverse functionality and flexibility, new crops provide tools for adaptation to various climatic and ecological conditions, which is crucial for global food security. Moreover, they can help preserve the environment by reducing ecological waste, harnessing biological resources, and decreasing greenhouse gas emissions.

The effective use of new crops is the key to achieving sustainable development in agriculture. They provide opportunities for innovation in all aspects of the production process - from variety selection and yield improvement to the development of new processing technologies. Thus, agriculture can become more resource-efficient, effective, and sustainable, contributing to the well-being of our society and the preservation of the planet.

Ultimately, new crops are not just an opportunity for the agricultural sector; they are rather an essential element for its future. Their role in creating sustainable and environmentally friendly production models is undoubtedly crucial for our planet and future generations.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE EVOLUTION OF FOOD CONSUMPTION IN ROMANIA IN THE POST-ACCESSION PERIOD TO THE EUROPEAN UNION

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Abstract

Among the fundamental human needs, the provision of food products can be mentioned, as a necessary condition for the survival of each individual. Among the influencing factors of food consumption can be mentioned the income and expenditure of the population allocated to the purchase of food. After the accession to the EU, oscillating evolutions of consumption were recorded, regardless of whether it is about the consumption of different social categories, in total, development regions or environments, but also by nutritional elements. In the context of these aspects, the object of this approach is represented by the analysis of the consumption of food products, respectively highlighting the changes and gaps registered after joining the EU. From a methodological point of view, the current approach is based on public information regarding the evolution of food consumption and the main influencing factors. The analysis of the existing data highlighted the increasing trend in the consumption of certain food products, as well as the incomes and expenses of the population by social category. It is also worth noting the worrying trend of increasing the consumption of carbohydrates and lipids with negative effects on the health of the population.

Key words**:** *consumption, incomes, expenses, social categories, nutritional elements*

INTRODUCTION

Defined as the total expenses incurred for the procurement of goods in a given period of time, consumption represents the use of the goods purchased to satisfy personal and collective needs. Among the purchased goods and services, food and beverages have an important place, given the need to ensure the population's food.

The increase in the consumption of agri-food products largely depends on the increase of population’s incomes, as well as on the consumption behaviors specific to each social category.

The approach to the problem of consumption in general has been the subject of several specialized studies over time, but also of the elaboration of specific regulations in this field. The size and structure of consumption are determined by economic factors, namely the population’s incomes and the prices of consumer goods, but also by demographic, social, geographical, conjunctural factors, etc. [9, 11].

On the other hand, we should not overlook the fact that the importance of this indicator, namely the consumption of food products, is justified by the total percentage held in the consumption expenses of each social category [6].

In economic theory, consumption provides the conditions for increased productivity and economic growth, with positive effects on the population’s well-being [10].

We can consider that a sustainable food system, which includes consumption, must ensure a sufficient and diversified supply of safe, nutritious, accessible and sustainable food for the population, at all times.

According to experts, while in the EU the average consumption of energy, red meat, sugars, salt and fat continues to exceed recommendations, consumption of whole grains, fruit and vegetables, legumes and nuts is insufficient [12].

Given the environmental impact of food consumption, there is growing concern about the ability to decouple economic growth and the environmental impact of consumption, resource use and waste generation [4].

In the opinion of the European Commission, current patterns of food consumption are not sustainable, neither from the point of view of health, nor from the point of view of impact on the environment.

Thus, in order to improve the availability and prices of sustainable food products and to promote a healthy and sustainable diet for the population, there is a need to identify ways to establish mandatory minimum criteria for sustainable food purchases [3].

According to some specialists [5], ensuring a sustainable food system contributes, among other things, to increasing the productivity of the agri-food sector and reducing production costs.

In Romania, the studies carried out in the field of food consumption are closely related to its role in the need to ensure food safety and security.

Thus, the interaction between agricultural policies and food security, as well as the effects of agricultural policies on food security are multiple, both direct and indirect, determining both the balance of the markets and the individual consumption of the population [7].

Without reviewing the entire specialized literature, in reference to the object of this approach, it should be mentioned that experts consider that the changes produced in the agri-food sector have had an important impact on the consumption of food products in the post-accession period.

Thus, in the last decade, there was an increasing acute shortage of domestic food supply that could not support the consumption needs of the population, under the pressure of increasing consumption of products with high nutritional value (animal products, vegetables, fruits, fish), against the background of economic growth and of the increase in population incomes implicitly [1, 2].

In the context of the above, the object of this approach is the analysis of the structure of food consumption and the most relevant influencing factors.

MATERIALS AND METHODS

Information from the Tempo-Online (INS) database was used to analyze the changes in the structure of food consumption as well as the influencing factors. This information was analyzed using the methods of dynamics and structures. Also, an econometric model was developed to measure the degree of influence of the factors.

The following primary indicators were taken into account for the analysis, respectively: consumption of food products, expenses incurred for the purchase of agri-food products, as well as the incomes obtained, by total social categories, later detailed by categories of employees, pensioners and farmers.

To ensure the comparability of the value indicators, they were transformed into comparable prices, using the general index of consumer prices, based on 2007. The analysis period is 2007-2022. To facilitate the tabulation of results, the annual values at 5 years from the reference period were retained.

RESULTS AND DISCUSSIONS

The accession to the European Union required sustained efforts to adapt to European requirements and rigors, but at the same time it generated deep changes at all levels of economic and social life.

As an important element of food security, the consumption of food products has had oscillating evolutions from one year to the next, being influenced both by the level of expenses for food procurement, and mainly by the incomes obtained by each social category. The inflation rate is added to these, with a direct impact on the purchasing power of the population, as well as the existing gaps by residence areas, which consequently influenced the consumption of food products.

As regards the total average income per household, the period 2007-2022 is characterized by an increasing trend both for the national economy as a whole and for urban/rural areas. Thus, while the overall average household incomes doubled in 2022 compared to 2007, with percentages that oscillated from +73.8% (pensioners) to 111.7% (employees), in the rural areas, the average incomes registered a total increase of 112.6%, with the category of employees above the total average, by a 2.3 percent increase (Table 1).

Table 1. Evolution of total average monthly incomes per household in rural areas, in the period 2007-2022 (lei, constant prices 2022)

	Total	Employees	Farmers	Pensioners
2007	2,572.1	3,794.9	2,350.1	2,231.5
2011	3,063.2	4,100.4	3,061.3	2,758.5
2016	3,305.0	4,805.0	2,920.5	2,722.8
2021	5,242.6	7,986.1	3,973.6	3,692.8
2022	5,468.3	8,132.2	4,221.2	3,897.6

Source: Own calculation on the basis of Tempo-Online data, NIS, 2023 [8].

Speaking about the total average monthly expenses per household, it should be noted that over the course of 16 years, i.e. after the accession to the European Union, these expenses have increased by 98.3%, with percentages ranging from 58.5% (pensioners) to 106% (employees).

In the rural areas, the increase in total average monthly expenses per household is more pronounced compared to total, doubling in 2022 compared to 2007. While in the case of pensioners' households, the average total monthly expenses per household increased by 56.7% in 2022 compared to 2007, in employees' households the increase exceeded the total average by 13.5 percentage points (Table 2).

Table 2. Evolution of total average monthly expenses per household in rural areas, in the period 2007-2022 (lei, constant prices 2022)

	Total	Employees	Farmers	Pensioners
2007	2,388.2	3,367.9	2,256.0	2,094.2
2011	2,872.5	3,808.3	2,932.1	2,545.5
2016	2,903.9	4,190.6	2,652.0	2,357.1
2021	4,521.3	6,841.4	3,619.7	3,153.1
2022	4,807.0	7,235.8	3,896.4	3,282.5

Source: Own calculation on the basis of Tempo-Online data, NIS, 2023 [8].

In the same reference period, the total average expenditure per household for food and beverages consumed increased by 64.2% in total, with percentages ranging from 52.2% (employees) to 84.8% (farmers). Unlike the total average, in rural areas, this category of expenses increased by no less than 90.7% in 2022 compared to 2007, the largest increase being found in farmers' households (+84.8%). However, in constant prices, the highest expenses for food and drinks purchased in rural areas were noticed in the category of employees, i.e. 1,098.4 RON/month in 2022 compared to 645.6 RON/month (2007) (Table 3).

Table 3. Evolution of average monthly expenses for food and beverages per household, in rural areas, in the period 2007-2022 (lei, constant prices 2022)

	Total	Employees	Farmers	Pensioners
2007	447.7	645.6	382.7	378.2
2011	525.5	701.7	460.7	468.5
2016	561.7	743.2	493.1	469.8
2021	792.7	1,022.0	646.7	645.2
2022	853.9	1,098.4	707.4	678.4

Source: Own calculation on the basis of Tempo-Online data, NIS, 2023 [8].

Expenditures for the purchase of food products registered a total increase by 60% at national level, by percentages ranging from 47.5% (employees) to 84.1% (farmers). In rural areas, increases in this category of expenses ranged from 66.3% (employees) to 84.7% (farmers), while the rural average increased by 87.8% (Table 4).

Table 4. Evolution of average monthly expenses for the purchase of food per household, in rural areas, in the period 2007-2022 (lei, constant prices 2022)

	Total	Employees	Farmers	Pensioners
2007	440.2	631.2	375.5	373.7
2011	516.5	686.5	452.8	463.1
2016	546.5	714.2	478.4	461.3
2021	771.2	984.0	635.0	633.4
2022	826.8	1,049.7	693.6	665.5

Source: Own calculation on the basis of Tempo-Online data, NIS, 2023 [8].

Regarding the average monthly consumption, from the data provided by the INS, information was selected for a number of 9 products, from the analysis of which the following aspects can be deduced:

-The average monthly consumption of bread and bakery products decreased by 2%, from 9.9 kg/inhabitant (2007) to 7.9 kg/inhabitant (2022) respectively, by percentages that oscillated from -1.9% (farmers) to -2.3% (employees);

-The average monthly consumption of meat and meat preparations, as well as that of cheese and cream, and also eggs, had an upward trend, while oil consumption remained relatively constant, except for pensioners' households (+0,1%); among the previously mentioned products, the most significant increases in consumption were found in eggs, with percentages that oscillated from 1.1%

(employees and farmers) to 2.6% (pensioners). Practically, from a total average monthly consumption of 13.3 eggs in rural areas in 2007, after 16 years, the consumption reached 14.6 eggs in 2022;

-In potatoes, although this product is known to be a basic food product, in the year 2022 compared to 2007, in the rural areas, the average monthly consumption decreased by 0.7% both in total, as well as in the categories of employees and pensioners (Table 5).

Table 5. Dynamics of the average monthly consumption of food products in the rural area, in the period 2007-2022 (%)

	Total	Employees	Farmers	Pensioners
Bread and bakery products (kg)	-2.0	-2.3	-1.9	-2.0
Fresh meat (kg)	1.2	0.8	0.4	1.4
Meat products (kg)	0.5	0.4	0.4	0.6
Milk (liters)	-1.4	-1.3	-1.7	-1.2
Cheese and cream (kg)	0.3	0.3	0.1	0.3
Eggs (number)	1.6	1.1	1.1	2.6
Oil (kg)	0.0	0.0	0.0	0.1
Potatoes (kg)	-0.7	-0.7	-0.6	-0.7
Sugar (kg)	-0.1	-0.1	0.0	-0.1

Source: Own calculation on the basis of Tempo-Online data, NIS, 2023 [8].

As regards consumption by nutritional factors, it should be noted that in 2022 compared to 2008, the average daily food intake in calories increased by 0.3%, by percentages oscillating from -1.1% (employees) to 3.9% (pensioners). Specifically, with reference to pensioners, for instance, the average daily food intake in calories increased from 2,616.8 calories (2008) to 2,718.5 calories (2022). Practically, in the year 2022, the average daily food intake in calories in the case of pensioners exceeded the national average by 227.4 calories, being the highest consumption among the analyzed social categories.

The same upward trend was noticed in the average daily consumption of protein which reached 86.4 grams in 2022, up by 4.3% compared to 2008. The highest increase was also noticed in the category of pensioners (+8.2%), from 87 grams (2008) to 94.1 grams (2022) respectively.

However, quite a worrying increase is noticeable in the average daily consumption of fats and carbohydrates, with negative effects on population's health. Thus, in fats, the average daily consumption increased from 85 grams (2008) to 98.6 grams (2022) overall, while for carbohydrates, this indicator increased from 316.6 grams (2008) to 357.4 grams (2022). In the case of these two indicators, the category of pensioners also showed the highest increase among the analyzed social categories, namely +20.9% (fats), and +3% (carbohydrates) respectively, which reflects an unbalanced diet of the population.

From the analysis of available information, it results that the level and quality of food consumption essentially depends on the level of incomes and expenditures allocated to the procurement of food products. Also, as I mentioned before, an important factor is the level of inflation, with influence on the prices of food products and the purchasing power of the population.

In order to test this statement, during this approach, an econometric model was built for exemplification, based on the following indicators, for the category of rural pensioners: consumption of fresh meat (cons), average monthly expenses for the procurement of food (expenses), average monthly earned income (income) and inflation rate (ipc).

This model can later be extended for all categories of products, incomes and expenses, for each social category separately. It should be noted that the model was built based on the E-views software.

In the context of the above-mentioned, between the analyzed indicators there is a degree of correlation ranging from 85.3253 (ipc-expenditures) to 98.9046 (consumption-ipc) (Table 6).

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 6. The degree of correlation of analyzed indicators

	Expenses	**Cons**	**Ipc**	**Income**
Expenses	1.0000	0.8647	0.8533	0.9265
Cons	0.8647	1.0000	0.9890	0.8739
ipc	0.8533	0.9890	1.0000	0.8261
Income	0.9265	0.8740	0.8261	1.0000

Source: author's own calculations using E-views software.

To build an equation, it is considered that the level of consumption is a function of expenses, income and inflation.

In this sense, to explain the verified economic phenomenon, a multifactorial model was used (it has several explanatory variables of back-looking type). The equation of the model is:

cons c expenses income ipc

Following the application of this equation, the influence of the indicators on consumption generated the following values (Table 7).

Table 7. The influence of indicators on consumption
Method: Least Squares
Period: 2007-2022
Number of observations:16

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Expenses	-0.008868	0.004286	-2.069.067	0.0608
Income	0.001487	0.000613	2.424.715	0.0320
IPC	2.070.352	0.431832	4.794.344	0.0004
C	0.564822	0.249333	2.265.335	0.0428
R-squared	0.913530	Mean dependent var		3.331.250
Adjusted R-squared	0.891913	S.D. dependent var		0.430068
S.E. of regression	0.141392	Akaike info criterion		-0.862249
Sum squared resid	0.239899	Schwarz criterion		-0.669102
Log likelihood	1.089.799	F-statistic		4.225.905
Durbin-Watson stat	1.522.463	Prob(F-statistic)		0.000001

Source: author's own calculations using E-views software.

Analyzing the estimated parameters, it can be noticed that they are statistically significant at a significance threshold of 5%. Since in the Prob column the values recorded for the probabilities associated with the t-statistic tests are less than 0.05, we can state with a 95% probability that the estimated parameters are statistically significant.

Analyzing the data from Table 7, it can be noticed that:

-R^2 = 0.913530 represents the coefficient of determination of the model.

This high value of R^2 indicates that the proposed model explains well the economic phenomenon in reality.

-F-statistic = 42.025906, tests the hypothesis that all coefficients of the proposed model are simultaneously 0.

-Prob (F-statistic) = 0.000001, represents the probability associated with the F-statistic test, which must be as small as possible to reject the null hypothesis, according to which all model coefficients are zero.

For model testing and stability, two methods were used, namely the existence of autocorrelations at residual level and the CUSUM test.

Regarding the existence of some autocorrelations at residual level, the correlogram of residuals was made, with 24 lags. Analyzing this correlogram it is noticed that there are no autocorrelations (all probabilities associated with the statistical Q test - Ljung-Box Test > 0.1) (Fig. 1).

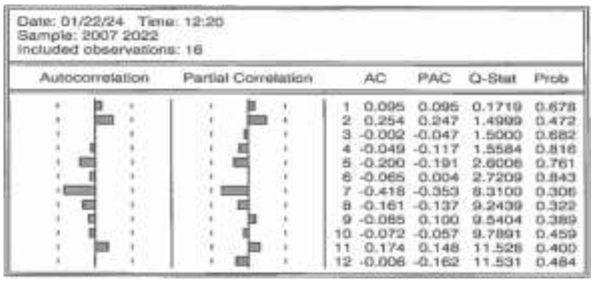

Fig. 1. Correlogram of residuals
Source: author's own calculations using E-views software.

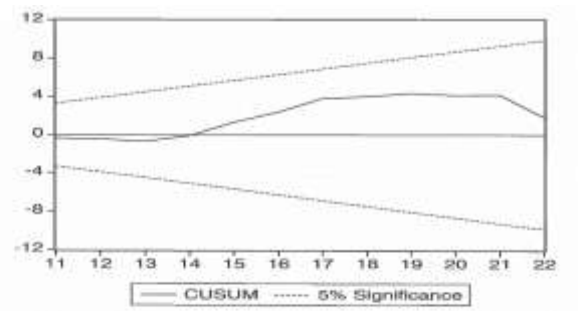

Fig. 2. CUSUM test
Source: author's own calculations using E-views software.

Regarding the stability of the model, from the analysis of the Cusum test it can be noticed that there are some shocks of the explanatory variables, but these do not create instability at the level of the explained variable (Fig.2).

CONCLUSIONS

From the analysis of available information, it results that both incomes and expenses for the procurement of food registered important increases in the post-accession period. However, the growth rate of incomes is clearly lower than that of expenses for food procurement, the latter being influenced by the increase in product prices, as well as by the inflation rate.

From the nine categories of products analyzed, a decrease in consumption is found in five categories, the highest decreases being noticed in bread and bakery products, for all social categories.

Increases in consumption were recorded for four products with percentages varying, in total, between 0.3% (cheeses) and 1.2% (fresh meat).

A worrying phenomenon is represented by the increase in the consumption of fats and carbohydrates, with negative effects on population's health.

In the context of the above, we consider it necessary for decision-makers to implement measures to ensure sustainable consumption, with beneficial effects at all levels of economic life, also including population's health.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ROMANIA'S RURAL DIGITAL TRANSFORMATION AND IMPLICATIONS FOR AGRICULTURE

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Abstract

This paper aimed to analyzes the development of access to the internet in Romania for the last decade highlighting digitalization in rural areas. The main indicators studied in this research are: household access to the Internet in different regions of Romania and in the EU, and internet usage of households in Romania and the EU, analyzed in their dynamics in the period 2014-2023, based on Eurostat data. The results proved an increase in internet connectivity across three tiers of location: cities, towns, and rural areas. While internet reached almost the entire population of the cities, this has been more than doubled in rural areas: from 41.08% in 2014 to 88.12% in 2023. Despite these increases, Romania still ranks behind most the EU countries regarding overall digitalization, particularly at a rural level. In this context, the rapid increase in rural internet access indeed points to an improvement in digital infrastructure, but further investments in improving the gap will be required. The study, therefore, highlights the importance of sustained efforts toward improving rural digital literacy and connectivity for all, but in particular for embracing digital agriculture technologies.

Key words: *digital divide, rural development, Romania*

INTRODUCTION

Digitalization has become an essential driver for growth in the majority of European economies. There is still inequality between the towns and the countryside, and many gaps remain to be filled-especially for countries like Romania [9]. Digitalisation will produce important changes in labour market regarding high IT skills and training level [8], as well as in the capacity to process big data [3], and to improve technical endowment and infrastructure in all the EU countries [17] and not only.
In this respect, the European Union has promoted policies and provided significant funding in recent years for policy actions, such as CAP and the Digital Agenda for Europe in order to make sure that all countries are digitally included and work toward rural development [13, 6]. The facilitation of digital technologies has gone so far in rural areas within Western European countries, while many countries like Romania still have huge infrastructure and digital literacy gaps that will not let them fully realize the digital transformation in rural areas [2].
Up to now, economic development and the technological advance of rural areas in Romania remain minimal when comparing to the rest of Europe [15]. This trend started to turn around over the last two or three years. According to [10], through National Rural Development Programme (NRDP), European funding has been very important for digital infrastructure and to support entrepreneurship in rural areas of Romania. The availability of funds is present, while other challenges regarding poor access to the Internet, low digital skills, and institutional support restrain further development compared to other EU countries [11].
The infrastructure, digital literacy, and socio-economic barriers are so wide in rural areas that more efforts are needed on the part of Romania toward true rural digitalization [7].
Digital transformation in agriculture and rural development has been one of the major focus

areas for Romania. Considering that rural areas are usually lagging behind in technological infrastructure, recent developments of digital tools have changed the scenery [12]. Thus, in agriculture, for instance, digitalization has shown promising signs of development: productivity, sustainability, and efficiency. Rural areas, however, still present specific challenges due to socio-economic factors and gaps in infrastructural conditions [16, 5]. While national and EU initiatives have accelerated this process of bridging the gap in the digital divide, there is still an acute need for comprehensive solutions that integrate local needs with digital literacy and economic incentives [10]. Whereas cities have raced ahead, rural areas are now rapidly catching up as smart farming technologies and data-driven agricultural practices gain momentum [1].

Against this background, the paper analyses the differences in access to internet between Romania and other European countries, pointing out both the advances and areas that need further efforts with respect to rural development.

MATERIALS AND METHODS

Data used within this paper have been retrieved from national and European statistical sources, such as Eurostat and the National Institute of Statistics-INSSE, Romania. These refer to the period 2014-2023. The subject of this analysis is the use of the internet in households in three regions: cities, towns, and rural areas in Romania. Data were divided into such geographic categories for assessing digitalization tendencies and gaps between urban and rural households.

In this regard, annual usage percentages were subjected to a longitudinal analysis to depict the digital divide and the stepwise progress that has occurred in Internet penetration. Data were further matched against urban and rural areas to show trends and test the effectiveness of national policies with respect to improving digital infrastructure across rural communities. Descriptive statistics were used to outline the increase in internet penetration, and the results were discussed in terms of digital transformation in agriculture and rural development.

The analysis involved establishing the rate of change in internet access over the ten-year period, underlining all the important points of inflection when rural internet penetration started to climb rapidly. These trends in data would then be wrapped into a broader discussion of implications for rural development, with particular interest in digital agriculture and prospect for technological adoption in underserved.

RESULTS AND DISCUSSIONS

Connectivity through the Internet in rural areas serves as a vital component in expanding economic growth, social inclusion, and modernization of different sectors, particularly agriculture.

With this, farmers in the countryside are able to access a wider spectrum of technologies-precise agriculture, for example-operating on optimized resources for better productivity and sustainability.

The general trend of the internet access in Romania was steadily increasing from 60.54% in 2014 and to 92.00% by 2023 across all households (Figure 1).

Urban households (cities) registered the highest percentage of individuals with internet access throughout the period, starting from 79.10% in 2014 to 96.04% in 2023. Rural households have experienced the most significant increase in internet connectivity, rising from 41.08% in 2014 to 88.12% in 2023. Town households also registered a rise from 62.98% in 2014 to 91.84% by 2023, reflecting great achievements in digital access.

This is even more relevant for the discussions on digitalization in rural areas. It puts forth that there has indeed been progress toward bridging the digital divide. Because rural areas started with much lower penetration, the rapid growth of the past decade actually demonstrates that efforts to improve digital infrastructure in these regions are paying off.

This is essential to enable rural populations to become connected and participate in the digital economy, access e-services, and improve agricultural practices by applying digital tools.

Yet, even as the gap narrows, it still persists. Thus, investment in digital infrastructure should be continued across the rural areas in order to ensure equality in the digital age.

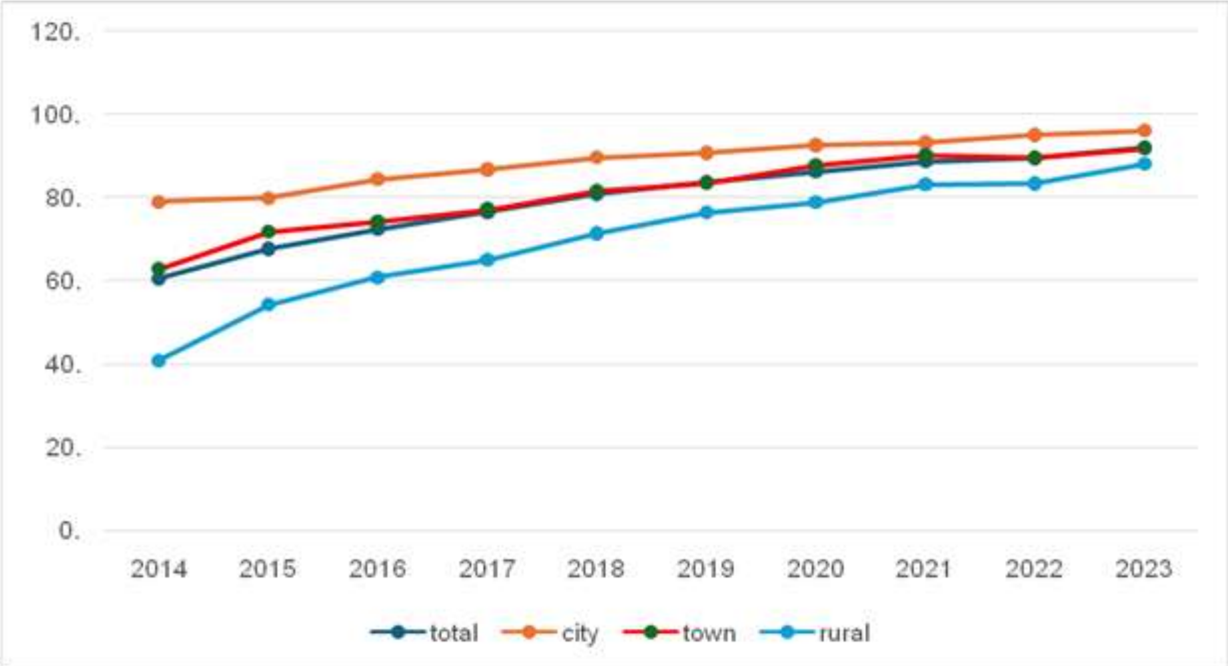

Fig. 1. Household access to the Internet in different regions of Romania (%)
Source: Authors ‘own elaboration based on Eurostat data [4].

The chart in Figure 2 gives an overview of the percentage of households accessing the internet in various EU countries between 2014 and 2023. From a comparison of Romania to other European Union nations, it is easily perceived that Romania has grown much in its Internet penetration, yet stands lower in rank compared to most of its European counterparts.

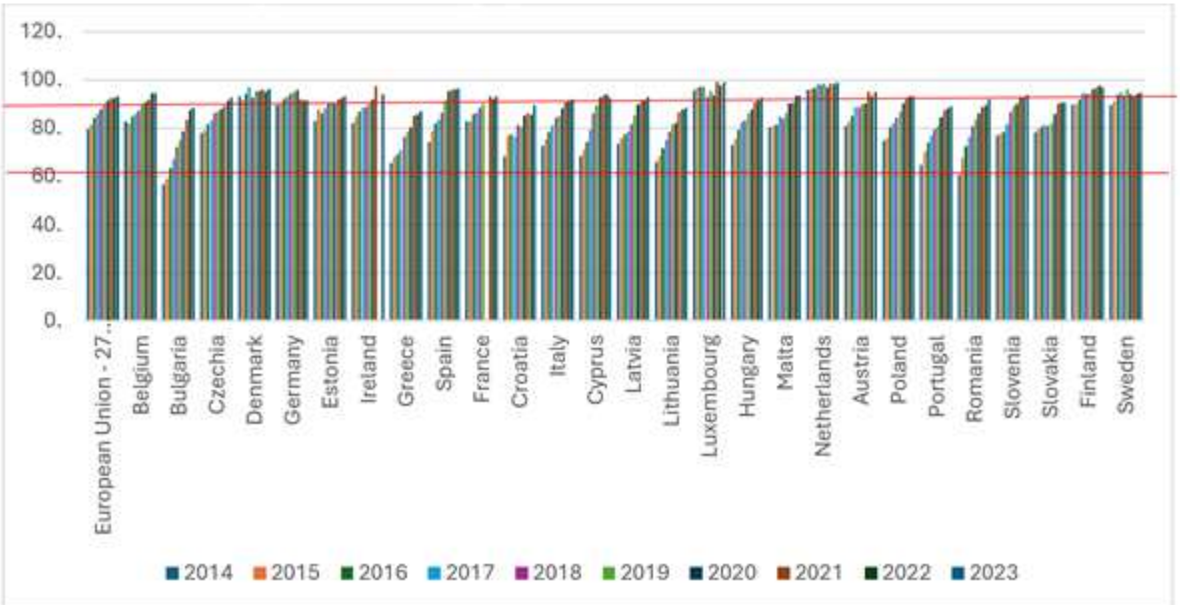

Fig. 2. Internet access of households in EU countries (%) red lines delineate the minimum and maximum for Romania)
Source: Authors' own elaboration based on Eurostat data [4].

While most of the EU member states show near-universal access by 2023, with figures tending to or above 95%, Romania, despite making several improvements, stays a little lower. The general trend for Romania is a steep increase in internet adoption, especially on the latter part of the timeline; however, it hasn't reached the same level of connectivity as top-tier countries.

This graph shows Bulgaria, Slovakia, and most of the other Central and Eastern European countries have moved similarly to Romania; in 2014, internet penetration started lower but grew faster. On the other hand, these continuous improvements in digital infrastructure represented by Romania's data signal a move toward closing the gap between this country and other EU members. By the year 2023, Romania has managed to get close to the EU average, but more digital infrastructure investment is still needed, especially in less densely populated regions.

Over recent years, an appreciable increase in the use of the internet has taken place across Romanian territory (Figure 3). In 2014, only 30.60% of households in rural areas had access to the internet, while in the urban ones, this was 65.29%. As of 2023, this number has more than doubled to 83.23%, which is a remarkable increase in bridging the gap between the rural and urban divide in the use of the Internet.

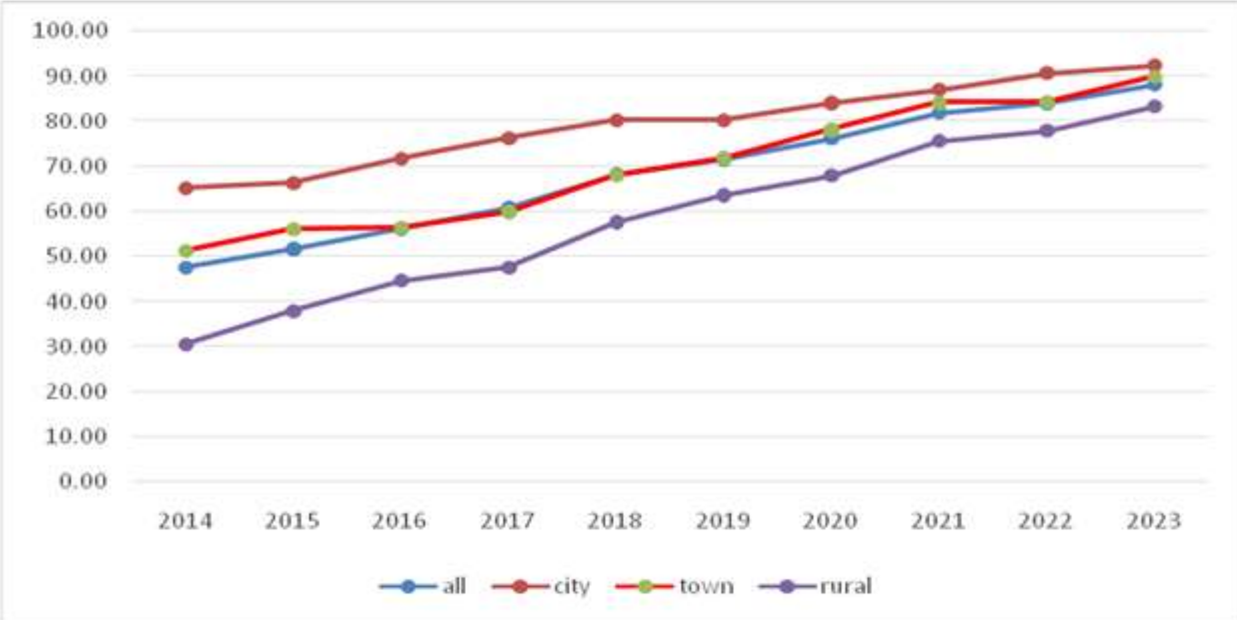

Fig. 3. Internet usage of households in Romania (%)
Source: Authors' own elaboration based on Eurostat data [4].

Comparing the rural versus urban areas, while the urban communities' usage of internet was reaching 92.42% of households connected by 2023, rural communities remain behind, with a steep increase only from 2017 onward, where rural internet access leaped from 47.57% to 83.23%. This is suggesting a focused effort in improving digital infrastructure within rural settings, which can be considered as an important enabler for the digital transformation of the agricultural sector in Romania. The more rural households become connected, the more opportunities will be opened for adopting digital tools, such as precision agriculture technologies.

In Figure 4 is showed the internet usage in selected European countries for the last decade. Romania had an upward trend in the usage of the internet, starting from 47.7% in 2014 to 88.05% in 2023, and it is well on its way with digitalization. This is anotable increase as compared with the EU average, which recorded growth from 72.48% in 2014 to 90.27% in 2023. Taking into consideration that a decade ago Romania was situated way below the starting baseline, and at this moment has been catching up with European median, this reflects a focused effort to extend the availability of the internet across the country.

Compared to other countries within the EU, rural areas in Romania continue to face slower adoption relative to urban centres.

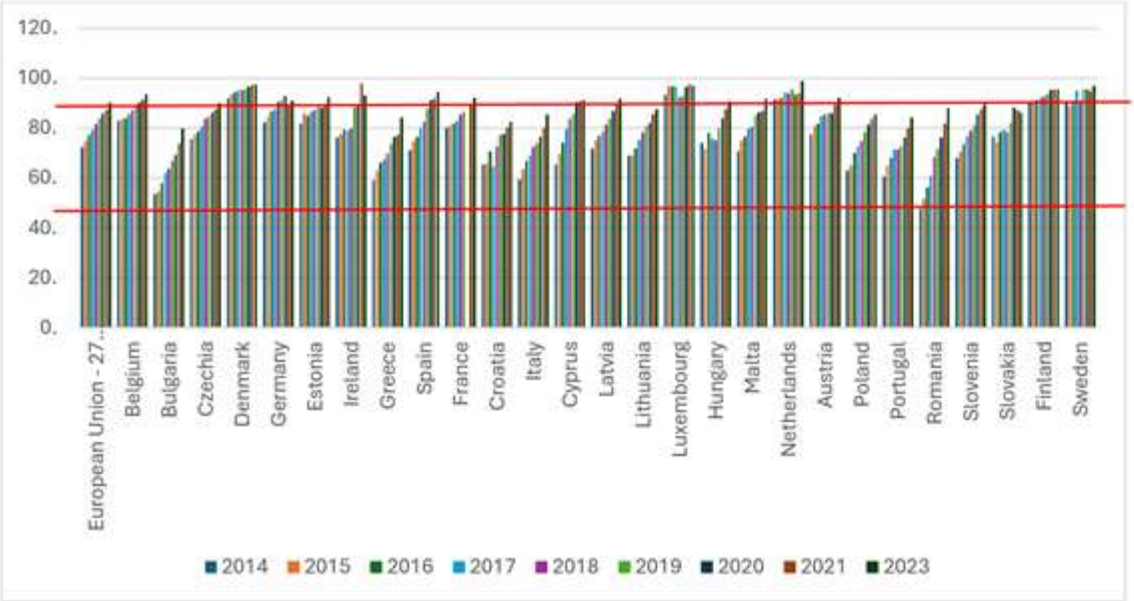

Fig. 4. Internet usage of households in EU countries (%) (red lines delineate the minimum and maximum for Romania)
Source: Authors' own elaboration based on Eurostat data [4].

For example, Denmark, Luxembourg, and Finland have consistently shown high internet usage, with their access rates exceeding 90% by as early as 2014.

Other countries, such as Bulgaria and Greece, while starting from a similar low baseline as Romania, have also seen similar positive trends. In 2023, at a value of 88.05%, Romania already surpassed the internet usage rate in certain EU countries such as Slovakia, which scored 86.06%, and was above Hungary with 90.63%, though it still lags behind digital leaders like Denmark, at 97.47%, and the Netherlands with 98.92%.

From this perspective, the implication of improving internet access and usage as one of the most valued drivers of digital transformation in agriculture and rural development is immense for Romania's rural area.

This represents steady growth in internet connectivity, aligned with the broader goals of digitalization within Romania, while bridging the gap and including rural communities in the economy through digital means.

At the same time, this also demands further investment to make sure that Romania catches up with EU leaders in terms of comprehensive internet coverage across all regions.

Yet, equal access between rural and urban areas remains a priority to ensure rural communities' participation in the broader digital economy.

This gap will be bridged, and a path toward more sustainable rural development will be achieved, with further investment in digital infrastructure coupled with efforts towards increased digital literacy.

CONCLUSIONS

Similar to many other Eastern European countries, Romania faces the challenge of rapid increases in internet access so that its benefits increase not only to urban areas but also to rural households, for whom access has traditionally been limited.

While the digital divide is reducing, it still needs attention if Romania is to exploit the full potential of digital technologies in agriculture and elsewhere.

ACKNOWLEDGEMENTS

The present research is part of the Project ADER 22.1.1. The design of technical-economic models for the analysis of the resilience and sustainability capacity of the agricultural sector and the optimization of production processes, of the Research Institute for Agricultural Economics and Rural Development (ICEADR Bucharest).

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY ON THE INVENTORY AND CHARACTERIZATION OF TOURIST POTENTIAL AND ACTIVITY IN THE CORABIA - OLT AREA, ROMANIA

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Abstract

The paper presents a multidisciplinary and complex study carried out in the Corabia - Olt area, in which, in the first stage, an inventory and characterization of the natural tourist potential of the area is carried out, which is not very rich and attractive, but as a novelty for the area, an attempt is made to the very important asset for tourism in general is highlighted, that the town is located on the bank of the largest water course in Romania and even in Europe, the Danube River. After that, a study is carried out regarding the anthropic tourism potential, which from the data presented was found to be rich, diversified and very valuable through the touristic sights of historical, cultural and religious importance that it possesses. Unlike other areas in the country, which have an equally rich anthropogenic tourism potential, the town of Corabia can clearly differentiate itself in terms of the tourist offer, by making maximum use of the advantages offered by the tourist port, with all its endowments. The study on the characterization of the tourist activity based on some quality indices that we determined, highlighted the fact that the tourist activity in the area is less, but it can be revived by creating an attractive and original offer, based on the practice of tourism specialized in hunting and fishing and in cruise and transit tourism, through cross-border cooperation with other countries bordering the Danube.

Key words: *agritourism, boarding house, management, tourism, tourist potential*

INTRODUCTION

It is well known that tourism is a key sector of the European economy, comprising a wide variety of products and destinations and involving many relevant actors, generating more than 5% of EU GDP, with around 1.8 million operators that are active in the field and have an employed staff around the level of 5.2% of the total workforce (approximately 9.7 million jobs). Together with related sectors, tourism's estimated contribution to GDP is much higher: tourism indirectly generates more than 10% of the European Union's GDP, providing jobs for around 12% of the workforce [3, 14, 16].

A significant contribution in this field is also made by the member countries of the Danube Region, who requested the Commission to propose a framework through which to provide effective solutions to the key problems faced by this region. The four outlined priorities, called "pillars", are: connecting the Danube region; environmental protection in the Danube region; ensuring the prosperity of the Danube region; consolidation of the Danube region. The EU strategy for the Danube region confirms and supports the ongoing development of the river cruise tourism industry. The Danube Tourism Commission (DTC) knows from its own experience the practical problems that arise, such as the administrative procedures imposed on crews. Facilitating dialogue between the many authorities and cruise companies involved can accelerate and facilitate initiatives to encourage both companies and tourists [5, 9, 18, 20].

Knowing very well the situation of the tourism industry in Romania, the Government of Romania established that it is urgent and necessary to develop a Master Plan for the development of this industry, covering a period of 20 years, until 2026 and including six-year action program years correlated with financial support through structural instruments. The immediate objective is the formulation of a general policy framework for the development and sustainable management of the tourism industry in terms of natural and cultural resources and the presentation of this objective in the form of a long-term tourism development plan [6, 12, 26, 38].

Each Member State develops a National Strategic Reference Framework (NSRF), as a reference document for the programming of the Structural and Cohesion Funds. At the NSRF level, tourism is analyzed from the perspective of the competitiveness of the Romanian economy and its growth prospects. Relevant aspects for the development of tourism are analyzed in the context of the sections dedicated to the territorial dimension, rural development and the promotion of a balanced territorial development [29, 30, 40].

Aligning with balanced regional development, there are counties in Romania that have already inventoried the entire natural and cultural endowment they have as tourist attractions, so that a patrimonial re-evaluation of priorities for promotion or re-promotion is sufficient, in order to determine the necessary funds. In the regional policy regarding the valorisation at the European level of touristic objectives of a certain value, correctly ranked in terms of attractiveness, intrinsic value, national importance, etc., financial means must also be provided for their protection [17, 32, 33].

In the current study carried out in the area of Corabia, a city located on the banks of the Danube, we want to contribute to a good extent to the inventory of the tourist potential and to the complex and realistic analysis of the actual situation of tourism, since ignorance, indifference and lack of education, important elements of local, natural and cultural heritage are left to fate, with serious repercussions both in the short and long term. Also, based on the results obtained, we want to contribute to the improvement to a good extent to the development and promotion of tourism in the area, both on a national level and, why not, on a European and world level.

MATERIALS AND METHODS

In the conducted study, the correct and well-documented inventory of the natural and human tourism potential of the Corabia area was primarily aimed at. This study was carried out by consulting a series of monographic data, from several materials published over time, as well as a field study to see what the real situation of these data is. In addition to these, I have consulted several thematic maps of the respective area, where the details are reproduced in detail with the help of symbols and conventional signs [8, 13].

The inventory of the natural tourist potential confirmed our hypothesis that the Corabia area has a lower potential compared to other tourist areas in the country, but still, the town being placed on the bank of the Danube River can very well exploit this asset and create a original and authentic tourist offer, by which it can clearly differentiate itself from other offers at the national or even international level. This offer can be developed and promoted very well through the cross-border cooperation between the member countries of the Danube Region, which should have a common policy and strategy for the implementation and development of tourism in the region. From the beginning, I considered that the topic addressed in this study is one of topicality and of particular relevance for the area, because even the localities along the Danube in our country must keep up with similar localities on the other side, from other countries, which it seems from the data we have that they realized more quickly and responsibly what the real possibilities are for the implementation and development of such tourism [2, 4].

Starting from these assumptions, we carried out this research using the case study method [1, 10, 15, 22]. In the first part of the work, we carried out a careful analysis of the situation of the access roads in the area and the natural tourist potential, which is less interesting and attractive for tourists, but which can be compensated by making the most of the assets given by the location of the localities in the proximity of the Danube River.

In the second part, a complex and multidisciplinary study was carried out of the data that make up the anthropic tourist potential of the area, from which it emerges that it is a rich one, with many objectives of great touristic and cultural value. The last part of the research focused on the analysis of the main indicators through which we can perform the analysis and characterization of tourist activities in the area.

We also analyzed the natural and anthropic tourism potential in a radius of at least 30 km, around the town of Corabia, because in the tourism research all the tourist objectives and attractions in this radius can significantly influence the tourist activity.

In this sense, the existing reception structures in the locality at the reference time 1990 and today were studied. After that, other relevant indicators were determined in the characterization of the tourist activity, such as; the number of tourists arriving in the area, the number of overnight stays, the average number of tourist arrivals, the average length of stay and the degree of occupancy, all of which were determined based on data collected from the field and from the National Institute of Statistics (NIS) [22, 27, 34].

RESULTS AND DISCUSSIONS

The case study was carried out on the area and the town of Corabia, located at the southern end of Olt county, on the left bank of the Danube, the second largest river in Europe, from which 2/3 of its length flows through the territory of our country , being an urban center of great economic, cultural and strategic importance, Corabia in Bulgarian Korab (кораб), in Russian Korabovo (кораб), in Turkish (Korab) is a city in Olt County, formed by the component localities Corabia (residence) , Tudor Vladimirescu and from the village of Vârtopu. It has a population of 16,441 inhabitants (2011) [11, 28, 36, 39].

The city of Corabia was formed and developed in the south of the former Balta County, which was then called Romanati County, and today, Olt County, between older settlements: Corabia Veche to the west, Dașova to the east and Siliștoara, which over time became suburbs of the city. After the last administrative-territorial division of 16.02.1968, the localities of Celei, Vârtop, Tudor Vladimirescu and the suburban commune of Gârcov also became part of the city. Although the city of Corabia is of recent date, having been established in 1871, material traces, written documents and oral tradition confirm its existence, starting from ancient times [11, 28, 39].

Study on the accessibility of the area and the natural tourist potential

The city of Corabia is connected by the secondary railway 910, a secondary branch of the highway 900 (Bucuresti Nord - Jimbolia), with the city of Caracal, the railway 910 having a total length of 41 km, consisting of a simple non-electrified railway. The Corabia-Caracal-Piatra Olt-Sibiu railway starts from Corabia, which is intersected by the Bucharest-Caracal-Craiova-Timișoara and Bucharest-Piatra Olt-Craiova-Simeria-Arad railways.

The town of Corabia is traversed from north to east by National Road 54, a road of considerable importance, connecting to the north with the town of Caracal and to the E with the town of Turnu Măgurele and then the capital Bucharest. National road 54 (DN 54), has a length of 15.31 km on the territory of the city of Corabia, and national road DN 54A, with a length of 6.46 km on the territory of the city of Corabia. County roads of interest are county road 543 (DJ 543), with a length of 5.9 km on the territory of the city of Corabia, and DJ 544A, with a length of 4.8 km on the territory of the city of Corabia. The total number of streets is 94 in the total length of 110 km. The city is crossed by the Danube to the south [11, 28, 39].

The economic value of the Danube is well known, the port of Corabia being an important connection point of the county with the other Danube cities and the Black Sea. River transport is ensured with the help of the port of Corabia, the only port in Olt County, being positioned between kilometres 628 + 500 -630. It covers an area of 227,763 m², which is under the administration of A.P.D.F. - TO. George. The jurisdictional radius of the port extends from km 655 to km 617 [11, 28, 31].

In addition to these very important and easy-to-use access routes, the city is located only 94 km from Craiova International Airport, which has recently been undergoing an important expansion and modernization process, thus greatly increasing air traffic from area.

The relief and the soil

Located on the terrace of the same name, bathed by the waters of the Danube, the town of Corabia is 50 m above sea level, thus being the lowest urban settlement in the county. The town of Corabia is part of the Corabia Plain, located to the right of Olt and stretches from the southern edge of the county to the Danube. The Danube Valley, oriented from the west, has an obvious asymmetric character, with the right side of the high and steep Pre-Balkan Plateau dominating the lower Danube plateau with extended terraces on the Romanian shore. The bed of the Danube has a width that varies between 1 and 1.5 km, and branches into numerous arms that close islands of different sizes, such as: Păpădia, Grădiștea, Dragoveiul, Băloiul, Calovaț, in the meadow it reaches a width of 8-9 km, near the town of Potelul and narrows at Corabia, where it is wider on the Bulgarian shore. The terraces are developed in well-defined steps, starting from the Tăuca-Orlea-Corabia-Gareav line and up to the Obârsia-Crușov line, the most developed being the 15-20 m high one, called the Corabia terrace. The varied and extensive microrelief consists of sand dunes in the Obârsia-Potelu area, roofs in the Boianului Plain, beams and microdepressions. It consists of meadows, surprises and landslides, fields and torrential reception basins, dejection cones, and in the south of numerous anthropogenic forms such as gorges [11, 28, 39].

The predominant soil is chernozem in the following varieties: 87% silvosteppe leached chernozem, with a medium texture throughout the northern part of the city; 5% chocolate chernozem stretching as a narrow strip accompanying the road to the east; 5% chocolate chernozem of the slope, which forms a narrow strip to the west, towards Celei; 2% alluvial soil in the meadow area, along the Danube valley [11, 28, 39].

The climate

Geographical position and relief largely determine the manifestation of climatic elements. In the territory of the city, the climate is temperate-continental with a more arid shade due to the waves of dry air from the east, which cause harsh winters and dry summers. The average annual temperature is 11.2 degrees Celsius. The area of the city of Corabia is distinguished both by the average of the higher summer months (32.2 degrees Celsius) and by the extreme values that have been recorded so far: 42 degrees Celsius in July of 1945 and - 32 degrees Celsius in January 1924 and 1942. About 200-210 days of the year there is no frost [11, 28, 39].

The amount of annual precipitation is on average 500 mm, differentially influencing the evolution of the vegetation period and the development of work on agricultural crops. The winds that characterize the climate are: Crivățul - which brings blizzards and snow in winter, rain in spring and drought in summer; Austrul-a dry wind that blows from the southwest; Băltăreță - who brings rain. Average wind speed is 5 m/s. The wind regime directly influences water losses through evacuation, accepting soil moisture deficit [11, 28, 31].

Hydrography

The Danube waters the Olt County in the southern part for a distance of 47 km and collects the county's entire hydrographic network on the territory of the city of Corabia. Regarding the floods and the maximum flow in the Corabia sector, from the recorded hydrometric data it appears that the Danube reached a maximum level of 722 cm and even 796 cm influenced by the freezing phenomena. The Danube has a multiannual average level of 275 cm and an absolute average level of 101 cm, resulting in a maximum amplitude of 832 cm. The economic value of the Danube is well-known, the port of Corabia being an important connection point of the county with the other Danube cities and the Black Sea [11, 28, 36, 39].

Groundwater has variable depths and a rather large influence in some sectors of the county (Vădastra, Vișina) causing excess moisture in rainy years. The water table is at depths of 0-3 m in the Olt and Danube meadows, 5-10 m and 10-15 m in the Olt and Danube terraces, over 20 m in the Boian high field [11, 28, 36, 39].

The flora it is mainly represented by the following plant species: Steppe vegetation predominates, followed by meadow vegetation. Among the important crops in the area, we mention: wheat, corn and some industrial plants, such as sugar beet and sunflower. As fodder plants we find: alfalfa, Sudan grass and "borceag" (a mix between a cereal and a leguminous plant) [7]. The most common fruit trees are: the apple, the apple tree, the cork tree and the plum tree. With the damming of the Danube, the return of the land from the meadow for agriculture made it possible to cultivate large areas of: apricot, peach, apple and plum. Cherry is also grown in Răzleț [11, 28, 39].

In the Danube meadow you can find sedge, sedge, cane, and among the trees, willow, Canadian poplar and pyramidal poplar. From the spontaneous vegetation we find: fir, cypress, swelling, tumbleweed, etc. In the forests and on their edges, we find axeman and violins. In the city park, as well as in the landscaped green spaces, you can admire roses, sage, tulips, violets, woodpeckers, wood stilts, carnations and bluebells. In the areas of the Danube Meadow, where the water stagnates, reeds, sedges, water lilies and water lilies grow. An important role in this area is played by medicinal plants such as linden, the city of Corabia is rightly considered the city of linden trees. An important resource is also the agricultural land exploited through grain crops, technical plants, vines and fruit trees. The hunting area is represented by forests and hunting reserves such as Reșca, Seaca, Brebeni, Teslui, Sarului forest [11, 28, 39].

The fauna that lives on the studied territory is represented, mainly, by the following species: the woodpecker, the vole and the field mouse. A common fauna animal is the rabbit. The birds specific to the area are: sparrowhawks, larks, starlings and nightingales. Herons, sitars, ducks, wild geese are also found. Over the entire surface of the county, the Slatina Forestry Directorate manages 13 hunting funds with a total area of 111,391 hectares, of which 107,296 hectares are productive for hunting, an area where various species of animals live such as: red deer, fallow deer, roe deer, wild boar, foxes, rabbits, pheasant, partridges, wild and marsh game [19, 21, 25]. The fishing grounds offer wide opportunities for sport fishing: on the Danube where carp, bream, pike, pike, grayling, Danube mackerel predominate, on the lakes in the west of Olt or on the natural ponds carp, catfish, bream, pike, redfish, the perch [19, 21, 25].

Study on the anthropic tourism potential

In addition to the main tourist attractions in Corabia, the Danube and its meadow, for those who want to visit the historical monuments in the city there are the Sucidava Fortress, the Holy Trinity Cathedral, the Independence Monument, the Cross of Heroes, the Church of Saint Spyridon, the Church of Saint Demetrius, the Bust and the Obelisk priest Radu Șapcă, as well as the Museum of Archaeology and Ethnography. To these are added the islands of Băloiu and Păpădia, where hunting or fishing parties can be organized. Also, a very important and representative tourist objective for the studied area is the Sucidava archaeological complex, where, through a program with European funding, extensive works were carried out to highlight the archaeological discoveries and facilitate access for tourists, including the construction of a space museum. The walls of the Byzantine fortress Celei-Corabia with the Secret Fountain – a unique monument of Byzantine Roman architecture [11, 23, 28, 31, 39].

At the same time, the museum, installed in the most representative building in the city, that of the House of Culture, attracts many visitors through its high-value exhibits. The building, a heritage objective, in itself, represents an architectural monument. In 2020, an extensive rehabilitation process was completed that brought back the beauty and elegance of the era in which it was built. Also in 2020, The Danube cliff park was redeveloped, the local authorities wanting to integrate the entire area into a complex project to facilitate tourism, including a forest park, picnic area and a recreation area on the non-permanent Coșcan stream [11, 23, 28, 31, 39].

In the immediate vicinity of the Danube, a tourist port was built, with European funding, which was populated, by the locals, with boats that make trips on the Danube, thus being able to visit the Ostrovul Băloiu, which belongs to the Romanian state, located in the middle of the Danube. Tourists sailing on the Danube, in transit, can use the facilities of the Tourist Port. In this area there is also the Sucidava hotel, where tourists staying here can enjoy the special scenery of the Danube. Also taking into account the fact that the city is not polluted by industrial agents, the central park, recently redeveloped through a project with European funds under the theme of the Fishermen's

Public Garden in Corabia, which offers moments of peace and relaxation [11, 23, 28, 36].

In addition to the anthropogenic tourist attractions in the locality, tourists can also visit a series of historical and cultural vestiges of particular importance at the level of the region, in Olt county, such as: the Geto-Dacian fortified settlement at Sprâncenata; The medieval watchtower from Hotăreni; Câmpu Mare Fortress; The memorial house of the outlaw Iancu Jianu from Caracal; Nicolae Titulescu memorial center in the village of the same name; Neolithic vestiges from Vădastra, Fărcașele, Brebene, Slatina, Oboga, Orlea; Tabula Pentingeriana (map of the Roman world drawn up between 260-271 AD) which preserved the names of some daves (centres) such as Acidava (located in the village of Enoșești, center of the Geto-Dacians) and Sucidava (located in Corabia-Celei, juice center); The ruins of the Roman Fortress and the secret well at Sucidava (in Celei, near Corabia), built by Emperor Aurelian in the years 271-275; The ruins of the largest Roman city in Southern Dacia Romula - Malva, at Reșca (com. Dobrosloveni) 8 km from Caracal [11, 23, 28, 31, 39].

For ecumenical tourism, we mention the religious edifices with a spread in almost all localities, which are generally well preserved, among them we mention: Brâncoveni Monastery - century. XVI; Clocociov Monastery - the beginning of the century. XVI; Striharet Monastery; Călui Monastery (Oboga commune, 15 km from the city of Balș); The Royal Church of Caracal, etc. [11, 23, 37].

The development of cultural tourism in the area can be favored by the existence of numerous buildings with a major contribution to the cultural background of the entire region, such as: the Scornicești Museum (1979) dedicated to the leader of Romania from 1965 to 1989 (Nicolae Ceaușescu); Olt - Slatina County Museum (1952), with sections of history and ethnography, with over 25,000 pieces specific to the culture and civilization of Olt; The History Museum - Caracal, famous for the brothel where the famous outlaw Iancu Jianu lived; Museum of History and Ethnography - Corabia; The Museum of History and Natural Sciences - Orlea (5 km from Corabia); Caracal National Theater [11, 23, 28, 36, 31].

A unique tourist attraction is the Secret Fountain, the wonder preserved for 14 centuries in the land of the fortress, a unique monument in Romano-Byzantine architecture. It is spectacular due to its construction system and its archaeological value. The underground construction has two components: the well itself, located at a depth of about 18 meters from the level of the fortress plateau and the 26-meter-long access corridor, which descends from the fortress premises to the spring. Legend has it that the water from the undried spring is attributed with the virtue of intensifying the love of couples and uniting those who are separated.

Study on the tourist activity in the Corabia area

The development and promotion of tourism presupposes the existence of a tourist potential which, through its attractiveness, aims to incite and ensure the integration of an area, a region with a tourist vocation in the domestic and international tourist circuits and which allows the access of tourists through the appropriate facilities. The first priority in carrying out this study was a new and innovative approach to the idea of capitalizing on the tourism potential in the area, namely the implementation of an integrated vision of tourism development at the level of the area, which expresses the added value that can also result from the promotion of the connections that can create between different points of attraction, located throughout the territory.

Table 1. Number of tourist reception structures with accommodation functions in Corabia

Types of structures of tourist reception	Years					
	1990	2018	2019	2020	2021	2022
Hotels and Hostels	1	-	2	2	2	2
Camps	1	-	-	-	-	-
Boarding houses	-	1	1	1	1	1
Total	2	1	3	3	3	3

Source: processing according to data collected from the field and from NIS [24].

This integrated vision must include, in addition to the previously presented studies that focused on the natural and anthropogenic potential, and the realistic presentation and analysis of the current situation in the tourism industry in the Corabia area. In order to better and more responsibly characterize the tourist activity as a whole, we took into account several indicators, based on which to make its correct interpretation.

From Table 1 it can be seen that in Corabia there is a smaller number of tourist reception structures, in the reference year 1990 there was only one hotel and a campsite, which provided accommodation for a small number of tourists. Boarding houses didn't exist until this year, because accommodation in guesthouses and locals was totally prohibited by law during the communist period, with the exception of a few localities from our country, which were included in the ONT (National Tourism Organization) program. Later, after the revolution, the private tourism activity began to develop more and more, boarding houses appeared, especially in the areas of Bran, Moeciu, Mărginimea Sibiului and other areas. In the south, and especially in the studied area, it is observed that their number is reduced, of only one during the entire research period. Also, from this table it can be seen that in addition to the hotel in operation, existing since the communist period, a hostel also appeared. An important thing to note is the fact that after 1990, the only existing campsite disappeared, a negative aspect, because with a minimum of equipment, these campsites could provide accommodation for tourists, who wanted to admire the beauty and wildness of the landscapes from the Danube route.

Table 2. The number of existing accommodation places in the tourist reception structures in Corabia

Types of structures of tourist reception	Years					
	1990	2018	2019	2020	2021	2022
Hotels/Hostels	35	-	35	47	47	48
Camps	83	-	-	-	-	-
Boarding houses	-	12	12	12	12	12
Total	128	12	47	59	59	60

Source: processing according to data collected from the field and from NIS [24].

The number of accommodation places was higher in the reference year 1990, due to the existence of 83 accommodation places at the campsite, which was still operating in this year. In the period 2018-2022, their number varied from 47, to 60 in 2022, when there is also a revival of tourist activity after the period of decline during the pandemic.

A very important aspect to point out is the fact that although the number of places has decreased, the quality of accommodation services has improved, because the Sucidava hotel has been modernized and new accommodation structures have appeared that have been classified at least 3 stars/daisies (Table 2).

Table 3. Number of tourists arriving in tourist reception structures in Corabia

Types of structures of tourist reception	Years					
	1990	2018	2019	2020	2021	2022
Hotels and Hostels	75	-	950	601	1,243	1,411
Boarding houses	-	497	602	353	386	418
Total	75	497	1,552	954	1,629	1,829

Source: processing according to data collected from the field and from NIS [24].

Table 3 shows that the number of tourists arriving in 1990 was very low, because this year was considered to be a year in which the economic and port activity in the locality was greatly reduced, due to the political instability of that period. In the period 2018-2022, it varied from 497, to 1,829 in 2022, this being also the year with the most tourists who visited this area, especially as part of transit or business tourism. The lowest number of tourists was recorded in 2020, when the direct effects of the pandemic on the tourism activity were also felt considerably in this area.

Table 4. Number of overnight stays in tourist reception structures in Corabia

Types of structures of tourist reception	Years					
	1990	2018	2019	2020	2021	2022
Hotels and Hostels	158	-	2,187	1,863	2,983	3,158
Boarding houses	-	1,144	1,454	1,127	1,005	1,187
Total	158	1,144	3,641	2,963	3,988	4,345

Source: processing according to data collected from the field and from NIS [24].

Regarding the number of overnight stays in Table 4, it can be seen that it varied directly proportional to the number of tourists arriving, reaching minimum and maximum values in the same reference years as this one. The maximum value was reached in 2022, the year in which from the field study we found that in addition to the transit tourism practiced, in the vast majority of cases, tourists interested in a series of ancient historical vestiges existing in the proximity of the town of Corabia, as well as other cultural-historical and religious values, previously presented in the study on human tourism potential.

Table 5. Average length of stay in tourist reception structures in Corabia

Types of structures of tourist reception	Years					
	1990	2018	2019	2020	2021	2022
Hotels and Hostels	2.0	-	2.3	3.1	2.4	2.2
Boarding houses	-	2.3	2.4	3.2	2.6	2.8
Total	2.0	2.3	2.35	3.15	2.5	2.5

Source: processing according to data collected from the field and from NIS [24].

The data entered in Table 5 show us very clearly that transit and cross-border tourism is practiced in the Corabia area, because the maximum length of stay does not exceed 3.15, and is around the value of 2.3-2.5, during the entire study period, the value lower, being recorded in the reference year 1990.

In the guesthouses, the short average duration of only about 2.5 nights over the entire duration of the study, shows us that they practice transit tourism as well as recreation at weekends, when the free period is not more than 3 days. Pensions practicing a more flexible management and more adapted to the new conditions in tourism, are also oriented towards the practice of business and conference tourism and last but not least towards ecological and cultural tourism.

Regarding the number of tourists arriving per day in tourist reception structures in Corabia, it can be seen from the data entered in table 6, that it is lower in boarding houses, of a maximum of 1.65 in 2019, compared to the maximum reached by hotel-type structures, of 3.86 in the year 2022. A year in which it is found that group and itinerant tourist activity has greatly revived, after the pandemic period, when the maximum restrictions on the movement and safety of tourists in 2020, led to the registration of a minimum number of tourists to guesthouses, of 0.97 tourists/day, as well as in the hotel industry of only 1.65. The low number of tourists arriving per day shows us that although the area has a very rich natural and especially anthropogenic tourism potential, it is not sufficiently promoted, an aspect primarily due to the lack of an integrated program to promote and support tourist activity, in to co-opt both the local authorities and the private actors in the field of tourism in the area.

Table 6. Number of tourists arriving per day in tourist reception structures in Corabia

Types of structures of tourist reception	Years					
	1990	2018	2019	2020	2021	2022
Hotels and Hostels	0.2	-	2.6	1.65	3.4	3.86
Boarding houses	-	1.36	1.65	0.97	1.06	1.15
Total	0.2	1.36	4.25	2.62	4.46	5.01

Source: processing according to data collected from the field and from NIS [24].

From the analysis of the data entered in Table 7, it can be observed that in the years of study the capacity of accommodation in operation is much higher in the reception structures of the hotel type, of a maximum of 15,792 place-days, in the year 2022, compared to only 3,576, in the same year, at boarding houses.

Although the accommodation capacity in operation is still reduced at the level of the small town of Corabia, a lack of its use is noted, at least at a level comparable to the values at the national level.

The utilization index of accommodation capacities at the locality level is not higher than 18%, but still it is more than 2% higher than the net utilization index of accommodation places for May 2023, which was 12.6% on total tourist accommodation structures." sent to the Regional Directorate of Statistics Olt.

Table 7. Accommodation capacity in operation (places-days) of the on types of tourist reception structures in Corabia, in the period 2018-2022

Year	Accommodation capacity in operation(places-days) of the hotels and hostels		Accommodation capacity in operation (places-days) of the boarding house		Total accommodation capacity in operation (places-days) in Corabia
	Number of days operation (Nzf)	Accommodation Capacity in function C.C.F.L.	Number of days operation (Nzf)	Accommodation capacity in function C.C.F.L.	
1990	302	10,570	-	-	10,570
2018	324	-	269	3,228	3,228
2019	337	11,795	287	3,444	15,239
2020	282	13,254	221	2,652	15,906
2021	305	14,335	258	3,096	17,431
2022	329	15,792	298	3,576	19,368

Source: processing according to data collected from the field and from NIS [24].

The accommodation capacity in operation at the level of the Corabia locality should increase considerably with the appearance of new investments in the field, due to the implementation and development of attractive forms of tourism specific to the localities located on the banks of the Danube. In addition to the appearance of new accommodation structures, the existing ones must be modernized and brought to a higher quality standard, leading to an increase in the effective number of their operation.

Fig. 1. Degree of occupancy (Do) of the structures of tourist reception from Corabia
Source: processing according to data collected from the field and from NIS [24].

The degree of occupancy (Do) of the tourist reception structures in Corabia is at a low level, which is, as can be seen from figure 1, a maximum of 39.9%, in the year 2022, in the hotel-type structures and 31.3%, in the structures type of tourist guesthouses. Its lowest value was recorded in 2020, both in hotels and in guesthouses, this being also correlated with the reduced number of days of operation, in the same year. Its reduced value is also due to the reduced average length of stay, recorded in the tourist reception structures in the area. It could increase considerably by achieving cross-border cooperation between the countries along the Danube, through which they have a common strategy for the development and promotion of tourism, and especially transit and cruise tourism, on the Danube.

As it is well known, an important asset in attracting tourists to an area is quality gastronomy, which according to the criteria for identifying the quality of a future tourist destination is in eighth place, within the level II criteria.

For this, we present in Table 8 two of the most important tourist structures classified for public catering, from Corabia. These structures, as can be seen from the table, are classified at 3 stars, according to the obtained classification certificate.

Their classification at this quality level attests to the fact that the services provided are at an appropriate quality level, even if they are not at the highest level, and tourists are insured in terms of the services offered and the safety and traceability of the food and specialties served. These two classic restaurants offer Romanian and foreign tourists the opportunity to experience traditional Romanian specialties: local fish soup, belly soup, "sarmale" or "mititei". They are prepared according to our own recipes that give them a special taste "like at home".

Table 8. Tourist reception structures with classified public catering functions in Corabia

Type of structure	Name	Category	No. of places	Economic operator	Number in the Trade Register	No. Certificate	Certificate issue date
Classic restaurant	La Belgianu	3 stars	150	SC Corabia Expres SRL	J28/78/1998	10445A	15 June 2011
Classic restaurant	Sucidava	3 stars	118	SC Hotel Sucidava SRL	J28/759/2003	16585	15-04-2019

Source: Tourism authorization, http://turism.gov.ro/web/autorizare-turism/? [35].

Also, these structures are considered to be one of the few places where a variety of bread, cakes and pastries are prepared in their own kitchen, a detail that guests appreciate and enjoy a lot. At the same time, the culinary experience is completed by a dessert prepared by our own chefs, which includes a portion of burnt sugar cream or a vanilla ice cream with forest fruits, but also a traditional one of "papanasi" with cream.

CONCLUSIONS

From the study it was concluded that the natural tourist potential is less attractive for tourists, because it is not sprinkled with exceptional mountain landscapes, the area can be revitalized from this point of view by exploiting to the maximum the huge advantages, given the fact that the town is located on the banks of the most important river in our country and even in Europe.

In order to exploit this potential to the maximum, the locality must implement a series of tourism programs in collaboration with the member states of the Danube Region, which should focus primarily on cruise and transit tourism, but also on other forms of tourism specific to the localities located on the Danube route, which until now has hardly been exploited at all. In order to improve the activity of the tourism industry in the Corabia area, the very rich tourist potential, specialized in hunting and fishing, must be exploited to the maximum because, in Olt County, there are 13 hunting funds, the area in which they live: red deer, fallow deer, roe deer, wild boar, foxes, hares, pheasant, partridges, wild and marsh game. The very rich and diversified fish stock offers wide possibilities for practicing sport fishing: on the Danube, carp, bream, pike, pike, grayling, Danube mackerel predominate, and the lakes and the Olt route are populated with valuable species for fishing such as: catfish, carp, bream, pike, caracuda, redfish, perch.

Unlike the natural tourism potential, the anthropogenic tourism potential in the area is rich and very valuable, having a series of valuable tourist objectives, represented by historical monuments, museums and ancient fortresses. One of the most important tourist attractions is the Sucidava citadel, where the Secret Fountain is located, a wonder preserved for 14 centuries, a unique monument of Roman-Byzantine architecture. It is spectacular because of the building system and the archaeological value, but also because of the unique story regarding the properties of the water from the source of this well.

From the study of tourist activity based on rigorously calculated, analyzed and interpreted data, it was concluded that it is one less adapted to the new conditions and trends in modern tourism, because it was not sufficiently able to adapt quickly and constantly to the continuous demand's transformation and modernization of tourism from us in the country and especially from the international one. The lower values of the main indices on the basis of which the quality of the tourist activity in the Corabia area is characterized highlighted the fact that in the area the existing tourist reception structures are not able to use the existing tourist capacities to the maximum, an aspect largely due to the specific conditions in the pandemic period, but also the management practiced and the lack of support from the local authorities for the entire tourist activity.

In the future, the tourist activity in the Corabia area must focus on attracting tourists through new original and personalized offers that include event tourism based on cultural-artistic events with national and even international participation, traditional local festivals, traditions and customs, holidays popular and other local events taking place in the area.

Also, the offer can be an authentic one by making the most of the original legend of Secret Fountains, from the Sucidava fortress and the navigable channel of the Danube, which connects with some of the largest cities and capitals of Europe, for the realization of specialized tourism on cruises and culturalization, ships can dock in the tourist port of Corabia, and accommodation can also be done at tourist reception structures in the area.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY ON THE STAGE OF DEVELOPMENT AND VALUATION OF THE TOURIST POTENTIAL IN THE DANUBE DELTA AREA, ROMANIA

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Abstract

The current stage of development and capitalization of the tourist potential in the Danube Delta area was identified based on multidisciplinary research, presented in this paper, in which three stages were completed, which aimed at the study of the natural and anthropic tourist potential, as well as the circulation and activity touristic. Regarding the natural potential, it was found that it is very rich, diversified and valuable, showing a strong character of uniqueness and authenticity, through the multitude of endemic and protected plant and animal species, many of which are included in the UNESCO international heritage. Although the cultural-historical and monumental heritage is not very rich, compared to other areas in the country, it represents a strong asset for attracting tourists due to the age and date of attestation of the existing historical fortresses and monuments. The current stage of development of tourism capacities was highlighted through the analysis of several indicators that focused primarily on the development of tourist activity in the villages of this region and through their comparative analysis with the values recorded at the national level. A comparative assessment of the flow of Romanian and foreign tourists arriving in the period 2018-2022, in this area, was also carried out, in order to highlight the level of capitalization of the existing tourist capacities and the stage of its promotion, at the national and international level.

Key words**:** *agritourism, boarding house, management, sustainable tourism, tourism in protected areas*

INTRODUCTION

In the current conception, recognized by most researchers, agritourism and tourism, as an economic activity, must be fully connected to the concept of sustainable development, being an activity dependent on the natural resources and the cultural heritage of each society and which uses these resources in common with other users, including local communities [20].
The tourism industry has adopted the concept of sustainable development, whereby all tourism activities in a country must be compatible with the carrying capacity of tourists and tourism equipment of the natural environment, thus ensuring sustainable ecological and economic functioning at all levels. In the area of natural parks and other protected areas, it is very important to explain to tourists as well as the local population the role and way of putting sustainable tourism into practice, and the gradual realization of a way of life compatible with international environmental protection norms, important aspect for the development requirements of future generations [14]. Today, more and more managers and employees in the field of tourism activities recognize that natural resources have a special economic value, current and potential, only if they are properly managed.
The World Tourism Organization (UNWTO) recommends the development, especially in protected areas, of tourism based on environmental conservation, i.e. sustainable tourism or ecotourism, which is the form of tourism in which the main motivation is the observation and appreciation of nature and local traditions", and the conditions that must be met reveal the definite destination of this form of tourism: conservation and protection of nature, use of local human resources; educational character and respect for nature; awareness of nature protection among tourists and the local community; minimizing the negative impact on the natural and social environment - cultural [10, 20, 22].
From the existing data at the national and international level, it can be seen that rural tourism with its component agrotourism and scientific tourism will be established as forms of ecological tourism, especially in protected areas. It has also been observed that these

forms of tourism contribute to rural development, if the local population participates in their development, being at the same time a means of protecting the environment, cultural-historical traditions and rural, local crafts [7].

In our country, the Danube Delta Biosphere Reserve is a protected area, where sustainable tourism, based on the protection of the environment, can be applied and developed in all its complexity. Here the requirements to protect the deltaic ecosystems and to preserve the natural areas still undisturbed by humans are intertwined with the maintenance and development of the traditional local economy and human habitats with their ancestral traditions [11].

In order to support such tourism, the Ministry of Tourism initiated a series of normative acts for the use and protection of sea beaches, mountain areas and tourist resorts, the establishment and protection of tourist heritage, the organization and development of tourism activities in Romania. At the same time, Romania became a party to many world and European organizations and conventions and signed a series of documents stipulating the protection of nature, human habitats, the development of tourism on ecological principles, and, as a signatory party, respects the recommendations and directives of these institutions and with especially of the EU. In Romania, there are few protected areas included in the tourist circuit (ecotourism). These are the Danube Delta Biosphere Reserve, the Retest National Park, the Rodna National Park (which have some areas declared Biosphere Reserves), but only the first two have their own administrations and programs for economic development, including tourism [11].

In order to adhere to these principles presented above, in the research undertaken by us an attempt was made to create an inventory of the tourist potential of the Danube Delta area and a complex and well-documented analysis of the current state of tourism activity as well as the possibilities of tourism development sustainable, based on ecological principles, which can be practiced in the best conditions in this area [6].

MATERIALS AND METHODS

As is known, the Danube Delta has great prestige not only in our country but also abroad, that is why foreign tourists are attracted by its wonderful landscapes. Over time, the Danube Delta has experienced an important economic development thanks to tourism and managed to be counted among the most important tourist areas in Romania, being a good reason for a long-term stay in this region.

In order to carry out the most relevant and realistic analysis of the tourist potential of this region, we used the classical method and the case study method as a research method, with the help of which, in the first stage, we carried out an observation process on the overview of the tourist potential of this region [2]. After this, we went on to describe mainly all the natural and human resources available to the area, insisting on the practice of tourism specialized in hunting and sport fishing, which is done with some restrictions and with the approval of the Danube Delta RB Administration, on the routes and in the places specially arranged and especially of non-invasive tourism, based on the hunting of images. In the reservations with integral protection regime and ecological reconstruction areas, they are excluded from tourist circulation; buffer zones can be included in the tourist circuit (sports fishing, cruises with non-polluting boats), without setting up tourist facilities, and economic zones are used for tourists only with authorization and under conditions of protection of the deltaic ecosystems.

Afterwards, a careful analysis was carried out on all aspects related to the tourist activity and its related activities, noting the need for more responsible involvement of the inhabitants of the delta in the activity of sustainable tourism through: the development of agritourism and rural tourism, as well as by attracting the labour force in tourism, among the local population, an aspect that will have beneficial economic and social effects on the deltaic settlements and will lead to an increase in the standard of living of the inhabitants [1].

Also, the actual current situation in the tourism industry in the Danube Delta Region was analyzed, by studying several reference indicators, based on which a pertinent characterization from all points of view of the tourism practiced, at this moment, and which are its development prospects. Indicators analyzed were: the number of existing tourist structures in this area, the number of tourists arriving especially in rural areas [1, 8]. Later, the comparative analysis was carried out based on the case study, between certain indicators determined at the national level with the values of the same indicators in the researched area. Indicators were calculated based on data taken from the field and from the National Institute of Statistics (NIS), making a comparison between the values of these indicators at the national level with those of the Delta Zone, including the city of Tulcea. These values were also analyzed by types of tourists, Romanians and foreigners arriving in the period 2019-2022, as well as the average length of their stay, both at the national level and in the researched region [19].

At the end, several conclusions were drawn from which the current stage of tourism development in the Danube Delta Region resulted and what are the measures that must be taken for the more sustained development of sustainable tourism, based on ecological principles, in this area.

RESULTS AND DISCUSSIONS

The Danube Delta, due to the unique value of its ecosystems and especially as a bird habitat, was recognized in 1990 as a "wetland" of international importance and was included in the UNESCO heritage. By Law no. 82/20.10.1993 became the "Danube Delta Biosphere Reserve" – RBDD, as an area of national and international ecological importance. The creation of the RBDD had as its main objective the protection and conservation of natural habitats, but it also supports sustainable development with the ecological support of traditional economic and cultural activities – including tourism, of local communities [5, 8].

Of the 580,000-ha total area of the RBDD, areas with a full protection regime (in which no economic activities are practiced) occupy 50,600 ha (18 reserves), buffer zones with selective activities 223,300 ha (12), economic areas (including for tourism) 306,100 ha, of which ecological reconstruction 11,425 ha [6, 20].

Study on the accessibility and inventory of natural tourism resources

Accessibility in the Danube Delta area is ensured primarily by sea, through the classic routes: Brăila - Galați - Tulcea - Sulina (8 hours), Tulcea - Sulina (3 hours), Tulcea - Sf. Gheorghe (6 hours), Tulcea - Chilia veche - Periprava (4.30 hours), Crișan - Mila 23 (1 hour), and the special routes: Tulcea - Sulina (1.30 hours), Brăila - Galati - Tulcea - Sulina (4.30 hours), Tulcea - Sf. Gheorghe (2 hours) [4].

Access can also be done by rail and road, with accelerated and personal trains, Bucharest - Medgidia - Tulcea (5-8 hours) and personal trains, Constanta - Tulcea (4 hours) and regular bus/minibus routes from: Bucharest, Galați, Constanta to Tulcea, Bucharest – Slobozia (Autostrada Soarelui – 100 km) A2 – Tulcea, Bucharest (DN2) - Urziceni (57 km) - Slobozia (121 km) - Hârșova (DN22A) - Tulcea (270 km).

By air - The Danube Delta Airport in Tulcea is located approximately 3 km south of the town of Cataloi and 17 km from the Municipality of Tulcea. Regular trains, Bucharest - Tulcea (45 minutes) [17].

Regarding the natural resources, an inventory was carried out to reveal their current state. The following resources were targeted in the study: relief, climate, waters, fauna, therapeutic muds.

The relief according to the FAO classification, the Danube Delta is included in the category of regional relief forms of wet plain type on fluvial alluvial deposits with a high degree of fragmentation. The relief through the sand dunes on the Letea and Caraorman ridges, usually associated with a vegetation and fauna specific to these forms of relief, which increases their complexity and aesthetic and scientific value. The coastal strip - the beaches - forms of accumulation relief that are constantly changing - those from Sulina, Sfântu Gheorghe, Gura Portiței are natural tourist resources directly exploited through the practice of spa tourism, the physical support in the helio-marine cure [5, 6, 18, 21].

***Climate*.** The Danube Delta falls within the area with a temperate semi-arid climate specific to the Pontic steppes. This is considered the place with the least precipitation in Romania. At the entrance to the Danube Delta (Tulcea), a multiannual average amount of precipitation of 450 mm is recorded, and at Sulina, of 360 mm. In most of the delta, between 350 and 400 mm of rain fall, and on the delta coast and most of the lagoons, below 350 mm.

In the Danube delta area specific weather conditions are established: mild winter days and frosty winter days with strong winds, hot and dry summer days or rainy summer days. The duration of sunshine is long, the multiannual average being 2,250 hours, but it can reach 2,600 hours in years with low cloud cover. The temperature is unevenly distributed on the surface of the delta. The multiannual averages indicate an increase in temperature from west to east, with values varying around 11.6^{o} C [5, 6, 12,18, 21].

***Ground water and surface water*.** The hydrographic network of the Danube Delta is quite complex, presenting a special interest from a geographical, economic, as well as tourist point of view. It ensures the water supply of the lakes, as well as navigability.

This hydrographic network includes: the arms of the Danube, the lakes, the ponds, the marshes, the gorges, the sloughs, the canals, the sahales. The Danube arms, in number of 4, of which only Chilia, Sulina and Sfântu Gheorghe have mouths of discharge into the sea, the 4th, the Tulcea arm (splits into the Sulina and Sfântu Gheorghe arms), being delimited between Chilia and Saint George [5, 6, 12, 15, 18, 21, 23].

The lakes, located especially between the main arms, with edges invaded by reeds and reeds, constitute an important morpho-hydrographic category in the Danube Delta as a whole, even if through the development works of numerous enclosures, many lakes and even lake complexes have been dried up (the Pardina agricultural facilities, Sireasa). Numerous shallow ponds also appear, which disappear completely in severe droughts, and are partially covered by reeds and reeds.

The backwater are elongated depressions, from the meadow of a flowing water, among the natural backwater, there are still in operation backwater with a total length of 285 km, part of them remaining in the dammed enclosures (the Pardina, Sireasa, Murighiol-Dunavăț agricultural facilities, etc.). In the 1960-1970 period, canals together with natural estuaries represented the most efficient internal hydrographic network in terms of water circulation and naval transport. Between 1991-1994, the dike and the accompanying canal were built between Sulina and Sf. Gheorghe with some negative ecological consequences [5, 6, 13,18, 21].

Vegetation occupies an area of about 3,000 km², about 68% of the delta's surface; forests, 2%; natural pastures, about 9% and reed beds almost 57% [6]. The dominant element in the vegetation of the delta is the reed beds, in the area of 2,530 km², consisting of homogeneous reeds and reeds mixed with other marsh plants such as: sedge, marsh fern, sedge, etc. In the area between the reed belt and the parts protected from flooding, species of sedge, papering, horsetail, pond lilies, etc. grow. The water kingdom is mostly covered with aquatic vegetation, differentiated according to water level, soil, etc. [5, 6, 15,18, 21].

Submerged vegetation, which develops in stagnant waters, has, in most cases, its roots embedded in the mud, the surface of the water being traversed by the floral organs. A wide distribution has the marsh sedge and the cossor, then the frog, the scaly, the water plague, brought from Canada to several countries in central Europe. In our country, there is only the female plant, the propagation being only vegetative.

Closer to the shore, plants with floating leaves develop, with a tissue structure that allows them to stay on the surface of the water, these plants being fixed or not by roots. From the first group, the white-water lily and the yellow water lily give a special touch to the gorges of the delta. When in full vegetation, the delta appears as an endless green expanse of reeds and reeds, interrupted by innumerable strips or eyes of water, fringed with rushes, with poplars or white willows covered with a carpet of floating leaves of water-lilies, and other aquatic plants, whose white and yellow flowers bring a touch of tenderness to the landscape.

Unflooded alluvial beds have the high parts occupied by grasses that make up pastures; drought-resistant species can also appear like the weed *Bromus secalinus* (obsiga in Romanian) and *Lolium perenne* (zâzania in Romanian). The rest of the land is occupied by willow, willow, sedge and buckthorn. On the fluvial-maritime ridges, with sand dunes that reach the highest heights in the delta (about 7 m), there are some areas of land devoid of vegetation, and others offer living conditions for the vegetation cover, being covered by grassy steppes, sedges and forests, with luxuriant development, such as those on the Letea and Caraorman ridges. Near the sea, the vegetation is poorer, with plants adapted to sandy soils: sand plantain, field reed and sea cabbage. The oak forest on the Letea ridge has a mixture of essences and especially lianas, wild vines and Mediterranean plants. Similar are the forests on the maritime ridges of the delta, in which white poplar, black poplar and quaking poplar, oak, ash and wild vine grow [5, 6, 12, 18, 19, 21, 23].

Fauna. The Danube Delta contains more than 360 species of birds and 45 species of freshwater fish in its many lakes and streams. This is the place where millions of birds from different corners of the Earth (Europe, Asia, Africa, Mediterranean Sea) come to nest. The major fish species in the Danube Delta are pike and catfish. The fauna of the delta is rich and varied in species of mammals, birds, reptiles, amphibians, fish, crustaceans, snails, molluscs and insects; some of which are protected.

Mammals found in the Danube delta are: wild boar, otters, river otter, European mink, small ermine, weasel, spotted ferret, steppe ferret, golden jackal, hare, European ptarmigan, hedgehogs, pygmy mouse.

The national park shelters and provides food and nesting conditions for several migratory, migratory or sedentary birds protected at European level, among the bird species reported in the delta area: eagles, skylark, ducks: mallard duck, little duck, quack duck, brown-headed duck, ruddy duck, tufted duck. Gooses: Summer Goose, Greylag Goose, Red-breasted Goose, Red-necked Wagtail, Wood Wagtail, Upland Wagtail, Gray Heron, Night Heron, Little Egret, Red Heron, Yellow Heron, Blue Gull, Gull black-headed gull, laughing gull, slender-billed gull, little gull [5, 6, 13, 15, 18, 19, 21].

Other species are: summer swan, winter swan, little swan, black stork, white stork, merganser, plover, bittern, garden bird, garden woodpecker, oak woodpecker, black woodpecker, little egret, great egret, curly pelican, common pelican, Danube falcon, peregrine falcon, evening tern, Banatian stoner, eastern stoner, southern stoner.

The fish species with higher value are: avat, grig, grayling, Danube flounder, Danube flounder, catfish, flounder, perch, widow, pike, crucian, bream, sturgeons (mullet, bream, trout, blind) [5, 6, 15, 18, 21].

The protected nature of the Danube Delta includes 20 strictly protected areas, totalling a total area of over 50,000 ha, representing approximately 9% of the total area of the reserve. The most important of these are: Roșca - Buhaiova, Sărături - Murighiol, Popina Island, Periteașca - Leahova, Grindul Lupilor and Chituc, Ceaplace Island, Letea and Caraorman Forests, Nebunu Lake, Sacalin - Zătoane, Belciug Lake, etc. [5, 6, 12, 15, 18, 21].

***Therapeutic muds*.** Sapropelic sludge is a type of sludge rich in organic substances in various stages of decomposition. Its basic component is sapropel, a silty sediment, rich in organic substances (vegetable remains, algae, zooplankton, etc.) − decomposing, unconsolidated, formed in an anoxygenic (euxinic) environment. They have a content in organic substances > 10 % relative to the weight of the dry substance. Such muds are found at salts lake [5, 6, 15, 18, 19, 21].

Study on the inventory and analysis of anthropogenic tourism resources

Anthropogenic potential - represents the totality of tourism resources resulting from human creation from a cultural-historical and technical-economic point of view within a territory or a settlement. In the studied area, several tourist objectives represented by the main existing archaeological remains were taken into account, such as: fortresses, religious edifices, museums and monuments.

Citadels. The Aegysus Citadel was a Getic settlement, surrounded by strong walls, located on the bank of the Danube, which was very difficult to reach, but was conquered by the Romans. The name of the fortress is of Celtic origin. The first identification with the city of Tulcea is made at the end of the 18th century - the beginning of the 19th century and was confirmed by the discovery of inscriptions in Latin in 1949 [4, 5, 6, 18, 21].

Histria Fortress was built 2,600 years ago by Greek sailors and merchants on the shores of Lake Sinoe in the northern part of the Istrian peninsula to trade with the native Geto-Dacians. The fortress was surrounded by a very strong defensive wall and was supplied with water through 20 km long pipes, the streets were paved with stone and there were educational and cultural institutions. It existed until the 6th century when it was invaded and destroyed and the inhabitants left in search of a better place. Slowly, slowly the fortress of Histria was ruined and the place and the name were forgotten until 1914 when it was brought to light by the excavations of the great historian and archaeologist Vasile Pârvan. Histria is considered the oldest urban settlement in the country. [4, 5, 6, 15, 18, 21].

The fortress of Enisala or Heracleea was a settlement built by Genoese merchants in the second half of the 14th century 17 km from Jurilovca and 2 km from the town of Enisala on a limestone hill, a hill that dominates the Razim and Babadag lakes. This fortress was part of the defences system of Wallachia until 1420 when it was conquered by the Turks. The citadel has an irregular polygonal plan and in the southeast and east it is guarded by walls 3 m thick and about 6 m high [5, 6, 13, 18, 21].

The Troesmis fortress is located 3 km from the Turcoaia commune and is a Getic fortress mentioned in the century. III BC During the Roman period, it became a strong military strategic point, later elevated to the rank of "municipium". Between the 1st century - the VII AD it was one of the biggest cities in Dobrogea, then it lost its urban function.

The Chilia Veche fortress is located on the left bank of the Danube, in the area of the town of the same name. The fortress dates back to Greek Antiquity and the name comes from the Greek word Cellie, which means a pantry for storing food. The settlement was a well-appointed fortress that kept merchants' goods safe [5, 6, 17,18, 19, 21].

The Byzantine fortress of Salsovia, Mahmudia (3rd century AD). Civil and military settlement from the Roman-Byzantine era, fortified with two ditches and a mound of earth between them. It is assumed that the waters of the Danube reached the base of the fortress and the walls were 2 m thick. Destroyed by the Goths in the second century. 4th century, the fortress was rebuilt by the Byzantines and continued to exist until the c. the ninth.

Noviodunum Fortress, Isaccea. Romano-Byzantine fortress with a Celtic name ("dunum" means "fortified settlement" in the Celtic language), built in 369 AD. on the bank of the Danube at the point "Pontonul Vechi" 2 km from the current city of Isaccea. It had an important strategic commercial and economic role being a fortified settlement with an urban character that experienced a great flourishing as indicated by the public edifices and monuments, as well as the baths. Currently, the citadel is an archaeological site located in the eastern part of the city of Isaccea that has not yet been fully excavated.

Arrubium Citadel, Măcin - The Roman fort of Arrubium, whose ruins are located on the territory of the city of Măcin in the north-west, is documented for the first time around the year 100 CE. in two military diplomas just as the Emperor Trajan prepares the attack camp against Decebalus. The presence of an auxiliary Roman unit (ala) formed by the Thracian population of Dardania, dardani, is mentioned at Arrubium [4, 5, 6, 18, 21].

Dinogetea Fortress, Gărvan. Its name was mentioned for the first time by Ptolemy in his well-known work "Geographia" (2nd century AD). Originally a Geto-Dacian and then a Roman settlement, the Dinogetia fortress was built during the reign of Emperor Diocletian (284-305 AD). Destroyed in 559 AD. by a Hunno-Bulgarian tribe, the fortress was reconsolidated and enlarged in the c. X-XII.

The most important building is the basilica in the middle of the fortress, the oldest in our country [5, 6, 18, 21].

Religious buildings. Celic-Dere Monastery. Monastery of nuns dedicated to the "Assumption of the Virgin Mary" (August 15); is located in Frecăței commune, Tulcea county, it is reached on the modernized Tulcea - Frecăței road. The monastery was built after 1841 on the hearth of an old hermitage inhabited by Romanians, by Archimandrite Athanasie Lisavenco and other Romanian monks.

The Rooster Monastery. It is a monastery of monks, it is patronized by "Holy Trinity", it is located in Niculitel commune, Tulcea county, it is reached on the modernized Tulcea-Isaccea road. The monastery is located in a secluded place, at the foot of a hill enveloped in the scent of linden forests. The legend says that the name of the monastery comes from the fact that once, a long time ago, from this hill one night the song of a wild rooster was heard accompanied by the beating of a stoop. The monks say that this song is still heard today, sometimes [5, 6, 12, 17, 18, 21].

Saon Monastery. This holy settlement came into existence under the Ottoman rule in 1846, by the departure of some monks from the Celic-Dere Monastery. A few years later Saon becomes an independent monastery, the monks built the current old church from adobe and wood dedicated to "The Entry of the Mother of God into the Church", which still exists today, as well as two cells, of which only the row of the Chapel.

The church with a clock The Church of St. George was finished and consecrated in 1857. The founders of the church are Dumitrache Bei Teodorof and Hagi Valici Stefanoff, who are buried in the churchyard. The church was built in the shape of a ship and the author and no site of an older church is known [5, 6, 12, 18, 21].

Greek Church. The "Buna Vestire" church in the municipality of Tulcea is one of the oldest churches in the north of Dobrogea. The church is not a foundation, the funds necessary for its construction were obtained from the donations of the faithful, the church was finished in 1854.

The Cathedral or Church of Saint Nicholas is located in the centre of Tulcea. The monumental construction, in Byzantine style in the shape of a cross, dominates the surroundings with its majesty, and on feast days its existence is made known by the sound of its famous bells, cast in Bavaria in 1882. The Holy Table is made of stone blocks, on which can still be seen today on the southern side, probably a former cross [5, 6, 13, 18, 21].

Museums. "Danube Delta" Museum An architectural monument, the museum building belonged to the Greek shipowner Alexandru Avramide and was built by two Italian craftsmen as a symbol of his family's prosperity. After 1944, the Avramide house became the seat of the Greek Democratic Committee. Currently the house functions entirely as a Museum of Natural Sciences, with a collection of 1,500 biological pieces and a voluminous herbarium, dating from 1964.

The Art Museum is located near the Danube embankment and houses collections of contemporary art, engraving and sculpture and boasts an exceptional collection of interwar avant-garde signed by Romanian artists such as: Gheorghe Petrașcu, Nicolae Tonitza, Frederic Storck, Ion Jalea, Theodor Pallady, Nicolae Grigorescu, Oscar Han, Victor Brauner - the most important painting collection in the country. The jewel of reference remains his painting collection, which is made up of some of the most valuable works of Romanian art [4, 5, 6, 13, 17, 18, 21, 23].

The History Museum is located on one of the hills of the city of Tulcea. The museum makes a foray from antiquity to the medieval era of the history of Northern Dobrogea, exhibiting a rich archaeological heritage - almost 90,000 archaeological, numismatic and epigraphic pieces.

The Museum of Ethnography and Folk Art houses numerous temporary exhibitions of creations and traditional folk customs specific to Dobrogea and the entire country, holding a number of approximately 6,400 pieces. The museum also manages the Memorial House of the Dobrogean writer Panait Cerna, the Panaghia House in Babadag - a beautiful exhibition of oriental art and the Museum of the Dobrogean Village in Enisala - a preserved "in situ" peasant household.

On the main artery of the city of Tulcea there are also the House of Culture, the County Library, the Art Galleries of the Plastic Fund [4, 5, 6, 18, 19, 21].

Monuments. The lighthouse of the European Commission of the Lower Danube, the construction of this lighthouse was established after the establishment of the European Commission of the Danube, by the "Public Act regarding navigation on the Danube", issued on November 2, 1865 in Galați. The plans and construction of this objective were carried out by English engineers who also participated in the realization of the plans for the construction of the navigable channel as well as those for the permanent maintenance of the Sulina arm [4, 5, 6, 18, 19, 21, 23].

The Water Tower from Sulina. The exact date of construction of this lens is unknown, but it is still in very good working order today. It is a construction that impresses with its grandeur and solidity.

The palace of the former European Commission of the Danube, the building is U-shaped, with a ground floor and an upper floor, and functioned as the headquarters of the European Commission of the Danube until 1921. The architecture of the building, which has the scope of a university, is in the neoclassical style, with a symmetrical composition in plane and space [5, 6, 12, 17, 18, 21, 23].

The Observatory Lighthouse also built during the period of the European Commission of the Danube, currently unusable. It is located on the left bank of the Danube, and its connection with the mainland is achieved by a long stone pier.

The Sulina Maritime Cemetery houses the only grave in Europe with the famous pirate sign: the skull with two crossed bones. Here rests the pirate Ghiorghios Kontoguris, who died in Sulina at the age of 33 and was buried by his brother.

Geamia Azzizie from Tulcea. Historical monument and religious architecture. The building was built in 1924 in the shape and style of the old window from 1863. It is one of the tallest buildings in the city. Azizie Mosque, the largest mosque built by the Ottoman Empire in Dobrogea and was built by the local ruler Izmail Pasa. Geamia is the most important place of worship for the Muslim community in Tulcea [5, 6, 17, 18, 21, 23].

Pieta Civico in Tulcea was built between 1970-1972, and is a wide, beautiful square, floored with marble tiles, with artesian fountains, being a place of recreation for locals and guests. In the centre of the square is the statue of Mircea the Elder, the work of the Tulcean sculptor Ion Jalea [5, 6, 13, 17, 18, 21, 23].

Study on the tourist activity in the Danube Delta area

The study was mainly carried out as a case study on the tourist activity in Tulcea county, because most tourist reception structures in the Danube Delta area are concentrated in this county.

In our study, we insisted on the tourist activity carried out especially in the rural area, but also on the tourist activity as a whole, through the analysis of the tourist circulation, differentiated by categories of Romanian and foreign tourists who arrived in the period 2019-2022, in the studied area.

The data entered in Table 1 show us that the total number of tourist reception structures in the villages of Tulcea county increased from year to year, reaching 324 in 2022. Among the localities studied, it can be observed that most tourist reception structures tourist reception are built in Murighiol locality, 98 in 2019, and the fewest in Luncavița and Chilia Veche localities.

Table 1. Number of tourist reception units in the villages of the Danube Delta-County Tulcea

Types of structures of tourist reception	Localities	Years/Number of units			
		2019	2020	2021	2022
Total	Total	298	316	312	324
	Chilia Veche	5	5	5	5
	Crișan	34	28	39	33
	Jurilovca	19	21	19	22
	Luncavița	3	3	3	3
	Mahmudia	17	18	14	21
	Maliuc	8	10	10	13
	Murighiol	80	88	98	94
	Sf. Gheorghe	31	32	17	35
	Other localities	101	111	107	98

Source: own data and from National Institute of Statistics, NIS [9].

Table 2. Number of tourist reception units in the villages of the Danube Delta-County Tulcea, by types of accommodation structures

Types of structures of tourist reception	**Localities**	**Years/Number of units**			
		2019	2020	2021	2022
Hotels	Total	18	18	20	21
	Crişan	1	1	1	2
	Mahmudia	0	1	0	1
	Murighiol	4	3	4	4
	Other localities	13	13	15	14
Hotels apartment	Total	0	0	1	0
	Murighiol	0	0	1	0
Tourist villas	Total	75	78	61	88
	Crişan	1	0	0	2
	Murighiol	19	21	18	26
	Sfântu Gheorghe	23	22	9	30
	Other localities	32	35	34	30
Bungalows	Total	37	39	48	46
	Chilia Veche	1	1	1	1
	Crişan	10	10	10	10
	Jurilovca	14	16	14	18
	Murighiol	11	11	17	15
	Other localities	1	1	6	2
Campgrounds	Total	4	5	3	5
	Crişan	1	1	0	1
	Murighiol	2	3	2	3
	Sfântu Gheorghe	1	1	1	1
Tourist stops	Total	3	3	4	4
	Maliuc	1	1	1	1
	Murighiol	2	2	3	3
Tourist cottages	Total	5	4	3	5
	Jurilovca	1	1	1	1
	Mahmudia	2	2	1	2
	Murighiol	2	1	1	2
Boarding houses tourist	Total	13	26	26	26
	Crişan	0	1	0	1
	Other localities	13	25	26	25
Boarding houses agritourist	Total	118	113	133	144
	Chilia Veche	4	4	4	4
	Crişan	19	13	24	20
	Jurilovca	3	3	3	3
	Luncaviţa	3	3	3	3
	Mahmudia	13	13	11	16
	Maliuc	2	14	4	18
	Murighiol	37	41	47	48
	Sfântu Gheorghe	7	9	7	15
	Other localities	30	13	30	17
Accommodation spaces from the ships fluvial and sea	Total	21	24	24	27
	Crişan	2	2	4	3
	Jurilovca	1	1	1	1
	Mahmudia	2	2	2	2
	Maliuc	5	5	5	5
	Murighiol	3	6	5	8
	Other localities	8	8	7	8

Source: own data and from NIS [9].

In order to highlight the level of development of sustainable tourism in the researched area, a more thorough analysis of the number of tourist reception structures, differentiated by accommodation units, was carried out. It is known from previous studies that rural tourism and agritourism are two specific forms of tourism that fall into the category of sustainable tourism, based on the principles of environmental protection and ecotourism.

From Table 2, it can be seen that the tourist structures where rural tourism is generally practiced, such as villas, rest stops, cottages and tourist guesthouses, have developed a lot in the period 2019-2022, because the local people have realized that such structures smaller in size, it fits much better into the traditional deltaic architecture and the surrounding environment. It is also noted that the agritourism reception structures have developed sustainably during the studied period, their number increasing by almost 35%, compared to 2019, reaching 144 in 2022. The increase in the number of tourist reception structures of this type it is mainly due to the increase in the degree of culture and the level of information of the people of the places, but especially of those who invest in this field, in terms of the need to practice a flexible tourist activity, with smaller structures that can adapt to the needs specific to the Danube Delta area and from which to obtain maximum profits, respecting and protecting all the components of the wonderful environment.

Also, in order to highlight the level of development of tourist activities in this area, the number of tourists arriving especially in the villages of Tulcea county was determined, by types of reception structures and by forms of tourism, classically in hotels and other structures of this type and rural tourism based on sustainable principles, practiced in tourist and agritourism guesthouses.

From Table 3 it can be seen that the number of tourists from guesthouses is approximately more than twice as high, 42,000 tourists, than that of those who arrived in classic tourism, which in the same year 2022 was only slightly over 23,000.

Table 3. Number of tourists arriving in the villages of the Danube Delta-County Tulcea, by types of structures

Types of structures of tourist reception	Localities	Years/ Number of tourists arrived			
		2019	2020	2021	2022
Hotels	Total	15,978	5,976	9,288	10,876
	Crișan	2,797	1,522	1,958	2,770
	Mahmudia	0	1,377	0	2,506
	Murighiol	13,181	3,077	7,330	5,600
Hotels apartment	Total	0	3,776	0	7,023
	Murighiol	0	3,776	0	7,023
Tourist villas	Total	13,300	7,524	11,094	11,715
	Crișan	78	0	4	0
	Murighiol	2,112	1,842	340	3,352
	Sfântu Gheorghe	11,110	4,595	10,750	8,363
Tourist cabins	Total	178	40	231	75
Bungalows	Total	6,166	9,365	7,214	10,756
	Crișan	0	892	0	1,033
	Jurilovca	5,214	6,521	5,927	7,489
	Murighiol	952	1,952	1,287	2,234
Holiday villages	Total	684	150	59	612
Campgrounds	Total	3,011	3,885	2,460	4,382
	Crișan	390	17	0	120
	Murighiol	543	946	776	1,050
	Sfântu Gheorghe	2,078	2,922	1,684	3,212
Tourist stops	Total	893	409	1,241	744
	Maliuc	893	409	1,077	744
	Murighiol	0	0	164	0
Tourist cottages	Total	186	4,.900	605	6,229
	Jurilovca	0	2,169	447	2,711
	Mahmudia	186	410	152	512
	Murighiol	0	615	6	769
	Sfântu Gheorghe	0	1,706	0	2,237
Boarding houses tourist	Total	7,443	6,153	6,008	6,998
Boarding houses agritourist	Total	33,215	29,913	30,826	45,073
	Chilia Veche	714	825	627	1,237
	Crișan	8,725	7,540	5,841	11,310
	Jurilovca	813	629	1,204	943
	Luncavița	505	94	383	345
	Mahmudia	2,433	2,365	1,995	3,547
	Maliuc	616	1,197	711	1,796
	Murighiol	18,412	16,110	19,391	24,165
	Sfântu Gheorghe	997	1,153	674	1,730
Accommodation spaces from the ships fluvial and sea	Total	2,839	2,312	3,668	4,533
	Crișan	0	0	156	0
	Jurilovca	241	124	432	421
	Mahmudia	204	188	264	272
	Maliuc	1,043	328	1,400	1,322
	Murighiol	1,351	1,672	1,416	2,518

Source: own data and from NIS [9].

Another indicator that helps us determine the stage of development and promotion of tourism in the Danube Delta area, both nationally and internationally, is the number of tourists who arrived in the analyzed period, in this region, by types of tourists. As can be seen from the comparative study carried out on the basis of the data entered in Table 4, the total number of tourists arriving at the national level was the highest in 2019, over 13 million, it decreased a lot in 2020, during the pandemic period, at only 6.3 million. The same decrease is also observed among foreign tourists, in 2020 being only 453,263.

The pronounced downward trend in tourist traffic is also found in the Danube Delta area and the city of Tulcea, including, as can be seen from the same table, the number of tourists arriving decreased from 166,411 in 2019 to only 106,830 in 2022, an obvious decrease is found among foreign tourists, their number being only 1,528, in 2020, the year in which the negative effects of the pandemic were felt the most, especially in the circulation of foreign tourists. It is found that even after the lifting of all restrictions, the tourist activity in this area recovers more difficult, due to the specific conditions of the delta and the lack of more sustained promotion, the number of tourists arriving in 2022 being lower, by almost 50%, than in 2019 [3, 16].

Table 4. Arrivals in accommodation structures by tourist destinations and types of tourists

Destinations	Types of tourists	Years/ Number of tourists arrived			
		2019	2020	2021	2022
Total Romania	General	**13,268,756**	**6,335,401**	**9,276,719**	**11,299,111**
	Romanian	10,597,048	5,882,136	8,436,145	9,718,046
	Foreigners	2,671,708	453,265	840,574	1,581,065
Total, Delta area Danube, including the city Tulcea	General	**166,411**	**118,325**	**137,123**	**106,830**
	Romanian	146,006	116,797	131,165	97,203
	Foreigners	20,405	1,528	5,958	9,627

Source: own data and from NIS [9].

Table 5. Overnight stays in accommodation structures by tourist destinations and types of tourists

Destinations tourist	Types of tourists	Years/ Number of nights			
		2019	2020	2021	2022
Total Romania	General	**29,870,358**	**14,444,727**	**20,653,053**	**24,319,613**
	Romanian	24,603,394	13,448,882	18,824,936	20,860,755
	Foreigners	5,266,964	995,845	1,828,117	3,458,858
Total, Delta area Danube, including the city Tulcea	General	**380,375**	**299,766**	**280,935**	**217,221**
	Romanian	333,885	295,084	269,831	194,699
	Foreigners	46,490	4,682	11,104	22,522

Source: own data and from NIS [9].

As can be seen from Table 5, the total number of overnight stays in the studied area has the same sustained downward trend as the number of arrivals, which are more than 45% lower in 2022, compared to the normal year before the pandemic 2019.

An interesting aspect that was found in the studied period 2019-2022 is the fact that the average length of stay increased especially in 2020, the year in which the restrictions on the movement of tourists of all types were the highest. The values recorded this year exceeded by 20% the average values recorded in the other reference years, which were approximately around 2.2 days.

The average value of the stay in 2022 being 2.73 days for the general total and 2.52 days for Romanian tourists and 2.94 days for foreign tourists (Table 6).

The longer average length of stay in the studied area in 2020 can be explained by the fact that the tourists who arrived this year found more favorable conditions for isolation and distancing, in the villages and tourist reception structures in this area, due to the richer natural resources and diversified existing and due to the environment kept unchanged, i.e. not urbanized and not excessively industrialized

Regarding the net utilization index (Iu %) of the accommodation capacity in Romania, as can be seen from Table 7, it decreased from 34.2% in 2019 to only 22.9% in 2020, year when tourist circulation at national and international level was considerably reduced due to the maximum-security conditions imposed to limit the spread of the Covid-19 virus.

Table 6. Average length of stay compared to the level national and the studied area

Destinations tourist	Types of tourists	Years/ Number of days				/ Number of days
		2019	2020	2021	2022	
Total Romania	General	**2.25**	**2.28**	**2.23**	**2.16**	
	Romanian	2.32	2.28	2.26	2.14	
	Foreigners	1.98	2.28	2.20	2.18	
Total, Delta area Danube, including the city Tulcea	General	**2.28**	**2.73**	**2.05**	**2.13**	
	Romanian	2.28	2.52	2.1	2.0	
	Foreigners	2.28	2.94	2.0	2.26	

Source: own data and from NIS [9].

Table 7. Indices of net utilization (Iu %) of the capacity of tourist accommodation in operation on total tourist reception structures, in the period 2019-2022

Destinations tourist	**Index**	**Years**			
		2019	2020	2021	2022
Romania	Iu %	34.2	22.9	26.5	30.1
Delta area Danube, including the city Tulcea	Iu %	32.8	31.1	27.9	23.5

Source: own data and from NIS [9].

A special phenomenon was registered at the level of the studied area, because as can be seen from the same table, in 2020, the usage index remained around the value of over 31.1%, this aspect can be explained by the fact that during this period in the studied area the average length of stay was higher by more than 25%, compared to the other years, reaching the maximum value of more than 2.73 days, compared to the average of 2.2 days, in the other research years. In 2020, Romanian and especially foreign tourists stayed longer in the area, the length of stay of foreign tourists being over 2.93 days. This was primarily due to the specific environmental conditions in the Danube Delta, which allowed tourists to find very good conditions of isolation, safety and relaxation, which were sought by most of them, after a year of pandemic and restrictions imposed on tourist traffic.

Based on the complex and well-documented study that covered the aspects presented above, it was possible **to identify and highlight the main strong and weak points of the tourist activity in the Danube Delta area**, as follows:

The strong points are:

• Very rich and varied natural and anthropogenic tourist potential (unique landscapes, a multitude of birds, specific traditions and customs, etc.);
• Numerous tourist routes (most with river boats);
• Tourist bases for accommodation, food and leisure in development;
• The existence of many leisure possibilities, especially the practice of various sports.

The weak points of this area are:

• Lack of investors in the field;
• Poorly developed infrastructure;
• Lack of an accessible database regarding the development of cultural events in the area;
• The reduced number of training programs for tourism and the non-adaptation of the existing ones to market requirements;
• Non-observance of cleanliness in the area of the Danube delta, especially in the perimeter of the protected areas;
• Lack of telephone or internet signal in certain localities;
• Weak promotion of the area and insufficient capitalization of the tourist potential of the delta;
• Very little involvement of the authorities in obtaining financing;
• The strong effects of the current pandemic that have led to a significant decrease in the number of tourists in the delta.

It was also identified which are **the main measures that must be taken for a better exploitation and development of sustainable tourism in the Danube Delta,** such as:

• valorisation of currently unused natural potential;
• infrastructure investments;
• increasing the quality of tourist services, correct quality-price ratio;
• preservation, restoration and enhancement of the architectural and cultural heritage of local communities - rehabilitation of monuments and historical ensembles;
• construction, rehabilitation of museums, exhibition halls, cinemas and historical monuments;
• the modernization of tourist reception structures, but also the modernization and diversification of the services they offer;
• creation, rehabilitation and expansion of tourism infrastructure for spending free time and related utilities;
• training and education of personnel involved in tourism services at all levels, through training, qualification and improvement courses;
• increasing actions to promote the area;
• more sustained involvement of the authorities in attracting investments or financing.

CONCLUSIONS

From the analysis of accessibility in the area, it was concluded that it is greatly hampered by the lack of paved roads, the poor condition of some county and communal roads, the reduced number of boats transporting tourists to villages with tourist potential and the almost total lack of parking and public health groups, in many localities.

It was also found that the natural tourist potential of the area is very rich, diversified and unique, but responsible and clear measures must be taken for its protection and conservation, by promoting education programs and increasing citizens' interest in protecting the environment and tourist resources, the protection and conservation of natural habitats and species of flora and fauna endemic to the Danube Delta. This aspect must also aim at a sustainable management of the forests, through which the forest exploitation regime is strictly respected, because the Delta area is also a sandy area and forest vegetation is needed to fix the soil.

A very important fact regarding the protection of deltaic fauna in particular is the prevention and prevention of poaching, which unfortunately has greatly contributed to the reduction of the number of protected species and specimens. In order to further reduce the disappearance of valuable specimens of bird and animal species, it would be very good for tourist reception structures and actors in the field of tourism to orient themselves as much as possible towards the practice of specialized tourism on the hunting of images and less on hunting classic type.

Also, from the study carried out by us, it was concluded that the anthropic component consisting of museums, vestiges of previous civilizations, elements of ethnography and folklore unique in the world, etc., represents a strong element of tourist attraction at the level of the Danube Delta. This together with the natural component representing the basic premises of an efficient and intense activity, for almost all forms of tourism: holiday, cultural, recreational, knowledge, sport fishing, adventure, hunting as a sport and more recently hunting of images.

The analysis of the main indicators on the basis of which the quality of the tourist activity in the Danube Delta area was characterized brought out the conclusion that their values are at a lower level compared to the average values recorded at the national level and therefore effective measures must be taken to improve them such as: reconsideration the place of domestic tourism and the promotion of domestic tourist circulation; penetration into new tourist markets; loyalty of the current tourist clientele through tourist packages at a more attractive price; promotion of the "Danube Delta" tourist product, differentiated according to the specificity of the offer of each locality; active promotion and support of sustainable tourism packages (agritourism, ecotourism, sports tourism, etc.); organizing events, fairs, celebrations and capitalizing on ethnographic and historical tradition: valuing and promoting the existing multiculturalism and capitalizing on the traditional customs specific to the various ethnic groups in the delta, etc.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ORDERED LOGISTIC MODELS FOR THE STAGES OF ADOPTION OF VEGETABLE TECHNOLOGIES

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Abstract

This study aimed to explain the level of adoption of vegetable technologies among the youth members of 4-H clubs in some parts of Southern Leyte, Philippines, and expose its governing predictors. The data gathering employed cross-sectional and primary information among the 118 youth members selected in the form of a census. The study used a researcher-developed research instrument adapted from existing studies in the literature. The collected data were summarized using some standard descriptive metrics in statistics and an ordinal regression model was constructed to determine the predictors of vegetable technology adoption. The findings revealed that there are only a few youth members are implementing (8.47%) and adopting (4.24%) the vegetable technologies even if they have positively perceived the 4-H coordinator. The regression model revealed that youth members are more like to implement the vegetable technology if they have a higher income (p-value<0.1), they have no financial debt (p-value<0.01) and they learned from an effective 4-H coordinator (p-value<0.1). Furthermore, the ordered regression model revealed that youth members are going to implement (p-value<0.01) and adopt (p-value<0.01) the technology if it is not complex to follow. Conclusively, the local government must support the youth members regarding the financial aspect, and by providing expert agricultural extension agents to guide them in implementing and adopting the vegetable technologies.

Key words*: *youth, 4-H club, vegetable technology, adoption, ordered regression analysis

INTRODUCTION

Vegetables are important parts of plants that are consumed as food by humans which is a source of minerals and vitamins. In the journey toward maintaining a balanced and nutritious diet, vegetables play a crucial role, presenting a varied spectrum of shapes, colors, and flavors to cater to diverse tastes and nutritional needs. Their significance lies in nutrient density, as vegetables are not only low in calories but also rich in essential nutrients such as vitamins A and C, potassium, folate, and dietary fiber [1], [9], [22].Consuming a variety ensures a broad spectrum of benefits, promoting digestive health and aiding in weight management. Many vegetables boast antioxidants, protecting cells from free radical damage and reducing the risk of chronic diseases. Regular consumption is linked to a lower risk of health conditions, while diverse preparation methods highlight their culinary versatility[29], [40], [44]. Incorporating a vibrant variety of vegetables into daily meals is integral to maintaining overall well-being and sustaining a balanced and nutritious lifestyle.

Originally established in the United States, the 4-H club has evolved into a global youth development organization, symbolizing Head, Heart, Hands, and Health. Rooted in the late 19th century, it began as a rural youth program focused on agricultural and home-based skills but has expanded to cover science, technology, engineering, arts, and mathematics (STEAM) [2], [16], [17]. The 4-H club's mission is to create a supportive and inclusive environment for young individuals, emphasizing life skills, leadership, and responsibility through hands-on projects and activities. Diverse educational programs span areas like agriculture, science, healthy living, and citizenship, allowing youth to actively participate and learn through practical experiences [4], [5], [17], [27]. Leadership development, community service, and civic engagement are integral focus areas, with camps and events enhancing personal growth and camaraderie. While originating in the United States, the 4-H club has adapted globally, playing a vital role in shaping the lives of young people through leadership skills, community engagement, and a commitment to lifelong learning [8], [12].

Youth members, aged 12 to 24, constitute a dynamic segment of society undergoing significant physical, cognitive, emotional, and social development. Recognizing diversity based on cultural background, socioeconomic status, and individual experiences is crucial during this critical period of identity formation. Active engagement in formal education or skill development programs highlights the importance of access to quality education. Participation in civic activities and social initiatives reflects a growing awareness of social issues and a desire to contribute positively to communities. Growing up in a digital age, youth members adeptly utilize technology, influencing their social interactions and perspectives on global issues [20]. They face challenges, including academic pressures, peer influences, and the transition to adulthood, requiring supportive environments and resources. Numerous youth organizations and programs globally support their development, emphasizing education, leadership, skill-building, mentorship, and personal development [33].

Government policies are crucial for the growth and effectiveness of 4-H clubs, encompassing financial support, regulatory frameworks, and collaboration initiatives. Financial allocations impact the ability of 4-H clubs to operate, while regulatory frameworks ensure alignment with educational standards and safety guidelines [27]. Policies may outline collaboration with other educational institutions or community organizations, reinforcing the positive impact of 4-H clubs on youth development. The transition from youth to adulthood involves decisions about education, career paths, and personal relationships, requiring supportive networks, mentorship, and guidance [11], [45]. The adoption of vegetable technology represents a holistic strategy incorporating innovative practices and advancements in cultivating, processing, and distributing vegetables. Precision farming and smart agriculture tools optimize planting patterns and improve resource efficiency. Biotechnology and genetic engineering lead to genetically modified vegetables with enhanced resistance and increased yield [23], [25]. Hydroponics and vertical farming minimize environmental impact and enable year-round cultivation. Automation and robotics address labor shortages, while the Internet of Things and sensor technologies provide real-time data for decision-making. Data analytics aid in crop planning and risk management. Post-harvest technologies preserve vegetable quality, and market access technologies ensure transparency. Effective extension services and training programs are vital for educating farmers about technology benefits [10], [36],[39]. Adopting vegetable technology enhances productivity, resource efficiency, and sustainability, requiring collaboration, ongoing research, and continuous education for farmers to fully harness these advancements [24].

The exploration of topics such as "vegetable,""4-H club,""youth members,""government policy to 4-H club," and "adoption of vegetable technology" offers a comprehensive view of agriculture, youth development, and technology adoption [14], [31]. Noteworthy research gaps warrant further investigation to deepen our understanding. Research on vegetables could explore sustainable cultivation practices, considering environmental impact, resource efficiency, and agricultural system resilience. For the 4-H club, evaluating program effectiveness in fostering youth development, leadership, and community engagement is crucial, along with investigating inclusivity and diversity. Exploring the impact of 4-H club participation on the mental health and well-being of youth members, as well as educational outcomes, provides valuable insights. Assessing government policies' impact on 4-H club growth and conducting a comparative analysis of policies supporting youth development worldwide are vital. According to [21], in the

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

realm of vegetable technology adoption, investigating factors influencing smallholder farmers and exploring emerging technologies contribute to a nuanced understanding. Addressing these gaps enables researchers and practitioners to significantly contribute to informed decision-making and the development of policies promoting sustainable agriculture and youth development.

The research objective to investigate the adoption of vegetable technologies among 4-H club youth in Southern Leyte, Philippines, is crucial. It informs agricultural innovation, revealing how younger generations engage in sustainable farming amid technological advancements. This insight is vital in an era shaping agricultural landscapes. The study also impacts youth development and education, offering insights into the effectiveness of agricultural programs. Uncovering how participation influences knowledge and skills informs future strategies. Crucially, it aids policymakers, guiding targeted policies for sustainable agriculture, and contributing to regional economic development. Socially, it explores the youth's role in shaping local agriculture, revealing the potential for community engagement and leadership development in sustainable agriculture.

MATERIALS AND METHODS

The Framework and Research Design

In the paper of Rogers [38], innovation adoption involves five (5) stages such as (a) awareness, (b) interest, (c) decision, (d) implementation, and (e) adoption. In that case, the awareness stage can develop a curiosity that leads to interest in the use of technology. When the farmer is now interested in the new learning, then it is more likely to make a decision on what to do next, that is, the implementation. If the farmer has found it useful and economically practical, then the final stage is adoption. It is viewed in [13] and [15] that the adoption of technology is governed by the following factors namely (1) demographic profile, (2) economic variables, (3) technological and institutional factors, (4) constraints and problems. Hence, this study adopted the complex-correlational research design to elucidate the governing factors of adoption stages and formulate a plan of action or policy that promotes sustainability for vegetables.

Locale, respondents, Sampling, and Ethics

The researchers noticed that 4-H clubs are actively operating in Southern Leyte, Philippines wherein they have conducted seminars and workshops influencing the youth members and other people residing in the place to the benefits and strength of vegetable technologies. Hence, the researchers decided to conduct the survey, particularly in the municipalities that include Maasin City, Tomas Oppus, Hinunangan, Saint Bernard, and Macrohon where 4-H clubs are highly influential. The dotted portion with red color in the map below is the location of Southern, Leyte, Philippines (Fig. 1).

Fig. 1. Location of the survey (dotted with red).
Source: [19].

In each survey area, the number of members is manageable, hence, the study employed a census known as complete enumeration. In fact, the advantage of complete enumeration is that accurate information about the desired population is more likely obtained [28]. Table 1 presents the distribution of 4-H club members as respondents of this survey research.

Hence, this study surveyed the 118 youth members of the 4-H club in regard to the adoption stages of vegetable technologies. The study has implemented an ethical procedure as follows: (1) a formal letter of consent to the higher authorities was accomplished prior to the conduct of the study, and (2) respondents were informed that their cooperation to the said survey is voluntary and information gathered from them is solely used for this paper only.

Table 1. 4-H club members

Municipality	Barangay	Number of Members
Hinunangan	Sto. Niño I	23
Tomas Oppus	San Isidro	20
Maasin City	Mahayahay	25
St. Bernard	Panian	25
Macrohon	Guadalupe	25
Total	-	**118**

Source: Authors' own constructions (2024).

Survey Instrument and Data Collection

The researchers had read the literature (see [13], [15], [34], [41]) and came up with a developed semi-structured questionnaire for the survey. The content of the questionnaire is the following: (1) demographic profile; (2) influence profile of 4-H club members; (3) rating of vegetable technology characteristics; (4) effectiveness of 4-H club coordinator; and (5) stages of adoption of vegetable technologies.

As for youth members' demographic profiles, they were asked about their age, sex, education, educational status, monthly income, household size, and credit access. Secondly, for the influence profile, they were asked if they were convinced by the 4-H club members, family members, and through agricultural training.

Thirdly, the youth members were asked to rate from 1 to 5 scaling in regard to the vegetable technology characteristics.

In addition, they were asked also about the effectiveness of the 4-H coordinator with 1 to 5 scaling.

Table 2 below shows the interval perception scores that the mean might fall, the linguistic description, and its corresponding level of effectiveness.

Table 2. Guidelines for vegetable technology characteristics and 4-H coordinator ratings

Interval perception scores	Verbal Description	Level of effectiveness
4.21 – 5.00	Strongly agree	Highly effective
3.41 – 4.20	Agree	Effective
2.61 – 3.40	Neutral	Uncertain
1.81 – 2.60	disagree	Ineffective
1.00 – 1.80	Strongly disagree	Highly ineffective

Source: Authors' own constructions (2024).

For the last section of the questionnaire, the youth members were asked about their stages of adoption regarding vegetable technologies with 1 to 3 scaling. The different levels of adoption with their corresponding perception score intervals and verbal interpretation are presented in Table 3 below.

Table 3. Levels of adoption and its description

Levels	Perception scores	Verbal description
Awareness	1.00-1.60	Not aware
	1.61-2.30	Slightly aware
	2.31-3.00	Aware
Interest	1.00-1.60	Not interested
	1.61-2.30	Slightly interested
	2.31-3.00	Interested
Decision	1.00-1.60	Rejected
	1.61-2.30	Moderately decided
	2.31-3.00	Decided
Implementation	1.00-1.60	Not Implemented
	1.61-2.30	Slightly implemented
	2.31-3.00	Implemented
Adoption	1.00-1.60	Not adopted
	1.61-2.30	Slightly adopted
	2.31-3.00	Adopted

Source: Authors' own constructions (2024).

Empirical Model and Data Analysis

When the survey was done, collected data from the respondents were then encoded into Microsoft Excel and coded to transform the qualitative response into quantitative. Additionally, the data were properly aligned to suit for STATA statistical package calculation. For the researchers to describe and give insights to the data, appropriate statistical measures were calculated namely, counts (n) and percentages (%), mean (M), and standard deviation (SD). Moreover, bar graphs and statistical tables were constructed to present the statistical calculations. The dependent variable in this study is the levels of adoption which is ordinal in nature (Scale of 1 to 3). Hence, in determining the statistical predictors of the stages of adoption, ordinal logistic regression was employed in the data inference analysis. The empirical model of this study is as follows:

$$\begin{aligned} Y_i = \alpha_0 + \alpha_1 Age_i + \alpha_2 Male_i + \alpha_3 Educ_i \\ + \alpha_4 EducStat_i + \alpha_5 Income_i \\ + \alpha_6 Inf4Hmem_i \\ + \alpha_7 Inffam_i + \alpha_8 Training_i \\ + \alpha_9 Complex_i + \alpha_{10} Econ_i \\ + \alpha_{11} Compa_i + \alpha_{12} Esafe_i \\ + \alpha_{13} Minrisk_i + \alpha_{14} Credit_i \\ + \alpha_{15} Effcoor_i + \varepsilon_i \ldots\ldots (1) \end{aligned}$$

where: Y_i = Awareness$_i$, Interest$_i$, Decision$_i$, Implementation$_i$, Adoption$_i$, and can take the values of 0, 1, and 2 in view of Table 3 and the concept of ordered logistic model. In model (1), i=1,2,...,118 (youth members of 4-H club), Age_i represents the age (in years) of youth members, $Male_i$ is dummy variable that refers to a male youth member (0-female, 1-male), $Educ_i$ refers to the level of education (1-elementary level, 2-elementary graduate, 3-high school level, 4-high school graduate, 5-college level, 6-college graduate), $EducStat_i$ is a dummy variable that refers to a youth members who are in-school youth (0-out of school youth, 1-in school youth), $Inf4Hmem$ is a dummy variable that refers to youth members who are influence by 4-H coordinator (0-No, 1-Yes), $Inffam_i$ is a dummy variable that refers to youth members who are influence by family (0-No, 1-Yes), $Training_i$ is a dummy variable that refers to youth members who attended training in vegetable technology (0-No, 1-Yes), $Complex_i$ refers to the rating (scale of 1 to 5) of youth members to the complexity of vegetable technology, $Econ_i$ refers to the rating (scale of 1 to 5) of youth members on how economically viable is the vegetable technology, $Compa_i$ refers to the rating (scale of 1 to 5) of youth members to the compatibility of vegetable technology, $Esafe_i$ refers to the rating (scale of 1 to 5) of youth members on how safe to the environment is the vegetable technology, $Minrisk_i$ refers to the rating (scale of 1 to 5) of youth members on how risky is the vegetable technology, $Credit_i$ is a dummy variable that refers to a youth members who have access to credit, $Effcoor_i$ refers to the rating (scale of 1 to 5) of youth members on how effective are the 4-H coordinator to their assigned task and $\varepsilon_i$represents to the remaining random error of model (1). Post-estimation techniques (diagnostics) were done to validate the statistical results and all computations were tested its significance.

RESULTS AND DISCUSSIONS

Demographic Profile

Table 4 below shows a demographic profile of the youth members under study. The age-wise distribution indicates that the majority fall within the 15-30 age range, comprising 83.90% of the sample, with a mean age of 20.78. This suggests a predominantly young demographic. In terms of gender, there is a nearly equal distribution, with 50.80% female and 49.20% male members. Educationally, the sample is diverse, ranging from elementary level to college graduates, with high school graduates forming the largest group (24.60%).

Table 4. Demographic profile of youth members

Profile	**Category**	**n**	**%**
Age	10-14	10	8.50
	15-30	99	83.90
	31-40	8	6.77
	41 and above	1	0.85
	Mean	20.78	
Sex	Female	60	50.80
	Male	58	49.20
Educational attainment	Elementary level	2	1.70
	Elementary graduate	2	1.70
	Highschool level	37	31.40
	Highschool graduate	29	24.60
	College level	33	28.00
	College Graduate	15	12.70
Educational status	In-School Youth	73	61.90
	Out-of-School Youth	45	38.10
Monthly Family Income (PHP)	3,000 below	7	5.93
	3,000 - 5,999	59	50.00
	6,000 - 8,999	27	22.90
	9,000 - 11,999	17	14.40
	12,000 - 14,999	3	2.50
	15,000 and above	5	4.23
	Mean	6,647.83	
Household size	2-4 members	17	14.40
	5-7 members	56	47.50
	8-10 members	42	35.60
	11-13 members	3	2.50
Credit Access	Yes	16	13.56
	No	102	86.44

Note: PHP-Philippine peso (0.0178 USD)
Source: Authors' computations (2024).

Regarding educational status, 61.90% are in-school youth, emphasizing the importance of education in this demographic. Monthly family income distribution illustrates a varied economic background, with the majority (50.00%) earning between PHP 3,000 and 5,999, while credit access is limited, with only 13.56% having access. The household size is relatively diverse, with the most common range being 5-7 members (47.50%). The demographic profile of the youth members provides valuable insights for crafting targeted interventions and strategies. The concentration of youth in the 15-30 age range suggests a dynamic group, offering opportunities for initiatives aligned with their energy. Nearly equal gender distribution supports inclusive programs catering to diverse needs. Educational diversity, spanning from elementary to college graduates, hints at a varied skill set, allowing for multifaceted development initiatives [6],[46]. Emphasizing in-school youth reveals a platform for integrating agricultural education into formal learning. Varied economic backgrounds indicate the need for inclusive economic support, and limited credit access highlights potential financial challenges, prompting financial literacy programs [7], [18], [30]. Diverse household sizes stress the importance of considering family dynamics in effective interventions. These insights inform tailored programs for the youth in Southern Leyte, fostering sustainable agriculture and technology adoption.

Influence Profile

Table 5 outlines the profile of youth in the 4-H club, providing insights into their influences and participation. The overwhelming majority, 94.10%, report being influenced by other 4-H club members, indicating a strong peer influence within the club. Additionally, 77.97% acknowledge the influence of family members, highlighting the role of familial support in their engagement with the 4-H club. Furthermore, a significant proportion, also 77.97%, have attended training, emphasizing a commitment to skill development and knowledge enhancement among the youth in the 4-H club. These findings suggest a positive and supportive environment within the club, fostering peer connections, family involvement, and a dedication to learning and development through training opportunities. A noteworthy observation is the prevalent influence of fellow 4-H club members, with a significant majority acknowledging this peer impact. Moreover, a substantial proportion of youth in the 4-H club recognize the influence of their family members, emphasizing the supportive role of family in their involvement [42]. The data also reveals a significant commitment to learning and development, as a considerable percentage of youth have attended training sessions within the 4-H club. These insights underscore the importance of peer and family support, as well as the dedication of the youth to skill enhancement and knowledge acquisition through training opportunities within the club.

Table 5. Influence profile of youth in the 4-H club

Profile	Category	n	%
Influence from 4-H club members	Yes	111	94.10
	No	7	5.90
Influence from family members	Yes	92	77.97
	No	26	22.03
Attended Training	Yes	92	77.97
	No	26	22.03

Source: Author's computations (2024).

Vegetable Technology Characteristics

Table 6 presents the results of a rating assessment on various characteristics related to vegetable technology. The mean (M) and standard deviation (SD) values offer insights into the perceived attributes of these technologies among the respondents. The characteristic "Vegetable-Complexity" received a mean rating of 2.84 with a standard deviation of 0.73, indicating a neutral perception. "Vegetable-Economically viable" scored a mean of 3.59 with a standard deviation of 1.15, suggesting general agreement among respondents. On the contrary, "Vegetable-Compatibility" exhibited a mean of 1.76 with a standard deviation of 0.96, signaling a strong disagreement regarding its compatibility. "Vegetable-Environmentally safe" garnered a mean of 3.67 with a standard deviation of 1.17, reflecting an overall agreement. Lastly, "Vegetable-Minimal risk" obtained a mean of 2.74 and a standard deviation of 1.08, positioning it within a neutral range. The scale used for assessment ranges from 1 to 5. These ratings offer a quantitative measure of the perceived characteristics of vegetable technology, providing a basis for further analysis and interpretation. Notably, the characteristic "Vegetable complexity" is described as having a neutral perception, suggesting a middling level of complexity without specifying the exact rating. "Vegetable-Economically viable" is portrayed as generally agreeable among respondents, indicating a positive inclination towards the economic feasibility of vegetable technology [26], [35], [43]. Conversely, "Vegetable compatibility" is highlighted for its strong disagreement, emphasizing a perceived lack of compatibility. "Vegetable-environmentally safe" is characterized by an overall agreement on its safety aspects. Lastly, "Vegetable-Minimal risk" is positioned within a neutral range, suggesting a mixed perception regarding the level of risk associated with vegetable technology.

Table 6. Rating of vegetable technology characteristics

Characteristics	M	SD	Description[b]
Vegetable-Complexity[a]	2.84	0.73	Neutral
Vegetable-Economically viable[a]	3.59	1.15	Agree
Vegetable-Compatibility[a]	1.76	0.96	Strongly disagree
Vegetable-Environmentally safe[a]	3.67	1.17	Agree
Vegetable-Minimal risk[a]	2.74	1.08	Neutral

Note: a - Scale of 1 to 5; b - See Table 1.
Source: Authors' computations (2024).

On average, the youth members' rating for the 4-H club coordinator is close to 4.55 (SD=0.64) which can be interpreted as highly effective (See Table 1). This indicates that the coordinator has assisted effectively the youth members in regard to technical capability with a sense of responsibility. Additionally, coordinators have provided clear instructions, effectively followed up on 4-H programs with youth members, and handled the problems effectively by providing solutions. It is evident in Fig. 2 that most of the youth members have rated the 4-H coordinator as 5 out of a 5-point rating scale which can be described as highly effective in their responsibilities. In [15], it is depicted that the 4-H club is doing its best to reach out to farmers in regard to new innovative technologies for the improvement of agricultural production and well-being.

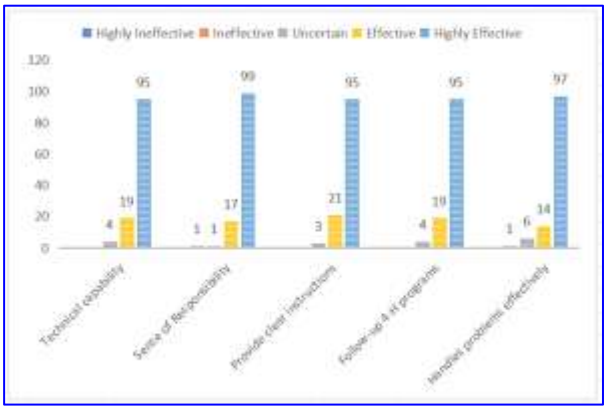

Fig. 2. Effectiveness level of 4-H coordinator.
Source: Authors' frequency construction (2024).

Stages of Adoption

Table 7 shows that most of the youth members of the 4-H club are aware, interested, and decided to implement vegetable technologies in their respective areas. However, during the survey, there are only a few of them are actually implementing and adopting the said vegetable technologies.

Table 7. Stages of adoption among youth members

Levels	Categories	n	%
Awareness	Not aware	4	3.39
	Slightly aware	58	49.15
	Aware	56	47.46
Interest	Not interested	13	11.02
	Slightly interested	31	26.27
	Interested	74	62.71
Decision	Rejected	12	10.17
	Moderately decided	40	33.90
	Decided	66	55.93
Implementation	Not implemented	88	74.58
	Slightly implemented	20	16.95
	Implemented	10	8.47
Adoption	Not adopted	109	92.37
	Slightly adopted	4	3.39
	Adopted	5	4.24

Source: Authors' computations (2024).

Ordered Logistic Models

The five (5) regression models as reflected in Tables 8 and 9 do not possess a multicollinearity problem considering that the computed variance inflation factor (VIF) does not exceed 10 and this indication is based on [3]. Table 8 shows the first three regression models representing the initial stages of vegetable technology adoption. These 3 models (Model 1 (Awareness): X^2=43.57, R^2=0.231; Model 2 (Interest): X^2=31.50, R^2=0.128; Model 3 (Decision): X^2=36.05, R^2=0.159) are significant at 1% level which indicates that there are significant factors affecting the initial stages of adoption. In model 1, it is shown that smaller household size (p-value<0.05) is a significant predictor of awareness of vegetable technology at a 5% level. This indicates that if a member does not have a lot of family responsibilities, they can be easily aware of the technology and be guided by the 4-H coordinator. Secondly, model 1 depicted that if a vegetable technology is less complex (p-value<0.05), youth members are more like aware of its characteristics. This implies that the awareness of the youth members increases if they can follow easily the procedure of the said technology. In [37], it is portrayed that if the farmer can focus on agricultural training, they become aware of the various characteristics of the newly introduced technologies. Model 1 also depicted that youth members with no financial liability or debt (p-value<0.05) are more likely aware of the content of vegetable technologies. It is worth noting that if a member has no other responsibilities to other organizations, they can concentrate on acquiring knowledge in the agricultural training implemented by the 4-H club [32].

Model 2 revealed that if the vegetable technology is not complex (p-value<0.05) to follow, youth members are more likely interested. This shows that youth members are showing interest in the technology if they can easily understand the procedure of applying the said technology. Schemes in sustainable agriculture that are motivating processes an interesting and satisfying to learn for the better future [8], [14]. In model 3, it is portrayed that female members (p-value<0.05) are more likely to decide to apply the vegetable technology. Note that vegetable planting is not a masculine job wherein females are capable of doing the task of plant growing. Decision-making in the application of agricultural technology must suit to the interest and awareness of the characteristics and features [12]. Plus, Model 3 also depicted that if the technology is not complex (p-value<0.01) to follow, youth members have a higher likelihood to decide in applying the technology. In [25], doable innovations are ideal to obtain a progressive and sustainable agriculture in which an individual are more likely to apply for the quality of products and good marketability. Moreover, youth members are more likely to decide to apply vegetable technology if they have no credit access or financial debt (p-value<0.01) from other institutions. This means that they are willing to invest and take the risk for the technology if they do not have other money obligations.

In fact, investing in innovative technology requires more information and details to avoid risk and ensure a progressive adoption of the agricultural technology [30]. In addition, youth members need budget support in applying agricultural technology [46].

Table 8. Ordinal logistic models 1-3

Predictors	Dependent variables (1 to 3 scaling)		
	Model 1 (Awareness)	**Model 2 (Interest)**	**Model 3 (Decision)**
Age	0.136^{ns} (0.075)	0.001^{ns} (0.066)	0.037^{ns} (0.065)
Sex[a]	0.602^{ns} (0.430)	-0.426^{ns} (0.389)	-0.822* (0.407)
Educational attainment[b]	0.225^{ns} (0.231)	0.252^{ns} (0.196)	0.109^{ns} (0.223)
Educational status[a]	-0.557^{ns} (0.586)	0.341^{ns} (0.527)	0.114^{ns} (0.539)
Monthly Family Income (PHP)	<0.001^{ns} (0.0001)	<0.001^{ns} (0.0001)	<0.001^{ns} (0.0001)
Household size	-0.445* (0.129)	-0.044^{ns} (0.099)	-0.064^{ns} (0.109)
Influence from 4-H club members[a]	0.209^{ns} (0.981)	-0.904^{ns} (1.981)	0.621^{ns} (0.995)
Influence from family members[a]	0.500^{ns} (0.701)	-0.182^{ns} (0.508)	-0.447^{ns} (0.707)
Attended Training[a]	0.093^{ns} (0.613)	0.594^{ns} (0.694)	0.487^{ns} (0.592)
Vegetable-Complexity[c]	-1.481* (0.452)	-0.708* (0.316)	-1.039** (0.340)
Vegetable-Economically viable[c]	-0.005^{ns} (0.208)	0.088^{ns} (0.185)	0.262^{ns} (0.202)
Vegetable-Compatibility[c]	-0.126^{ns} (0.237)	0.059^{ns} (0.226)	-0.045^{ns} (0.228)
Vegetable-Environmentally safe[c]	-0.097^{ns} (0.219)	-0.025^{ns} (0.211)	-0.115^{ns} (0.208)
Vegetable-Minimal risk[c]	-0.078^{ns} (0.252)	0.111^{ns} (0.206)	0.114^{ns} (0.245)
Credit Access[a]	-3.348* (1.314)	-1.674^{ns} (0.889)	-3.108** (1.158)
Effectiveness of 4-H coordinator[c]	0.138^{ns} (0.408)	0.645^{ns} (0.405)	0.138^{ns} (0.387)
Participants	115	115	115
X^2-computed	43.57**	31.50**	36.05**
p-value (two-tailed)	<0.001	<0.001	<0.001
Pseudo R-squared	0.231	0.128	0.159

Note: a - dummy variable; b -(1-elementary level, 2-elementary graduate, 3-high school level, 4-high school graduate, 5-college level, 6-college graduate) c - 1 to 5 scaling; ns - not significant; *p<0.05; **p<0.01.
Source: Authors' computations (2024).

Model 4 showed that youth members with higher monthly income (p-value<0.1), are more likely to implement the vegetable technologies that they have learned from the 4-H club (Table 9). This means that youth members are willing to invest in the technology to produce quality vegetables if they have enough budget for the financial requirements of the agricultural program. In [13], in order to encourage the youth members to implement the technology, they must be supported by the local government in regard to the financial aspect and training activities. Additionally, Model 4 depicted that youth members are implementing the vegetable technologies if it is not complex (p-value<0.01) to follow the series of steps. This is also true in Model 5 with the same level of significance. Hence, it indicates that youth members will adopt the technology if they have grasped the procedures and they can easily implement them in their respective areas. Nowadays, youth are more likely to adopt a technology if they can relate and it is easy for them to manipulate and the effects are favorable for them [23], [29]. Moreover, if the 4-H coordinators are effective in transferring the knowledge of the technology, then youth members are more likely to implement it. Youth farmers can adopt technologies if they have learned the pros and cons as well as the impact of the technology on their lives [15]. Lastly, youth members are going to implement the technology if they don't have financial debt and it is significant at a 1% level.

Table 9. Ordinal logistic models 4 and 5

Predictors	Dependent variables (1 to 3 scaling)	
	Model 4 (Implementation)	Model 5 (Adoption)
Age	0.098^{ns} (0.061)	0.136^{ns} (0.101)
Sex^{a}	-0.497^{ns} (0.433)	-0.008^{ns} (0.449)
Educational attainment^{b}	0.029^{ns} (0.246)	-0.283^{ns} (0.355)
Educational status^{a}	-0.243^{ns} (0.509)	-0.256^{ns} (0.561)
Monthly Family Income (PHP)	<0.001* (<0.001)	<0.001^{ns} (0.0001)
Household size	-0.122^{ns} (0.109)	-0.223^{ns} (0.121)
Influence from 4-H club members^{a}	0.629^{ns} (0.889)	0.026^{ns} (0.991)
Influence from family members^{a}	-0.025^{ns} (0.597)	0.311^{ns} (0.838)
Attended Training^{a}	-0.055^{ns} (0.505)	-0.192^{ns} (0.586)
Vegetable-Complexity^{c}	-1.028** (0.372)	-0.986** (0.368)
Vegetable-Economically viable^{c}	0.031^{ns} (0.232)	0.2186^{ns} (0.206)
Vegetable-Compatibility^{c}	-0.009^{ns} (0.251)	-0.089^{ns} (0.238)
Vegetable-Environmentally safe^{c}	-0.092^{ns} (0.213)	-0.178^{ns} (0.229)
Vegetable-Minimal risk^{c}	0.036^{ns} (0.183)	0.043^{ns} (0.255)
Credit Access^{a}	-4.362** (1.458)	-5.649^{ns} (3.136)
Effectiveness of 4-H coordinator^{c}	0.714* (0.309)	0.373^{ns} (0.415)
Participants	115	115
X^2-computed	43.41**	19.87^{ns}
p-value (two-tailed)	<0.001	0.226
Pseudo R-squared	0.172	0.184

Note: a - dummy variable; b -(1-elementary level, 2-elementary graduate, 3-high school level, 4-high school graduate, 5-college level, 6-college graduate) c - 1 to 5 scaling; ns - not significant; *p<0.1; **p<0.01.
Source: Authors' computations (2024).

This implies that the technology requires a budget aspect and youth members are not able to focus on investing if they have other financial responsibilities. In that case, youth members must be supported by the government for their lack of funds to implement the vegetable technology [21], [24].

CONCLUSIONS

In this research endeavor, the primary focus revolves around clarifying the extent of adoption of vegetable technologies within the demographic of youth affiliated with the 4-H club in specific regions of Southern Leyte, Philippines. The results revealed that during the conduct of the survey, there are only a few youth members are implementing and adopting vegetable technologies. It is revealed that youth members are more like to implement the vegetable technology if they have a higher income and if they do not have financial problems. Additionally, it is depicted that youth members are going to implement and adopt the technology if it is not complex to follow and they are guided by an expert 4-H coordinator. Hence, the study strongly suggests that the local government must support the youth members in regard to financial aid in implementing the vegetable technology. Moreover, the Department of Agriculture (DA) must send more agricultural extension agents to guide the youth farmers in implementing and adopting vegetable technologies in their respective areas. Hence, this study endeavors to contribute valuable insights into the predictors that shape the decisions and behaviors of policy-making bodies in embracing agricultural innovations. For future research, one must undertake a differentiated understanding of the intersection between the youth, 4-H club dynamics, and vegetable technology adoption that paves the way for informed strategies and interventions in the realm of sustainable agriculture.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THEORETICAL APPROACH ON THE NITROGEN POTENTIAL CONTRIBUTION FROM SUSTAINABLE NATURAL FERTILIZATION WITH CATTLE MANURE

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Abstract

The paper aimed to present a theoretical approach on the nitrogen potential contribution of the cattle manure for natural and sustainable soil fertilization, on different development regions of Romania, during 2017-2021. Calculations are based on statistical data provided by Ministry of Agriculture and Rural Development and National Institute of Statistics. Taking into account the maximum amount of nitrogen of 170 kg/ha that can be administered, the share of the nitrogen coverage potential from cattle manure was determined for each development region and for the different crops. The results showed that the amounts of nutrients from cattle manure could cover different shares for different crops, and for many of them, even 100%, like legumes, or potatoes, or vegetables, or orchards for fruit. The sustainable fertilization of the cattle manure represents a valuable argument for the importance of this species – bovine, in the present opinion exchanges.

Key words: *nitrogen, cattle, fertilization, crops, sustainability*

INTRODUCTION

The manure is one of the most used organic fertilizers, due to its availability [9], but also the manure application may improve sustainable soil productivity and crop yield, soil organic carbon, available nitrogen, phosphorus and potassium, and the abundances of bacteria [2].
According to [12, 13], fertilization of crops with organic manure has important effects on chemical and biological soil properties.
The use of chemical fertilizers in agriculture has increased concerns for the soil fertility, so that, natural inputs are required to ensure that intensive productions do not affect the sustainability of the soil [4, 7].
Also, the animal manure can be a valuable source of resources into a circular concept [6].
Animal manure is widely used to provide additional organic matter for improving soil structure and nutrients for crop growth [5].
Improving the soil quality for increasing the agricultural sustainability means the use of organic amendment through the addition of manure [3].
The utilization management of livestock manure is considered an important way to avoid environmental pollution in animal farms [8]. The European legislation has regulated the use of animal manure, referring to human health, preserving environmental quality, and the equilibration of the dairy markets [14].
The application of manure provides benefits like better crop productivity, improved organic matter, reduced soil erosion, improves soil water availability [1].
In this context, the purpose of this research is to analyze the nitrogen potential contribution of the cattle manure for natural and sustainable soil fertilization, in different development regions of Romania, during 2017-2021, using the statistical data provided by Ministry of Agriculture and Rural Development and National Institute of Statistics.

MATERIALS AND METHODS

In order to estimate the nitrogen potential contribution of the cattle manure for natural soil fertilization, available data from the Ministry of Agriculture and Rural Development and national official statistics were used: quantities of manure produced from different categories of cattle, on development regions, during 2017-2021, areas cultivated with different crops, on development regions, the cattle manure content in nutrients and the maximum quantity of nitrogen per hectare that can be administered.

The methods used in this research have been: dynamic analysis, fixed basis indices, structural indices, regression functions, R square, graphical design and comparison method.

RESULTS AND DISCUSSIONS

Calculations based on operative data from Ministry of Agriculture and Rural Development from 2021 indicate the structure of manure, by species (Table 1), in which cattle manure has the largest share, of 35.45%, followed by poultry with 22.20% and sheep and goats with 20.96%.

Table 1. The structure of manure, by species

Species	Quantity, tons	Share, %
Cattle	15,329,744	35.45
Horses	2,180,736	5.04
Poultry	9,599,152	22.20
Sheep and goats	9,063,451	20.96
Pigs	7,069,252	16.35
Total	**43,242,335**	**100.00**

Source: Own calculations based on operative data from MARD [10].

Center Region

In the Center Region, the amount of cattle manure produced in during 2017-2021 had an oscillating course, increasing slightly by 2.25% (Figure 1).

Fig. 1. The evolution of cattle manure production in the Center Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

The provenance structure of manure, by category of cattle, in 2017, was 76.89% from cows, 13.02% from young cattle over 1 year, 9.81% from young cattle under 1 year and only 0.28% from oxen.

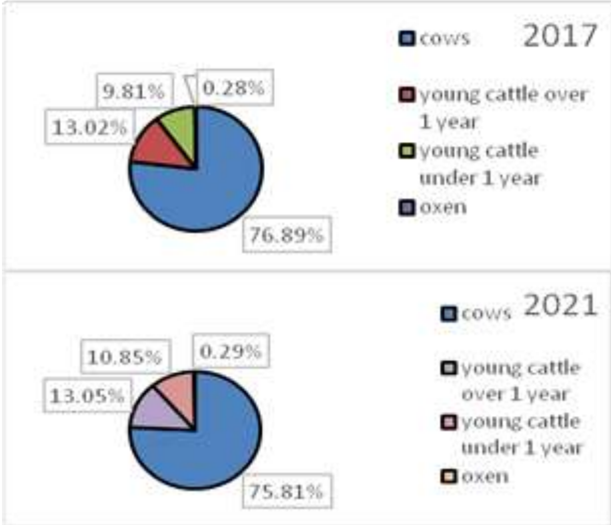

Fig. 2. The provenance structure of cattle manure in the Center Region
Source: Own calculations and graphing following MARD operational data [10].

This structure changed slightly in 2021, in the sense of a decrease in the share of the quantities coming from cows (75.81%), respectively an increase in the share of the other categories (Figure 2).

Consequently, the nutrient production from cattle manure increased by 2.25%, mentioning nitrogen, from 14,178 tons to 14,497 tons (Figure 3).

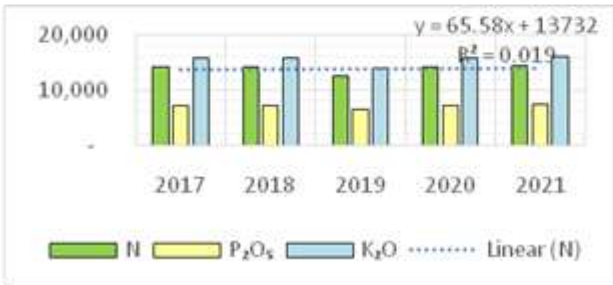

Fig. 3. The evolution of nutrient production from cattle manure in the Center Region (tons)
Source: Own calculations.

According to data in Table 2, the area cultivated in Center Region was 574.0 thousand ha in 2017, decreasing to 561.6 thousand ha in 2021 (-2.1%). Of this, 54.8% was occupied by cereals, followed by green fodder from arable land (28.7%-30.3%).

Taking into account the maximum amount of nitrogen of 170 kg/ha that can be administered, the share of the nitrogen coverage potential from cattle manure was determined, which varied between 14.5% in 2017 and 15.18% in 2021, for the total cultivated areas in the Center Region.

For the areas cultivated with cereals, the fertilization potential with cattle manure was between 26.9% in 2017 and 27.70% in the year 2021. Another variant consisted in fertilizing the areas with green fodder from arable land, which could be naturally fertilized up to 47.9% in 2017, respectively up to 52.76% in 2021.

Table 2. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the Center Region

Specification	*2017*	NFC, *%*	*2018*	NFC, *%*	*2019*	NFC, *%*	*2020*	NFC, *%*	*2021*	NFC, *%*
Total	574,039	14.5	585,866	14.22	576,947	12.87	558,595	14.93	561,626	15.18
Cereals	310,453	26.9	313,907	26.54	311,774	23.82	305,555	27.30	307,811	27.70
Legumes	1,706	>100.0	1,487	>100.0	1,296	>100.0	1,283	>100.0	960	>100.0
Textile plants	471	>100.0	222	>100.0	493	>100.0	575	>100.0	692	>100.0
Oily plants	29,956	>100.0	33,094	>100.0	35,139	>100.0	38,660	>100.0	42,702	>100.0
Medicinal and aromatic plants	115	>100.0	173	>100.0	182	>100.0	192	>100.0	210	>100.0
Potatoes - total	35,667	>100.0	36,048	>100.0	35,977	>100.0	25,029	>100.0	30,141	>100.0
Vegetables - total	18,502	>100.0	18,703	>100.0	18,561	>100.0	16,139	>100.0	16,410	>100.0
Green forages from arable land	174,025	47.9	178,109	46.78	170,067	43.67	168,376	49.54	161,618	52.76
Fodder roots	1,076	>100.0	958	>100.0	1,052	>100.0	1,541	>100.0	655	100.0
Flowers and ornamental plants	77	>100.0	79	>100.0	105	>100.0	76	>100.0	92	>100.0
Orchards	7,827	>100.0	7,719	>100.0	7,643	>100.0	7,355	>100.0	7,604	>100.0
Surface of the greenhouses	10	>100.0	9	>100.0	10	>100.0	11	>100.0	5	>100.0
Arable land not cultivated	48,045	>100.0	47,665	>100.0	47,646	>100.0	46,941	>100.0	38,021	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

The other crops, separately, like legumes, textile plants, oily plants, medicinal and aromatic plants, potatoes, vegetables, fodder roots, flowers and ornamental plants, orchards, greenhouses would be 100% and over, covered by the nitrogen from cattle manure.

West Region

In the West Region, in the time interval 2017-2021, the amount of manure produced by cattle decreased by 26,971 tons per year, respectively by 5.57% during the periodstudied, following an oscillating trend (Figure 4). In this region, in 2017, the provenance structure of manure, by category of cattle, was 76.63% from cows, 14.5% from young cattle over 1 year, 8.69% from young cattle under 1 year and 0.18% from oxen. In 2021, the share of the manure produced by cows increased, up to 79.38% (+2.75%) (Figure 5).

Fig. 4. The evolution of cattle manure production in the West Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

According to Figure 6, the nutrient productions also decreased by 5.5% over the analyzed period, nitrogen reaching from 6,270 tons in 2017, to 5,920 tons in 2021.

The area cultivated in the West Region decreased in 2021 by 19.1% compared to 2017, reaching 769.5 thousand hectares, of which 505.4 thousand hectares were cultivated with cereals (65.6%) (Table 3).

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

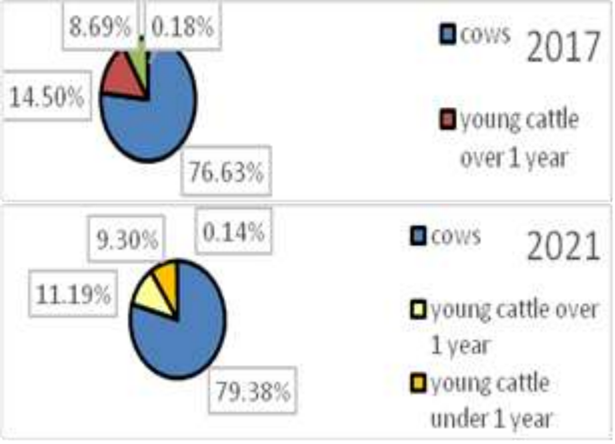

Fig. 5. The provenance structure of cattle manure in the West Region
Source: Own calculations and graphing following MARD operational data [10].

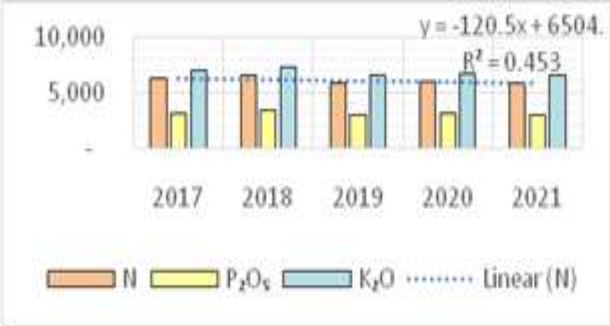

Fig. 6. The evolution of nutrient production from cattle manure in the West Region (tons)
Source: Own calculations.

Table 3. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the West Region

Specification	*2017*	NFC, %	*2018*	NFC, %	*2019*	NFC, %	*2020*	NFC, %	*2021*	NFC, %
Total	951,684	3.88	979,204	3.95	1,155,731	3.00	844,476	4.22	769,508	4.53
Cereals	613,325	6.01	613,607	6.30	768,741	4.50	541,104	6.59	505,430	6.89
Legumes	1,995	>100.0	3,407	>100.0	1,666	>100.0	2,907	>100.0	1,578	>100.0
Textile plants	215	>100.0	0	0	98	>100.0	0	0	5	>100.0
Oily plants	207,888	17.74	229,336	16.85	246,203	14.07	185,963	19.18	144,949	24.03
Medicinal and aromatic plants	117	>100.0	24	>100.0	36	>100.0	30	>100.0	30	>100.0
Potatoes - total	16,963	>100.0	16,938	>100.0	16,902	>100.0	9,080	>100.0	7,129	>100.0
Vegetables - total	28,493	>100.0	28,599	>100.0	28,816	>100.0	29,275	>100.0	23,367	>100.0
Green forages from arable land	85,616	43.08	93,189	41.48	100,775	34.36	85,272	41.83	94,397	36.89
Fodder roots	1,411	>100.0	1,289	>100.0	1,363	>100.0	1,290	>100.0	669	>100.0
Flowers and ornamental plants	10	>100.0	8	>100.0	8	>100.0	7	>100.0	11	>100.0
Orchards	11,590	>100.0	11,304	>100.0	11,530	>100.0	11,351	>100.0	11,675	>100.0
Surface of the greenhouses	32	>100.0	22	>100.0	21	>100.0	8	>100.0	18	>100.0
Arable land not cultivated	83,431	44.20	90,575	42.68	98,462	35.17	93,376	38.20	81,129	42.93

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

According to the maximum amount of nitrogen of 170 kg/ha, the nitrogen coverage potential of cattle manure in the West Region, on total cultivated area, was between 3.88% in 2017 and 4.53% in 2021.
The amount produced had a coverage potential of between 6.01% - 6.89% for the cereal area in the region, or 17.74% - 24.03% for oilseeds, or 34.36% - 43.08 % for green fodder from arable land, or 100% for vegetables.

South-MunteniaRegion

During the analyzed period, in the South-Muntenia Region, the amount of cattle manure decreased continuously, by 104,201 tons per year, respectively by 21.8% during the studied period (Figure 7).

Fig. 7. The evolution of cattle manure production in the South-Muntenia Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

Of the total cattle manure produced in 2017, 77.98% was from the cow category and increased to 80.25% in 2021, the rest being from the other categories, according to Figure 8.

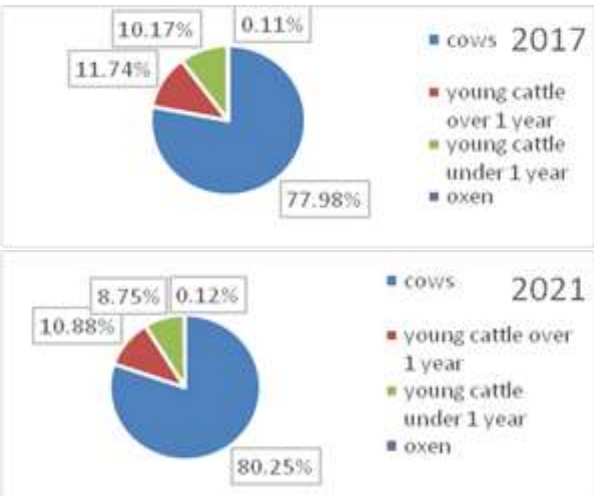

Fig. 8. The provenance structure of cattle manure in the South-Muntenia Region
Source: Own calculations and graphing following MARD operational data [10].

In this interval, the amounts of nutrients produced, having the cattle manure as a source, decreased by 21.8%, as follows: nitrogen from 8,341 tons to 6,521 tons (by 468.9 tons/year), phosphorus from 4,263 tons to 3,333 tons, and potash from 9,268 tons to 7,245 tons (Figure 9).

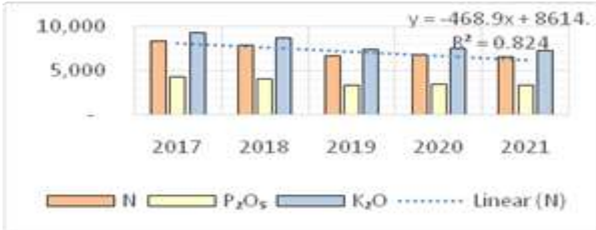

Fig. 9. The evolution of nutrient production from cattle manure in the South-Muntenia Region (tons)
Source: Own calculations.

In the South-Muntenia Region, the areacultivated was 1.86 million hectares in 2017 and decreased to 1.83 million hectares in 2021 (-1.6%) (Table 4). Here too, the largest share is held by the areas cultivated with cereals (63.9%), followed by those with oil plants (26.1%).

Table 4. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the South-Muntenia Region

Specification	***2017***	NFC, %	***2018***	NFC, %	***2019***	NFC, %	***2020***	NFC, %	***2021***	NFC, %
Total	1,864,136	2.63	1,870,788	2.45	1,891,769	2.06	1,849,701	2.15	1,832,684	2.09
Cereals	1,191,855	4.12	1,189,048	3.86	1,277,791	3.05	1,296,492	3.07	1,249,906	3.07
Legumes	38,161	>100.0	40,512	>100.0	35,577	>100.0	26,562	>100.0	18,490	>100.0
Textile plants	8	>100.0	40	>100.0	12	>100.0	14	>100.0	16	>100.0
Oily plants	487,323	10.07	500,670	9.17	431,177	9.02	391,388	10.16	439,539	8.73
Medicinal and aromatic plants	606	>100.0	381	>100.0	194	>100.0	212	>100.0	354	>100.0
Potatoes - total	16,599	>100.0	16,576	>100.0	16,597	>100.0	10,309	>100.0	6,903	>100.0
Vegetables - total	41,157	>100.0	41,327	>100.0	43,430	89.59	33,600	>100.0	35,632	>100.0
Green forages from arable land	104,813	46.81	97,697	47.00	105,138	37.01	104,526	38.03	97,365	39.39
Fodder roots	724	>100.0	684	>100.0	681	>100.0	669	>100.0	569	>100.0
Flowers and ornamental plants	54	>100.0	57	>100.0	54	>100.0	55	>100.0	56	>100.0
Orchards	40,349	>100.0	39,613	>100.0	38,942	99.92	39,967	99.45	39,679	96.67
Surface of the greenhouses	42	>100.0	44	>100.0	40	>100.0	38	>100.0	23	>100.0
Arable land not cultivated	10,510	>100.0	13,077	>100.0	11,065	>100.0	11,069	>100.0	17,679	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

Considering the areas cultivated in the South-Muntenia Region, shown in Table 4, the share of the nitrogen coverage potential from the cattle manure produced in the region was between 2.63% in 2017 and 2.09% in 2021. However, for example, the areas cultivated with legumes, or with vegetables, or with orchards could be completely fertilized.

North-East Region

In the North-East Region, between 2017 and 2021, cattle manure production decreased by 14.8%, falling by 159,017 tonnes per year to 3.38 million tonnes (Figure 10).

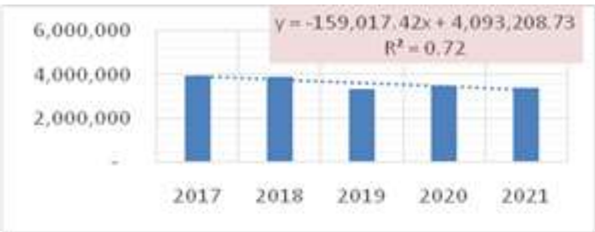

Fig. 10. The evolution of cattle manure production in the North-East Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

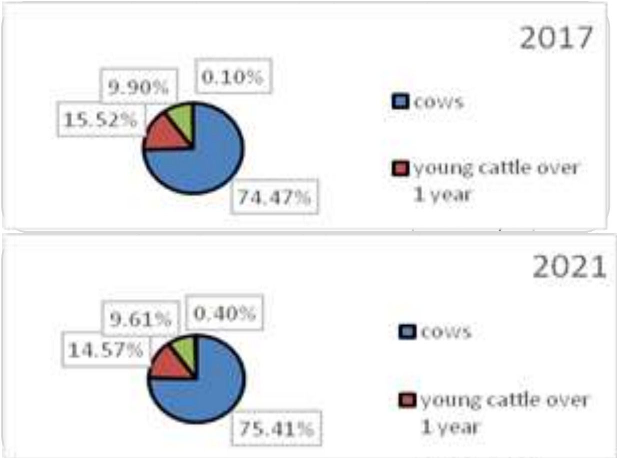

Fig. 11. The provenance structure of cattle manure in the North-East Region
Source: Own calculations and graphing following MARD operational data [10].

The origin structure of the manure indicates that it was produced in a proportion of 74.47% by the category of cows in 2017, respectively 75.41% in 2021, the rest being from young cattle and oxen (Figure 11). Consecutively, the amounts of nutrients decreased, from 17,844 tons of nitrogen to 15,202 tons (-795.1 tons/year), phosphorus from 9,120 tons to 7,770 tons, potassium from 19,827 tons to 16,891 tons (Figure 12). The area cultivated in the North-East Region was 1.28 million hectares in 2021, 9.2% more extensive than in 2017 (Table 5).

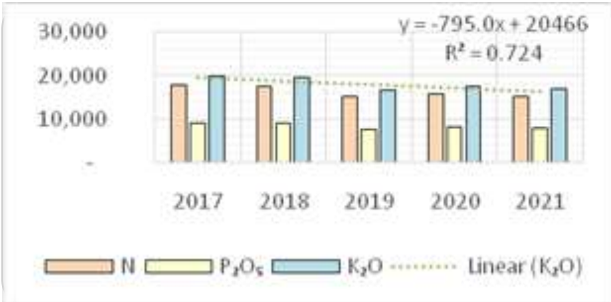

Fig. 12. The evolution of nutrient production from cattle manure in the North-East Region (tons)
Source: Own calculations.

Table 5. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the North-East Region

Specification	*2017*	NFC, %	*2018*	NFC, %	*2019*	NFC, %	*2020*	NFC, %	*2021*	NFC, %
Total	1,175,107	8.93	1,207,636	8.55	1,275,621	6.95	1,256,264	7.35	1,283,145	6.97
Cereals	665,108	15.78	683,539	15.11	696,491	12.73	700,952	13.17	759,005	11.78
Legumes	9,435	>100.0	11,452	>100.0	7,720	>100.0	6,158	>100.0	7,327	>100.0
Textile plants	621	>100.0	962	>100.0	559	>100.0	387	>100.0	12	>100.0
Oily plants	210,775	49.80	213,751	48.33	271,351	32.66	273,689	33.72	250,976	35.63
Medicinal and aromatic plants	126	>100.0	61	>100.0	70	>100.0	78	>100.0	152	>100.0
Potatoes - total	42,413	>100.0	43,776	>100.0	44,522	>100.0	25,199	>100.0	22,366	>100.0
Vegetables - total	40,212	>100.0	42,330	>100.0	42,526	>100.0	37,249	>100.0	39,452	>100.0
Green forages from arable land	208,030	50.46	213,634	48.35	213,092	41.59	213,148	43.30	206,815	43.24
Fodder roots	3,942	>100.0	3,928	>100.0	3,752	>100.0	3,346	>100.0	2,446	>100.0
Flowers and ornamental plants	28	>100.0	30	>100.0	27	>100.0	19	>100.0	15	>100.0
Orchards	12,035	>100.0	13,474	>100.0	11,930	>100.0	11,920	>100.0	13,254	>100.0
Surface of the greenhouses	13	>100.0	7	>100.0	5	>100.0	5	>100.0	:	:
Arable land not cultivated	4,790	>100.0	3,938	>100.0	4,025	>100.0	3,918	>100.0	2,158	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure.

Of this area, 59.2% was cultivated with cereals, on second place being the one with oil plants (19.6%). The nitrogen coverage potential from cattle manure was 8.93% in 2017, respectively 6.97% in 2021, for the entire cultivated area of the North-East Region. Other variants of such natural fertilization were total coverage of the areas cultivated with potatoes or those with vegetables.

North-West Region

In the North-West Region, in 2017, 2,976.5 thousand tons of cattle manure were produced, and in 2021, by 6% more, respectively 3,156.3 thousand tons (Figure 13).

Fig. 13. The evolution of cattle manure production in the North-West Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

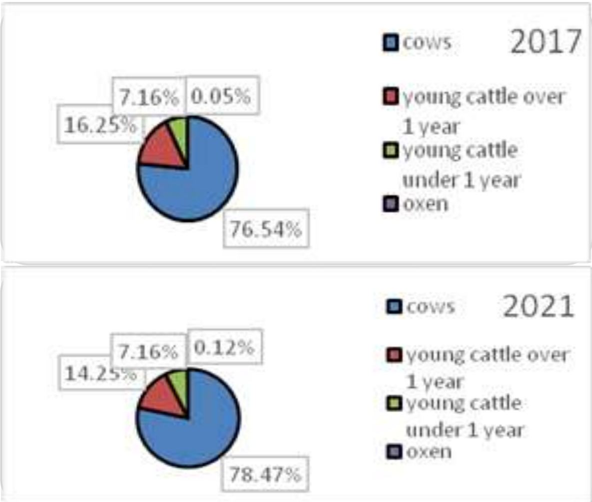

Fig. 14. The provenance structure of cattle manure in the North-West Region
Source: Own calculations and graphing following MARD operational data [10].

The share of the category of cows, as the main source of manure, increased from 76.54% to 78.47% (Figure 14).

In this region, the production of nutrients, during the period 2017-2021, followed an increasing curve, by 6% per interval, the amount of nitrogen increasing annually by 155.4 tons and reaching 14.2 thousand tons in 2021 (Figure 15).

The area cultivated in the North-West Region was 838.8 thousand hectares in 2021, meaning by 5.4% higher than in 2017 (Table 6).

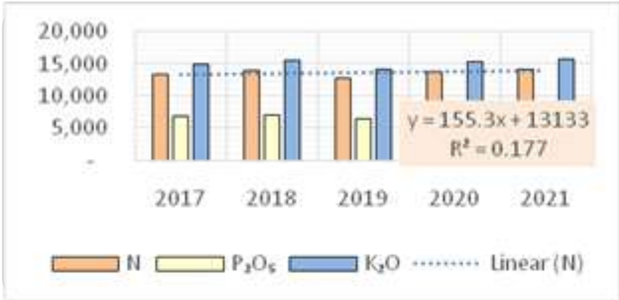

Fig. 15. The evolution of nutrient production from cattle manure in the North-West Region (tons)
Source: Own calculations.

Almost 60% of the area is cultivated with cereals.

Starting from the cultivated area in this region, the nitrogen coverage potential from cattle manure was 9.9% in 2017 and 9.96% in 2021, respectively, for total cultivated area.

This means that it was registered a slight increase but of less importance, becuase th cultivated area is very large and demand of nitrogen could be higher than it is applied.

Other options: 16-16.65% of areas with cereals, or full fertilization for areas with potatoes or vegetables.

Table 6. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the North-West Region

Specification	*2017*	NFC, *%*	*2018*	NFC, *%*	*2019*	NFC, *%*	*2020*	NFC, *%*	*2021*	NFC, *%*
Total	795,602	9.90	830,310	9.84	841,476	8.87	827,392	9.83	838,819	9.96
Cereals	492,397	16.00	504,764	16.18	504,988	14.78	500,350	16.25	501,819	16.65
Legumes	2,225	>100.0	2,429	>100.0	2,705	>100.0	3,168	>100.0	2,756	>100.0
Textile plants	213	>100.0	215	>100.0	212	>100.0	212	>100.0	:	:
Oily plants	93,578	84.20	100,652	81.14	124,652	59.89	131,058	62.03	145,083	57.59
Medicinal and aromatic plants	481	>100.0	317	>100.0	310	>100.0	314	>100.0	237	>100.0
Potatoes - total	37,657	>100.0	37,320	>100.0	37,508	>100.0	18,582	>100.0	13,896	>100.0
Vegetables - total	22,736	>100.0	22,994	>100.0	22,909	>100.0	21,420	>100.0	21,342	>100.0
Green forages from arable land	147,832	53.30	165,298	49.41	152,591	48.93	156,769	51.85	159,511	52.38
Fodder roots	2,522	>100.0	2,488	>100.0	2,485	>100.0	2,567	>100.0	1,331	>100.0
Flowers and ornamental plants	32	>100.0	33	>100.0	31	>100.0	33	>100.0	70	>100.0
Orchards	25,603	>100.0	24,264	>100.0	24,306	>100.0	24,454	>100.0	26,147	>100.0
Surface of the greenhouses	7	>100.0	8	>100.0	10	>100.0	10	>100.0	6	>100.0
Arable land not cultivated	62,244	>100.0	41,202	>100.0	42,126	>100.0	41,610	>100.0	35,046	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

South-East Region

According to data illustrated in Figure 16, in the South-East Region, in 2017, 1.9 million tons of cattle manure were produced, respectively 1.72 million tons in 2021 (-10%).

Fig. 16. The evolution of cattle manure production in the South-East Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

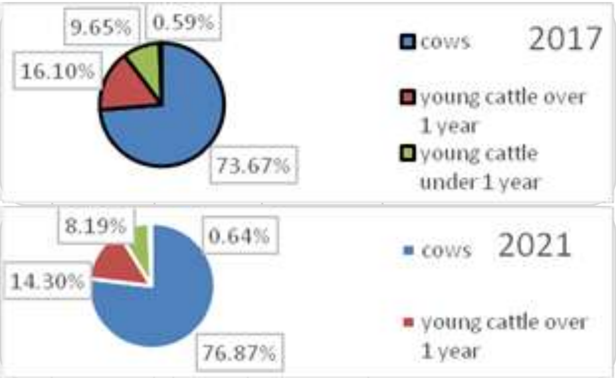

Fig. 17. The provenance structure of cattle manure in the South-East Region
Source: Own calculations and graphing following MARD operational data [10].

The main source of manure was represented by the category of cows, whose share accounted for - 73.67% in 2017, respectively for 76.87% in 2021 (Figure 17).

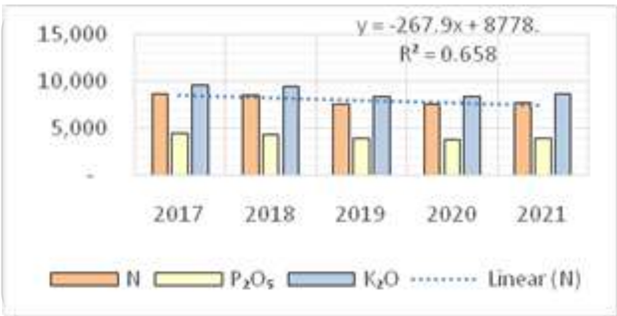

Fig. 18. The evolution of nutrient production from cattle manure in the South-East Region (tons)
Source: Own calculations.

In this region, the area cultivated was 1.77 million hectares in 2021, only 1.3% higher than in 2017 (Table 7), with cereals taking first place, occupying 67.9% of the area. The amount of nutrients from the cattle manure produced here could have completely fertilized (100% of the area) in this region, for example, the areas cultivated with vegetables, or those with fruit orchards, not to mention that of the greenhouses.

Table 7. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the South-East Region

Specification	*2017*	NFC, %	*2018*	NFC, %	*2019*	NFC, %	*2020*	NFC, %	*2021*	NFC, %
Total	1,746,723	2.89	1,781,171	2.80	1,745,808	2.55	1,712,153	2.58	1,770,974	2.57
Cereals	1,068,340	4.73	1,096,077	4.55	1,139,603	3.90	1,119,979	3.94	1,203,778	3.78
Legumes	44,344	>100.0	49,600	>100.0	46,724	95.13	42,004	>100.0	33,395	>100.0
Textile plants	160	>100.0	49	>100.0	60	>100.0	27	>100.0	5	>100.0
Oily plants	504,570	10.02	505,012	9.88	429,548	10.35	428,035	10.31	407,987	11.17
Medicinal and aromatic plants	1,689	>100.0	781	>100.0	893	>100.0	878	>100.0	1,210	>100.0
Potatoes - total	5,925	>100.0	5,949	>100.0	5,856	>100.0	2,840	>100.0	927	>100.0
Vegetables - total	32,474	>100.0	31,937	>100.0	31,505	>100.0	29,275	>100.0	27,487	>100.0
Green forages from arable land	100,323	50.39	102,398	48.71	102,750	43.26	100,580	43.87	107,360	42.43
Fodder roots	182	>100.0	195	>100.0	208	>100.0	207	>100.0	168	>100.0
Flowers and ornamental plants	30	>100.0	30	>100.0	30	>100.0	27	>100.0	25	>100.0
Orchards	14,678	>100.0	14,194	>100.0	14,190	>100.0	14,322	>100.0	12,113	>100.0
Surface of the greenhouses	46	>100.0	48	>100.0	34	>100.0	15	>100.0	14	>100.0
Arable land not cultivated	6,571	>100.0	4,704	>100.0	5,135	>100.0	4,636	>100.0	3,511	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure.

South-West Oltenia Region

In the South-West Oltenia Region, from the total of 1.45 million tons of cattle manure in 2017, only 1.05 million tons remained in 2021, the decrease being 27.4% per period (Figure 19).

The category of cows was also the main source in this area, with 74.2% and 73.3% participation respectively (Figure 20).

Fig. 19. The evolution of cattle manure production in the South-West Oltenia Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

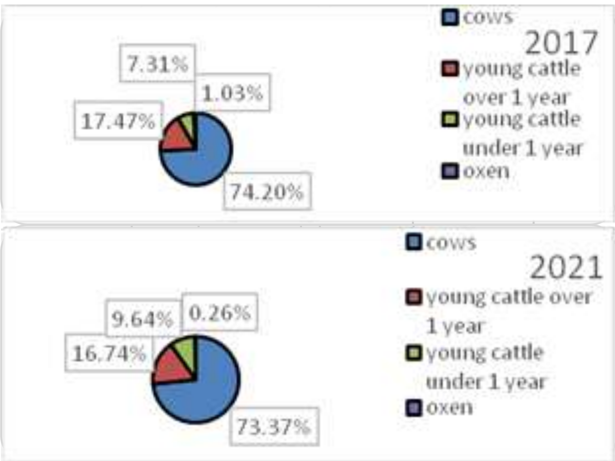

Fig. 20. The provenance structure of cattle manure in the South-West Oltenia Region
Source: Own calculations and graphing following MARD operational data [10].

Considering these developments, the amount of nitrogen decreased from 6.5 thousand tons in 2017 to 4.7 thousand tons in 2021 (Figure 21).

Fig. 21. The evolution of nutrient production from cattle manure in the South-West Oltenia Region (tons)
Source: Own calculations.

During the period 2017-2021, the surfaces cultivated in the South-West Oltenia Region remained approximately constant, at 1.13 million hectares. In this surface, the highest share was held by crops for grains, which are very well adapted to the soil and climate conditions in this part of the country (Table 8). The coverage potential with cattle manure was 100% for potatoes, or vegetables, or fruit orchards, or 78.3%, respectively 57.06% for green fodder from arable land.

Table 8. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the South-West Oltenia Region

Specification	***2017***	NFC, %	***2018***	NFC, %	***2019***	NFC, %	***2020***	NFC, %	***2021***	NFC, %
Total	1,133,523	3.39	1,144,855	3.14	1,186,362	2.69	1,152,776	2.70	1,133,178	2.46
Cereals	816,332	4.71	822,223	4.37	833,352	3.82	837,868	3.71	780,482	3.58
Legumes	20,100	>100.0	23,248	>100.0	19,788	>100.0	24,773	>100.0	19,705	>100.0
Textile plants	:	0	50	>100.0	:	0	:	0	:	0
Oily plants	210,373	18.27	209,591	17.13	243,857	13.07	212,075	14.67	261,937	10.65
Medicinal and aromatic plants	36	>100.0	20	>100.0	34	>100.0	31	>100.0	460	>100.0
Potatoes - total	11,732	>100.0	12,199	>100.0	12,205	>100.0	6,961	>100.0	3,014	>100.0
Vegetables - total	35,506	>100.0	35,022	>100.0	34,685	91.89	28,280	>100.0	28,391	98.28
Green forages from arable land	49,088	78.32	51,983	69.06	51,740	61.60	53,331	58.35	48,905	57.06
Fodder roots	496	>100.0	509	>100.0	1,100	>100.0	507	>100.0	478	>100.0
Flowers and ornamental plants	3	>100.0	2	>100.0	3	>100.0	4	>100.0	5	>100.0
Orchards	26,469	>100.0	26,260	>100.0	26,135	>100.0	26,182	>100.0	26,863	>100.0
Surface of the greenhouses	51	>100.0	44	>100.0	43	>100.0	76	>100.0	60	>100.0
Arable land not cultivated	19,187	>100.0	16,772	>100.0	19,374	>100.0	16,770	>100.0	145,816	19.14

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

Bucharest-Ilfov Region

In Bucharest-Ilfov Region, the production of cattle manure decreased in the analyzed interval by 37.5% (Figure 22), up to the amount of 34.5 thousand tons.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

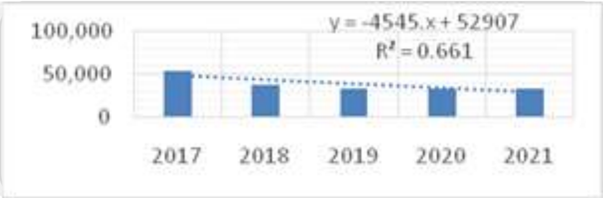

Fig. 22. The evolution of cattle manure production in Bucharest-Ilfov Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

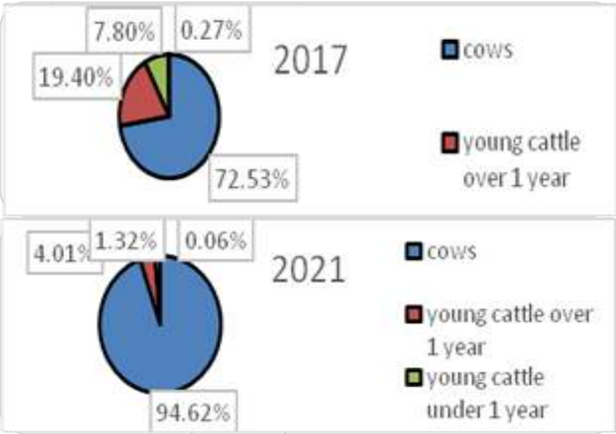

Fig. 23. The provenance structure of cattle manure in Bucharest-Ilfov Region
Source: Own calculations and graphing following MARD operational data [10].

Unlike the other regions, here the share of cows as a source of bovine manure has increased from 72.5% to 94.6%, which means that both the categories of bovine youth and that of oxen have been drastically reduced (Figure 23).

Following the decrease in manure production, the amounts of nutrients were reduced by 37.5%, nitrogen reaching an availability of 154 tons in this region (Figure 24).

Fig. 24. The evolution of nutrient production from cattle manure in Bucharest-Ilfov Region (tons)
Source: Own calculations.

The total cultivated area increased in 2021 by 11%, up to 73.9 thousand hectares. Of this, 58.5% was occupied with grains, and 30% with oil plants (Table 9). Even if the nutrient productions from cattle manure were reduced, considering the cultivated areas in this region, the areas with legumes, or those with fruit orchards, or greenhouses could be naturally fertilized from this species.

Table 9. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in Bucharest-Ilfov Region

Specification	***2017***	NFC, *%*	***2018***	NFC, *%*	***2019***	NFC, *%*	***2020***	NFC, *%*	***2021***	NFC, *%*
Total	66,530	2.18	66,829	1.54	63,561	1.43	62,315	1.46	73,893	1.22
Cereals	34,530	4.19	34,004	3.03	36,350	2.49	35,767	2.55	43,316	2.09
Legumes	1,334	>100.0	1,273	80.82	497	>100.0	589	>100.0	688	>100.0
Oily plants	21,877	6.61	22,898	4.49	18,205	4.98	17,964	5.07	22,181	4.08
Medicinal and aromatic plants	23	>100.0	23	>100.0	25	>100.0	25	>100.0	24	>100.0
Potatoes - total	468	>100.0	496	>100.0	496	>100.0	498	>100.0	25	>100.0
Vegetables - total	5,491	26.36	5,416	19.00	5,287	17.13	5,262	17.32	5,596	16.16
Green forages from arable land	4,926	29.38	4,943	20.81	4,825	18.77	4,855	18.77	4,766	18.97
Flowers and ornamental plants	76	>100.0	73	>100.0	60	>100.0	58	>100.0	71	>100.0
Orchards	448	>100.0	434	>100.0	425	>100.0	440	>100.0	282	>100.0
Surface of the greenhouses	49	>100.0	51	>100.0	43	>100.0	44	>100.0	116	>100.0
Arable land not cultivated	1,140	>100.0	1,035	99.40	1,201	75.42	863	>100.0	548	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure.

Total Romania

On total country, the amount of cattle manure was 16.7 million tons in 2017, respectively 15.3 million tons in 2021 (-8.5%) (Figure 25).

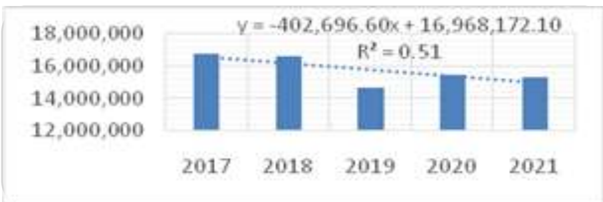

Fig. 25. The evolution of cattle manure production in Romania (tons)
Source: Own calculations and graphing following MARD operational data [10].

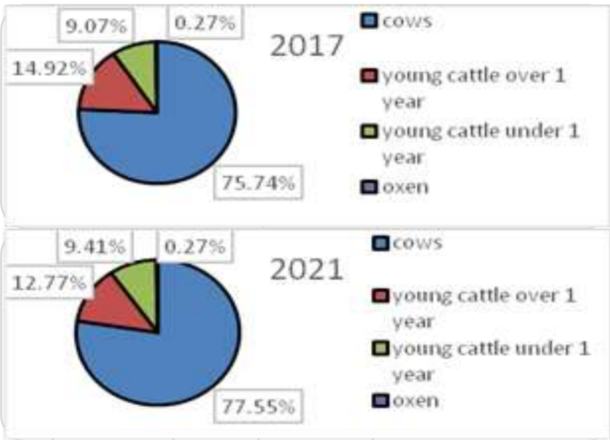

Fig. 26. The provenance structure of cattle manure in Romania
Source: Own calculations and graphing following MARD operational data [10].

The category of animals that mostly participated in the production of bovine manure was that of cows, with 75.7% in 2017, respectively 77.55% in 2021 (Figure 26).

The total amount of nutrients from bovine manure was 75.4 thousand tons of nitrogen in 2017, respectively 68.9 thousand tons in 2021, 38.5 thousand tons of phosphorus in 2017, respectively 35.2 thousand tons in 2021 and 83.7 thousand tons in 2017, respectively 76.6 thousand tons in 2021 (Figure 27).

Fig. 27. The evolution of nutrient production from cattle manure in Romania (tons)
Source: Own calculations.

As indicated by the data in Table 10, Romania's cultivated area in 2021 was 8.26 million hectares, 0.5% less than in 2017.

The area cultivated with grains holds the largest share (64 .8% in 2021), followed by that with oil plants (20.7%).

Table 10. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in Romania

Specification	*2017*	NFC, %	*2018*	NFC, %	*2019*	NFC, %	*2020*	NFC, %	*2021*	NFC, %
Total	8,307,344	5.34	8,466,658	5.19	8,737,275	4.44	8,263,672	4.94	8,263,827	4.91
Cereals	5,192,340	8.54	5,257,168	8.36	5,569,090	6.97	5,338,067	7.65	5,351,547	7.58
Legumes	119,300	>100.0	133,408	>100.0	115,974	>100.0	107,443	>100.0	84,899	>100.0
Textile plants	1,688	>100.0	1,539	>100.0	1,433	>100.0	1,214	>100.0	729	>100.0
Oily plants	1,766,340	25.11	1,815,002	24.22	1,800,132	21.57	1,678,832	24.34	1,715,354	23.66
Medicinal and aromatic plants	3,193	>100.0	1,781	>100.0	1,745	>100.0	1,759	>100.0	2,677	>100.0
Potatoes - total	167,424	>100.0	169,304	>100.0	170,063	>100.0	98,498	>100.0	84,402	>100.0
Vegetables - total	224,571	>100.0	226,328	>100.0	227,720	>100.0	200,501	>100.0	197,677	>100.0
Green forages from arable land	874,653	50.71	907,250	48.46	900,979	43.10	886,857	46.07	880,737	46.07
Fodder roots	10,353	>100.0	10,051	>100.0	10,641	>100.0	10,127	>100.0	6,316	>100.0
Flowers and ornamental plants	310	>100.0	312	>100.0	317	>100.0	278	>100.0	345	>100.0
Orchards	138,999	>100.0	137,263	>100.0	135,102	>100.0	135,991	>100.0	137,617	>100.0
Surface of the greenhouses	250	>100.0	233	>100.0	206	>100.0	207	>100.0	242	>100.0
Arable land not cultivated	235,918	>100.0	218,968	>100.0	229,034	>100.0	219,183	>100.0	323,908	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

The amounts of nutrients from cattle manure could cover 5.34% of the total cultivated area at country level in 2017, respectively 4.91% in 2021. Another option - 8.54% of the total area with cereals, in 2017, respectively 7.58% in 2021.

In proportion of 100%, it would have been possible to fertilize the areas cultivated with legumes, or those with potatoes, or with vegetables, or orchards for fruit.

CONCLUSIONS

In the current economic, social and environmental context in which agricultural activities are carried out, debates regarding environmental protection, or factors with a positive or negative influence on the environment and climate include topics related to the involving of the bovine species. Assuming the theoretical and estimated limitations, the work is written as an argument in favour of the contribution that the bovine species has, as a supplier of natural and sustainable fertility for the soil, of course, under the conditions of a proper management of nutrients. The practice of different agricultural systems has demonstrated that nature creates and regenerates itself, with the support, of course, of man, who, through the sustainable measures he undertakes, can reset the balance in agricultural activities.

ACKNOWLEDGEMENTS

The work is part of the ADER Project 22.1.2, Phase 2 - „Technical-economic models of sustainable agricultural management of forage crops in dairy cows and young bull farms for fattening, in the conditions of climate change„ financed by the Ministry of Agriculture and Rural Development.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

MAIN MEASURES FOR SMALL FARMS AFTER THE ACCESSION TO THE EUROPEAN UNION THROUGH THE NATIONAL RURAL DEVELOPMENT PROGRAM

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Abstract

The small family farm is recognized, both in the literature and at the level of European and national decision-makers, as a main actor in supporting the vitality of rural areas and rural economies, being treated prioritarily. This paper aimed to present the main measures addressed to the small farms after the accession to the EU through the National Rural Development Programme (NRDP) in Romania. For this purpose, it was used a methodology based on the collection of information from the literature, as well as from the European and national reports on small family farms in Europe and in Romania. After the accession to the European Union, Romania has constantly supported the small/semi-subsistence farms through a set of measures from National Rural Development Programme NRDP2007-2013/NRDP 2014-2020 and from the National Strategic Plan 2023-2027 that is under implementation at the moment. These measures mainly aimed at the market orientation of small/semi-subsistence farms, yet this support was not sufficient to contribute to farm consolidation. To reverse this situation, a national strategic vision is needed, with a national budget, supplemented by EU funding.

Key words**:** *rural development, small family farm, NRDP*

INTRODUCTION

If small family farms were analyzed only in terms of agricultural production, this would reveal a number of drawbacks: they still largely use traditional technology, they use limited resources inefficiently, have insufficient (poor) financial resources, have low efficiency and productivity, are poorly integrated in the market – which would reinforce the idea that the small farm is not a competitive agricultural structure and it would be inefficient and irrelevant to modern agriculture. However, it should not be overlooked that almost 50% of the world population lives and works in the rural areas and on small family farms, which provides them an important social role. Rural population density and thus rural viability/sustainability depend on small farm viability [1].

Researchers have found that there is a direct link between the number of small farms and the degree of rural depopulation, which can be explained through the following causality phenomenon: as the number of small farms decreases, the agricultural labour force that is not absorbed by large-scale agriculture also decreases, as large-scale agriculture is highly specialized, much more mechanized and needs less labour; it is not absorbed by the non-agricultural sector either, thus leading to unemployment and rural migration implicitly [2].

Researchers highlight the role of small farms in economic growth, in poverty alleviation and food security, mainly in the developing regions of the world. At the same time, they suggest that an increase of small-scale agriculture would have greater multiplier effects than any other sector [8], [17].

Small family farms have a high level of resilience, and thus producers can survive in difficult and risky conditions [5]. Small farms also play an important role in the creation and protection of cultural and natural heritage.

Last but not least, small-scale agriculture is considered to be more environment friendly, as it offers a number of benefits, such as biodiversity conservation, limiting the use of chemical fertilizers and pesticides and guaranteeing animal welfare. For a long period of time, small-scale family farms were disadvantaged as compared to large (industrial) farms; yet, with the increasing awareness of the important role of small family farms in promoting sustainable agriculture, in the sustainable development of rural areas, there have been a change of paradigm according to which the role of these small-sized farm entities is not limited to the production of foodstuffs, but they also contribute to the supply of public social and environmental goods [4], [7], [16]. This is the reason why the economic viability of farms cannot be measured according to economic principles (income, income or value added and production costs, as well as indices of efficiency, profitability, liquidity, stability, productivity and investments [6], but it should also take into consideration social aspects (aimed at empowerment, equity and inclusion) and environmental aspects (natural resources, pollution and biodiversity) that the household farm provides.

Globally, the Food and Agriculture Organization (FAO) [3] underlines the importance of family farming in alleviating hunger and poverty and for improving food security and living standards in rural areas, while protecting environment and biodiversity. The social, economic and environmental importance of family farming [3] is also highlighted by the fact that the year 2014 was declared by the United Nations as the "International Year of Family Farming", and the period 2019-2028 as the "International Decade of Family Farming". Even though family farming has been the key element of the European Model of Agriculture since 1997 (European Council in Luxembourg), for many years the small family farm was "neglected" by the Common Agricultural Policies, by the NRDP respectively, which has favoured the category of large farms in terms of absorption of EU funds, for the modernization and development of farm businesses. At EU level, recently, there have been an increased criticism of the ineffective policies supporting family farms, a great number of these farms disappearing from the European rural landscape; to keep the countryside "alive" particular attention should be paid to small farms. Researchers suggest that encouraging/supporting small farms would have greater multiplier effects than any other sector.

The reality of our days places the future of family farm in front of a new challenge that they have to face, namely the new requirements with regard to the sustainable farming practice that lies at the core of several European strategies and policies from the European Green Deal.

In this context, the purpose of this study was to present the main measures addressed to the small farms after the accession to the EU through the National Rural Development Programme (NRDP) in Romania.

MATERIALS AND METHODS

In the present paper, the main working hypothesis is that sustainable agriculture is the core subject of several European strategies and policies, generating additional requirements for Romania's agriculture, for small family farms. The transposition of objectives from the European strategies and policies on agriculture is achieved through the National Strategic Plan for the period 2023-2027.

For the purpose of this paper, a methodology based on the collection of information from the literature (online scientific papers – Researchgate, Google Academic, Academica.edu etc., various scientific journals, specialty books) was used, as well as from the European and national reports on the role of small family farms across the world and in Europe; the analysis of the new NSP 2023-2027 applicable in Romania in terms of the new perspectives opened for the farms in our country was also used. This literature review aims at achieving an overall picture and understanding the processes that take place with regard to the approached thematic.

The paper will also make an analysis of effects at the level of small farms in Romania in the period of the two programming periods, NRDP 2007-2013 and NRDP 2014-2020; as well as an analysis of these agricultural units in demographic, social, cultural and environmental terms, on the basis of available statistical data from the National Institute of Statistics (Tempo-online, Farm Structure

Survey, Population censuses), as well as from Eurostat database.

RESULTS AND DISCUSSIONS

Support to small family farms through NRDP 2007-2013

The NRDP 2007-2013 measures which were directly aimed at supporting the restructuring and modernization of agricultural holdings were the following: Measure 141 "Support for semi-subsistence agricultural holdings", Measure 112 "Setting up of young farmers", Measure 121 "Modernization of agricultural holdings", Measure 123 "Adding value to agricultural and forestry products".

Table 1. NRDP 2007-2013 – Main measures aimed at small farmers

Measure	Allocated funds – total cost (thou. euros)	Number of contracts (no.)	Financial execution rate (%)
M112	303,913.97	12,700	98.27
M121	1,531,325.19	2,787	87.74
M123	1,786,571.13	518	76.78
M141	359,568.42	50,486	92.73

Source: [10].

In the period 2007-2013, the small farm targeted by the NRDP was the semi-subsistence farm that produced mainly for self-consumption but also sold part of its production. The semi-subsistence farm size was 2-8 ESU. The beneficiaries could be natural and authorized natural persons up to 62 years of age, who presented a Business plan for the restructuring of agricultural holding.

In the case of Measure 121, small farmers had co-financing problems (non-refundable aid amounting to 40-70%), which limited the access of potential beneficiaries that would have been interested. Starting from the eligibility conditions specific to this measure, it can be noted that the segment of agricultural holdings that already have a high competitiveness level has received support, while small and medium-sized holdings are self-excluded due to their low ability to provide co-financing. A similar situation was found in the case of Measure 123, where the co-financing rate was even higher (50-80%), and small processors' access even more difficult [9].

These two measures (M121 and 123) were allocated the largest amounts, but they were accessible only for those agricultural holdings that already had a high development level. At the same time, small farmers (M141) and setting up of young farmers (M112) received significantly lower public resources.

In conclusion, the NRDP 2007-2013 measures did not positively influence the consolidation of small farmers, as these received insufficient financial support for this purpose, while the large and competitive farmers continue to receive significant support.

Support to small family farms through NRDP 2014-2020

NRDP 2014-2020 came with a set of measures meant to improve the general performance of small-sized agricultural holdings; to increase market orientation, job opportunities and incomes of small-sized agricultural holdings; to encourage small farmers association and small farm transformation. The following measures directly targeted small farms: sM4.1 Investments in agricultural holdings, sM6.1 Support for setting up of small farmers, sM6.3 Support for the development of small farms, sM6.5 "Small Farmer Scheme".

Table 2. NRDP 2014-2020 – Main measures dedicated to small farmers

Measure	Allocated funds (thousand euros)	Number of contracts (ongoing and completed)	Financial execution rate (%)
sM4.1	1,601,904.55	3,028	60.50
sM4.1 ITI	33,000.00	49	55.92
sM4.1a	325,435.04	564	66.74
sM4.1a ITI	5,000.00	6	66.77
sM6.1	466,843.87	10,704	93.41
sM6.1 ITI	10,000.00	201	81.32
sM6.3	241,633.56	13,730	84.96
sM6.3 ITI	5,000.00	187	55.54
sM6.5	6,000	3	54.16

Source: [12].

The support provided through *Sub-measure 4.1 "Investments in agricultural holdings"* was addressed to all agricultural holdings, to small farms inclusively. The investment had to be made on a farm with a minimum economic size of 8,000 SO (standard output). This sub-measure received a significant financial allocation that represented 12.4% of total public allocation of NRDP. For small farms, the problem was limited access to financing as these did not meet the economic farm size criterion. Small farms would have had access to this type of funding if they had been members in an association, but there were very few cooperatives in Romania (230 active cooperatives and 1,000 non-active cooperatives in the year 2018).

The interest for *Sub-measure 6.1 "Setting up of young farmers"* was quite significant, sM6.1 led to the establishment of 10,228 new farms, through the financial support to setting up of young professional farmers who operate 65,557.40 hectares. By rejuvenating the managerial body and its professionalization, Sub-measure 6.1 has contributed, at least indirectly, to innovation, as the young farm owners/managers supported through NRDP have a higher level of knowledge and technical skills. As a result, an increase of productivity can be noticed in the case of farms that receive financial support through sM6.1 [11].

The high interest of beneficiaries to access *Sub-measure 6.3 "Support for the development of small farms*", revealed by the great number of submitted applications, points to the need to continue to support farm structural changes, farm production diversification and its market orientation.

According to the On-Going Evaluation Study of NRDP 2014-2020, the sM6.3 support contributed to the diversification of production oriented towards consumer needs, to the increase of sales and better access to the market; but the greatest contribution is that it reduced land abandonment, in mountain and marginal areas in particular, by creating new opportunities in agriculture [13].

The effect on the farms supported by sM 6.3 was not sufficient to produce obvious structural changes, due to the low value of financial allocation dedicated to small farms and the low value of supported projects.

The high interest of potential beneficiaries in accessing *Sub-measure 6.5 "Small Farmer Scheme"* can be seen in the high value of submitted applications (63,296 euros) as compared to the allocated amount (6,000 euros). Yet it is considered that there is a low access to this measure, and among the factors that contributed to this we can list the following [14]: i) reluctance of small agricultural land owners to permanently transfer their land; ii) relatively small value of support (120% of the support previously received under the Simplified Small Farmer Scheme from Pillar I) and the relatively short period – of 5 years – for which the support is provided, compared to a permanent transfer (or a minimum 20-year lease); iii) problems concerning the cadastre of agricultural land in Romania, in the conditions when in some situations the ownership of the land or the physical boundaries of land into ownership could not be proven otherwise than by Land Book documents; iv) the condition of prior registration at APIA is not justified and the measure might be also applied to applicants who have not benefitted from any other support from EAFRD; v) the persons who previously received support under the Simplified Small Farmer Scheme from Pillar I for holdings consisting partly of land into ownership and partly of leased land were excluded from eligibility for funding. Also excluded from eligibility for funding were the persons who wished to transfer only part of the holding for which they had previously received support.

In addition to these, there are also problems in relation to the administrative conditions for financing, out of which: a) the caravans for information and communication to potential eligible beneficiaries of Sub-measure 6.5 about this funding opportunity were not sufficient, and the target group was informed only to a low extent; b) beneficiaries did not know when to submit the application and how to formulate it so as to meet the eligibility condition for the transfer of the holding and not lose the payment related to the year in which the funding application was submitted; c) potential eligible beneficiaries of transfers are informed on the availability of funding only directly, and consultants are not financially motivated to provide advice for this measure; d) potential eligible beneficiaries have no experience in writing projects and no digital skills to complete the funding application online, neither legal knowledge necessary to verify the submitted documents and the contractual provisions necessary to be inserted in the legal documents related to the transfer of holding; e) misunderstanding the conditions regarding the land lease period, namely the land lease contract had to be concluded for a period of minimum 20 years, starting with the year when the funding application was submitted, but many applicants concluded the contract for 20 years from the date of signing the contract, thus losing days or weeks compared to the minimum period and thus became non-eligible.

After Romania's accession to the EU, our country's agriculture modernization through the utilization of European funds became noticeable. Romania has benefitted from more than 15 billion euros from EAFRD managed under AFIR for the implementation of the two National Rural Development Plans, as well as over 19 billion euros from EAGF – for direct payments managed by APIA.

Obviously, the European funds allocated through EAGF and EAFRD were not the only funding sources for agriculture development. Many agricultural entrepreneurs, especially the owners of large and very large farms, have chosen in recent years to reinvest the profit obtained in the modernization of their own business. The problem of Romanian agriculture is that we can count such farms on the fingers of our hand, and there are very many small and very small agricultural holdings with no access to modern equipment and technologies and no noticeable concern to improve their performance. There is an excessive polarization, with a few very large "high-tech" farms, and with hundreds of thousand "low-tech" farms.

The main objective of Romania regarding agriculture is the consolidation of small and medium-sized farms according to the new National Strategic Plan for the next period.

Support to small family farms through the National Strategic Plan 2023-2027

The support to small and medium-sized farms and generational renewal in farms are priority objectives of the new financial programming period 2023-2027, and there are specifically designed interventions to help these farms, under both Pillar I and Pillar II.

In the case of direct payments, the most important contribution for small farmers comes from the PD-02 intervention in Complementary Redistributive Income Support for Sustainability (CRISS), with a total allocated amount of 978.8 million euros, representing 10.00% of the amount allocated for direct payments. Another important intervention is PD-05 – Environment-friendly agricultural practices on small farms (traditional household farms), with a total allocated amount of 478.5 million euros (4.89%). The support provided to young farmers through interventions from Pillar I has a relatively low share, i.e. 0.69%.

From Pillar II, 1.84% of the allocated amount goes to small-sized farms (DR-14) and 4.27% to setting up of young farmers (DR-30), and 2.89% to the consolidation of farms with recently set-up farm heads (DR-12).

The new NSP 2023-2027 comes with a novelty regarding the support to small farms, targeting the farms with an area of 1-50 ha – which represent the large majority of farms in Romania and are the key elements of EAFRD funding, contributing to the balanced structural development desideratum and reducing structural disparities.

Under Pillar 1, funds specially allocated to small farms (1-50 ha) are provided under the form of *PD-02 "Complementary Redistributive Income Support for Sustainability" (CRISS)* to contribute to supporting the rural area vitality. In addition to the aid granted, this support also comes with a series of environmental conditionalities that generate certain difficulties for farmers.

The CRISS is also addressed to farmers with very small areas, taking into consideration the fact that these will no longer benefit from "Small Farmer" payment, as this support proved to be non-attractive for them in the CAP programming period 2014-2020; yet these farmers are the most important vectors of the short supply chain and environment-friendly farming practice. The CRISS aims to directly contribute to the diminution of income disparities between the agricultural sector and other sectors of national economy, thus leading to the diminution of rural-urban migration of rural youth and of external migration.

In the year 2020, according to APIA, the farms with a physical size between 1 and 50 hectares represented 758,512 farm beneficiaries. The support provided to these farms (with 1 to 50 hectares) is a guarantee to support food and social security and to increase the environmental ambition of the Union [15].

These farms, although representing most farmers registered in the Integrated Administration and Control System (IACS), i.e. 97.1% of total farmers, use only 3,748.473 ha (39% of total IACS area, with an average farm size of 6 hectares), in the context of accelerated concentration of agricultural areas by the categories of medium and large-sized farms, in Romania's agrarian structure.

Box 1. PD-02 – Complementary Redistributive Income Support for Sustainability (CRISS)

For the CRISS, Romania allocates 10% of the direct payments ceiling, respectively 978.7 million euros for the period 2023-2027, of which: 189.7 million euros in 2024, 192.8 million euros in 2025, 195.2 million euros in 2026, 198.0 million euros in 2027 and 203.0 million euros in 2028. For the farms with areas of 1-50 ha, respectively 3,748,473 ha, in the year 2023, the annual planned unit amount is 50.61 euros/ha in 2024, 51.42 euros/ha in 2025, 52.08 euros/ha in 2026, 52.82 euros/ha in 2027 and 54.16 euros/ha in 2028. This support is complementary to other forms of support also from Pillar 1 Direct Payments, such as BISS – Basic Income Support for Sustainability, eco-schemes for the crop production sector or coupled support schemes for the crop and/or animal sector.

Source: [15].

The agricultural pattern represented by the farms with 1-50 ha also directly contributes to the objectives of the UN 2030 Agenda for Sustainable Development (sustainable development objectives: 2, 3, 12 and 13), and to achieve the objectives from the EU Farm to Fork Strategy by developing the sustainable food production across the country.

Another intervention benefitting small farms also under Pillar I is *PD-05 – Environment-friendly agricultural practices on small farms (traditional household farms),* which is an eco-scheme addressed to small-sized farmers (1-10 ha). This eco-scheme represents a uniform annual payment rate per eligible land area, supplementing BISS.

The purpose of this eco-scheme is to encourage traditional household farms, with an area up to 10 ha, to apply environment-friendly farming practices and continue the traditions of rural areas in agriculture. At the same time, the eco-scheme also helps small farmers by maintaining rural area vitality, protecting natural capital and maintaining biodiversity.

Mandatory requirements for this eco-scheme are the following: a) the farmer must own, in addition to agricultural land, a number of animals from the following species: sheep, goats, cattle, buffaloes, equids ranging from 0.3 to 1 LLU/ha, registered in the National Database of ANSVSA and ANZ, as appropriate, for a period of minimum 6 months (according to SMR 11); b) in the case when the farmer operates arable land, this must cultivate at least 10% of the area with: leguminous, nitrogen-fixing crops, which are rich in plant protein, according to phyto-technical and agricultural technology practices.

Box 2. PD-05 – Environment-friendly farming practice on small farms (traditional household farms)

Indicative annual financial allocation (total public expenditure) 478.5 million euros of which: 2024 (91.3 million euros), 2025 (93.7 million euros), 2026 (95.7 million euros), 2027 (96.5 million euros) and 2028 (101.3 million euros). The planned unit amount for the period 2023-2027 is 76 euros/ha. The maximum amount is 98.8 euros/ ha. The minimum amount is 64.60 euros/ ha.

Source: [15].

Thus, the cultivation of these protein-rich species improves the sustainable cycle of nitrogen and organic matter in soil, being good precursor crops. By adding nitrogen to soil, the application of chemical fertilizers will be reduced.

One of the following specific conditions add to the above-mentioned requirements: a) Farmers must plant at least 2 trees per ha, at farm level, each year. For grassland areas, only this variant is applied. This requirement contributes to crop protection, halting and reversing biodiversity loss, improving eco-system services and conserving habitats and landscapes that can be a refuge for birds and animals. On medium term, this requirement also contributes to the reduction of soil erosion, to the reduction of soil temperature in the areas in the proximity of farm, also having a slight influence on the capacity to retain water in soil and carbon sequestration; b) Farmers are obliged in the period June 15 – October 15 to keep the land covered on at least 85% of the arable area of holding, respectively on at least 75% of land covered with permanent crops, thus exceeding the environmental target imposed by GAEC 6 of 80% for arable land and 50% for permanent crops respectively.

On the basis of the experience in implementing Sub-measure 4.1 "Investments in agricultural holdings", the intervention of *DR-14 Investments in small farms* is a useful tool meant to determine the structural change and opening to the market of small farms with potential to become viable agricultural holdings, as well as to increase the capacity to identify new opportunities to valorize the production of these farms.

Box 3. DR-14 – Investments in small farms

Indicative annual financial allocation (total public expenditure) 108 million euros, of which: 81.0 million euros in 2025 and 27.0 million euros in 2026.
Maximum non-reimbursable public support 15,000 50,000 euros.
The investment must be made on a farm with an economic size ranging from 4,000 to 11,999 SO, respectively 2,000 to 11,999 SO for the livestock farms populated with native breeds; no decrease of the economic size under this threshold will be accepted.
Small farmers will have to prove the commercialization of their own production in a percentage of at least 20%.

Source: [15].

The small farms taken into consideration in this intervention are those agricultural holdings with an economic size ranging from 4,000 SO to 11,999 SO. These represent 12.45% of total farms and 81.53% of farms with an economic size over 4,000 SO (NIS 2016), being an important segment of farms in Romania that have a primordial role in ensuring food security and resilience and in promoting extensive environment-friendly farming practices.

Romania's new NSP provides support to small-sized/subsistence farms through DR 14 "Investments in small farms", promoting, on the basis of selection criteria, digitalization/precision farming actions at the level of investments proposed by these.

In the NPS 2023-2027, there are a series of actions generally targeting small and medium-sized farms (through DR 12 Consolidation of holdings of newly set up farmers, DR 20 – Investments in the livestock sector, DR 30 Support for setting up young farmers).

Box 4. DR-12 Investments in consolidating the holdings of already set up and newly set up farmers

Indicative annual financial allocation (total public expenditure) = 169.5 million euros (of which 67.8 million euros in 2025 and 101.7 million euros in 2026)
Maximum value 200,000 euros per project.
Eligible beneficiaries: Young farmers who have completed the implementation of business plan under Sub-measure 6.1 of the NRDP 2014-2020, transition included, or farmers who have set up no more than 5 years before submitting the application for support for this intervention, up to 45 years old at the moment of submitting the financing request and are farm heads.
The intensity of non-reimbursable public support will be related to the eligible costs per project and will not exceed 80% of eligible costs for the investments made by young farmers and 65% of eligible costs in the case of other categories of beneficiaries.
The investment must be made on a farm with a minimum economic farm size of 12,000 € SO.

Source: [15].

The DR 30 intervention "Setting up of new farmers" is considered extremely important for Romania through the expected impact on limiting the abandonment of these areas, with environment, social and economic effects, young farmers having high potential for integrating know-how, digitalization/ innovation solutions in rural areas.

A problem that is considered very important for the development of the Romanian rural area is generational renewal of farmers; the new NSP encourages already set up farmers to continue to develop their farms. Thus, under CAP Pillar II, the intervention *DR-12 "Investments in consolidating the holdings of already set up or newly set up farmers"*, targeting the modernization, increase in competitiveness and environmental performance for the farms owned by young farmers established through the NRDP 2014-2020 (including the transition period) or young persons established in the agri-food sector in the last five years, which will ensure the consolidation of these farms and management efficiency increase, in order to increase farm viability. This intervention will support investments in primary production, in production conditioning and/or storage, on-farm processing to add value to farmers' agricultural products.

The intervention will prioritize the projects that contribute to the encouragement and development of holdings managed by young farmers with an appropriate qualification level and their membership in associative structures, the promotion of modern production technologies with low environmental impact, efficient use of natural resources and actions for appropriate risk management on the farm, for encouraging the ownership of the holding. Thus, ensuring the continuity of support provided to this segment also responds to the environmental and social objectives, on the achievement of which the functioning and revitalization of rural areas depend.

Complementary to intervention DR12 "Investments in the consolidation of holdings of already set up and newly set up farmers" is *CIS-YF (30) Complementary income support for young farmers (financed from Pillar I – EAGF)* to encourage and support young people to remain in the rural areas through the improvement of the economic performance of farms.

Box 5. PD-03 Complementary Income Support for Young Farmers (CIS-YF)

The planned unit amount for the entire period is 67.2 million euros of which: 12.9 million euros in 2023, 13.1 million euros in 2024, 13.4 million euros in 2025, 13.7 million euros in 2026 and 14.0 million euros in 2027.
The annual planned unit amount: 46.00 euros/ha in 2023, 47.00 euros/ha in 2024, 48 euros/ha in 2025, 49 euros/ha in 2026 and 50 euros/ha in 2027. Only the first 50 ha are eligible for payment, regardless of the maximum size.
The basic income support for young farmers is an annual payment made to young farmers who are entitled to the basic income support for sustainability and fall into the category of eligible beneficiaries, namely: - The young farmer is defined according to the specific section from the NSP (chapter 4); - The young farmer is set up for the first time as head of the holding; - The young farmer is eligible for BISS payment.

Source: [15].

The Complementary Income Support for Young Farmers (CIS-YF) is a payment decoupled from production per eligible hectare declared by the young farmer. The CIS-YF intervention contributes to the increase of farmers' incomes after the setting up period.

The young farmers who apply for CIS-YF in the CAP programming period 2023-2027 have a payment request deadline of maximum 24 months from setting up as young farmers in the rural area (farm establishment), with the cumulative compliance of eligibility conditions mentioned above.

In continuity with the previous programming period, the farmers who benefitted from full payment, in the CAP programming period 2014-2020, can no longer apply for the complementary income support of this intervention in the period 2023-2027. But, if small farmers did not benefit from full payment of support, on the basis of programming period 2014-2020 and during the transition to the new CAP 2021-2022, are entitled to the payment of support in the programming period 2023-2027, until the deadline of the 5 years foreseen, with the maintenance of eligibility conditions provided at the time of granting the support. The number of years that have passed since the first submission of the request for support for young farmers is deducted from the period for which this support is granted.

Box 6. DR 30 – Support for the setting up of young farmers

Indicative annual financial allocation (total public expenditure) 250.7 million euros of which: 2024 (131.6 million euros), 2025 (56.4 million euros), 2026 (43.8 million euros), 2027 (18.9 million euros).
Maximum non-reimbursable public support 50,000 70,000 euros
For the farmers up to 40 years of age with maximum 24 months since they set up as young farmers and who have not benefitted from support under the NRDP 2014-2020 or NSP.
Eligible farmers must propose a Business plan for an agricultural holding in use with an economic size of minimum 12,000 SO, respectively 8,000 SO in the mountain area and maximum 100,000 SO.
The guideline is basically the same as that of Sub-measure 6.1 The support rate is 100%.

Source: [15].

The DR-30 intervention for the setting up of young farmers aims to improve the age structure of farmers and will contribute to generational renewal. Young farmers with appropriate training level and skills for an efficient management of farm will be encouraged, who will promote modern production technologies and techniques, and these in their turn will contribute to resilient farming practices, to competitive agriculture, with low environmental impact. All these will also have a beneficial effect in the consolidation of the socio-economic structure of rural areas.

The Complementary Income Support for Young Farmers (PD 03 CIS-YF) and the Support for the Setting Up of Young Farmers (DR-30) directly contributes to the achievement of SO7 Attract and sustain young farmers and other new farmers and facilitate sustainable business development in rural areas. The target value for R.36 generational renewal is 36,000 young farmers in the period 2023-2027.

CONCLUSIONS

The resilience of small farms is recognized in the literature and by the European political decision-makers, resilience being the result of their multi-functionality; but in order to maintain small farm resilience, increasing the attractiveness of the agricultural sector for young people must be taken into consideration. For this purpose, integrated policies are needed (demographic, social, economic, cultural, ecological, technological) that take into consideration the increase of agricultural incomes, the improvement of professional training, ensuring minimal conditions regarding healthcare services, increasing the social appreciation of farmers, etc.

The future of family farming does not depend only on farmers' adaptation to change, but mainly on the intention of young members of the family to continue the farming activity in the future. Hence the importance of appropriate training of the new generation of farmers, so that they can cope with innovative and sustainable strategies.

In recent years, the development of large farms has been encouraged, to the detriment of small farms; in the areas where the large farms were successful in Romania, mainly in the South, South-West, South-East and North-East regions, very small farms disappeared, no other employment opportunities existed, which resulted in deeper rural poverty in these areas.

The new NSP comes with a series of opportunities for modernization and increase of small farmers' incomes, but also with a series of challenges for the environmental objectives that Romania has assumed. For Romania, the environmental and climate objectives proposed by the NSP 2023-2027, which overlap the EU targets, seem difficult to achieve, due to complex requirements, and the financial support is not correlated with the level of losses suffered by farmers, even though the environmental effects are positive. On the other hand, our country has a good level of environmental indicators, and the decrease of the current level of chemical inputs used in agriculture would lead to reducing land productivity, jeopardizing food security implicitly.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

CAPITALIZING ON THE TOURIST AND CULTURAL-HISTORICAL POTENTIAL THROUGH TOURIST PRODUCTS. CASE STUDY: TOURIST CIRCUIT IN DOBROGEA, ROMANIA

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Abstract

Romania possesses both elements of significance for tourism and a multitude of means that can facilitate activities specific to this field. The distribution of these elements across the territory varies, with some areas having clusters of attractions that have led to concentrations of methods and resources for their development, while other areas are more dispersed. Furthermore, within the first category, local and regional development varies, with certain types of tourism activities becoming prominent, some of which are recognized nationally and internationally, while others, although equally significant, are less known and have fewer means for development.This paper aims to highlight the tourist potential of Dobrogea through tourism products. This endeavor is based on the study and highlighting of the material base necessary for the conduct of tourism activities, as well as the types of tourism products that can be utilized. To this end, we will present a case study focusing on a tourist circuit undertaken by students from Mihail Kogălniceanu Theoretical High School, Snagov, in Dobrogea.

Key words: *Dobrogea, tourism, history and culture, producers*

INTRODUCTION

Caught between water and sky, the land of Dobrogea undulates in broad and gentle slopes, planted with rectangular fields from which the slender, straight silhouettes of wind turbines rise (Photo 1). Well-paved, straight roads also cut through the landscape, already lined vertically and horizontally by fields and wind turbines. Few other places in Romania are as abundant in straight lines. We associate Dobrogea with the Seaside or the Danube Delta, but beyond these summer tourist highlights, Romania's eastern most historical province holds an entire treasure trove of interesting destinations.

Dobrogea is linked to the earliest historical writings about cities on what is now Romanian territory. Greek colonists arrived here at the dawn of history, in search of wealth or at least a better life. They built walls facing the land inhabited by barbarians, while remaining open to the sea, *thalassa*, which connected them to their warm homelands beyond the Bosporus. After hundreds of years, the Romans took their place, organizing the land between the Danube and the Pontus, filling it with settlements both inland and along the Danube. Now, an impressive array of ancient ruins traces the outline of Dobrogea along its natural borders: Troesmis, Carsium, Dinogetia, Noviodunum, Aegyssus, Capidava, Argamum. But without a doubt, the most well-known are the urban trio of Histria, Tomis, and Callatis, taught from the earliest history lessons [8].

Photo 1. The Babadag Plateau (Podișul Babadagului)
Source: personal archive.

Dobrogea is a historical and geographical habitat situated between the Danube and the Black Sea, which is part of the territories of Romania, Bulgaria, and Ukraine. In antiquity, the region was known as *Scythia Minor*, though it did not designate a province, as the area was part of the province of *Moesia Inferior* and later, in the Middle Ages, of the Byzantine *theme of Paristrion*. Today, administratively, it includes the counties of Tulcea and Constanța in Romania and the regions of Dobrich and Silistra in Bulgaria [7] (Map 1).

Map 1. Map of Dobrogea: the Romanian part in orange, the Bulgarian part (the Cadrilater) in yellow
Source: ro.wikipedia.org [24].

The main cities in the north are: Constanța, Tulcea, Medgidia, and Mangalia, along with the balneary and vacation resorts on the Romanian coast: Mamaia, Eforie, Costinești, and the resorts in the Comorova area of Mangalia. In the northeastern part, Dobrogea includes the Danube Delta, a habitat listed as a UNESCO World Heritage Site. In the south, in Bulgaria, the main cities are Dobrich, Silistra, Tutrakan, and Kavarna, while tourist sites include the resorts of Albena, Balchik, Shabla, and the medieval fortress on Cape Kaliakra [3]. According to data provided by the National Institute of Statistics, as of January 1, 2023, the two counties in the Romanian part of Dobrogea had a population of 848,058 inhabitants (Constanța 657,060 inhabitants, Tulcea 190,998 inhabitants).

Dobrogea is the only Romanian province, and among the few in the world, whose name comes from a real historical figure. Historical sources provide the first information about Dobrotici in the context of the Byzantine civil war, as an opponent between 1342-1347, of Emperor John V Palaiologos [3], [16].

Dobrotici (or Dobrotiță) (Photo 2) was a ruler of the "Land of Karvuna" („Țării Cărvunei”) between 1347 and 1386 (with the title of despot after 1367). He was the one who moved the capital of this feudal state from Karvuna (in Byzantine or Genoese sources, which can be, according to historical assumptions, either Balchik or Kavarna) to Kaliakra (where the ruins of a fortress can still be admired today) [17], [22].

Photo 2. Dobrotici
Source: www.istorie-pe-scurt.ro [9].

In this context, the purpose of this paper is to to highlight the tourist potential of Dobrogea through tourism products.

MATERIALS AND METHODS

To establish a foundation for a comprehensive program of organization and tourism development for the country and any territory, it is necessary to start with a correct inventory of everything that exists and differentiate units that can be included in a hierarchical system. Components of different orders will have a certain structure and functionality, but also connections that ensure interdependence and thereby the unity of the system. For tourism, it is important to establish precise taxonomic units that, on one hand, each reflect a certain level of potential resources, and on the other hand, a minimum of possible facilities at any given time for their utilization. Tourism in Romania focuses on its natural landscapes and rich history, also making a significant contribution to the country's economy [13], [14].

As a part of the tourism offer, the potential, due to the value, originality, and diversity of its components, constitutes the essential condition for the development of tourism in a given area. The tourism potential of a territory is defined as the set of elements (natural, tourist, and those suitable for development) for visiting and receiving tourists. These natural or anthropic elements are viewed as "tourist attractions" or "tourist resources," terms whose content differs. Therefore, the tourism potential represents the potential tourism offer of a given territory (Fig. 1).

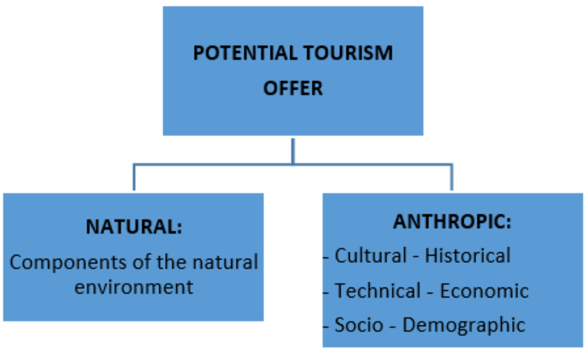

Fig. 1. Existing tourism potential or tourism offer
Source: Glăvan, V., 1996, Geography of tourism in Romania, Publishing House of the Institute of Management - Tourism EDEN, Bucharest [7].

The natural touristic potential of Romania is structured into the following components (Fig. 2):

Relief – it is the most varied and important element of tourist potential, both through its scenic value and the wide possibilities it offers for practicing tourism. The main attractions of the relief are generated by: the steps and forms of relief, rocks with bizarre shapes, and geological phenomena. The relief constitutes an independent tourist attraction, stimulating hiking, mountaineering, rest and recreation, speleotourism, and serves as a support for other potential elements (hydrography, flora, fauna, etc.) [4], [20].

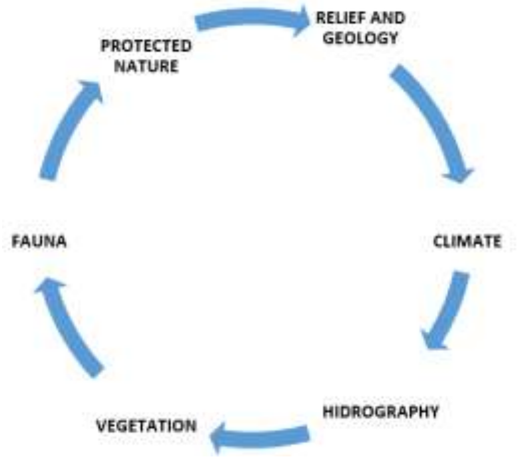

Fig. 2. The Structure of Natural Touristic Potential
Source: Glăvan, V., 1996, Geography of tourism in Romania, Publishing House of the Institute of Management - Tourism EDEN, Bucharest [7].

Climate – contributes to creating a favorable travel ambiance through: the precipitation regime; air temperature and humidity; atmospheric cloudiness; mountain and marine breezes. The climate is a fundamental condition for practicing certain forms of tourism: winter sports, heliomarine therapy, climatotherapy [20].

Hidrography– contributes to enhancing the attractiveness of a touristic area through the presence of the following elements of touristic potential: rivers, streams; natural lakes (including therapeutic ones) and artificial lakes; seas, deltas, and estuaries; mineral and thermomineral waters, and it favors the practice of weekend tourism, fishing, heliomarine therapy, water sports, and spa treatments [5].

Vegetation–represented by forests, meadows, and groves, it constitutes a tourist attraction in itself (examples: natural parks – as vacation destinations, dendrological parks, scientific reserves), as well as an element that enhances the attractiveness of other components of touristic potential. It is of particular interest for leisure, recreation, and amusement tourism [5].

Fauna – from a touristic point of view, it has importance in terms of cinegetics (hunting) and fishing – due to the richness and variety of

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

species; aesthetics – thus contributing to the increased attractiveness of visited areas; scientific – due to the existence of rare or endangered species, protected in reserves and zoological parks, and it serves as a motivation for practicing hunting and sport fishing, scientific tourism, and educational tourism [7].

Natural reservations –are regarded for their aesthetic value as well as their cognitive scientific significance, being a basis for professional and educational tourism. Due to more than two millennia of history, this region has a rich and valuable anthropological potential;

Fig. 3. The Structure of Anthropic Touristic Potential
Source: Glăvan, V., 1996, Geography of tourism in Romania, Publishing House of the Institute of Management - Tourism EDEN, Bucharest [7].

The components of the anthropogenic tourism potential, which stand out for their attractiveness and value, are categorized as follows (Fig. 3):

a. Cultural-Historical Potential

1. There are a large number of archaeological relics in Romania that are of great significance to our people's history, culture, and civilization as well as to world history. The Dacian, Dacian-Roman and Greek fortifications, and the medieval and peasant fortresses, area few examples of such historical edifices.

2. The numerous historical and art monuments showcase the development of the local culture and civilization, as well as the influences of other cultures that it has interacted with. The most notable ones are the monasteries and churches, castles, and plastic art creations.

3. The distinctive appeal of our nation lies in its ethnic and folklore features, which are distinguished by their uniqueness, richness, and variety. These consist of particular popular architecture and building methods, artistic creations, handicrafts and craftsmanship, customs, popular traditions, and traditional clothing.

4. The cultural institutions, museums, and memorial houses with a variety of profiles, as well as cultural events like music, film and theater festivals, exhibitions, fairs, and celebrations all serve as reflections of the intensity of spiritual life, tradition, and modernism in the region's culture.

b. The Technical-Economic Potential includes, for example: storage dams, bridges, and other technical-economic elements that can serve as attractions.

c. The Socio-Demographic Potential includes cities that are attractive due to their specific architecture, the art values they house, or the events they host, as well as rural localities which, in addition to these values, offer exceptionally attractive natural conditions for leisure activities (peace, clean air, unique landscapes) [4], [20], [23].

RESULTS AND DISCUSSIONS

The value of Romania's touristic potential, characterized by the variety and harmony of its relief forms, the diversity of natural and anthropictourist attractions, as well as the existence of unique resources, places Romania among the most favored countries, with the possibility of practicing a "total tourism." Realizing this potential involves designing original and attractive touristic programs, with itineraries as varied as possible, specific to the different regions of the country. The circuits include visiting the most interesting tourist attractions (both natural and anthropic), with varied profiles. They can have different durations, ranging from 3 to 12 days, and can include, as appropriate, other activities such as Romanian-themed evenings, fishing, wine tastings, camp fires, to enhance their attractiveness [2], [12].

The diversity and depth of Dobrogea's tourism potential set it apart and led to the creation of numerous initiatives of such kind. From the 2nd to the 4th of August 2023, we took part in a tour in this area, organized by Mihail Kogălniceanu Theoretical High School, with the goal of learning as much as we could about the geographical, touristic, and cultural-historical legacy of Dobrogea. Among the proposed objectives were: Cheile Dobrogei, Histria

Fortress, Argamum – Orgame Fortress and Capul Doloșman, Enisala Fortress, Babadag Plateau, the city of Tulcea, Celic – Dere, Cocoș, and Saon Monasteries, and the Danube Delta Museum.

The first objective visited was the Dobrogea Gorges. These are among the most exquisite and well-known sights in the area. Geologists value them for the ancient age and significance of the Jurassic reefs from the Paleozoic era, while tourists visit them for the breathtaking scenery they provide. The age of the Dobrogea Gorges is over 2 million years (Photo 3). They provide an incredible karst landscape, with several gorges that are far more worn than they were in the past. Initially, those rocks were over 1,000 meters high, but external forces like water, wind, and rushing rivers kept eroding them until they reached their current height of slightly over a 100 meters [17], [10].

Photo 3. Dobrogea Gorges
Source: personal archive.

Several limestone rock towers with coralline origins that date back to the Mesozoic era define the region. Here, experts have identified more than 600 endemic and rare plant species. In terms of fauna, various species of reptiles, birds of prey, and bats can be identified from a paleontological perspective, the limestones in the Dobrogea Gorges area host the richest fossil site with Mesozoic fauna in the Casimcea Plateau [17], [19].

The Cheia Geological Massif was declared a protected natural reserve in 1970 and is located in the northern part of Constanța County, in the Casimcea Plateau, near the village of Cheia. There are more than ten caves located within the Gura Dobrogei perimeter, two of them being of a larger size and more well-known due to speleologists' research that has been done. These are the intriguingly named Gura Dobrogei Cave, also called the Bats' Cave, and the La Adam Cave. [1], [10].

Photo 4. Histria Fortress
Source: personal archive.

Another point of interest we visited during our tour was the Histria Fortress (Photo 4, Photo 5 and Photo 6). Currently, the ruins of the city are located within the administrative territory of the Istria commune, in Constanța County. Histria was founded by Greek colonists from Miletus around 657 BC. The city of Histria experienced uninterrupted development for almost 1300 years, starting from the Greek period and ending in the Byzantine period. During the Greek period, the city consisted of two distinct parts, the acropolis and the civilian settlement, following a model found in ancient Greek cities. This structure was maintained until the city was abandoned in the 7th century. One of the reasons for the city's abandonment was the silting of the ancient bay of the Black Sea, where the port was located, which is now known as the Razim-Sinoe lagoon complex [11], [16].

Photo 5. Histria Fortress
Source: personal archive.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Danube was known to the Greeks as the Istros River, which is where the name of the Histria Fortress (Istria in Greek) originates. The settlement had stone-paved streets, a strong defensive wall surrounding it (only the western part of the fortress wall had 10 towers and two gates), was supplied with water through pipes spanning more than 20 kilometers, which also supplied the baths built during the Roman era and it had both physical education institutions (gymnasion) and cultural-artistic institutions (museion).

Photo 6. Histria Fortress
Source: personal archive.

The "Histria" Archaeological Museum has numerous bas-reliefs, an impressive collection of amphorae, and altars dating back more than two millennia, including a part of the marble facade of the temple dedicated to the "Great God." Visitors can also see the fortress's defensive wall, equipped with towers and bastions, the well-preserved ruins of Greek temples, a few paved streets, residential houses, several Christian basilicas dating from the 6th century AD, the temples of Aphrodite and Zeus, the forum, the marketplace, the street network, and even some sewer pipes [19].

On our journey, the next objective was the Argamum – Orgame Fortress. It is an archaeological site that is situated within the Jurilovca commune in the eastern portion of Tulcea County, in the place called Capul Doloșman. This site marks the intersection of the Razim Lake (Photo 7) and the Babadag Plateau, which was formerly an open gulf of the Black Sea (the Gulf of Argamon). According to Hecateus of Miletus, an ancient source from the early 6th century BC, Argamon is the earliest settlement on Romanian land, being established by the Greek immigrants from Asia Minor around the middle of the 7th century BC [16].

Photo 7. Lake Razim
Source: personal archive.

Sources related to the Argamum-Orgame Fortress are very few (Photo 8). Archaeological research is also not very advanced; the site, which covers almost 100 hectares, has been excavated to a small extent, about 15%, so more historical evidence can emerge at any time.

In the vicinity of the ancient Greek necropolis lies the "heroon tumulus," the oldest Greek tomb in the entire Black Sea region. This gives archaeologists much more evidence to support their theory that Orgame was among the first Greek settlements in the Black Sea. It is notable to mention that here lies also one of the first Greek cremation tombs, more specifically a small mound, being unique for the Balkan peninsula and the Black Sea basin. It was so important to the inhabitants of the city that a hero cult was developed around it, which lasted for about 400 years.

Photo 8. The Argamum - Orgame Fortress site
Source: personal archive.

All archaeological sources collected from the site indicate that the tumulus dates from the second half of the 7th century BC, around 640-630 BC, a period close to when the colony was founded. It was likely an important figure, as archaeologists have concluded that the person cremated there was probably the leader of the colony. For almost 400 years afterwards, the inhabitants of the fortress brought offerings to this figure and considered him a hero [16].

The multiculturalism, archaeological remains, wild places, local gastronomy, and stunning landscapes make this little-known area one of the most enchanting tourist destinations on the Romanian coast.

Photo 9. Doloşman Cape
Source: personal archive.

Doloșman Cape (Photo 9 and Photo 10) is a protected national area located to the east of the village of Jurilovca, within the administrative territory of the Jurilovca commune. It represents a geological formation (a limestone cliff) that includes the ruins of the Argamum-Orgame fortress and the steep rocky slope of the cliff.

Photo 10. Doloşman Cape
Source: https://discoverdobrogea.ro/ [6].

It is the highest rocky cliff on the Romanian coast, stretching nearly 3 kilometers and offering tourists a wonderful perspective. The Cretaceous cliff, composed of sandstones and limestones, stands 29 meters high, but it continues with a very steep hill that reaches up to 56 meters. The name Doloșman has Turkish origins and means "Bad Head" [8].

In our exploration of the history of Dobrogea, we reached the Enisala Fortress (Photo 11). The ruins of the medieval fortress Yeni-Sale (Enisala, Enișala, Eraclea, or Heracleia) are located 2 kilometers from the village of Enisala, on a limestone hill that overlooks the Razim and Babadag lakes.

Photo 11. Enisala Fortress
Source: personal archive.

The Yeni-Sale Fortress has an irregular polygonal plan that follows the sinuosities of the Jurassic limestone massif on which it is located. Following the study of portolans from the 13th to 14th centuries, the settlement that appears under the names Bambola or Pampolo has been identified with the Enisala Fortress. It was first mentioned by the name Yeni-Sale in the 15th century [21].

Photo 12. Babadag Plateau
Source: personal archive.

The primary purpose of this fortress was military: defensive and for high-altitude surveillance of land and water routes. It was abandoned by the Turks, and in the following centuries, the fortress fell into ruin.

However, a unique element that sets this fortress apart is that it survived the Russo-Turkish armed confrontations that took place in Dobrogea, according to historians. Here's how: two centuries ago, Russian army generals ordered the destruction of all medieval fortresses in northern Dobrogea that housed Ottoman Empire garrisons. Only one escaped because it was no longer active at that time. Thus, Enisala remained standing. It has been partially reconstructed, making it the only medieval fortress in Dobrogea, and it has once again become a major tourist attraction in Northern Dobrogea [19].

The city of Tulcea is located in the northern part of the Dobrogea region, serving as the gateway to the Danube Delta. Nicknamed the city of seven hills, the entire area has developed on the hillside terraces that surround it. As a result, Tulcea's streets continue to have a distinct picturesque charm. Even the road to Tulcea, which passes close to the town, stands out from the typical Dobrogea landscape. The occasionally high slopes have produced winding roads that take you to new places. The one-and-a-half-kilometre-long waterfront has undergone rehabilitation and has been renamed in honor of the renowned Romanian athlete Ivan Patzaichin. Currently, Tulcea's residents enjoy a new port infrastructure that spans more than 36,000 square meters, along with a modern promenade.

Photo 13. The Aquarium - Danube Delta Museum
Source: personal archive.

The Danube Delta Eco-Tourism Museum Centeris one of Tulcea's top tourist destinations, which functions as a comprehensive cultural center, including a public aquarium and a museum. At the same time, it features a permanent exhibition that primarily displays elements characteristic of the natural heritage of the Danube Delta Biosphere Reserve (Photos 13, 14 and 15).

Photo 14. The Letea Forest Habitat Exhibit - Danube Delta Museum
Source: personal archive.

As previously mentioned, the complex also features a public aquarium and several temporary exhibitions, all of which are housed in an environment that faithfully reproduces habitats specific to the Danube Delta, the Razim-Sinoie Lagoon Complex, and other nationally significant protected areas in the Dobrogea Plateau (Photo 12), such as the Macin Mountains National Park.

Photo 15. The Letea Forest Habitat Exhibit - Danube Delta Museum
Source: personal archive.

The permanent exhibition features 46 plant species, 3 reptile species, 44 bird species, and 12 mammal species, all of which are shown in different ecological interactions and scenarios, allowing visitors to learn about the vast biological diversity of the geographical regions (Photo 16). Through the films that are available along the visiting route, visitors can learn about the birds that have been designated as natural monuments, rare animal species that are protected both nationally and internationally, species that have vanished from the deltaic and Dobrogean areas, recently introduced species in the delta's fauna and other aspects of their lives.

The aquarium can hold 150 tons of water and is equipped with modern installations. It includes a collection of 8 marine invertebrate species, 6 types of imported corals from Indonesia, 24 native fish species from the Danube Delta and the Black Sea, and 23 reef fish species (Photo 17). Not only are the aquariums featuring fish and invertebrates from coral reefs unique to Tulcea, but they are also distinctive among other public aquariums in Romania.

Photo 16. Turtles (*Testudines*) - Danube Delta Museum
Source: personal archive.

Visitors can experience what it's like to be in the middle of a reef for a short while, surrounded by eye-pleasing fish and corals with remarkable shapes and colors, thanks to a system of two concentric cylinder aquariums. Similar feelings can also be felt when passing down the tunnel that leads to the aquarium's largest tank, which is home to eels and sturgeons—two of the oldest species of fish currently in existence. Sturgeons are noted for their distinctive reproductive habits.

Photo 17. Lionfish (*Pterois volitans*) - Danube Delta Museum
Source: personal archive.

The Independence Monument in Tulcea (Photo 18) is the main tourist attraction of the city, due to its location, which offers a panoramic view of the city at the mouths of the Danube.

The foundation stone of the first monument dedicated to the War of Independence and the reunification of Dobrogea with the Romanian state on Hora Hill was laid by „domnitorul” (ruler) Carol I during his visit to Tulcea on October 17-18, 1879.

However, the official inauguration took place much later, in 1904, also in his presence and alongside Queen Elisabeta [21].

Photo 18. Independence Monument in Tulcea
Source: personal archive.

Besides these historical and cultural places, Dobrogea has also a rich heritage regarding the local traditions (architecture of the houses, gardens, agriculture and animal raising, agro-food products, folk music and dances, vineyards and wines, and gastronomy which are of high attraction for tourists and which favored the development of rural tourism and agro-tourism [15, 18].

CONCLUSIONS

Thus, the territory of Dobrogea offers a rich wealth of cultural and historical values that cater to various motivations for tourism, including ancient ruins, treasures of folk art, ethnography, and folklore, which collectively represent a hallmark of our people.

The harmonious natural setting, with its varied and picturesque landscapes and numerous tourist potentials, highlights the beauty and value of the Romanian village. The need to capitalize on the unspoiled heritage through tourism is therefore imperative.

In establishing criteria and analyzing tourism heritage, the quality of the surrounding environmen tis of at least the same importance as the ethnographic and folkloric value of the area. Tourism, more than any other field of activity, is dependent on the environment, which represents its "raw material," the object and domain of its activity, and the bearer of its resources.The tourism potential and its exploitation in Dobrogea should be a priority for Romania, as Dobrogea is a region where one can find a variety of geographical features, from the Danube Delta to the ancient mountains of Dobrogea, archaeological sites, monasteries, caves, and not least, a chain of resorts along the Black Seacoast. This region generally benefits from an infrastructure network that facilitates access to these tourist attractions. Starting from this, we can highlight three important directions for the development of tourism in the Dobrogea area:

-**Danube Delta**: Tourists can stay in hotels and guesthouses, and benefit from boat excursions on the channels, which can be organized for fishing trips or to show case the Delta's diverse flora and fauna.

-**Archaeological Sites, Monasteries, Caves, and Vineyards**: These attractions are significant as they offer visitors the chance to explore ancient Greek ruins along the coast, the Cave of Saint Andrew, considered the Christianizer of these lands, and renowned vineyards where wine-tasting events are organized. Additionally, Dobrogea also features Muslim and Lipovan heritagesites, which add to the range of important tourist destinations.

Romanian Black Sea Coastline: Along the coastline, from Vama Veche to Năvodari, there is a chain of resorts where tourists can find accommodation in hotels ranging from 2 to 5 stars, with options for spa treatments and wellness services.

Tourists should consider the destination as a combination of several criteria: local traditions, natural setting, quality accommodation services, recreational activities, gastronomy, and opportunities for leisure.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

FRUIT GROWING IN THE SOUTH-WEST OLTENIA REGION IN THE NATIONAL CONTEXT (2016-2022)

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Abstract

The paper aims to anchor the fruit-growing heritage of the South-West Oltenia Development Region within the context of national realities. Thus, for the period 2016-2022, information is presented regarding the number of existing trees, total fruit production (tons), and average production per tree (kg). The general situation of the sector is addressed based on information related to the following species: plum, apple, pear, peach, nectarine, cherry, sour cherry, apricot, and other fruit trees – for the number of trees and average production per tree. Additionally, for these species, information on total production also includes strawberries and fruits from family gardens. This analysis is based on the main statistical database provided by the National Institute of Statistics. In terms of tree count, the region accounted for 18.03% of the national total, representing 13,501,467 trees. The variation ranges from 6.20% for nectarines (2,594 trees) to 34.66% for other fruit trees (469,931 trees).In the context of total national fruit production, the region accounted for 18.35% (277,886.57 out of 1,514,463.43 tons), with extreme shares of 6.59% for peaches (1,162.71 tons at the regional level compared to 17,633.86 tons at the national level) and 27.03% for other fruits (8,550.56 compared to 31,631.29 tons). The average production per tree (21 kg) places the region 5% above the national level (20 kg). There is a need for a significant revival of the fruit-growing sector, particularly through species that align with the agro-productive characteristics of the region, given adequate support from the authorized governmental bodies.

Key words*: *plum, apple, pear, peach, total production, average production

INTRODUCTION

Fruits have been one of the primary foods used in human nutrition. They can generally be consumed in their natural state, without additional energy consumption for preparation or processing [2].

The earliest written evidence of fruit tree cultivation dates back to the era of the Old Egyptian Kingdom (3000-2400 BC) with "orchards where the olive tree occupied a central place". The Hindu poem 'Ramayana' also mentions fruit trees cultivated in India.

Together with cereals and vegetables, fruits are important elements of human nutrition, as they generate a healthy diet due to their appreciable and varied content of bioactive substances [8, 12].

Fruits are used in nutrition mainly as desserts or between meals, fresh or prepared in various forms: baked (apples, pears), food made from fresh or dried fruits, salad, marmalade, jams, purees, compotes, soft drinks or alcoholic beverages, and for seasoning other dishes [5].

Fruits obtained through traditional technologies are characterized by superior quality compared to those produced through intensive or super-intensive technologies, and therefore they should be preferentially introduced into the consumption structure [3, 10].

Contemporary socio-economic shifts influence the consumption structure of the population and, consequently, the consumption of fruits [13].

The use of fruits in nutrition is influenced by their quality, which is affected by a multitude of factors that can manifest throughout the entire value chain [4].

The importance of fruit production is also highlighted by the fact that after 2015, at the national level, there has been a noticeable change in the structure of the dietary ration, with the increased use of fruits [11].

Older, indigenous varieties are better adapted to local climatic conditions and exhibit high tolerance to environmental factors. However, currently, their fruits may be considered qualitatively outdated by market demands. Nevertheless, it can be stated that some traditional varieties are still successfully cultivated today: Tuleu gras, Gras românesc, Vânătromânesc - for plums; Boambe de Cotnari, Pietroasenegre de Cisnădie - for cherries; Crișana and Mocănești - for sour cherries; Pătul and Crețesc - for apples, etc. [1].

Even though Romania has a tradition in fruit growing, currently, due to the way orchards are exploited and the aging of the fruit-growing heritage, meeting the internal consumption needs is achieved through significant import operations, which clearly exceed export operations (amid declining production), an aspect with various consequences for fruit producers and consumers [6, 14].

The strategy for developing fruit growing in Romania must be based on the most modern scientific, financial, technological, and organizational foundations for the sector to enter the competitive international market. This strategy should naturally follow the evolutionary course of modern global fruit growing. The current climate changes necessitate research for the acclimatization and introduction, as much as possible, of new species into cultivation, such as: persimmon, kiwi, pomegranate, jojoba, goji, goumi, etc.

More than this, the higher demand of fruits in human ration has intensified the trade with fruits at the international level [9].

South West Romania is well known for its fruit trees plantations and also vineyards [7].

In this context, the purpose of this paper is to present the fruit-growing heritage of the South-West Oltenia Development Region of Romania in terms of the number of existing trees, total fruit production (tons), and average production per tree in their evolution in the period 2016-2022.

MATERIALS AND METHODS

The realization of the work involves the use of three indicators: the number of fruit trees, total fruit production (t), and average production per tree (kg). The analysis was conducted over a seven-year period (2016-2022), for which an average of the period was also determined. At this level, the existing national and regional data were used to determine the structure of the number of trees, the total production (by species), and in the case of the average production, to position the species comparatively with the general level of the indicator. Additionally, for the average of the period, the positions of the South-West Oltenia Development Region were established in the national context (shares or positions compared to the national situation). Information regarding the number of trees and average production is provided both at the general level and for specific species, including plum, apple, pear, peach, nectarine, cherry, sour cherry, apricot, walnut, and other trees or fruits.In the case of total production, in addition to this information, data on strawberries and fruits obtained in family gardens are also included [8]. In the category of other trees or other fruits, the following can be included: quince, hazelnut, fig, edible chestnut, almond.

RESULTS AND DISCUSSIONS

Table 1 presents the data regarding the number of trees, at the general sector level as well as for the cultivated species, both for Romania and for the South-West Oltenia Region.

At the national level, the total number of trees varied from 73,149,036 in 2019 to 78,325,345 in 2018, showing an uneven evolution of the indicator, while at the regional level we are discussing extreme levels of 13,204,185 and 14,028,994 trees in the years 2019 and 2020 respectively, maintaining the fluctuating trend of the indicator's evolution over time.

The total number of plum trees ranged between 34,195,891 and 34,743,975 trees for the years 2021 and 2016, noting that the level specific to the first term of the dynamic series was not reached by any other term, considering the evolution of the indicator to be a descending fluctuating one. Regarding the specific regional situation, extreme levels of the number of plum trees were observed at 8,548,829 and 8,799,614 trees in 2022 and 2016 respectively, with the descending fluctuating trend present at the national level also evident in this case.

For the apple species, variations in the number of trees ranged from 23,655,918 to 28,689,430 in the years 2019 and 2018 respectively, with the indicator's evolution being uneven.

In the case of the South-West Oltenia Region, we discuss extreme levels of 2,092,594 and 2,639,755 trees for the years 2019 and 2020 respectively, with the indicator's evolution being a fluctuating one.

Table 1.Number of fruit trees

Specification		Year							Period average**		
		2016*	2017*	2018*	2019*	2020*	2021*	2022*	Effective	Structure by species (%)	Share of the region at the national level (%)
Total**	N	74,820,882	74,814,990	78,325,345	73,149,036	73,487,088	74,512,910	7,494,1013	74,864,467	100	-
	R	13,481,924	13,390,970	13,406,226	13,204,185	14,028,994	13,664,237	13,333,737	13,501,467	100	18.03
Plums	N	34,743,975	34,591,325	34,534,473	34,459,654	34,214,693	34,195,891	34,210,196	34,421,458	45.98	-
	R	8,799,614	8,749,198	8,686,388	8,645,560	8,723,902	8,676,487	8,548,829	8,689,997	64.35	25.25
Apples	N	24,787,332	25,304,145	28,689,430	23,655,918	24,014,734	24,950,006	24,931,036	25,190,372	33.65	-
	R	2,163,069	2,143,438	2,142,714	2,092,594	2,639,755	2,450,292	2,318,978	2,278,691	16.88	9.05
Pears	N	3,251,246	3,153,616	3,192,913	3,147,062	3,313,645	3,331,620	3,247,171	3,233,896	4.32	-
	R	409,062	407,593	406,837	413,934	615,972	489,208	403,846	449,493	3.33	13.90
Peaches	N	1,092,259	1,075,956	1,135,512	1,184,277	1,095,561	1,142,911	1,094,746	1,117,317	1.49	-
	R	68,617	64,802	95,730	97,870	69,376	72,058	75,546	77,714	0.58	6.96
Nectarines	N	37,962	45,972	28,797	39,944	52,855	55,586	31,797	41,845	0.06	-
	R	3,086	3,892	2,745	2,641	2,636	1,593	1,563	2,594	0.02	6.20
Cherries and sour cherries	N	5,438,277	5,346,627	5323535	5,333,720	5,404,675	5,354,406	5,500,738	5,385,997	7.19	-
	R	783,871	776,157	800,469	801,727	809,597	800,146	802,137	796,301	5.90	14.78
Apricot	N	2,218,092	2,091,530	2,076,955	2,098,513	2,080,913	2,094,294	2,177,181	2,119,640	2.83	-
	R	474,636	470,133	468,529	448,838	450,940	448,979	452,408	459,209	3.40	21.66
Nuts	N	1,845,824	1,842,007	1,918,156	1,936,247	2,006,104	2,088,057	2,351,612	1,998,287	2.67	-
	R	272,285	269,854	295,171	272,054	272,909	279,551	280,938	277,537	2.06	13.89
Other trees	N	1,405,915	1,363,812	1,425,574	1,293,701	1,303,908	1,300,139	1,396,536	1,355,655	1.81	-
	R	507,684	505,903	507,643	428,967	443,907	445,923	449,492	469,931	3.48	34.66

Source: NIS, Tempo online data base, *http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table,AGR114A-The number of fruit trees, by forms of ownership, macro-regions, development regions and counties, Accessed on 12.06.2024 [8].

** own calculation;N – national level;R – regional level.

For pear trees, at the national level, the limits were 3,147,062 and 3,331,620 trees for the years 2019 and 2021 respectively, with the fluctuating evolution of the indicator being certain. At the regional level, the extreme years were 2018 and 2020 (406,837 and 615,972 trees respectively), with an uneven evolution.

Regarding peach trees, at the national level, extreme values of 1,075,956 and 1,184,277 trees were observed for the years 2017 and 2019, with the species showing a variable evolution over the analyzed period. The South-West Oltenia Region recorded limits of 64,802 and 97,870 trees in the same extreme years mentioned at the national level (2017 and 2019), with a similar dynamic as previously mentioned.

The total number of nectarine trees ranged between 28,797 and 55,586 trees for the years 2018 and 2021, with the indicator's evolution being a fluctuating one. Regarding the specific regional situation, extreme levels of nectarine trees were observed at 1,563 and 3,892 trees in 2022 and 2017 respectively, with a clear descending trend.

For cherry and sour cherry trees, variations in the number of trees ranged from 5,323,535 to 5,500,738 in the years 2018 and 2022 respectively, with the indicator's evolution being uneven and showing signs of recovery towards the end of the period. In the South-West Oltenia Region, we discuss extreme levels of 776,157 and 809,597 trees for the years 2017 and 2020 respectively, with the indicator's evolution being a fluctuating one.

Regarding apricot and myrobalan (cherry plum) trees, at the national level, extreme values of 2,076,955 and 2,218,092 trees were observed for the years 2018 and 2016 respectively, with the species showing a variable evolution over the analyzed period. The first term of the dynamic series was not equaled by any other component. The South-West Oltenia Region recorded limits of 448,838 and 474,636 trees in the years 2019 and 2016 respectively, with a dynamic similar to that mentioned previously.

For walnut trees, at the national level, the limits were 1,842,007 and 2,351,612 trees for the years 2017 and 2022 respectively, with the indicator's evolution marked by a decrease in 2017 compared to 2016, followed by a clearly ascending trend. At the regional level, the extreme years were 2017 and 2018 (269,854 and 295,171 trees respectively), with an evolution different from that mentioned at the national level (variable).

For other trees, the total number ranged between 1,293,701 and 1,425,574 trees for the years 2019 and 2018, with the indicator's evolution considered to be fluctuating. Regarding the specific regional situation, extreme levels of 428,967 and 507,684 trees were observed in 2019 and 2016 respectively, with the trend noted at the national level also being specific in this case.

At the national level, the average for the period was 74,864,467 trees, with the following species structure: 45.98% plums (34,421,458 trees), 33.65% apples (25,190,372 trees), 7.19% cherries and sour cherries (5,385,997 trees), 4.32% pears (3,233,896 trees), 2.83% apricots and cherry plums (2,119,640 trees), 2.67% walnuts (1,998,287 trees), 1.81% other trees (1,355,655 trees), 1.49% peaches (1,117,317 trees), 0.06% nectarines (41,845 trees).

Regarding the specific situation of the South-West Oltenia Region, an average of 13,501,467 trees was noted, with the following species structure: 0.02% nectarines (2,594 trees), 0.58% peaches (77,714 trees), 2.06% walnuts (277,537 trees), 3.33% pears (449,493 trees), 3.40% apricots and cherry plums (459,209 trees), 3.48% other trees (469,931 trees), 5.90% cherries and sour cherries (796,301 trees), 16.88% apples (2,278,691 trees), 64.35% plums (8,689,997 trees).

Figure 1 shows the share of the South-West Oltenia Region at the national level in terms of the number of fruit trees. Overall, the region accounted for 18.03% of the total number of trees, a proportion that is exceeded in the case of plums (25.25%), apricots and cherry plums (21.66%), and other trees (34.66%), while for the remaining species, the proportion is lower (6.20% for nectarines, 6.96% for peaches, 9.05% for apples, 13.89% for walnuts, 13.90% for pears, 14.78% for cherries and sour cherries).

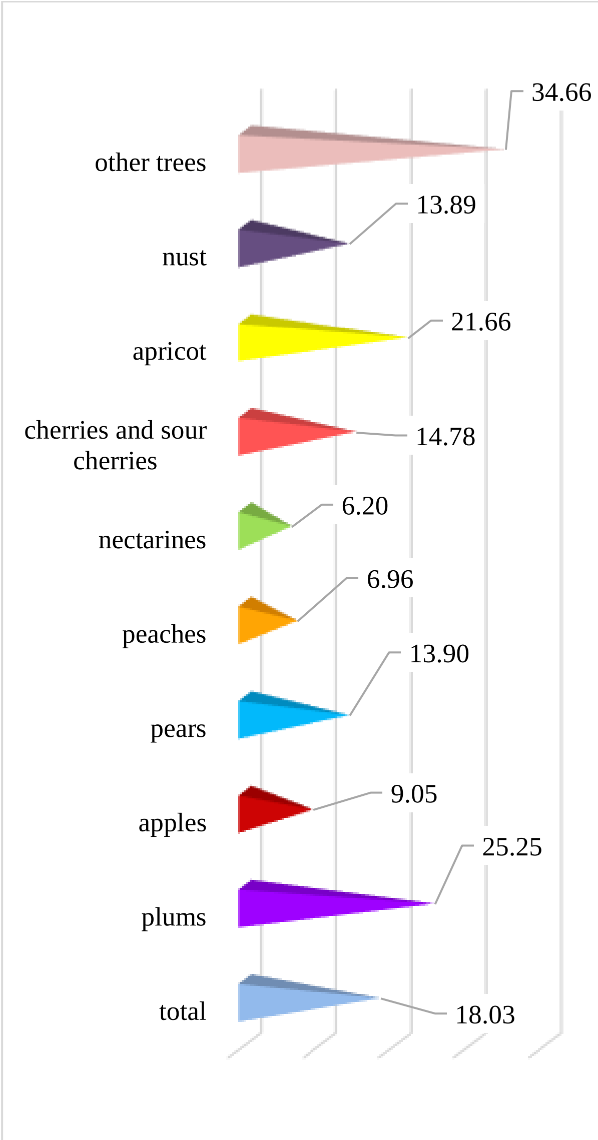

Fig.1. The share of the South-West Oltenia Region at the national level, within the total number of fruit trees - Period average (%)
Source: own calculation.

Table 2 contains data related to the total fruit production (in tones), both overall and broken down by specific fruit species. In addition to the previous indicators, it includes information regarding the production of strawberries and fruits obtained from family gardens.

Table 2. Total production of fruits (t)

Specification		Year							Period average**		
		2016*	2017*	2018*	2019*	2020*	2021*	2022*	Effective	Structure by species (%)	Share of the region at the national level (%)
Total**	N	1,273,354	1,088,312	1,846,170	1,519,654	1,622,449	1,737,000	1514,305	1,514,463.43	100	-
	R	216,180	206,018	315,220	283,361	325,524	335,678	263,225	277,886.57	100	18.35
Plums	N	512,975	444,922	842,132	704,817	769,874	819,358	677,021	681,585.57	45.01	-
	R	128,460	120,961	187,757	171,242	197,362	205,343	158,236	167,051.57	60.12	24.51
Apples	N	467,259	348,656	643,856	501,515	546,118	602,630	551,923	523,136.72	34.54	-
	R	43,814	38,454	68,411	58,110	74,437	76,112	57,491	59,547.00	21.43	11.38
Pears	N	52,751	48,878	60,440	49,268	49,657	52,592	45,230	51,259.43	3.38	-
	R	6,626	7,002	8,071	6,963	8,057	7,990	6,505	7,316.29	2.63	14.27
Peaches	N	22,869	18,546	22,199	17,634	15,894	14,015	12,280	17,633.86	1.16	-
	R	1,715	1,091	1,266	1,125	989	1,055	898	1,162.71	0.42	6.59
Nectarines	N	778	794	434	461	474	608	547	585.14	0.04	-
	R	48	75	35	32	33	29	22	39.14	0.01	6.69
Cherries and sour cherries	N	73,834	58,474	90,837	77,168	74,737	78,590	66,577	7,4316.71	4.91	-
	R	10,984	8,622	14,401	13,061	12,576	12,747	10,692	11,869.00	4.27	15.97
Apricot	N	30,726	33,851	35,704	30,651	27,966	28,106	24,641	30,235.00	2.00	-
	R	6,120	7,576	8,685	7,729	7,279	7,476	6,244	7,301.29	2.63	24.15
Nuts	N	34,095	45,797	56,053	51,602	50,342	56,296	55,332	49,931.00	3.30	-
	R	5,054	6,515	8,072	7,396	7,085	7,240	6,855	6,888.14	2.48	13.80
Strawberries	N	23,000	27,050	26,164	22,711	23,053	18,544	17,662	22,597.71	1.49	-
	R	2,582	2,845	2,772	2,538	2,488	2,164	1,989	2,482.57	0.89	10.99
Other fruits	N	23,299	31,526	35,601	31,623	32,680	33,811	32,879	31,631.29	2.09	-
	R	5,956	8,255	9,540	8,980	9,084	9,468	8,573	8,550.86	3.08	27.03
Fruits from family gardens	N	31,768	29,818	32,750	32,204	31,654	32,450	30,213	31,551.00	2.08	-
	R	4,821	4,622	6,210	6,185	6,134	6,054	5,720	5,678.00	2.04	18.0

Source: NIS, Tempo online data base, *http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table,AGR115A-Fruit production by tree species, ownership forms, macro-regions, development regions and counties(12.06.2024) [8].
**own calculation;N – national level;R – regional level.

At the national level, the total fruit production varied from 1,088,312 tons in 2017 to 1,846,170 tons in 2018, indicating an uneven evolution of the indicator. Meanwhile, at the regional level, extreme levels of 206,018 and 335,678 tons were recorded in 2017 and 2021 respectively, maintaining a fluctuating trend over time for this indicator.

The total plum production ranged from 444,922 to 842,132 tons for the years 2017 and 2018, with the indicator's evolution noted as uneven. Specifically at the regional level, extreme levels of plum production were observed at 120,961 and 205,343 tons in 2017 and 2021 respectively, reflecting the fluctuating trend seen at the national level.

For the apple species, total production varied from 348,656 to 643,856 tons for the years 2017 and 2018 respectively, with the evolution of the indicator being uneven. In the case of the South-West Oltenia Region, extreme levels were recorded at 38,454 and 76,112 tons for the years 2017 and 2021 respectively, indicating a fluctuating trend.

Regarding pears, at the national level, production limits were 48,878 and 60,440 tons for the years 2017 and 2018, respectively, with a clearly fluctuating trend in the indicator. Regionally, extreme years were 2022 and 2018 (6,505 and 8,071 tons respectively), with an uneven evolution observed.

For peaches, at the national level, extreme values were observed at 12,280 and 22,869 tons for the years 2022 and 2016, showing a variable evolution with declining trends over the analyzed period. In the South-West Oltenia Region, limits were recorded at 898 and 1,715 tons in the same extreme years (2022 and 2017), with a similar dynamic as mentioned earlier.

For nectarines, total production ranged from 434 to 794 tons for the years 2018 and 2017 respectively, with the indicator showing a fluctuating-descending trend. In the specific regional context, extreme levels of nectarine production were noted at 22 and 75 tons in 2022 and 2017 respectively, with a pronounced descending trend observed for the analyzed period, particularly after 2018.

Regarding cherries and sour cherries, total production varied from 58,474 to 90,837 tons for the years 2017 and 2018 respectively, with the indicator's evolution being uneven. In the South-West Oltenia Region, extreme levels were observed at 8,622 and 14,401 tons for the years 2017 and 2018 respectively, with the indicator showing a fluctuating trend and decreasing tendencies after 2018.

When it comes to the production of apricots, at the national level, extreme values were noted at 24,641 and 35,704 tons for the years 2022 and 2018, indicating a variable evolution with clear declining trends after 2018 when the indicator reached its maximum level. The South-West Oltenia Region recorded limits of 6,244 and 8,685 tons in 2022 and 2018 respectively, showing a similar dynamic as mentioned earlier.

For walnuts, at the national level, production ranged from 34,095 to 56,053 tons for the years 2016 and 2018 respectively, with the indicator showing growth in 2017 and 2018 compared to 2016, followed by fluctuating tendencies. Regionally, extreme years were 2016 and 2018 (5,054 and 8,072 tons respectively), with a similar variable evolution as observed nationally.

In terms of strawberries, national total production varied from 17,662 tons in 2022 to 27,050 tons in 2017, indicating a clear downward trend after 2017 for this indicator. Regionally, limits were recorded at 1,989 and 2,845 tons (2022 and 2018 respectively), with dynamics similar to those at the national level.

For other fruits, total production ranged from 23,299 to 35,601 tons for the years 2016 and 2018, considering the evolution of the indicator as uneven. In the specific regional context, extreme levels were observed at 5,956 and 9,540 tons in 2016 and 2018 respectively, mirroring the national trend.

Family gardens contributed total fruit production, varying between 29,818 and 32,750 tons for the years 2017 and 2018, highlighting the uneven trend of the indicator. In the South-West Oltenia Region, limits were noted at 4,622 and 6,210 tons for the same years (similar to the national situation), with dynamics characterized by a definite fluctuating trend.

At national level, the average for the period was 1,514,463.43 t, with the following structure, by species: 45.01% plums (681,585.57 t), 34.54% apples (523,136.72 t), 4.91% cherries and cherries (74,316.71 t), 3.38% pears (51,259.43 t), 3.30% walnuts (49,931 t), 2.09% other fruits (31,631.29 t), 2.08% fruits from family gardens (31,551 t), 2.0% apricots and vegetables (30,235 t), 1.49% strawberries (22,597.71 t), 1.16% peaches (17,633.86 t), 0.04% nectarines (585.14 t). As for the specific situation of the South-West Oltenia Region, there is an average of 277,886.57 t, with a structure by species, as follows: 0.01% nectarines (39.14 t), 0.42% peaches (1,162.71 t), 0.89% strawberries (2,482.57 t), 2.04% fruits from family gardens (5,678 t), 2.48% walnuts (6,888.14 t), 2.63% each for pears and apricots (7,316.29 and 7,301.29 t), 3.08% other fruits (8,550.86 t), 4.27% cherries and cherries (11,869 t), 21.43% apple trees (59,547 t), 60.12% plums (167,051.57 t).

Figure 2 shows the share of the South-West Oltenia Region, at national level, in relation to total fruit production. At the general level, the region held 18.35% of the total fruit production, a share that is exceeded in the case of plums (24.51%), apricots and vegetables (24.15%) and other fruits (27.03%), while for the rest of the species the share is lower (6.59% in the case of peaches, 6.69% for nectarines, 10.99% for strawberries, 11.38% for apples, 13.80% for walnuts, 14.27% for pears, 15.97% for cherries and cherries, 18.0% for fruits from family gardens).

Table 3 presents the situation of the average production per tree, at a general level and for the defining fruit species at national and regional level.

At the national general level, the variation of the average production from 15 to 24 kg/tree in the case of 2017 and 2018 respectively is observed, highlighting a trend uneven for the indicator. For the South-West Oltenia Region, the range of variation in average production was between 15 kg per tree in 2017 and 25 kg per tree in 2021, with fluctuating trends.

For plums specifically, the limits were 13 kg per tree in 2017 and 24 kg per tree in 2021(the minimum limit in 2017, the maximum level in the case of 2018 and 2021), the evolution of the average production being variable. As for the regional situation, extreme levels of 14 and 24 kg/tree are noted in 2017 and 2021 respectively, the dynamics showing an uneven trend.

If we do not refer to the specific situation of apples, there are extreme national levels of 14 and 24 kg/tree respectively for 2017 and 2021, the evolution of the indicator being variable. For the analyzed region, the limits were reached in 2017 and 2018 (18 and 32 kg/tree, respectively), the dynamics being fluctuating, with some trends of uniformity in the period 2018-2021.

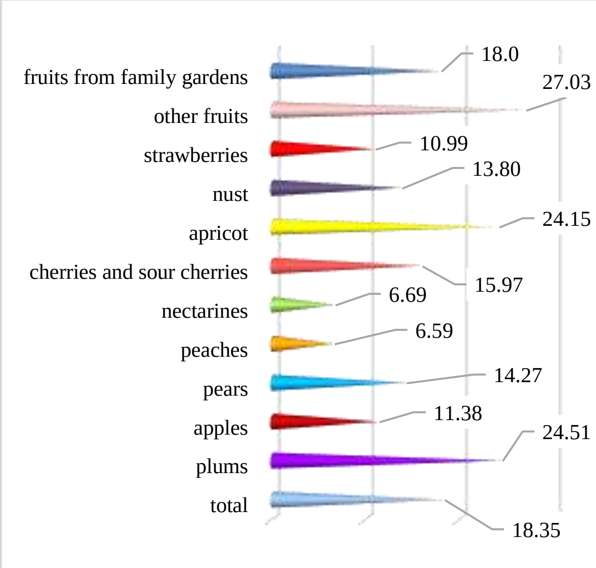

Fig.2. Share of the South-West Oltenia Region at national level, within the total production - Average of the period (%)
Source: own calculation.

Table 3.Average fruit yield (kg/tree)

Specification		Year							Period average**		
		2016*	2017*	2018*	2019*	2020*	2021*	2022*	Effective	species positioning relative to the general level (%)	Positioning of the region in relation to the national level (%)
Total**	N	17	15	24	21	22	23	20	20	100	-
	R	16	15	24	21	23	25	20	21	100	105.0
Plums	N	15	13	24	20	23	24	20	20	100.0	-
	R	15	14	22	20	23	24	19	19	90.48	95.0
Apples	N	19	14	22	21	23	24	22	21	105.0	-
	R	20	18	32	28	28	31	25	26	123.81	123.81
Pears	N	16	15	19	16	15	16	14	16	80.0	-
	R	16	17	20	17	13	16	16	16	76.19	100.0
Peaches	N	21	17	20	15	15	12	11	16	80.0	-
	R	25	17	13	11	14	15	12	15	71.43	93.75
Nectarines	N	20	17	15	12	9	11	17	14	70.0	-
	R	16	19	13	12	13	18	14	15	71.43	107.14
Cherries and sour cherries	N	14	11	17	14	14	15	12	14	70.0	-
	R	14	11	18	16	16	16	13	15	71.43	107.14
Apricot	N	14	16	17	15	13	13	11	14	70.0	-
	R	13	16	19	17	16	17	14	16	76.19	114.28
Nuts	N	18	25	29	27	25	27	24	25	125.0	-
	R	19	24	27	27	26	26	24	25	119.05	100.0
Other fruits	N	16	22	23	23	22	23	20	23	115.0	-
	R	12	16	19	21	20	20	18	18	85.71	78.26

Source: NIS Tempo online data base, *http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, AGR116A – Average fruit production by tree species, property forms, macro-regions, development regions and counties(12.06.2024) [8].
**own calculation;N – national level;R – regional level.

At the level of the pear species, the variation of the average production from 14 to 19 kg/tree is observed in the case of 2022 and 2018, respectively, highlighting a trend uneven of the indicator, with certain decreasing trends after 2018. For the South-West Oltenia Region, the variation limits were 13 kg per tree in 2020 and 20 kg per tree in 2018, with fluctuating trends. For peaches, the variation limits were recorded at 11 kg per tree in 2022 (the minimum) and 21 kg per tree in 2016 (the maximum), the evolution of the average production being variable, with a sharp downward trend after

2018. As for the regional situation, extreme levels of 11 and 25 kg/tree are noted at the level of 2019 and 2016 respectively, the dynamics showing a variable trend.

If we do not refer to the specific situation of nectarines, there are extreme national levels of 9 and 20 kg/tree respectively for the years 2020 and 2016, the evolution of the indicator being uneven. For the analyzed region, the limits were reached in 2019 and 2017 (12 kg/tree respectively), the dynamics being fluctuating.

At the level of cherry and cherry, the variation of the average production from 11 to 17 kg/tree for 2017 and 2018 respectively is observed, accentuate a trend uneven of the indicator, showing a decline following the peak year. For the South-West Oltenia Region, the variation limits ranged from 11 kg/tree in 2017 to 18 kg/tree in 2018, with fluctuations in the dynamics.

For apricots, the variation limits ranged from 11 kg/tree, with this being the minimum limit recorded in 2022, the maximum level in the case of 2018), the evolution of the average production being variable (ascending between 2016 and 2018, descending between 2018 and 2022). As for the regional situation, extreme levels of 14 and 19 kg/tree are noted in 2022 and 2018 respectively, the dynamics showing an uneven trend.

If we do not refer to the specific situation of the walnut tree, there are extreme national levels of 18 and 29 kg/tree respectively for 2016 and 2018, the evolution of the indicator being variable (alternating periods of increase and decrease). For the analyzed region, the limits were reached in 2016 and 2018 respectively 2019 (19 kg/tree respectively 27 kg/tree), the dynamics being fluctuating, with an upward trend from 2016 to 2018, stationary for 2019, decrease in 2020, stationary in 2021, decrease in 2022).

At the level of other fruits, the variation of the average production from 16 to 23 kg/tree is observed in the case of 2016 (minimum level) and 2018 and 2019 (for the maximum level, respectively), highlighting an uneven trend of the indicator. For the South-West Oltenia Region, the variation limits were 12 kg/tree in 2016 and 21 kg/tree in 2019, the dynamics being fluctuating, showing an increasing trend between 2016 and 2019, a decreasing trend in 2020, a stationary trend for 2021 and a decrease in the case of 2022.

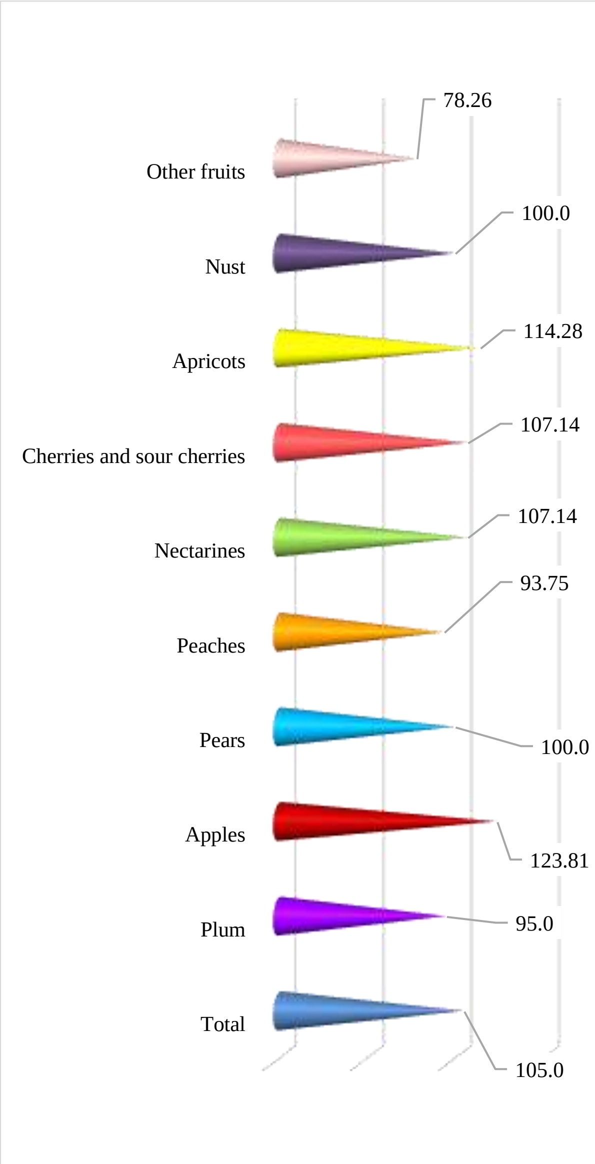

Fig. 3. Positioning of the South-West Oltenia Region at national level, in the case of average fruit production – Average of the period (%)
Source: Own calculation.

If we do not refer to the specific situation of the average of the period, at national level, there is a general situation of 20 kg/tree of the average production, compared to which there were supra-unit levels (for apples, other fruits and walnuts – 21, 23 and 25 kg/tree respectively), equal in the case of plum and sub-unit (16 kg/tree for pear and peach, 14 kg/tree for nectarine, cherry and cherry, apricot). For the analyzed region, the general level reached 21 kg/tree, which was exceeded in the case of apple and walnut (26 and 25 kg/tree), but there were also species that did not reach it (18 kg – other fruits, 16 kg each for apricots and vegetables, 15 kg each for peaches, nectarines, cherry and cherry).

Analyzing the situation of the South-West Oltenia Region, in the national context, it can be seen that it was positioned as follows (Fig. 3): above the national situation for the general level (+5.0%), nectarine respectively cherry and cherry (+7.14%), apricot (+14.28%), apple (+23.81%); at the same level in the case of the respective walnut hair; below the national level for plum (-5.0%), peach (-6.25%) and other fruits (-21.74%).

CONCLUSIONS

In terms of the number of trees, the South-West Oltenia Region is a significant area nationally, as it accounts for approximately 21% of apricot and blackberry plantations, 25% of plum trees, and 34% of plantations for other species.

Considering the total fruit production, the region contributed approximately 18% to the national output (+0.32% relative to the number of trees). It accounted for 27.03% of the production of other fruit species (-7.63% compared to the proportion of trees), 24.51% of plum production (-0.74% compared to the number of plum trees), and 24.15% of apricotproduction (+2.49% relative to the share of apricot trees).

In terms of the average production per tree, the region is above the national level of the indicator as a whole, but also for apple, nectarine, cherry and cherry respectively for apricot and greenery. In the case of pear and walnut, the ratio between the national and regional levels is equal, while for plum, peach and other fruits, the region is below the national situation.

For the South-West Oltenia Region, there is a need to revive the fruit sector by consolidating the situation of the species that lend themselves best to the regional pedoclimatic conditions, by making the most of the irrigable potential of some lands, based on the combination of the assortment of cultivated varieties, by expanding the variety of species cultivated in the conditions of current climatic changes (the introduction into cultivation of heat-loving species with increased resistance to drought), by modernizing production technologies, by exploiting opportunities related -at least- to the possibility of accessing non-reimbursable projects that allow the modernization of existing plantations and the establishment of new plantations.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

FILLING THE KNOWLEDGE GAP: HOW THE ABSENCE OF AN AGRICULTURAL EXTENSION SYSTEM DRIVES ROMANIAN FARMERS TO SEEK ADVICE AND INFORMAL CONSULTANCY ON SOCIAL MEDIA, INCREASING THE MISINFORMATION RISK

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Abstract

This study explores the role of informal agricultural consultancy through Facebook groups in Romania, particularly in the absence of a formal agricultural extension system. With no structured support in place, Romanian farmers have turned to social media platforms, especially Facebook, to seek advice, share knowledge, and engage in peer-to-peer learning. This study analyzed 20 Facebook groups from January 2023 to May 2024, focusing on group dynamics, user engagement, and the quality of discussions. Findings highlight that while these groups offer valuable real-time discussions on critical topics such as machinery maintenance, pest control, and sustainable farming practices, they also suffer from inconsistencies in the quality of information shared. The absence of expert moderation has led to varying degrees of accuracy, with some groups being prone to misinformation. The study suggests that integrating these informal platforms with a formal agricultural extension system could improve the quality of advice provided to farmers. A hybrid system, modeled after successful international frameworks like the American agricultural extension service, could combine grassroots knowledge-sharing with expert-backed guidance and structured training. However, risks such as misinformation, over-reliance on social media platforms, and the absence of a cohesive extension service continue to pose significant challenges. In conclusion, while Facebook groups play a crucial role in filling the advisory gap, they cannot replace a formal agricultural extension system. Further research is needed to explore how these informal platforms can be better integrated with professional services to enhance Romanian agriculture and rural development.

Key words**:** *agriculture extension system, informal consultancy, information accuracy, misinformation risk, social media*

INTRODUCTION

In Romania, the absence of an official and functional agricultural extension system has created a significant gap in farmers' access to technical information, professional advice, and educational support necessary for the development of a modern and competitive agricultural sector [26]. Agricultural extension systems are critical in many countries as they facilitate the transfer of knowledge between universities, research institutes, and farmers, ensuring the implementation of best practices and technological innovations [1]. Without such infrastructure, Romanian farmers have been compelled to seek alternative sources of information, one of the most prevalent being Facebook groups.

These Facebook groups have emerged as informal consultancy platforms, where farmers share experiences, resolve technical issues, and seek advice from other members of the community. These groups are accessible and provide a fast-response forum where anyone can post questions or suggestions. However, the use of these platforms raises concerns, particularly regarding the quality and accuracy of the information exchanged, as there is no formal validation or control mechanism in place to ensure reliability[22].

The situation in Romania starkly contrasts with the American agricultural extension model, which is built on a well-structured system where universities and academic institutions collaborate with farmers to ensure a constant flow of accurate and relevant information [28]. In the United States, each state has a publicly funded extension system that provides free access to professional agricultural consultancy [3]. The lack of such a system in Romania has led to a reliance on unofficial sources, such as Facebook groups, for access to agricultural knowledge, increasing the risk of misinformation [5].

Implementing an agricultural extension system in Romania has the potential to transform key areas of agriculture, agribusiness, and the trade of agricultural products [8]. By delivering expert guidance on modern farming techniques, crop protection, and sustainable agricultural practices, an extension service could help farmers boost productivity, enhance soil health, and improve crop resilience [14]. In agribusiness, access to specialized advice on supply chain optimization, marketing strategies, and the development of value-added products would enable farmers to better position their goods in both local and international markets [7]. Moreover, the extension service could facilitate smoother and more efficient agricultural trade by providing farmers and traders with essential information on product quality standards, certification processes, and compliance with market regulations [17]. This would not only elevate the competitiveness of Romanian agricultural products globally but also foster education and innovation and economic growth across the entire agricultural sector [19]. Through the integration of technical knowledge, market insights, and sustainable practices, an agricultural extension system could serve as a vital catalyst for the long-term development and modernization of Romania's agriculture and agribusiness landscape [20].

One of the few functional consultancy options currently available to Romanian farmers is private, fee-based consultancy, primarily focused on helping farmers develop projects for accessing European Union funding [4, 12]. These services, while helpful for navigating complex funding applications, do not address the broader needs of agricultural knowledge, management practices, or sustainability, which a comprehensive extension system could provide [10].

This paper examines the role of these Facebook groups in the context of the urgent need for the implementation of a national agricultural extension system. As Romanian farmers seek quick and effective solutions, Facebook groups have become a vital space for idea exchange [15]. However, these platforms remain limited in their capacity to replace an organized and systematic extension structure[13]. While these platforms provide some value, they cannot address the long-term challenges facing consultancy in the Romanian agricultural sector [23].

This paper explores the benefits and limitations of this phenomenon and argues for the necessity of implementing a formal agricultural extension system based on successful models from other countries, particularly the American system [25].

MATERIALS AND METHODS

The methodology of this study aimed to offer a comprehensive yet preliminary overview of the informal consultancy phenomenon within Romanian agriculture through Facebook groups [30], particularly in the absence of a formal agricultural extension system. The research explores how these digital communities bridge the knowledge gap by systematically analyzing posts and interactions from January 2023 to May 2024, a period chosen to capture a complete agricultural cycle, including key stages such as planting, fertilization, pest control, harvesting, and land preparation.

The data were examined using a mixed-methods approach, including:

•**Descriptive statistics** to quantify participation levels, post frequency, and engagement rates (comments, likes).

•**Content analysis** to qualitatively explore themes from user discussions, identifying key topics and recurring issues.

•**SWOT analysis** to evaluate the strengths, weaknesses, opportunities, and threats of using Facebook groups for informal agricultural consultancy.

This approach provides an initial understanding of informal agricultural knowledge exchange in Romania while highlighting the need for a formal extension system to mitigate the risks and limitations of relying solely on informal networks.

Data Collection and Survey Design

To ensure a robust sample, 20 Facebook groups with the largest membership and highest activity levels were selected for analysis. These groups were chosen based on several criteria:

•Membership of over 1,000 individuals to ensure relevance and representativeness.

•A focus on agricultural topics, including crop production, livestock management, machinery, and input markets.

•A broad geographical representation to capture discussions from diverse agricultural regions of Romania.

To systematically collect and analyze the data from the identified Facebook groups, a structured questionnaire was developed using Google Forms. The questionnaire served as the primary tool for filtering relevant data and extracting insights from the interactions within the groups. A total of 37 questions were included in the survey, focusing on various aspects of group dynamics, user engagement, and the nature of the discussions using the following key questions:

1.Group Age: Aimed to assess how long the group had been active, with older groups often having more established and trustworthy communities.

2.Number of Members: Tracked to assess the group's activity level and the potential reach of shared information, recognizing that larger groups may face challenges with information quality.

3.Main Domain of the Group: Identified each group's primary focus (e.g., general agriculture, machinery sales), helping to categorize the types of discussions and analyze their relevance.

4.Average Age of Members: Evaluated to understand the level of experience and engagement, with younger members possibly using the groups more for learning and older members contributing expert knowledge.

5.Geographical Distribution of Posts: Examined to determine whether certain regions were more active, helping to identify if the groups attract members equally from across Romania.

6.Daily Number of Posts: Measured the average daily activity, with more posts indicating higher engagement and knowledge exchange.

7.Number of Responses: Tracked to determine how interactive the group is and whether members are receiving adequate feedback on their queries.

8.Full-Time and Part-Time Farmers: This split helped assess the expertise level within each group, differentiating between professional and hobbyist farmers.

9.Percentage of Advertisements: Recorded to understand the balance between commercial content and consultancy, with a higher percentage indicating more trade-focused interactions.

10.Types of Questions: Categorized by topics such as machinery, crop protection, and fertilization, to highlight the areas most relevant to Romanian farmers.

11.Relevance of Questions: Evaluated to ensure the productivity of discussions and whether they addressed real agricultural challenges.

12.Objective Quality of Responses: Assessed the quality of responses based on their accuracy, completeness, and relevance.

13.Perception of Response Quality: Gathered feedback from question askers to measure how helpful they found the responses, indicating the group's overall effectiveness.

In the analysis of the pertinence of questions, as well as the correctness, completeness, and incorrectness or irony of responses, a scale of 10% increments was employed. This approach was adopted to address the inherent subjectivity in evaluating qualitative data such as user-generated content. By utilizing this gradation, the study aimed to more clearly distinguish between different levels of question and response quality. The use of a broader scale allowed for more discernible variations, facilitating a clearer understanding of the trends and discrepancies across the analyzed Facebook groups.

Analysis of group members' perception of answer quality and receptivity of initiators

The authors assessed the quality of answers and the receptivity of group initiators using a 1 to 10 rating scale. This evaluation was based on key metrics, including the number of replies, the depth of answers, follow-up questions, and overall engagement through likes and reactions.

The methodology included:

1.Counting Replies: Posts with more replies indicated higher engagement, reflecting both receptivity and the value of the original question.

2.Depth and Validity: Responses were rated based on their detail and accuracy, with more informative answers receiving higher quality ratings.

3.Follow-up Engagement: The number of follow-up replies and additional questions were analyzed, with active, layered discussions seen as a positive group dynamic.

4.Reactions and Likes: Higher engagement, as shown by likes or reactions, indicated greater perceived value within the community.

5.Receptivity of Initiators: The level of interaction from the original poster, such as responding with further questions or acknowledgments, was key in assessing their engagement, with low interaction resulting in lower scores.

Study limitations and future studies

While this study provides useful insights into the role of Facebook groups as informal agricultural consultancy platforms, several limitations must be considered:

1.Temporal Constraints: The analysis was limited to posts from January 2023 to May 2024. Although this period captures a full agricultural cycle, it may not reflect long-term trends or historical shifts in the use of digital platforms for agricultural advice.

2.Scope of Study: This research offers a broad overview rather than an in-depth analysis of specific groups or discussions. Further research should focus on detailed case studies of individual groups to better understand information dynamics and the quality of advice exchanged.

3.Quality of Information: The unverified nature of the advice shared is a key limitation. As the study did not assess users' qualifications or verify the accuracy of advice, future research should evaluate the reliability of the information provided, comparing it with professional standards.

4.Sample Bias: Focusing on large, active groups may have excluded smaller, niche communities with unique advice. Future research should explore these specialized groups to see if different trends or issues arise.

5.Reliance on Self-Reported Data: Information such as geographical origin and users' professional backgrounds (full-time or part-time farmers) was based on self-reported data, which may not always be accurate [21]. Future studies should employ a more structured data collection approach.

Methodological Approach for Future Studies.

This study offers a preliminary exploration, with further in-depth research needed. Future studies should include case studies of specific groups, focusing on user demographics, engagement, and long-term trends in the advice exchanged.

By integrating qualitative and quantitative methods, future research can provide a deeper understanding of how these platforms function as informal agricultural advisory networks [18].

RESULTS AND DISCUSSIONS

This section presents a comprehensive analysis of the informal agricultural consultancy occurring in Romanian Facebook groups. By examining group dynamics, user engagement, common discussion topics, and the quality of shared information, the study highlights both the advantages and risks associated with relying on these platforms.

Table 1 provides a clear snapshot of the size, year of establishment, and average daily posts of 20 different Facebook groups focused on agriculture in Romania.

The following are detailed observations on the group dynamics and how they reflect broader trends in agricultural consultancy via social media.

•High Membership and Activity Levels in Large Groups:

The largest groups, such as *Tractoare și Utilaje Agricole de Vânzare* (Tractors and Agricultural Equipment for Sale, 148,800 members) and *Agricole* (Agricultural, 105,600 members), exhibit the highest activity levels, with over 30 posts per day. The large membership sizes of these groups suggest that there is a strong demand for machinery-related information and a marketplace for agricultural equipment. Farmers actively engage in these groups to buy, sell, and trade equipment, a critical component of farm operations in Romania. The high post volume indicates that the machinery and equipment trade is a vital part of the farming community's daily operations, and Facebook groups are the go-to platforms for farmers seeking affordable and second-hand machinery.

•Niche Groups with Lower Membership but Focused Engagement:

Smaller, more specialized groups such as *Boli și Dăunători în Agricultura României* (Diseases and Pests in Romanian Agriculture, 12,000 members) and *NO-TILL România* (6,900 members) maintain lower membership numbers but display strong engagement levels within their specific agricultural niches. These groups appeal to farmers looking for specialized advice on pest management, disease control, and sustainable farming practices. The smaller size allows for more targeted discussions and often more personalized advice, which is crucial for farmers dealing with specific technical challenges in crop protection or those exploring no-till farming techniques.

Table 1. Facebook groups overview

Facebook group name	Established in	Members number	Average posts per day
Tractoare și Utilaje Agricole de Vânzare (Tractors and Agricultural Equipment for Sale)	2015	148,800	30+
Agricole (Agricultural)	2018	105,600	30+
Vânzări Tractoare și Utilaje Agricole (Tractors and Agricultural Equipment Sales)	2010	105000	10-15
Comerț cu Cereale, Utilaje și Produse Agricole (Trade with Grains, Equipment, and Agricultural Products)	2017	58,300	30+
Agricultura Românească (Romanian Agriculture)	2010	52,400	30+
Agricultura (Agriculture)	2019	29,500	5-10
Agricultura României (Poze &Videoclipuri) (Romanian Agriculture: Photos & Videos)	2011	29,300	30+
AgronetGrup (Agronet Group)	2015	24,400	30+
Ingineri Agronomi (Agricultural Engineers)	2014	23,700	30+
Agro TV	2020	18,600	15-20
Agricole de Vânzare (Agricultural for Sale)	2014	16,900	30+
AgroRomânia (Agro Romania)	2014	12,100	10-15
Boli și Dăunători în Agricultura României (Diseases and Pests in Romanian Agriculture)	2016	12,000	5-10
NO-TILL România (NO-TILL Romania)	2021	6,900	1-5
AgroSubvenții (Agro Subsidies)	2021	6,600	5-10
Agricultura România (Agriculture Romania)	2013	5,700	5-10
Bursa Transport Cereale (Grain Transport Exchange)	2020	1,400	1-5

Source: Own processing based on public data obtained from Facebook platform.

•Older Groups with Larger Memberships:

Groups that were established earlier, such as *Agricultura Românească* (Romanian

Agriculture, 2010) and *Vânzări Tractoare și Utilaje Agricole* (Tractors and Agricultural Equipment Sales, 2010), tend to have larger memberships and higher activity levels compared to newer groups. This reflects the fact that older groups have had more time to establish trust and build a community. Over time, these groups have become recognized platforms where farmers can seek advice and engage with peers. The longevity of these groups also implies a steady growth in their reputation, making them trusted sources for both newcomers and experienced farmers. The higher activity levels in older groups suggest that more experienced farmers frequently participate, contributing to the reliability and continuity of the advice provided.

•Correlation Between Membership Size and Activity:

There is a general correlation between membership size and activity levels. For example, groups like *Agricole* and *Tractoare și Utilaje Agricole de Vânzare*, both of which have over 100,000 members, demonstrate consistently high post frequencies, often exceeding 30 posts per day. This suggests that as groups grow larger, the diversity of the membership base increases, leading to more frequent interactions and a wider range of topics being discussed. It also points to the importance of critical mass in social media communities: once a group reaches a certain size, it becomes self-sustaining in terms of activity and engagement.

•The Importance of Focus in Group Activity:

Groups like *Boli și Dăunători în Agricultura României* and *NO-TILL România*—though smaller in size—demonstrate that focused topics can also drive engagement. These groups have a smaller but more engaged user base because their members share a common interest in highly specialized agricultural issues. The specificity of these groups makes them attractive to farmers who are looking for expert-level discussions on topics such as pest control or sustainable farming techniques. The niche appeal of these groups likely results in higher-quality interactions, as the discussions are driven by farmers seeking targeted advice rather than general information.

•The Role of Newer Groups:

While older groups like *Agricultura Românească* dominate in terms of size and activity, newer groups such as *AgroSubvenții* (Agro Subsidies, 2021) and *NO-TILL România* (2021) have also quickly attracted sizable memberships and demonstrate active engagement, despite being relatively new. This points to the fact that newer groups can grow rapidly if they tap into emerging trends or unmet needs within the agricultural community. For instance, *NO-TILL România* has seen strong interest in conservation agriculture, a topic gaining traction in recent years due to concerns about soil health and sustainable farming practices.

•Group Size as an Indicator of Group Maturity:

The relationship between the year of establishment and group size reveals that older, more established groups tend to have larger memberships. For example, groups like *Agricultura Românească* (52,400 members) and *Vânzări Tractoare și Utilaje Agricole* (105,000 members) were founded in 2010, giving them ample time to accumulate a substantial number of members. In contrast, newer groups such as *AgroSubvenții* (2021) or *NO-TILL România* (2021) are still in the growth phase, although they already exhibit notable activity and participation rates. The maturity of a group often correlates with increased trust and engagement among members, further solidifying the group's role as a reliable source of information.

•Increased Activity in Equipment-Oriented Groups:

Groups with a strong focus on machinery and equipment, such as *Tractoare și Utilaje Agricole de Vânzare* and *Agricole*, stand out in terms of both membership size and post frequency. The consistent high activity in these groups underscores the critical role that machinery and agricultural equipment play in Romanian farming. For many farmers, purchasing affordable, reliable equipment is essential for improving farm productivity, and these groups provide a vital marketplace for the exchange of second-hand machinery. Furthermore, the peer-to-peer nature of these transactions helps farmers avoid intermediary costs, making the groups a preferred platform for equipment trade.

•Diverse Range of Activity Levels:

While some groups consistently maintain high levels of activity (e.g., *Tractoare și Utilaje Agricole de Vânzare* and *Agricole*), others such as *Bursa Transport Cereale* (Grain Transport Exchange) have fewer daily posts. This suggests that group activity is closely tied to the specific needs of the members. For example, groups focused on machinery and equipment sales tend to have high-frequency posts due to the transactional nature of the group, whereas groups centered around consultation or knowledge exchange (e.g., *Ingineri Agronomi*) might see fewer, but more in-depth discussions.

Users' profile and professional focus

A significant number of full-time farmers dominate many of the groups, indicating their practical and professional focus.

1.Full-time farmers as primary contributors:

Groups like *Agricultura Românească* (80% full-time farmers) and *Comerț cu Cereale, Utilajeși Produse Agricole* (70%) primarily serve those who rely on agriculture for their livelihood. The high proportion of full-time farmers suggests these platforms play a key role in managing farm operations, providing practical advice and facilitating the trade of essential agricultural equipment. Their participation leads to more in-depth discussions, especially concerning machinery, inputs, and crop management.

2.Engagement from part-time farmers and other occupations:

In groups like *Agricultura* (40% full-time farmers, 40% users from other occupations), a broader participant base includes part-time farmers and individuals with different professions. These users seek agricultural advice for small-scale or hobby farming, contributing to more diverse, though possibly less specialized, discussions. In groups like *Bursa Transport Cereale* (60% users from other fields), the platform caters to individuals involved in ancillary industries such as logistics and supply chains, enriching conversations with their expertise in transportation, trade, and operational challenges.

3.Part-time farmers and agricultural Enthusiasts:

Groups like *AgroRomânia* (65% full-time, 20% part-time farmers) reflect a balance between professional engagement and amateur interest. Part-time farmers often participate for supplementary income or personal improvement, contributing to discussions on best practices for small-scale farming or balancing agriculture with other careers.

4.The role of other occupations: the high percentage of users from non-agricultural sectors in groups like *Bursa Transport Cereale* emphasizes the interconnectedness of agriculture with industries like logistics and machinery repairs. These participants add valuable insights into operational aspects of farming, ensuring discussions cover broader topics such as transportation, machinery maintenance, and market access, alongside crop production.

Discussions focus and user engagement levels vary significantly depending on the group's focus, whether general farming, specialized areas, or commercial activities.

General agricultural discussions: Groups like Ingineri Agronomi (50% of posts), Agricultura (60%), and Agricultura România (55%) focus on broad farming topics, including crop rotation, soil health, and equipment maintenance. These discussions reflect a community-driven approach, catering to farmers of varying expertise who share practical advice and experiences.

Specialized groups for targeted advice: Groups such as Boli și Dăunători în Agricultura României (80% focused on plant protection) and NO-TILL România (90% focused on no-till farming) cater to those seeking specialized advice. The technical discussions often involve expert insights on pest management, disease control, and sustainable farming practices, offering highly relevant and practical solutions.

Commercial activities and marketplace engagement: Groups like Tractoare și Utilaje Agricole de Vânzare (90% machinery sales) and Comerț cu Cereale, Utilaje și Produse Agricole (85% sales-related posts) serve as virtual marketplaces for agricultural equipment. Farmers use these groups for peer-to-peer transactions, with less emphasis on knowledge exchange and more on facilitating trade.

Quality of questions and discussions

As presented in Table 2, 67.6% of the questions posed are relevant, targeting specific farming challenges like crop protection and machinery maintenance. Groups like Ingineri Agronomi and Agricultura Românească show 80-90% well-formed, actionable questions, while groups like Agro TV and Comerț cu Cereale have a 50-50 mix of pertinent and non-pertinent questions, reflecting a wider range of participant expertise.

Non-pertinent questions, accounting for **32.4%**, usually reflect a lack of specific agricultural knowledge or experience from the poster. These posts are often repetitive, unspecific, or focused on topics that have been discussed previously, which may dilute the quality of the overall discussion.

Response quality and engagement

The responses quality within the groups is similarly varied, reflecting the decentralized and informal nature of the consultancy process. As presented in Table 2 and Figure 1, the analysis highlights four key categories of responses: detailed and correct answers, correct but incomplete answers, ironic responses, and incorrect answers.

Table 2. Quality of responses and discussions engagement

Facebook group name	Pertinent Questions	Incoherent Questions	Detailed Correct Answers	Incomplete Correct Answers	Ironic Answers	Wrong Answers
Ingineri Agronomi	80%	20%	40%	30%	20%	10%
Agricultura	70%	30%	30%	40%	20%	10%
Agricultura in Romania	90%	10%	50%	20%	10%	20%
Agro TV	50%	50%	30%	20%	30%	20%
Boli si Daunatori in Agricultura Romaniei	60%	40%	50%	30%	0%	20%
Tractoare si Utilaje Agricole de Vanzare	60%	40%	50%	30%	10%	10%
Agro Romania	70%	30%	60%	20%	10%	10%
Bursa Transport Cereale	80%	20%	40%	40%	10%	10%
Comert cu Cereale, Utilaje si Produse Agricole	50%	50%	30%	20%	20%	30%
Agricole	60%	40%	20%	30%	10%	40%
Agricultura Romaneasca	90%	10%	60%	20%	10%	10%
Agricole de vanzare	70%	30%	70%	10%	10%	10%
AgroSubventii	40%	60%	30%	20%	10%	40%
NO-TILL ROMANIA	80%	20%	40%	30%	30%	0%
Agronetgrup	50%	50%	70%	20%	0%	10%
Agricultura Romaniei (Poze&Videoclipuri)	60%	40%	60%	20%	10%	10%
Vanzari Tractoare si Utilaje Agricole Romania	90%	10%	70%	10%	10%	10%
Average	67.6%	32.35%	47.0%	24.1%	12.9%	15.8%

Source: Own processing based on public data obtained from Facebook platform.

1.Detailed and correct answers:

Approximately 44.7% of the responses are categorized as detailed and accurate, indicating that a large portion of the group members possess practical expertise in agriculture. These responses often come from experienced farmers, agronomists, or other professionals who have both the knowledge and willingness to provide helpful, thorough advice. Groups like *NO-TILL România* and *AgriculturaRomânească* excel in this category, where a majority of responses offer detailed explanations and guidance.

This high percentage of detailed responses reflects the role these groups play in fostering a sense of community, where members actively seek to help each other improve their farming practices.

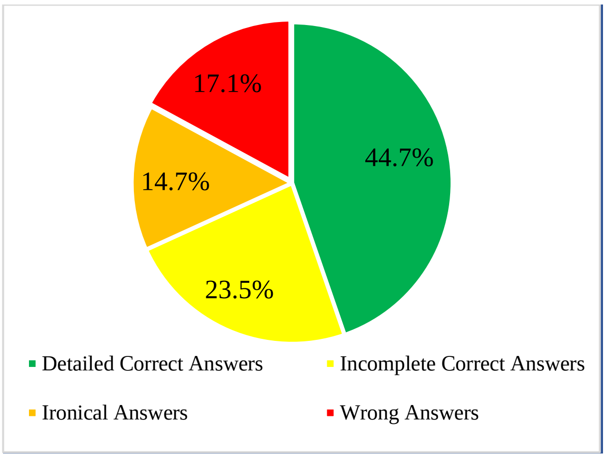

Fig. 1. Responses' quality
Source: own calculations.

2.Correct but incomplete answers:

•23.5% of the responses fall into this category. These answers, while technically correct, are often incomplete or too vague to provide full clarity on a problem. This often happens when the responder offers a brief solution but lacks the time or interest to elaborate on it.

•Groups such as *Ingineri Agronomi* and *AgroRomânia* showcase this type of engagement, where responses tend to address the question in part but leave the poster needing to conduct additional research or ask follow-up questions.

3.Ironic Responses:

14.7% of the responses are ironic or sarcastic in nature. While this is a relatively small percentage, it can still impact the quality of discourse within a group. These types of responses often occur in groups like *Agro TV* or *Comerț cu Cereale, UtilajeșiProduse Agricole*, where there is a broader mix of users, and questions can sometimes be seen as overly simplistic or redundant.

This kind of interaction may discourage new or less experienced members from participating, as they may feel belittled or dismissed.

4.Incorrect answers:

Alarmingly, 17.1% of the responses are incorrect, posing potential risks for those who follow them. This is particularly concerning in groups where members are making important decisions about crops, machinery purchases, or pest management.

The presence of incorrect answers suggests the need for a more structured or moderated approach to the information being shared. Without a verification mechanism, such as expert oversight or moderation, the prevalence of misinformation can cause harm, especially in critical areas like crop protection or the use of pesticides [6, 27].

Posting and engagement frequency

Another important dimension of the analysis is the engagement frequency, which varies significantly between groups. Some groups have upwards of **30 posts per day**, as seen in *Ingineri Agronomi*, *Tractoare și Utilaje Agricole de Vânzare*, and *Agricultura Românească*. The high posting frequency suggests that these groups are a central hub for daily consultations and interactions among farmers.

However, groups like *Bursa Transport Cereale* or *NO-TILL România* experience fewer posts (typically fewer than five per day), yet maintain a high engagement level through detailed and expert-led discussions. The lower volume of posts in these specialized groups does not reflect lower engagement but rather a focus on quality over quantity. Farmers may post less frequently but rely on these groups for in-depth advice and solutions to complex farming issues.

Member perception and responses satisfaction

Based on the data collected, Figure 2 presents scores on a scale of 1 to 10 for both the perceived quality of responses and the receptivity of the group initiators across various Facebook groups. These scores reflect an average assessment of interactions in each group.

The analysis revealed several key findings:

1.High scores for quality and receptivity:

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Groups like *Vânzări Tractoare și Utilaje Agricole* (Sales of Tractors and Agricultural Equipment) and *NO-TILL România* (focused on conservation agriculture) consistently scored high for both the quality of responses (8–9) and the receptivity of the initiators (8). These groups tend to foster high-quality interactions because of their focused nature. Discussions revolve around technical subjects like machinery sales or sustainable farming practices, where members are more likely to provide detailed and accurate advice. The high receptivity scores suggest that group members value and actively engage with these high-quality discussions.

2.Moderate scores for quality and receptivity: Several groups, such as *Agricultura* and *Bursa Transport Cereale* (Grain Transport Exchange), show moderate engagement and quality. These groups have a mix of transactional and informational posts, which explains the variation in scores. While members are generally receptive to replies, there is less depth in discussions compared to more specialized groups. In these groups, engagement tends to drop off after initial responses, with fewer follow-up questions or comments. The quality of responses often reflects this pattern, as replies tend to be shorter and more functional rather than detailed.

3.Lower scores for quality and receptivity: Groups like *Agro TV* and *Agricole de Vânzare* (Agricultural Products for Sale) score low for both response quality and receptivity. These groups are more focused on advertisements and sales, which could explain the lower interaction quality. Most discussions here center on buying and selling equipment or products, where the primary goal is to complete a transaction rather than engage in deep agricultural discussions. As a result, the quality of replies is often minimal, and initiators rarely follow up once the transaction is complete.

4.Impact of group focus on interaction quality: The focus of a group significantly impacts the quality of interactions. For example, *NO-TILL România* scored highly in both categories due to its niche focus on conservation agriculture, which attracts a smaller but more knowledgeable audience. In contrast, groups like *Agro TV*, which feature a mix of advertisements and occasional discussions, have lower scores because the engagement is less about exchanging knowledge and more about transactional efficiency.

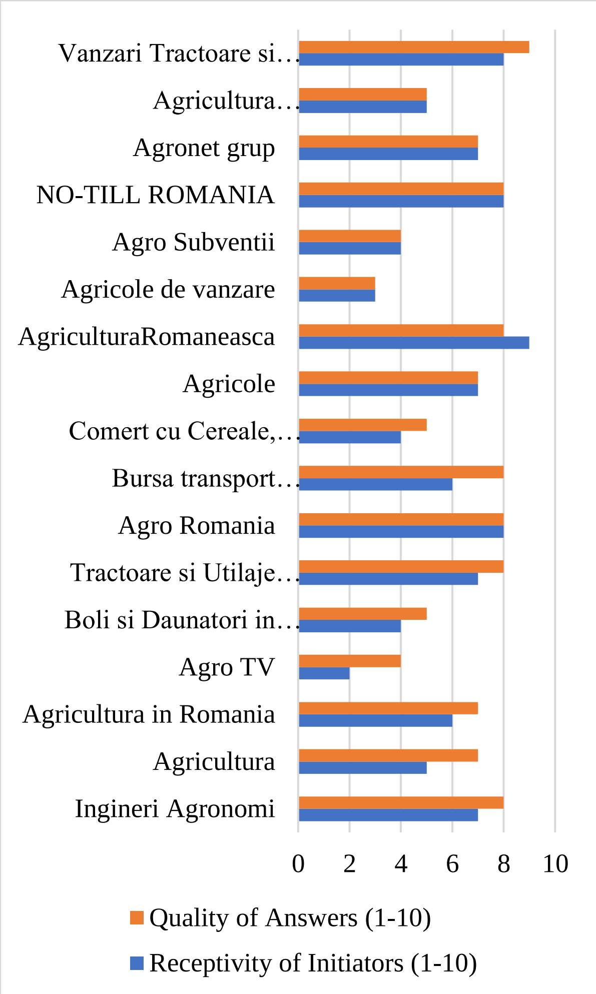

Fig. 2. Members' perception and satisfaction with responses
Source: own calculations

5.Variability in receptivity: The level of receptivity among group initiators varied widely across groups. In high-scoring groups like *Agricultura Românească* (Romanian Agriculture) and *AgroRomânia*, initiators were highly engaged, often asking follow-up questions and expressing appreciation for the answers. This level of engagement fosters a collaborative environment where discussions can develop into more nuanced conversations. Conversely, in lower-scoring groups, initiators often did not engage with replies beyond the initial question, leading to less dynamic interactions.

6.Overall trends: The analysis indicates that groups with a clear, focused purpose and an audience seeking specific information, such as *NO-TILL România* or *Ingineri Agronomi*, tend to foster higher-quality discussions and more engaged initiators. On the other hand, groups with a broad or commercial focus, such as *Agricole de Vânzare* or *Agro TV*, are more transactional, resulting in lower-quality interactions and less initiator engagement.

The data also sheds light on how members perceive the quality of the responses they receive. In groups such as *Vânzări Tractoare și Utilaje Agricole* and *Agricultura Românească*, members generally express high satisfaction with the responses, rating them between 8 and 9 out of 10. This positive feedback likely stems from the detailed and correct answers prevalent in these groups, where the user base consists primarily of experienced farmers or professionals with considerable agricultural knowledge.

Conversely, in groups like *Agro TV* or *Agricole de Vânzare*, member satisfaction is lower, averaging 3 to 5 out of 10, due to the higher percentage of incorrect or sarcastic responses. This disparity in user satisfaction highlights the varied nature of these groups and emphasizes the importance of targeted group dynamics for high-quality interaction.

SWOT analysis of informal agricultural consultancy in Romanian Facebook groups and its potential alignment with a formal extension system

Strengths:

1.Accessibility and Flexibility:

•Romanian Facebook groups provide accessible platforms for farmers to connect and share knowledge. This informal consultancy offers flexibility that allows farmers to ask questions and share experiences from any location. Compared to formal extension services, the ease of access through social media facilitates rapid exchanges of information.

•Similar to the American Extension System, which connects farmers with local agents for tailored advice, Romanian groups allow immediate feedback and create networks of farmers who offer insights based on real-world experience. However, unlike the structured U.S. extension, the informal nature of these platforms means that participation is voluntary and the advice unregulated.

2.Peer-to-Peer Knowledge Sharing:

•Informal Facebook groups in Romania encourage peer-to-peer knowledge sharing, allowing members to offer advice on common agricultural challenges, from machinery purchases to crop protection. The benefit here is that farmers can receive firsthand, practical advice from others who have faced similar problems, making the knowledge applicable and grounded in real-world experiences.

•While the U.S. extension model supports peer learning, it is usually guided by agricultural experts and extension agents, ensuring that information is backed by scientific research. The informal system in Romania lacks this formal oversight but is highly adaptable, as it is driven by the immediate needs of the farmers.

3.Community Support and Engagement:

•Facebook groups provide a sense of community among farmers, especially in rural areas where formal consultancy may not be available. They facilitate the exchange of moral and professional support, similar to how the American extension system builds strong farmer networks through field days and workshops.

•The informal discussions allow for a relaxed, open exchange of ideas, which can foster engagement among farmers who might not typically participate in formal systems. This dynamic interaction is beneficial for those in remote areas, as it provides an alternative source of consultancy.

4.Specialization in Niche Areas:

•Some Facebook groups focus on specific agricultural challenges, such as pest control (*Boli și Dăunători în Agricultura României*) or sustainable farming practices (*NO-TILL România*). These specialized groups allow for targeted discussions that attract farmers seeking expert advice in those particular areas [2].

•While the American extension system offers specialized advice through formal channels, these Romanian groups provide a platform where farmers can discuss niche topics in a more informal, accessible way, allowing for practical and immediate solutions.

Weaknesses:

1.Lack of Scientific Rigor and Verification:

•A significant weakness of the informal consultancy provided by Romanian Facebook groups is the lack of scientific oversight. In the U.S. extension model, advice is provided by trained professionals backed by university research, ensuring the information is accurate and up-to-date. Romanian groups, by contrast, rely on anecdotal knowledge, which may be outdated, inaccurate, or harmful if applied incorrectly.

•This absence of a formal extension system means there is no mechanism to validate the information being shared, which could lead to poor decision-making or inefficient farming practices. While the platform is useful for quick exchanges, the lack of verified, research-backed data is a major drawback.

2.Inconsistent Quality of Information:

•The quality of information in Romanian Facebook groups is inconsistent, varying from highly informed advice to less reliable suggestions. Unlike the U.S. system, where extension agents ensure that all farmers receive high-quality, standardized information, Romanian farmers must sift through diverse opinions, often with no clear consensus.

•For example, discussions in groups like *Agro TV* and *Agricole de Vânzare* tend to focus more on transactions and less on agronomic advice, leading to gaps in practical, evidence-based knowledge. The informal nature means that some discussions are not as helpful or reliable as those provided through structured, formal channels like the U.S. extension service.

3.No Formal Training for Contributors:

•While U.S. extension agents undergo formal training and continuous education to provide scientifically validated advice, Romanian Facebook group members are not formally trained, and their advice is based on personal experiences. This can lead to the dissemination of incomplete or incorrect information, especially on technical issues like pest control, crop management, or machinery repair.

•The absence of easy access to trained agricultural consultants means that many Romanian farmers may be missing out on the latest innovations and best practices in agriculture, something that the American model of extension successfully addresses by regularly updating farmers through training and outreach programs.

4.Fragmentation and Lack of Coordination:

•In the U.S. system, extension services are coordinated through universities, local offices, and government programs, providing a unified approach to agricultural consultancy. Romanian Facebook groups, on the other hand, are fragmented, with no overarching structure or coordination between groups. This fragmentation can result in a lack of comprehensive support for larger agricultural challenges, such as climate change adaptation, market integration, or technological advancements [9, 24].

•Without a formal extension service, Romanian farmers are left to rely on piecemeal advice from a variety of uncoordinated sources, making it difficult to address systemic agricultural issues on a national scale.

Opportunities:

1.Adapting Aspects of the U.S. Model:

•Romania could benefit from integrating elements of the U.S. extension system into its informal consultancy. Facebook groups could serve as a starting point for a more formal agricultural extension program, where trained agricultural experts offer regular, evidence-based advice within these online communities [13].

•This hybrid approach would allow Romania to maintain the flexibility of informal groups while incorporating the scientific rigor and structure of the U.S. extension model. For example, university-led webinars or Q&A sessions within Facebook groups could provide more reliable information to farmers [11].

2. Incorporating Digital Tools:

•As seen in the U.S., where extension services increasingly use digital tools, Romania could introduce more structured, technology-driven solutions. For instance, AI-powered chatbots could be integrated into Facebook groups to answer frequently asked questions or provide basic advice, supplementing the informal peer-to-peer exchanges with validated information.

•Virtual consultations with agricultural experts could also be offered as part of a formal extension service, ensuring that farmers receive accurate and timely advice tailored to their specific needs.

3.Developing a Formalized Agricultural Extension System:

•Drawing from the U.S. example, Romania could develop a formal agricultural extension system that complements the existing informal Facebook groups. Such a system would provide farmers with access to trained extension agents who can offer personalized advice based on research. This would not only improve the quality of information but also help farmers understand and address broader very important challenges, such as climate adaptation, market expansion, and farm modernization [16].

•A formal extension service, modeled after the U.S. system but adapted to local needs, would bridge the gap between informal knowledge exchanges and the need for research-based, scientifically valid solutions.

4.Enhancing Farmer Education:

•Romania could also use these platforms to enhance farmer education by offering online courses, webinars, and training sessions on best agricultural practices. This would allow Facebook groups to evolve into more structured educational platforms, offering real-time learning opportunities for farmers.

•By partnering with universities and research institutes, these groups could provide more formal educational resources to help farmers stay updated with modern farming techniques.

Threats:

1.Over-Reliance on Informal Consultancy:

•A major threat is the over-reliance on informal consultancy, which may limit the development of a formal, structured agricultural extension system in Romania. If farmers continue to rely solely on Facebook groups for advice, they may miss out on scientifically validated solutions and the benefits of formal training.

•Unlike the U.S. model, which integrates both formal education and peer-to-peer learning, Romanian farmers may become too dependent on informal advice, which could hinder agricultural progress and innovation in the long term.

2.Misinformation and Lack of Moderation:

•The lack of moderation in Facebook groups means that misinformation can spread quickly, leading to poor agricultural decisions. Without trained professionals to verify the accuracy of the information shared, farmers are at risk of adopting ineffective or even harmful practices.

•The American extension system mitigates this risk through trained agents who ensure that all advice given is evidence-based and accurate. The lack of such safeguards in Romanian Facebook groups represents a significant threat to the long-term success of agricultural consultancy [29].

3.Absence of Government Support:

•Without government investment in a formal extension system, Romania risks perpetuating a fragmented and uncoordinated approach to agricultural consultancy. The U.S. system is heavily supported by both federal and state governments, ensuring nationwide access to agricultural services [28].

• In Romania, the lack of a coordinated policy to develop agricultural consultancy could result in ongoing reliance on informal networks, which may not be sustainable in the face of future agricultural challenges.

4.Challenges in Scaling a Formal System:

•Implementing a formal agricultural extension system in Romania similar to the U.S. model would require significant resources and infrastructure development. Scaling this type of system may prove difficult without the necessary government support and financial investment.

•The risk is that informal Facebook groups may remain the primary source of consultancy for many farmers, leaving the agricultural sector vulnerable to misinformation and underdeveloped practices.

CONCLUSIONS

The study reveals the significant role that informal agricultural consultancy via Facebook groups plays in Romania, particularly in light of the absence of a formal agricultural extension system. With limited access to structured agricultural support, Romanian farmers have increasingly turned to online platforms, such as Facebook, for information sharing and peer-to-peer advice.

These groups provide a dynamic space where farmers address pressing issues like machinery maintenance, pest control, and the adoption of sustainable farming practices, all in real-time.

While the accessibility and community-driven approach of these platforms are clear benefits, the study identifies significant drawbacks. Chief among these is the inconsistent quality and accuracy of the information shared, often influenced by a lack of expert oversight and professional moderation. This can lead to misinformation or ineffective practices being adopted. Furthermore, the digital divide limits participation, as many farmers in rural or remote areas may lack reliable internet access or digital literacy, which reduces the inclusivity and reach of these online communities.

There are promising opportunities, particularly in integrating these informal networks with a formal agricultural extension system, similar to the American model. A hybrid approach could leverage the grassroots knowledge-sharing dynamics of Facebook groups while providing reliable, expert-backed guidance and structured educational resources. Sustainable practices, like no-till farming, which are increasingly gaining traction, could also benefit from this dual system of informal and formal consultancy.

However, the risks associated with misinformation, reliance on social media platforms, and the continued absence of a comprehensive extension service remain substantial. Without regulatory oversight or expert intervention, harmful agricultural practices could spread unchecked, leading to negative impacts on crop yields, soil health, and overall farm sustainability. The study also emphasizes the growing dependency on platforms like Facebook, which are subject to policy changes that could further disrupt these informal advisory channels.

In conclusion, while Facebook groups serve an essential role in filling the gap left by Romania’s lack of a formal extension system, they are insufficient as a stand-alone solution. A robust, well-funded formal extension system, drawing on successful international models and supplemented by digital tools and community engagement, is crucial for advancing Romanian agriculture and supporting rural development. This study provides a foundational analysis of the current state of informal consultancy in Romania’s agricultural sector, but more in-depth research is necessary to develop a comprehensive framework that combines both informal and formal agricultural extension services for maximum effectiveness.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

WEB PLATFORM FOR LEVERAGING THE TOURISTIC POTENTIAL OF ARGEȘ COUNTY, ROMANIA. CASE STUDY: PROMOTING THE LOCALITY OF NUCȘOARA

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Abstract

Located in the northern part of the Muntenia region, Argeș County benefits from the beauties that nature has generously provided. The Romanian relief is varied and spectacular, but in few regions can the grandeur of a sunset or the flavor of leaves moistened by mountain dew be fully captured. In a single place, the traveller can perceive the historically rich aroma of the streets of Golești and refresh themselves in the frozen breeze of the Transfăgărășan. This place, this natural amphitheater, is "Little Romania" or, according to the administrative map, Argeș County. Therefore, the concept of tourism seems at home when we talk about the mountain areas of the Făgăraș Mountains that belong to the Argeș territory. This work aims to exemplify modern techniques for promoting tourism. Promotion refers to the set of informational means, activities, and methods used to capture the attention of potential tourists to meet their needs and desires. In this work, we focused on the online promotion of tourist destinations. To this end, we went through the stages of creating a presentation website for the locality of Nucșoara. Currently, many people opt to search for certain information via the Internet, thus there are numerous advantages to this promotional method, which we have also mentioned in this work.

Key words: *Argeș, Nucșoara, promotion, tourism*

INTRODUCTION

Argeș County, named after the river that flows through it, encompasses the distant and little-known history of the ancestors of the Romanian people. A homeland whose antiquity stretches back into the mists of time, the county has gathered in its depressions and wide, fertile valleys a large population whose administrative and political organization has evolved over time. By 1247, the first Romanian administrative entity had been established in these lands, though the term "Argeș County" was first mentioned in documents in 1437 [9], [12].

Like all the counties at the southern foot of the Southern Carpathians, Argeș also has an elongated shape along the north-south axis. Located in the upper Argeș Basin, it borders the counties of Sibiu and Brașov to the north, with the high ridges of the Făgăraș Mountains, the highest mountain range in Romania, and the Piatra Craiului as the separating boundaries. To the east, it borders Dâmbovița County, with the Leaota Massif's ridges, rolling hills, and plains as the boundary. To the south, Argeș adjoins Teleorman County, sharing the Găvanu-Burdea Plain, and to the west, it borders the counties of Olt and Vâlcea, with the boundary following the watershed between the Olt, Argeș, and Vedea Basins [6].

The area of Argeș County is 6,826 km², representing 2.9% of the country's total area, making it the 11th largest in terms of size. Located in the south of the country, Argeș County is "cut" in two by the 45° north latitude parallel and is traversed to the east by the 25° east longitude meridian.

The county successively features all three characteristic landforms from north to south: mountains, hills, and plains. Hills predominate, covering more than half of the area. The mountains account for 25% of the county's territory and are part of the Southern Carpathians, specifically the southern slope of the Făgăraș Massif, which extends between the

Rucăr-Bran Corridor and the Olt Defile. The Sub-Carpathian hilly area covers 55% of the county and consists of the Getic Sub-Carpathians and the Getic Plateau, which is further composed of the Cândești, Argeș, and Cotmeana platforms. The Sub-Carpathians are characterized by a mix of small mountains, which only occasionally exceed 1,000 meters in altitude, with average heights of 800 meters. The transition from the Sub-Carpathians to the plateau hills occurs through a lower contact zone, consisting of small depressions, such as those at Curtea de Argeș and Domnești. The plain area represents 20% of the territory and extends across the southern part of the county. In its northern part, the character is piedmont, marked by the terraced plains of the Argeș River [1], [3], [4].

Photo 1. Podu Dâmboviței Village, Argeș
Source: https://www.romanianresorts.ro/[13].

The relief of Argeș County varies from north to south and presents itself as a natural amphitheater, encompassing a succession of characteristic steps: the Găvanu-Burdea Plain (150 m), the Plateau (with heights of 800 m), and the Getic Sub-Carpathians (with vineyards and orchards, and hills exceeding 1,000 m in altitude), the Făgăraș Mountains (including Moldoveanu Peak at 2,544 m, the highest point in the country, and Negoiu Peak at 2,535 m, as well as the Iezer-Păpușa, Leaota, Piatra Craiului Massifs, and the Rucăr-Bran Corridor).

Argeș County partially encompasses the Cândești and Cotmeana Piedmonts and entirely includes the Argeș Piedmont (Argeș Hills). The Romanian Plain constitutes the lowest step of the county's relief, with two subunits: the High Plain of Pitești (entirely) and the Găvanu-Burdea Plain (partially). The Găvanu-Burdea Plain is located to the east, while the valleys of the Olt and Argeș rivers extend to the west. Argeș County boasts exceptional tourism potential, placing it in a prominent national position in this field. Nature's generosity has provided the Argeș lands with various forms of beauty, from the splendor of the Făgăraș Mountains' peaks in the north to the majestic expanse of the Pitești and Găvanu-Burdea plains in the south. All these natural riches create a marvelous land with unique picturesque qualities that, when properly valorized, have the potential to significantly enhance tourism, though it has not yet reached its true potential [1], [4], [7].

The mountainous area, which represents a quarter of the county's territory, offers exceptional attractions: gorges, waterfalls, caves, lakes, numerous marked trails, and opportunities for climbing and skiing. Mountain tourism is practiced within two main areas: the Câmpulung area and the Curtea de Argeș area. In Argeș County, there are 22 climbing routes, 20 hiking trails in the Făgăraș Mountains, 15 hiking trails in the Iezer-Păpușa Mountains, 4 hiking trails in Piatra Craiului, and 7 hiking trails in the Leaota Mountains [7].

The Dâmbovița Valley and Gorges partly define the picturesque landscape of the Rucăr-Dâmbovicioara area (Photo 1), characterized by successive series of gorges. The rich vegetation, sparkling and cold waters, and the fact that some of the gorges (from Cetățeni) have been declared a natural reserve, along with the Dâmbovicioara Cave (30 km from Câmpulung), enhance the excitement of a journey through this valley [13].

Photo 2. Vidraru Dam and Lake
Source: https://www.infoghidromania.com/[8].

Vidraru Lake, an accumulation lake dammed by the impressive Vidraru Dam, which is part of the Argeş Hydroelectric Power Plant, is situated between the stone walls of the gorges (166 meters high) (Photo 2). Downstream from Vidraru, a chain of lakes has been constructed, accompanied by small hydroelectric plants: Oneşti, Cerbureni, Curtea de Argeş, Zigoneni, Bascov, and Ștefănești [8].

In the municipality of Curtea de Argeș, you can visit the Curtea de Argeș Court Ensemble, the Curtea de Argeș Monastery Church, the Fountain of Master Manole, and the Local History Museum, as well as the ruins of the Sân Nicoară Church (a historical monument from the late 13th century). Additionally, the county offers other anthropic tourist attractions such as: Poenari Fortress, Negru Vodă Fortress, the Corbii de Piatră, Nămăiești, and Cotmeana Monasteries, the Mateiaș Heroes' Mausoleum (Photo 3), the Brătianu Family Mansion in Ștefănești, and the Golești Museum of Viticulture and Pomology [1], [16]

Photo 3. The Mateiaș Heroes' Mausoleum
Source: Wikipedia [16].

In this contest, this study aims to exemplify modern techniques for promoting information about the tourism potential of the Arges County highlighting its special attractions which to capture the attention of potential tourists and to meet their needs and desires.

MATERIALS AND METHODS

Rural tourism occupies a distinct place in economic, social, and geographical practice, as a phenomenon that has developed over time. It has been practiced spontaneously, but recently it has expanded significantly due to several factors, such as urban expansion, increased transportation possibilities, and, not least, the rise in the financial resources of the population. Rural tourism primarily represents an economic component of the broader tourism sector and, secondly, a part of the economic base of rural settlements. Additionally, rural tourism serves as a means of nature conservation, a method of education, and an enhancement of the quality of life for those who engage in this wonderful activity. In Romania, rural tourism was practiced for a long time in an unorganized manner, stemming from the tourists' need to find affordable accommodation with a high level of comfort. Starting in 1989, the certification and classification of these accommodation spaces were implemented, simultaneously improving the range of services. More and more villagers began opening their homes to tourists. The first forms of organized rural tourism appeared in the Rucăr-Bran area, and later ANTREC was established. The National Association for Rural, Ecological, and Cultural Tourism in Romania (ANTREC) is a non-governmental, non-profit organization founded in 1994. It is a member of Eurogites under the patronage of the European Federation of Rural Tourism [11].

Rural tourism can be classified into several categories depending on the specific characteristics of the area where tourism activities take place. This has led to the emergence of terms such as ecological tourism, cultural tourism, thematic tourism, and, notably, agritourism. While rural tourism and agritourism are two distinct concepts, they do overlap to some extent.

Promotion or advertising is the fourth and most crucial element of the marketing mix for rural tourism, with the other elements being price, market, and product, each of significant importance.

Promotion encompasses the entire range of informational tools, activities, and methods used to attract potential tourists to satisfy their needs and desires and, implicitly, achieving a significant increase in the economic efficiency of the tourism services and products offered. The complementary use of promotional techniques and tools is essential and defining for the promotional mix. The components of the promotional mix are advertising, direct selling, public relations, and sales promotion, with advertising being the most effective component among these [2], [10].

Advertising is the primary method for promoting a region or tourism products and services. Within this framework, the following aspects can be distinguished:

-***Media Advertising*** - this involves distributing information through television and radio;

-***Outdoor Advertising*** - this involves creating various types of advertising panels, such as billboards and posters;

-***Direct Advertising*** - this consists of distributing information via electronic mail or telephone;

-***Online Advertising*** – this includes creating tourist or agritourism guides and speciality magazines [2].

Online Methods for Promoting Rural Tourism

The Internet has its origins in 1968, when the United States government aimed to connect universities, military departments, and defense agencies to facilitate collaboration on joint research projects. Today, the Internet is not only a very fast way to send emails but also a platform for socializing, acquiring information on a wide range of topics of interest, viewing and downloading high-quality films and music, and promoting various goods, services, or even regions, villages, and cities to increase their visibility and generate new revenue. The fundamental principle of the Internet's operation is based on the idea that two or more computers can communicate with each other. For this to be possible, it is essential to have a protocol or set of standards that each computer must follow to enable the exchange of information.

A Website refers to a collection of web pages that are accessible to anyone via the Internet. These pages usually share a common theme and are connected through hyperlinks. Websites can be created and managed by any entity, including companies, user networks, individual persons, or public institutions. The creation of web pages is typically done using HTML, or HyperText Markup Language. This language is designed to format and present information in a structured manner [17].

The concept of online promotion is increasingly utilized today and can be conducted through various means such as search engines, email, social networks, forums, blogs, and even by listing in specialized directories.

Search engines are essentially web pages created out of the need to organize and make the information available on the Internet more accessible. They index millions of other pages on the World Wide Web. When an individual searches for information on a particular topic and types in a keyword or phrase, the search engine scans its entire database of previously indexed pages. It then returns a list of pages considered most relevant to the search query.

Email is another effective method of online promotion, involving the sending of electronic messages to potential tourists to promote a specific website or other related content.

Social networks are also web pages where individuals can create accounts for socializing. However, in recent times, they have increasingly been used by various companies for promotional purposes. The most popular social networks currently are Facebook, Instagram, and X (former Twitter).

Forums and blogs are also excellent methods of promotion. A forum is an online discussion page where individuals can engage in conversations on specific topics. A blog, like a forum, is a web page that features articles on various subjects. It is frequently updated and can serve either as a personal journal or a promotional tool. One of the most well-known blogging platforms is WordPress.

Directories are web pages or portals specialized in certain fields such as medicine, tourism, the automotive industry, economics, etc. Listing in specialized directories can be done in exchange for a subscription fee, which may vary based on the listing options. Listings can be basic or placed in special categories, and there is also the possibility of customizing the web page entry by adding a personalized logo.

RESULTS AND DISCUSSIONS

Creating a website to promote rural tourism in Nucșoara

The commune of Nucșoara is located in the Subcarpathian area of the Southern

Carpathians, at the foot of the Făgăraș Mountains, on the upper course of the Doamnei River, in the northern part of the county, bordering Brașov County. All the valleys originating within the territory of Nucșoara commune are tributaries of the Doamnei River. The Doamnei River springs from the southern slopes of the Făgăraș Mountains. Upon reaching the village of Slatina, at a point known as “Gura Cernatului,” it meets one of its main tributaries, the Cernatul River. The Cernatul River originates from beneath the Malita Peak (2,247 m) and flows through numerous waterfalls before joining the Doamnei River [12].

A multitude of beautiful lakes can be found in the hilly area of the commune, as follows:

-Vulpoaia Lake - which is located in the village of Sboghitești at a place known as “La Vulpoaia”. This lake is surrounded by fir trees and is home to fish species such as the crucian carp and the minnow.

- “La Ferma” Lake - which is situated near the village of Slatina, at a location with the same name. This lake hosts the following types of fish: crucian carp, minnow, and common carp.

-In the commune, there are also several artificial lakes, created by the locals to have fish nearby. Two of these are located in the village of Nucșoara, at a place known as “La Măgura.” The most interesting is the lake in the village of Slatina, situated on the property of the Jubleanu Elena (Motor) family. This lake is stocked with fish and, being located in an exceptionally beautiful area, serves as an attraction for nature enthusiasts and fishermen.

-The most beautiful lake in the Nucșoara commune is "Învârtita" Lake (Photo 4) which is the only tectonic lake in the country [20].

In this area, we also find the natural reserves Pădurea Iedu-Cernat and the Iezer Natural Reservation. Pădurea Iedu-Cernat extends over 327 hectares and is managed by the Domnești Forest District. It is a beech forest located in the Nucșoara depression, within the basin of the Cernat River (a tributary of the Doamnei River). The reserve features a beech forest with the appearance of an ancient woodland, a lush, wild, and productive vegetation island that impresses with its majesty.

Photo 4. Învârtita Lake
Source: https://zigzagprinromania.com/[20].

The Iezer Natural Reservation covers approximately 300 hectares and is located in the Iezer-Păpușa massif. Access can be made via the Rucăr–Bran corridor or from the Făgăraș Mountains, crossing the Cremenii Peaks and the Ateneului Cross. The reservation includes the glacial valleys of Călțun and Iezer, as well as the Iezerul Mare Peak. It also encompasses Lake Iezer, which has an area of 8 hectares, with oligotrophic marshes along its shores that suggest the past existence of former wetlands and small ponds, where various moss species create a charming carpet. Notable plant species found here include mountain peony, alpine carnation, rooster's foot, mountain thyme, and many others [14], [15].

In this work, we have chosen to promote agrotourism in Nucșoara through the Internet, via a website. In addition to the "Homepage," the website also features the pages "Visit Nucșoara," "Accommodation," "Nucșoara Tour Offer," and "Contact." These pages are designed to provide visitors with the necessary information to encourage them to visit the commune of Nucșoara and its surroundings.

The stages of website creation

The services offered by the WordPress platform are complemented by the free services provided by the Webnode extension. Webnode is a surprisingly easy-to-use website creation platform. It doesn’t matter if you need a professional site for a company, an attractive portfolio, or an easily manageable online store—Webnode provides the perfect platform to create your website as you want it. Using Webnode, we can easily create websites without needing the services of designers or programmers. You simply choose one of the platform's templates and customize it in just a few minutes. The system is constantly improved and new features are developed to provide all the tools a person needs to create the perfect website—automatically generating a smart URL and sitemap.

WordPress is an open-source platform that describes the practice of producing or developing certain products, allowing users to freely engage in the production or development process for publishing blogs (Photo 5). The WordPress platform is written in PHP, used for managing databases in the MySQL system, and features a template system written in HTML and CSS. Its focus on aesthetics, web standards, and ease of use make it the number one choice among journalists, writers, and ordinary bloggers. Additionally, being available for free (as free software) allows for its free distribution and customization according to individual preferences.

Photo 5. The Official WordPress Website
Source: www.wordpress.ro [18].

The first step was downloading the application from the XAMPP server, from the official page, for the Windows operating system. The next step involved downloading WordPress from the official application page. The major advantages presented by WordPress are its simplicity, numerous plugins, and themes created by the internet community. A plugin is a program integrated into another base program to perform specific new functions or to extend or modify existing ones [19].

Next, XAMPP (Photo 6) was installed in the folder c:\xampp, where the Apache and MySQL services were selected. The Apache HTTP Server Project is an effort to develop and maintain an open-source HTTP server for modern operating systems, including UNIX and Windows. This project aims to provide a secure, efficient, and extensible server that ensures synchronization of HTTP services with current HTTP standards. Through any browser (Internet Explorer, Mozilla Firefox, Chrome, Safari, Opera, etc.), the local address "localhost" is accessed.

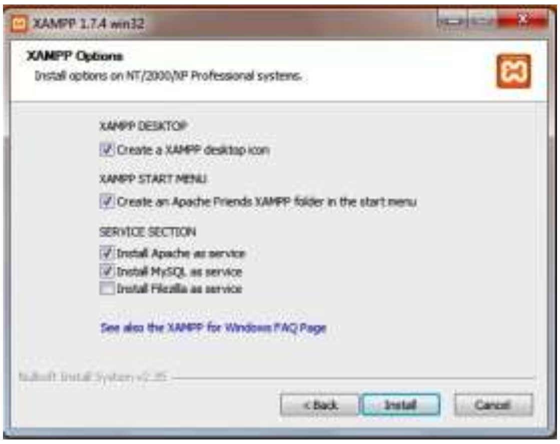

Photo 6. The XAMPP Website
Source: www.xampp.org [19].

The next step was installing WordPress, and the steps are presented below:
-extract the wordpress.zip file, which was downloaded previously.;
-copy the extracted "WordPress" folder to c:\xampp\htdocs\.;
-rename the "WordPress" folder to "Comuna Nucsoara" to specify its content.

The next step was to access the page "localhost/phpmyadmin" (in a separate browser window), where a new database was created so that WordPress could store the data for the site I was going to create. The database was aptly named "Comuna Nucsoara".

In the next step, I returned and configured WordPress to access the newly created database at "localhost/Comuna Nucsoara". Then, there were completed the details for the database name: username, password (for MySQL), database address (localhost), and table prefix (leaving it as the default: "wp_").

Following this, the initial site settings were made:
-site name: "Comuna Nucsoara";
-WordPress admin username: "admin";
-password;
-email for password recovery: "cristianciobanica@gmail.com" (created previously);
-under "private" I deselected "Allow my site to appear in search engines..." because this is a

demonstration site, and I do not currently want search engines such as Google, Bing, or Yahoo! to index its content.

The WordPress admin page allows for the creation and customization of the newly created site. From here, we can personalize the appearance of the site (colors, fonts, sizes), add, modify, or delete information pages, and maintain an integrated blog where we can post news, offers, and other information. Additionally, we have the option to customize the site menu, add images to pages or posts, and insert or set themes and add-ons (components installed later for the site's functionality) to enhance the user experience. The site design is represented by the layout and division on the page (header, footer, menu, etc.), the fonts used, colors, and overall dimensions. The WordPress platform integrates all of these elements into what is known as a "theme." [18], [19].

Description of the contents of the website

The online promotion platform for Comuna Nucșoara consists of a website that includes a significant portion of the information described in the previous chapter.

The main sections (menus) of the website are:

-"Homepage"

-"Visit Nucșoara", with the subsection "The Story of Elisabeta Rizea"

-"Accommodation", where links to sites with information about local guesthouses have been created:

- Carpatica Guesthouse
- Valea Doamnei Guesthouse
- Danvi Guesthouse
- Villa by the Morii Valley

- "Offer a Trip to Nucșoara"
- "Contact"

These sections should be standard for any presentation website. They are intended to provide visitors with the necessary information, which should be presented in a clear and comprehensible manner.

Homepage – this is the main page, which includes a series of general information about the tourist area of Nucșoara, located in the northern part of Argeș County (Photo 7).

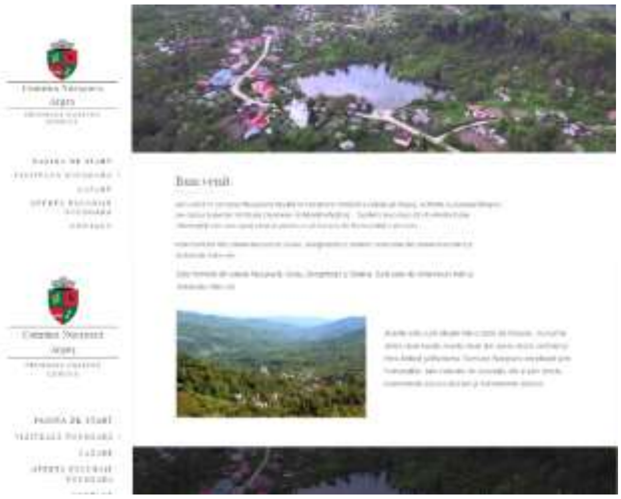

Photo 7. Website's homepage
Source: Own contribution.

"Visit Nucșoara" Section: The second section presents several stunning landscapes and reasons to visit Nucșoara (Photo 8 and 9).

Photo 8. "Visit Nucșoara" Section
Source: Own contribution.

Photo 9. "Visit Nucșoara" Section
Source: Own contribution.

Within the "Visit Nucșoara" Section, a subsection titled "The Story of Elisabeta Rizea" has been created. Elisabeta Rizea (1912-2003) from Nucșoara (Photo 10) is a symbol of the Romanian woman who fought against communism. In the anti-communist resistance group centered in Nucșoara, many residents from neighboring villages were drawn in, convinced by the calamities that the Bolsheviks would bring, while also hoping for Western assistance. What now seems like naivety was, at that time, desperation. In 1949, the arrests of the "haiduci" (outlaws) began, and those who remained free lived hidden in huts, on hills, and in the mountains. The Security forces sent so many people to Nucșoara and its surroundings that there were more security officers than residents. Elisabeta was arrested, interrogated, beaten, and tortured, and then imprisoned, but she did not reveal any secrets. After her initial release, she continued to help those who still opposed communism.

Photo 10. Subsection "The Story of Elisabeta Rizea"
Source: Own contribution.

The story of this woman and those who sacrificed themselves opposing the Bolshevik regime was first revealed in 1992, when she gave an interview to Lucia Hossu-Longin for the series "Memorialul durerii" (The Memorial of Suffering). She was visited in Nucșoara by former President Emil Constantinescu and the royal family. She had also known former King Michael I from childhood when he had attended a gathering in the village [5].

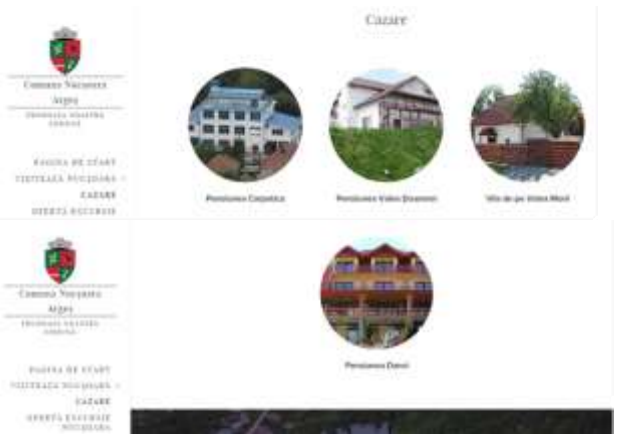

Photo 11. "Accommodation" Section
Source: Own contribution

In the "Accommodation" section (Photo 11), several lodging options operating within the territory of Comuna Nucșoara are displayed. Four such establishments are featured: Carpatica Guesthouse, Valea Doamnei Guesthouse, Villa by the Morii Valley, and Danvi Guesthouse. Each is represented by symbolic imagery with an attached link to other websites that promote their tourist activities and provide additional information for interested parties.

Photo 12. "Offer" Section
Source: Own contribution.

"Offer" Section (Photo 12). This section presents a tourist offer of 4 nights at Carpatica Guesthouse for an individual or a group of up to 28 people. The 5-day excursion is detailed with the itinerary and the places to be visited. Reservations can be made at the bottom of the page by completing a form or through the guesthouse's website (Photo 13).

Photo 13. Online Booking Form for the Stay
Source: Own contribution.

The final section of the website is titled "Contact" (Photo 14). This last page contains a list of contact information, including an email address, a phone number, and a Google map of Comuna Nucșoara.

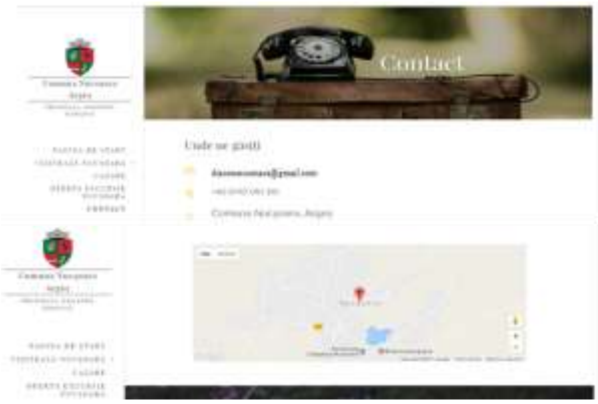

Photo 14. “Contact” Section
Source: Own contribution.

In a modest attempt to promote tourism in Argeș County, we have chosen to conduct a study on the locality of Nucșoara, with the following arguments:
Nucșoara excels in both its exceptional natural beauty and its historical past.
The villages of Comuna Nucșoara are situated in a transitional area, linking not only the hill-mountain and mountain-hill regions but also socially and historically between Transylvania and Muntenia, and vice versa. This offers the opportunity to distinguish the language, customs, and traditional attire of the Transylvanian locals from those in Wallachia.
Nothing has altered the dignity, love for the homeland, and ancestral customs of the inhabitants of Nucșoara, preserving the authenticity of the place.
The numerous marked mountain trails and the low levels of pollution in the air, water, and soil make Nucșoara an oasis of relaxation. Additionally, there are marked mountain trails with high difficulty levels for thrill-seekers.
We have chosen to analyze a modern technique for the online promotion of Comuna Nucșoara to increase its visibility, as the internet is a widely spreading and rapidly expanding medium [14].

CONCLUSIONS

As an element of the marketing mix, promotion is viewed as a means to acquire new customers, inform, and persuade. A company needs to make known and remind both current and potential customers of the advantages offered by its products and services (benefits such as product quality, an attractive price, warranty, after-sales services, etc., should be communicated to current and potential customers). To achieve maximum communication impact, the promotional mix must be effectively synchronized with all components of the marketing mix.
Among all the commercial communication methods used in practice by companies, advertising has been the most studied; numerous methods and techniques have been developed for it; more than in any other field, intuition and creative talent play an essential role here. Advertising has been and is most frequently viewed as a means to enhance sales, bring products manufactured in series out of anonymity, and as an indispensable tool for new retail systems. A characteristic of advertising is its ability to establish a certain connection between a producer/seller and a distant buyer. This would not have been possible without the decisive contribution of the media.
To better capitalize on the reception structures in Argeș County, more intense promotion through various advertising campaigns is necessary, by providing materials that highlight the strengths of this area and influence both Romanian and foreign tourists to visit these lands. Although Argeș County is of medium size and its natural tourist framework is elevated, it lacks the proper exploitation of its tourist potential, showing a lack of interest in this field, and it has not been utilized to its true value. It can be said that in the development of tourism in Argeș County, the accommodation component must be primarily considered, as it is essential to meet the increasingly varied demands of clients.
It is well-known that recently we spend more time in the virtual world than in the real one, as we socialize with people online and seek information and data about things that interest us also online. Nowadays, there are very few people who do not choose to search for certain information via the internet. Consequently, large companies have also chosen to promote their products and services in the virtual world,

where there are numerous advantages, including:

-The online environment represents an easily accessible and increasingly rapidly used medium.

-Advertising messages can be much more complex. They can include a range of images, sounds, and even small video presentations.-The space for promotion is unlimited.

-The online environment is the perfect research tool. It can accurately measure how many people have accessed certain information available on a web page and can suggest other web pages with similar content to the user.

-Through the internet, the consumer not only sees the advertisement but can also interact with other people to obtain information about a topic accessed—whether it be a product, service, or a particular region, county, tourist trails, tourist attractions, etc.

-Online promotion is significantly cheaper and more accessible, quickly reaching a very large audience share.

We believe that currently the best method of promotion is achieved through the internet due to its low costs and high accessibility, as well as the possibilities for interacting with website visitors to obtain information about their interests, to subsequently make improvements to the website.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

PREDICTIVE ANALYSIS IN RURAL ECONOMICS: TOOLS FOR PLANNING AND EVALUATING SUSTAINABLE INVESTMENTS

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Abstract

This article introduces a complex mathematical, economic model for analyzing rural economic development and guiding strategic decisions. Using specific data, it calculates global production, determines direct expense coefficients, and conducts a sensitivity analysis. Parameter adjustments are vital for aligning results with economic reality. The model provides insights for formulating economic policies, emphasizing the need for continuous adjustments amid economic changes. The article aims to analyze two branches of the rural economy through a detailed mathematical model, offering perspectives on economic interactions, optimal resource allocation, and facilitating strategic decision-making. Evaluating the model`s results underscores the importance of parameter adjustments for conformity with economic reality, providing a useful framework for economic policies and strategies. In terms of originality, the article highlights the model`s essential contribution to economic planning, resource optimization, and risk anticipation. It emphasizes the utility of transparently communicating economic policies for sustainable development. In conclusion, the importance of a complex mathematical and economic model for evaluating and making strategic decisions in rural economy branches. Continuous parameter adjustments are crucial, providing a valuable framework for economic planning and supporting sustainable development.

Key words: *economic performance, sensitivity analysis, sustainable investments, production, rural economics*

INTRODUCTION

In the current context of rural economic development, managing and understanding it pose essential challenges for states and organizations engaged in sustainable rural development.

In an increasingly interconnected world, the use of a complex mathematical-economic model becomes imperative for a detailed analysis of interactions among various sectors of the economy and for substantiating strategic decisions.

The present model, designed in several fundamental stages, provides a robust platform for initiating, evaluating, and managing economic data, delivering crucial information for economic policy development and rural investment planning. In the first stage, the process begins by initiating essential economic data, including overall production, productive consumption, and accumulated and consumed final products. This detailed approach provides a comprehensive picture of economic development over several years.

The second stage involves determining the coefficient of direct expenditures, reflected in matrix A, illustrating how resources are allocated among economic sectors.

This matrix becomes pivotal for understanding the impact of investments and production on the overall economy. Subsequent stages include determining the matrix of investment coefficients and the inverse matrix of matrix D, providing insight into the efficiency of investments and how they can influence overall production.

Through these complex calculations, the model ultimately allows the calculation of final production for each sector of the economy, facilitating the assessment of its capacity to meet internal and external demands.

The advantages of this complex model become evident in the current economic context, where the precision and detail of the analysis enable a deep understanding of the interdependencies among economic sectors. This facilitates long-term projections and optimizes resource utilization, thus contributing to improving the quality of life.

The adoption of a complex mathematical and economic model is not only a necessity but also an efficient solution for addressing the complexity of economic development and making sustainable impact-driven strategic decisions. This tool becomes essential in addressing contemporary challenges and successfully managing dynamic economic changes in the rural sector.

MATERIALS AND METHODS

This article focuses on analyzing the rural economic performance of two branches of the economy using data extracted from a specific table. The applied methods include calculating overall production, determining the coefficient of direct expenditures, and conducting a sensitivity analysis to adjust parameters [1].

The materials and methods used provide a comprehensive framework for evaluating investments, overall economic growth, and productive consumption. Parameter adjustments prove to be essential for obtaining results consistent with the rural economic reality. The conclusions obtained emphasize the importance of these adjustments, providing a relevant perspective for understanding economic evolution and making strategic decisions.

RESULTS AND DISCUSSIONS

The presented mathematical and economic model serves as an essential tool for evaluating economic trends and making strategic decisions regarding investments and development. The aforementioned calculation stages provide a detailed perspective on the interactions between economic sectors and allow for well-informed decision-making [2].

Initiating economic data is the first step, introducing specific information on overall production, productive consumption, and others, to gain a comprehensive understanding of economic trends [8]. Determining the coefficient of direct expenditures *(A)* brings to the forefront the allocation of resources between sectors, directly influencing final production.

The matrix of investment coefficients *(D)* and the inverse matrix of matrix *D* provide crucial information regarding the efficiency of investments and their impact on overall production. These elements become fundamental tools for assessing the viability and effectiveness of investments, guiding strategic decisions.

The calculation of final production, based on the inverse matrix of matrix *D*, offers a detailed insight into the economy's capacity to meet internal and external demands. Ultimately, determining the growth of overall production provides a crucial indicator of economic health.

This model offers a holistic perspective on economic trends, providing critical tools for formulating and implementing economic policies and investment strategies. Through detailed analysis and rigorous calculation, it becomes a valuable guide in navigating towards sustainable development and economic prosperity [5].

Next, we will present statistical data obtained from the economic entity *„X”,* for which we will conduct an economic-mathematical analysis for two economic branches, based on which overall production and the growth of overall production compared to the previous year will be calculated.

Table 1. Economic performance analysis through the use of mathematical modeling

Branch	Productive consumption in the branch		Final product accumulated and used in the branch		Final products consumed	Overall production	Growth in overall production compared to the previous year
	1	*2*	*1*	*2*			
	x_{i1}	x_{i2}	$y_{i1}^{(a)}$	$y_{i2}^{(a)}$	$y_{i2}^{(c)}$	x_i	Ax_i
1	108	158	148	218	108	736	40
2	188	308	78	88	278	940	50

Source: author's own elaboration.

Continuing the analysis of statistical data extracted from the economic entity „X”, we will conduct a detailed economic-mathematical analysis for two distinct economic sectors. Through this analysis, our aim is to calculate the overall production within these sectors and assess the growth in total production compared to the previous year.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

To carry out this process, we will utilize specific tools in economic analysis, such as mathematical models, performance indicators, and relevant historical data. By applying these tools, we will obtain a detailed picture of the economic evolution in the two sectors, highlighting trends, fluctuations, and potential influences on production [3].

The first step in our analysis will involve identifying the key variables and relevant economic indicators for each economic sector. These variables may include physical production, income, expenses, and any other factors that can influence the economic performance of entity *„X."*

Following the calculations performed, we can mention that:

Branch 1: Productive consumption in the sector represents the expenses incurred by the sector to produce goods and services. These include costs for raw materials, auxiliary materials, energy, production services, wages, etc.

Accumulated and used final product in the sector represents the value added generated by the sector, including depreciation.

Consumed final product represents the value added used by the sector for its own consumption, including the consumption of fixed capital [4].

Total production represents the sum of the production of the two sectors.

Growth in total production compared to the previous year represents the difference between the current year's total production and the total production of the previous year.

The next step will involve applying mathematical models to analyze the relationships between variables and to forecast total production in the two economic sectors [10]. This analysis will provide insight into the direction each sector is heading and facilitate the assessment of the impact of economic changes on production.

Branch 2: Gross output in the branch and accumulated final product used in the branch have the same meaning as in the case of branch 1. Consumed final product represents the value added used by the branch for its own consumption, including the consumption of fixed capital and investments. In the end, we will calculate the growth of global production compared to the previous year, allowing for the formulation of conclusions regarding the overall economic performance of entity „X". These conclusions will provide a solid foundation for making strategic decisions and optimizing economic activities in the future.

Global production *(GP)* is determined as the sum of the production of the two branches [9].

$$\boldsymbol{GP = X_1 + X_2} \quad \text{...(1)}$$

In first case, the result is:

$$\boldsymbol{GP = 108+188 = 296} \quad \text{...(2)}$$

The growth of global production *(GP)* compared to the previous year is calculated as the difference between the current-year global production and the global production from the previous year [9].

The growth of global production compared to the previous year = current global production-previous global production

In this instance, the growth of global production compared to the previous year is:

The growth of global production compared to the previous year = 296 – 256 = 40

After performing the calculations, the table results indicate a 40% growth in global production for the current year in comparison to the preceding year. This growth was primarily driven by the increase in production in branch 1, which grew by 32%. Branch 2 production increased by 16%. This growth was influenced by various factors such as increased domestic economy.

$$A = \begin{pmatrix} \frac{108}{736} & \frac{158}{940} \\ \frac{188}{736} & \frac{308}{940} \end{pmatrix} = \begin{pmatrix} 0.15 & 0.17 \\ 0.26 & 0.33 \end{pmatrix} \text{.....................(3)}$$

- ***We determine the matrix of investment coefficients;***

$$D = \begin{pmatrix} \frac{11,488}{40} & \frac{218}{50} \\ \frac{78}{40} & \frac{88}{50} \end{pmatrix} = \begin{pmatrix} 3.7 & 4.36 \\ 1.95 & 1.76 \end{pmatrix} \text{..................(4)}$$

- ***We determine the inverse matrix of the matrix;***

$$\left(\begin{array}{cc|cc} 3.7 & 4.36 & 1 & 0 \\ 1.95 & 1.76 & 0 & 1 \end{array}\right) \ |: 3.7$$

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

$$1.76-\frac{4.36\times1.95}{3.7}=-0.54 \quad (5)$$

$$\begin{pmatrix}1 & 1.18 \\ 0 & -0.54\end{pmatrix}\left|\begin{matrix}0.27 & 0 \\ -0.53 & 1\end{matrix}\right) \;|:(-0.54)$$

$$0-\frac{1\times1.95}{3.7}=-0.53 \quad (6)$$

$$\begin{pmatrix}1 & 0 \\ 0 & 1\end{pmatrix}\left|\begin{matrix}-0.89 & 2.19 \\ 0.98 & -1.85\end{matrix}\right) \qquad 0-\frac{1\times1.18}{-0.54}=2.19 \quad (7)$$

$$\begin{pmatrix}3.7 & 4.36 \\ 1.95 & 1.76\end{pmatrix}\begin{pmatrix}-0.89 & 2.19 \\ 0.98 & -1.85\end{pmatrix}=\begin{pmatrix}1 & 0 \\ 0 & 1\end{pmatrix}$$

$$0.27-\frac{1.18\times(-0.53)}{-0.54}=-0.9 \quad (8)$$

$$3.7\times(-0.9)+4.36\times0.98=-3.29+4.27=0.98\approx1 \quad (9)$$

$$3.7\times2.19+4.36\times(-1.85)=8.10-8.07=0.03\approx0 \quad (10)$$

$$1.95\times(-0.9)+1.76\times0.98=-1.76+1.72=-0.04\approx0 \quad (11)$$

$$1.95\times2.19+1.76\times(-1.85)=4.27-3.26=1.01\approx1 \quad (12)$$

Final Product;

$$\begin{pmatrix}474 \\ 444\end{pmatrix}\times\begin{pmatrix}0.89 & 2.19 \\ 0.98 & -1.85\end{pmatrix}=\begin{pmatrix}43 \\ 151\end{pmatrix}\begin{matrix}-producerea \\ -creșterea\end{matrix} \quad (13)$$

$$\begin{pmatrix}-0.89 & 2.19 \\ 0.89 & -1.85\end{pmatrix}\times\begin{pmatrix}474\alpha_1 \\ 474\alpha_2\end{pmatrix}\geq 0 \quad (14)$$

$$\begin{cases}-421.86\alpha_1+972.36\alpha_2\geq0|\times(-1) \\ 464.52\alpha_2-821.4\alpha_2\geq0\end{cases} \equiv> \begin{cases}972.36\alpha_2\geq421.86\alpha_1 \\ 821.4\alpha_2\geq464.52\alpha_1\end{cases} => \begin{cases}972\alpha_2\geq422\alpha_1 \\ 821\alpha_2\geq465\alpha_1\end{cases} \quad (15)$$

Following the calculations, we can formulate the following conclusions:

The coefficient of direct expenditures is 0.53. This means that, on average, 0.53 units of direct expenditures are required to produce or increase one unit of the product.

The final product is (43.151). This means that, for a value added of 474 lei, 43 lei represent production, and 151 lei represent growth.

Production represents the value of goods and services produced in a given period. Growth represents the value added generated by investments. In this case, the value added generated by investments is 151 lei, approximately 32% of the total production.

The first inequality indicates that production cannot be more than 2.5 times greater than growth. The second inequality indicates that growth must be positive. These conclusions can be interpreted as follows:

The rate of production growth is limited by the rate of investment growth.

Investments are necessary to ensure production growth.

These conclusions are important for economic planning, indicating that sustainable economic growth requires investment in developing production capacity.

Next, we will calculate the volume of investments in branches 1 and 2.

- ***We determine the volume of investments in branches 1 and 2;***

519.29 × 0.7799 = 404.99 ....(16)

485.85 × 0.4302 = 209.01 ....(17)

- ***We determine the overall economic growth;***

$$\begin{pmatrix}-0.89 & 2.19 \\ 0.98 & -1.85\end{pmatrix}\times\begin{pmatrix}404.99 \\ 209.01\end{pmatrix}=\begin{pmatrix}-360.44+457.73 \\ 396.89-386.67\end{pmatrix}=\begin{pmatrix}97.29 \\ 10.22\end{pmatrix} \quad (18)$$

In the condition when ***t = 3***

819.56 + 97.29 = 916.85 ....(19)

1,043.18 + 10.22 = 1,053.40 ....(20)

We know matrix A and the global product for ***t = 3***; we determine productive consumption

$$\begin{pmatrix}0.15 & 0.17 \\ 0.26 & 0.33\end{pmatrix}\times\begin{pmatrix}916.85 \\ 1{,}053.40\end{pmatrix}=\begin{pmatrix}137.53+179.08 \\ 238.38+347.62\end{pmatrix}=\begin{pmatrix}316.61 \\ 586.00\end{pmatrix} \quad (21)$$

Knowing the volume of global production and productive consumption, we determine the volume of the final product

$$\begin{pmatrix}y_1 \\ y_2\end{pmatrix}=\begin{pmatrix}x_1 \\ x_2\end{pmatrix}-\begin{pmatrix}A_1X_1 \\ A_2X_2\end{pmatrix}=\begin{pmatrix}916.85 \\ 1{,}053.40\end{pmatrix}-\begin{pmatrix}316.61 \\ 586.00\end{pmatrix}=\begin{pmatrix}600.24 \\ 467.40\end{pmatrix} \quad (22)$$

Divide the final product

$$\begin{pmatrix}-0.89 & 2.19\\ 0.98 & -1.85\end{pmatrix}\times\begin{pmatrix}600.24\\ 467.40\end{pmatrix} = \begin{pmatrix}-534.21+1{,}023.60\\ 588.24-864.69\end{pmatrix} = \begin{pmatrix}489.39\\ -276.45\end{pmatrix}$$
....(23)

The result is unacceptable.

- ***We determine α_1 and α_2;***

$$\begin{pmatrix}-0.89 & 2.19\\ 0.98 & -1.85\end{pmatrix}\times\begin{pmatrix}600.24\\ 467.40\end{pmatrix} = \begin{cases}534.21\alpha_1 \le 1{,}023.60\alpha_2\\ 588.24\alpha_1 \ge 864.69\alpha_2\end{cases}$$
....(24)

$\frac{534.21}{1{,}023.60} = 0.5218 \quad \alpha_1 = 0.7798$............(25)

$\frac{588.24}{864.69} = 0.6802 \quad \alpha_2 = 0.5218$............(26)

- ***We determine the volume of investments in the branch 1 and 2;***

600.24 × 0.7798 = 468.07...............................(27)

467.40 × 0.5218 = 243.89...............................(28)

- ***We determine the overall economic growth;***

$\begin{pmatrix}-0.89 & 2.17\\ 0.98 & -1.85\end{pmatrix}\times\begin{pmatrix}468.07\\ 243.89\end{pmatrix} = \begin{pmatrix}-416.58+529{,}24\\ 458.71-451.19\end{pmatrix} = \begin{pmatrix}112.66\\ 7.52\end{pmatrix}$...(29)

In the condition when ***t = 4***

916.85 + 112.66 = 1,029.51........................(30)
1,053.40 + 7.52 = 1,060.92.........................(31)

We know matrix *A* and the global product for ***t = 4,*** we determine productive consumption

$$\begin{pmatrix}0.15 & 0.17\\ 0.26 & 0.33\end{pmatrix}\times\begin{pmatrix}1{,}029.51\\ 1{,}060.92\end{pmatrix} = \begin{pmatrix}154.43+180.36\\ 267.67+350.11\end{pmatrix} = \begin{pmatrix}334.79\\ 617.78\end{pmatrix}$$
....(32)

Knowing the volume of global production and productive consumption, we determine the volume of the final product

$$\begin{pmatrix}y_1\\ y_2\end{pmatrix} = \begin{pmatrix}x_1\\ x_2\end{pmatrix} - \begin{pmatrix}A_1X_1\\ A_2X_2\end{pmatrix} = \begin{pmatrix}1{,}029.51\\ 1{,}060.92\end{pmatrix} - \begin{pmatrix}334.79\\ 617.78\end{pmatrix} = \begin{pmatrix}694.72\\ 443.14\end{pmatrix}$$
....(33)

- ***To divide the final product;***

$$\begin{pmatrix}-0.89 & 2.19\\ 0.98 & -1.85\end{pmatrix}\times\begin{pmatrix}694.72\\ 443.14\end{pmatrix} = \begin{pmatrix}-618.30+970.48\\ 680.83-819.81\end{pmatrix} = \begin{pmatrix}352.18\\ -138.98\end{pmatrix}$$
....(34)

The result is unacceptable; we determine α_1 and α_2.

$$\begin{pmatrix}-0.89 & 2.19\\ 0.98 & -1.85\end{pmatrix}\times\begin{pmatrix}694.72\alpha_1\\ 443.14\alpha_2\end{pmatrix} = \begin{cases}618.30\alpha_1 \le 970.48\alpha_2\\ 680.83\alpha_1 \ge 819.81\alpha_2\end{cases}$$
....(35)

$\frac{618.30}{970.48} = 0.6371 \qquad \alpha_1 = 0.7798$............(36)

$\frac{680.83}{819.81} = 0.8304 \qquad \alpha_2 = 0.6371$............(37)

Following the calculations, we can mention that:

- For ***t = 3***, the volume of investments in Branch 1 and 2 was 404.99 and 209.01, respectively. After adjustment for *t = 4*, these increased to 468.07 and 243.89.
- The initial overall economic growth for *t = 3* was 97.29 in Branch 1 and 10.22 in Branch 2. After adjustment for *t = 4*, this increased to 112.66 and 7.52.
- Productive consumption for *t = 4* was 334.79 in Branch 1 and 617.78 in Branch 2.
- The volume of the final product for *t = 4* was 694.72 in Branch 1 and 443.14 in Branch 2.
- Sensitivity analysis highlighted adjustments of parameters α_1 and α_2. For *t = 3*, these were 0.7798 and 0.5218, and for *t = 4*, they were 0.7798 and 0.6371.
- Reevaluating overall economic growth with adjusted α for *t = 4* indicated acceptable values of 112.66 in Branch 1 and 7.52 in Branch 2.

The conclusions suggest that adjusting the parameters has improved the model's conformity to economic reality, and sensitivity analysis remains essential for maintaining the stability and reliability of the model [6].

Additionally, we will calculate the volume of investments:

- ***We determine the volume of investments in the branch 1 and 2;***

$6{,}094.72 \times 0.7798 = 541.74$............................(38)

$443.14 \times 0.6371 = 282.32$ ....(39)

- ***We determine the overall economic growth;***

$$\begin{pmatrix} -0.89 & 2.19 \\ 0.98 & -1.85 \end{pmatrix} \times \begin{pmatrix} 541.74 \\ 282.32 \end{pmatrix} = \begin{pmatrix} -482.15+618.28 \\ 530.91-522.29 \end{pmatrix} = \begin{pmatrix} 136.13 \\ 8.62 \end{pmatrix} \quad (40)$$

In the condition when ***t = 5***

$1{,}029.51 + 136.13 = 1{,}165.64$.........................(41)

$1{,}060.92 + 8.62 = 1{,}069.54$.............................(42)

Knowing matrix, A and the global product for $t = 5$, we determine productive consumption:

$$\begin{pmatrix} 0.15 & 0.17 \\ 0.26 & 0.33 \end{pmatrix} \times \begin{pmatrix} 1{,}165.64 \\ 1{,}069.54 \end{pmatrix} = \begin{pmatrix} 174.85 + 181.82 \\ 303.07 + 352.95 \end{pmatrix} = \begin{pmatrix} 356.67 \\ 656.02 \end{pmatrix} \quad (43)$$

Knowing the volume of global production and productive consumption, we determine the volume of the final product [9]:

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} - \begin{pmatrix} A_1X_1 \\ A_2X_2 \end{pmatrix} = \begin{pmatrix} 1{,}165.64 \\ 1{,}069.54 \end{pmatrix} - \begin{pmatrix} 356.67 \\ 656.02 \end{pmatrix} = \begin{pmatrix} 808.97 \\ 413.52 \end{pmatrix} \quad (44)$$

Next, we will divide the final product:

$$\begin{pmatrix} -0.89 & 2.19 \\ 0.98 & -1.85 \end{pmatrix} \times \begin{pmatrix} 808.97 \\ 413.52 \end{pmatrix} = \begin{pmatrix} -719.98+905.61 \\ 792.79-765.01 \end{pmatrix} = \begin{pmatrix} 185.63 \\ -27.78 \end{pmatrix} \quad (45)$$

The result is unacceptable; we determine α_1 and α_2.

$$\begin{pmatrix} -0.89 & 2.19 \\ 0.98 & -1.85 \end{pmatrix} \times \begin{pmatrix} 808.97\alpha_1 \\ 413.52\alpha_2 \end{pmatrix} = \begin{cases} 719.98\alpha_1 \le 905.61\alpha_2 \\ 792.79\alpha_1 \ge 765.01\alpha_2 \end{cases} \quad (46)$$

$$\frac{719.98}{905.61} = 0.7950 \qquad \alpha_1 = 0.7798 \quad (47)$$

$$\frac{792.79}{765.01} = 1.0363 \qquad \alpha_2 = 0.7951 \quad (48)$$

- ***We determine the volume of investments in the branch 1 and 2;***

$$\begin{pmatrix} 808.97 \\ 413.52 \end{pmatrix} \times \begin{pmatrix} 0.7798 \\ 0.7951 \end{pmatrix} = \begin{pmatrix} 630.83 \\ 328.79 \end{pmatrix} \quad (49)$$

- ***We determine the overall economic growth;***

$$\begin{pmatrix} -0.89 & 2.19 \\ 0.98 & -1.85 \end{pmatrix} \times \begin{pmatrix} 630.83 \\ 328.79 \end{pmatrix} = \begin{pmatrix} -561.44+720.05 \\ 618.21-608.26 \end{pmatrix} = \begin{pmatrix} 158.61 \\ 9.95 \end{pmatrix} \quad (50)$$

After analyzing the data, we reach the following conclusions:

- The initial volume of investments in Branch 1 and 2 was 541.74 and 282.32, respectively. After adjusting for the moment $t = 5$, these investments increased to 630.83 in Branch 1 and 328.79 in Branch 2.
- The initial overall economic growth was 136.13 in Branch 1 and 8.62 in Branch 2. After adjustment for $t = 5$, it increased to 158.61 in Branch 1 and 9.95 in Branch 2.
- Productive consumption for $t = 5$ was 356.67 in Branch 1 and 656.02 in Branch 2.
- The volume of the final product for $t = 5$ was 808.97 in Branch 1 and 413.52 in Branch 2.
- Sensitivity analysis indicated that the parameters α_1 and α_2 were adjusted to 0.7798 and 0.7951, respectively. This adjustment contributed to stabilizing the model, and the obtained results were acceptable.

In conclusion, this analysis underscores the importance of parameter adjustments in evaluating economic outcomes and highlights the system's stability following these adjustments.

A complex mathematical and economic model, as presented earlier, has several significant advantages for assessing economic development and making strategic decisions regarding investments and growth [11]. Here are some arguments for using such a model:

1. ***Precision and Detail:*** Mathematical models allow for economic analysis at a very detailed level, considering numerous variables and their interdependencies. This level of precision can provide a clearer picture of how

changes in one sector can affect the entire economy [5].

2. ***Long-Term Projections:*** The model can be used to make long-term projections of economic development [6]. These projections are essential for developing a long-term investment strategy and anticipating future challenges or opportunities.

3. ***Resource Optimization:*** The model can help identify the optimal allocation of resources within the economy. This is crucial for governments and companies seeking to maximize the efficiency of resource utilization.

4. ***Economic Planning:*** Using a mathematical and economic model can assist governments in planning economic and fiscal policies. By analyzing the impact of various measures, more informed decisions can be made to stimulate economic growth or manage inflation and unemployment [12].

5. ***Risk Anticipation:*** The model can be used to assess economic risks. By simulating different scenarios, risk factors can be identified, and strategies for managing them can be developed.

6. ***Evaluation of Investment Impact:*** The model allows for the evaluation of the impact of investments on the economy. This is particularly useful for governments, non-profit organizations, and companies looking to understand how investments in a specific sector or project will influence economic development.

7. ***Transparency and Communication:*** Mathematical models can aid in communicating economic policies and government decisions to the public and other stakeholders. They can provide strong arguments for the decisions made.

8. ***Improvement of Quality of Life:*** Economic modeling allows us to track how investments and policies positively impact citizens' quality of life through job creation, income growth, and the provision of goods and services [7].

Thus, a complex mathematical and economic model serves as a powerful tool for evaluating economic development and making strategic decisions. It provides a clear and systematic picture of how different components of the economy interact and can support the formulation of policies and investment planning to achieve desired economic objectives.

CONCLUSIONS

Following the comprehensive presentation of the mathematical and economic model, we can draw significant conclusions regarding its utility and impact on assessing economic development and making strategic decisions. It represents a valuable tool, providing multiple benefits for the stakeholders involved in managing and guiding economic development. The mathematical and economic model offers a detailed and rigorous approach to analyzing the complex interactions between various sectors of the rural economy. This precision is essential for a profound understanding of economic evolution. The ability to make long-term projections is a major advantage, allowing anticipation of future economic trends and adjusting investment strategies to maximize positive impact within the rural domain.

By identifying optimal resource allocation, the model contributes to streamlining their use in the economy, a crucial component for achieving sustainable development. Governments can use this model for developing and implementing economic and fiscal policies, having detailed analyses of the measures' impact on the economy.

The ability to evaluate rural economic risks through simulating different scenarios provides a vital tool for developing risk management strategies and minimizing negative impact. The precise assessment of the impact of investments allows stakeholders to understand how these can contribute to economic development by generating employment, income growth, and improving the quality of life for rural citizens.

Mathematical models provide a transparent framework for communicating economic policies, offering solid and easily understandable arguments for government decisions. Overall, the presented mathematical and economic model is not just a necessity in the contemporary era of economic complexity but also an efficient solution for addressing this complexity and making informed strategic decisions. Integrating this type of approach into the decision-making process can significantly contribute to achieving economic objectives and promoting sustainable and prosperous development.

ACKNOWLEDGEMENTS

This article reflects the results of the individual research carried out as part of the associate professor thesis at the State University of Moldova. Within this research, a detailed mathematical-economic model was implemented, with the aim of analysing economic interactions and guiding strategic decisions in order to improve the rural economy.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

FEMININE LEADERSHIP AND CHALLENGES IN THE BUSINESS SECTOR. CASE STUDY: CALARASI COUNTY, ROMANIA

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Abstract

Feminine leadership is an increasingly relevant field of research, having a significant impact on organizational development and progress. Studies show that women in leader positions bring an unique and valuable perspective, contributing to innovation and performance within the organizations they lead. However, the perception of feminine leadership is often influenced by gender stereotypes that can create barriers to women's professional advancement. The main objective of this study was to identify and analyze leadership styles in feminine entrepreneurship in Călărași county, with a particular focus on how female entrepreneurs adapt and respond to the specific challenges of the local business sector. The selection of the sample was carried out through a stratified methodology, ensuring a proportional distribution for each of the demographic and professional categories specific to feminine entrepreneurs. This approach allowed a detailed and specific analysis of the distinctive features of female leadership in entrepreneurship in Călărași. Sample variables: age: the sample included women entrepreneurs between the ages of 25 and 52, thus ensuring the representation of a wide spectrum of life and professional experiences; level of education: from high school to postgraduate studies, including master and doctorate; residence area - urban and rural women, highlighting how geographic context and access to resources can impact leadership styles; the type of Commercial Company - from individual enterprises, to limited liability companies and joint-stock companies, highlighting the flexibility in choosing the business structure; field of activity: the participation of women entrepreneurs in a wide range of fields, from trade and services, to manufacturing and IT, highlighting the diversity and adaptability of businesses led by women. The methodology used in carrying out this research includes a combination of qualitative and quantitative analysis. Quantitative data were collected through a questionnaire distributed to a sample of 120 women entrepreneurs from Călărași county, Romania. The qualitative analysis involved detailed but unstructured interviews with the sampled participants to gain a deeper understanding of their experiences and perceptions regarding the challenges they face in a diverse and competitive business sector. In order to evaluate the results of the questionnaire and the association with the sample variables, the χ2 test was used, the null hypothesis was formulated, to determine if there is a causal relationship between the two variables-questions. The obtained results revealed significant insights about the leadership dynamics in the region. The analysis indicated a diversity of leadership styles, with a notable prevalence of the collaborative style, suggesting a general trend towards participative leadership models within the investigated organizations. Despite all the challenges they faced, women entrepreneurs demonstrate resilience and innovation, contributing significantly to the socio-economic development of the community. Their success highlights the importance of implementing policies and initiatives that promote gender equality in entrepreneurship and support the development of businesses led by women.

Key words**:** *entrepreneurship, questionnaire, leader, challenges, leadership styles.*

INTRODUCTION

The promotion of women in key positions in Romania was a significant catalyst for changing the leadership style, favoring the transition from an authoritarian, control-centered model to a more inclusive and participatory one. This evolution reflects a recognition of the unique skills and perspective that women bring to leadership roles, emphasizing the need for a style that values diversity, creativity and collaboration [17,11]. This new paradigm encourages approaches that not only support innovation, but also promote an organizational culture that is adaptable and responsive to global market dynamics [1, 11]. The contribution of women in entrepreneurship is vital for stimulating and sustaining economic development at the regional level. By starting and managing their own businesses, women entrepreneurs generate jobs, contribute to the diversification of the local economy and increase the competitiveness of the organizations they lead. Their role extends beyond the economic sphere, having a significant impact on the community through involvement in various social and philanthropic activities. This involvement not only strengthens their businesses, but also supports initiatives that improve the quality of life in the community [13, 5].

One of the main obstacles faced by women leader is fighting gender stereotypes that traditionally associate them with traits such as empathy and caring for others, at the expense of those associated with leadership, such as assertiveness and decision [3, 9]. This perceived incongruity between the feminine gender role and that of leadership contributes to the „glass ceiling”, phenomenon, limiting women's access to top positions [12]. In recent years, there has been an increased focus on promoting feminine entrepreneurship, while recognizing the importance of creating an enabling area for the development of businesses led by women [13,18].

Promoting gender equality in economic policies and business legislation is crucial. Legislative measures that prohibit gender discrimination and promote equal opportunities in business can significantly contribute to reduce the barriers faced by women entrepreneurs. Such initiatives may include objective criteria in hiring and promotion processes, eliminating wage discrimination and guaranteeing equal access to finance [2, 7]. As for the profile of women entrepreneurs, it explores the characteristics, motivations and challenges faced by women who choose to open their own businesses. The profile of women entrepreneurs reflects a wide diversity of educational backgrounds, life experiences and ambitions, but there are also commonalities that define this distinct group in the global entrepreneurial landscape. [2, 18].

Women entrepreneurs are often motivated by a desire for financial independence, flexibility in managing work-life balance, and passion for a particular field. These motivations are supported by studies showing that women place a high value on autonomy and the ability to achieve personal goals through entrepreneurial activities [12, 6].

A notable feature of women entrepreneurs is their tendency to start businesses in service-oriented, education, health and social care sectors, although their presence in STEM (science, technology, engineering and mathematics) fields is increasing. This indicates an adaptation to market needs, but also an alignment to personal skills and interests [7, 8].

A distinctive aspect of women entrepreneurs is their ability to build and maintain strong business relationships, often using their communication and empathy skills to create networks of support and collaboration. This tendency to value interpersonal relationships can serve as a competitive advantage in the business sector [4, 10].

The profile of women leaders reflects a mix of determination, innovation and the ability to navigate a complex economic and social landscape. Recognizing and supporting this vital group within the entrepreneurial community can lead to the development of a more diverse and inclusive business sector [8], [16].

The purpose of this research is to identify both the challenges faced by women leaders in the diverse landscape of businesses in Călăraşi county and the leadership styles shown by women entrepreneurs in the county, evaluating how these styles directly influence the success and sustainability of the businesses they lead.

MATERIALS AND METHODS

In the social economic and cultural context specific to Călărași county, the research aims to provide a brief analysis of the whay in which feminine leadership contributes to the local economic development and to the promotion of an inclusive and equal business sector in various organisational contexts in different fields of ativity of the business sector specific to the county.

The main objective of this research is to evaluate and compare the effectiveness of authoritarian, collaborative and facilitative leadership styles, taking into account the concrete challenges faced by the feminine business sector in Călărași county. The study aims to identify the specific characteristics of each leadership style and their impact on organizational success, in the context of feminine entrepreneurship.

By analyzing these leadership styles, the research intends to reveal how the authoritarian style, characterized by centralized decisions and firm control, influences operational efficiency and employee commitment, to what extent the collaborative style, which promotes the involvement and contributions of team members, facilitates organizational innovation and adaptability, and the effects of the facilitative style, focused on supporting and personal development of employees, on team morale and productivity.

This objective allows a deep understanding of how feminine leaders can use these styles to improve business performance, adapted to the local socio-economic context in Călărași.

The methodology used in carrying out this research includes a combination of qualitative and quantitative analysis. Quantitative data were collected through a questionnaire distributed to a sample of 120 women leaders from Călărași county. The qualitative analysis involved detailed but unstructured interviews with the sampled participants to gain a deeper understanding of their experiences and perceptions regarding the challenges they face in a diverse and competitive business sector.

The sample was structured on 2 levels, respectively, identification data that included age, level of education, resident area, type of commercial company, field of activity, which included organizations from different fields, from food and production services to IT and renewable energy, thus ensuring a broad and representative coverage of the local business sector. The second part of the semi-standardized questionnaire, through which we aimed to assess the ways in which leaders behave in usual situations of leading their teams, composed of 12 questions, the feminine entrepreneurs were asked to choose the answers that best reflect their typical actions within the team, respectively, their attitude when debating organizational issues within the team, the way they lead the meetings, how they inform and accept the opinions of subordinates regarding the development of the company, how they communicate and how they pursue the achievement of the team's objectives, how they facilitate/moderate a brainstorming, etc. Each question had a set of predefined answer options to simplify the process of filling in and analyzing the results. The answer options allowed respondents to choose the one that best reflects their perception of the respective question.

The responses were then scored and interpreted to classify leadership styles as authoritarian, collaborative or facilitative, based on a scoring system detailed in the questionnaire. The participants completed the questionnaire in an informal setting, at the workplace of the interviewed persons, the questionnaire being physically applied.

This methodology allowed not only the identification of individual styles, but also the aggregation of data to observe trends across the entire sample. In order to determine the cumulative distribution function that applies to statistical distributions we used the χ 2 ("hi-square") concordance test, a general test, applied to frequency data, by associating columns and lines in a two-entry contingency table, where the data were classified by many segmentation variables [14].

Thus, the null hypothesis was formulated, to determine if there is a causal link between the two variable-questions; the significance threshold was chosen and the number of degrees of freedom of the table was calculated, according to the formula (r-1)*(c-1); it was taken from the distribution table of theoretical $\chi 2$; the obtained results were compared and it was determined if the null hypothesis is rejected, respectively, if there is an association between the studied variables; the contingency coefficient C was calculated, to measure the degree of association between the variables of the contingency table [14]. The calculated $\chi 2$ is compared with the theoretical $\chi 2$ for different probability thresholds. The closer the value of C is to 1, the more closely the variables are correlated.

The information collected was centralized and analyzed to extract meaningful insights about leadership dynamics in the region. The analysis indicated a diversity of leadership styles, with a notable prevalence of the collaborative style, suggesting a general trend towards participative leadership models within the investigated organizations.

The information obtained through the application of the questionnaire and free discussions with women entrepreneurs provided a deep and multifaceted perspective on leadership styles, highlighting the importance of adaptability and reactivity in contemporary leadership practices. These findings support the continous need to develop and adjust leadership styles to effectively respond to the dynamic challenges of the modern business sector.

Table 1 shows the structure of the sample participating in the study, by age category, level of education, resident area of the respondents, legal form of their business, field of activity.

Table 1. Sample structure and social characteristics

Category	Description	Number of persons
Age		
20-30 years old	Young entrepreneurs	32
31-40 years old	Entrepreneurs at professional maturity	40
41-50 years old	Entrepreneurs with wide experience	38
51+ years old	Seniors in entrepreneurship	10
Total persons depending on: age		**120**
Study level		
Highschool	Pre-university education	24
University	Basic univerisity education	40
Postuniversity	Advanced studies	56
Total persons depending on: study level		**120**
Residence area		
Urban	Live in town	68
Rural	Live in rural area	52
Total persoons depending on: residence area		**120**
Type of commercial company		
SRL	Limited liability company	110
SA	Shares company	6
Sole enterprise/PFA	Sole owner	4
Total persons depending on: type of commercial company		**120**
Activity object		
Services	Including consultancy, education, health	32
Production	Food, textile, industrial	28
IT and Technology	Dezvelopment of software and consultancy IT	18
Commerce	Retail and distribution	16
Other fields	Including toruism, design, beauty & wellness	26
Total persons depending on: activity object		**120**

Source: Centralization of information obtained based on questionnaire [6].

The study highlights the diversity and peculiarities of the group of feminine entrepreneurs participating in the research through a sample of 120 feminine entrepreneurs from Călărași county, reflecting a wide spectrum of demographic and professional characteristics according to Table 1. In order to better understand the context in which these leadership styles are applied, it is essential to also analyze the business sector in which they operate.

Firms exclusively led by women range from innovative start-ups to traditional organizations with a strong presence in the local market.

The economy of Călăraşi county is dominated by the agricultural and industrial sectors, with a strong emphasis on grain cultivation, agro-zoology, steel industry, food industry, as well as the glass, paper and pulp industry, to which are added small and medium-sized businesses in various fields [6].

RESULTS AND DISCUSSIONS

The business sector in Călărași county is characterized by an interconnection of the agricultural and industrial sectors, supported by a natural and demographic framework leading to economic development as can be seen from Table 2.

Development and modernization efforts continue, accompanied by legislative initiatives and strategies of economic growth, promise a positive evolution of the business sector in this region, and underline the significant potential of Călărași county as an important economic center in South-Eastern Romania.

Table 2. Fields with the highest turnover, in Călărași county

No. crt.	Code CAEN	Activity field	Turnover
1	0111	Cereals growing (exclusively rice), vegetale plants and oil-seed plants	3.5 billion
2	4621	Wholesale trade of cereals, seeds, fodder and raw tabacco	1.2 billion
3	2410	Production of ferrous metals under primary forms and ferroalloys	743.1 billion
4	3832	Recovery of sorted recyclable materials	515.6 billion
5	4711	Retail trade in non-specialized stores, predominantly selling food, beverages and tobacco	513.6 billion

Source: Processing data taken from: TopFirme.com-Top firms in Romania [19].

In Călărași county, as in the rest of the country, women entreprenurs represent a vital part of the business sector, contributing to the economic diversification and development.

According to the data available at national level, about 40% of business in Romania is led by women, either as administrator, or as majority shareholders. This trend highlights the increasing role the women play in the Romanian economy, including in Călărași county.

Businesses led by women in Călărași, according to national trends, are concentrated in sectors such as trade, services, business and management consulting, freight and passenger transport, as well as accounting and tax consulting. These businesses are predominantly small and medium-sized, reflecting the general trend in the Romanian economy and offering essential services to the local community.

According to Table 3, The diversity of businesses led by women in Călărași county is reflected in Table 3.

Table 3. Structure of business sectors led by women, in Călărași county

	Business sector	Short descritpion	No. business
1	Trade	Retail sells and online.	588
2	Consulting	Services specialized for other organizations or entreprenerus.	360
3	Education and Training	Vocational training programs and tutoring.	240
4	Health and personal care	Beauty saloons, private clinics and wellness.	240
5	Food and Catering	Restaurants, cafes and catering services.	192
6	IT and digitalizati on	Software development, design web, IT services.	192
7	Fashion and Design	Clothes design workshops and clothing stores.	168
8	Agricultur e and food production	Agricultural and food production, including bio.	168
9	Tourism and Hospitality	Guesthouses, travel agencies.	120
10	Arts and Culture	Cultural events, creative workshops, workshops.	120

Source: Processing date taken from Călărași Trade Register [15].

The percentages in Figure 1 show us their distribution in different fields, based on the information available at the county level.

Trade is the dominant sector, followed by consulting and education, which indicates an orientation towards services and high value-added sectors. The lower percentages allocated to areas such as tourism and art highlight potential market niches and opportunities for diversification and innovation in feminine entrepreneurship in the county.

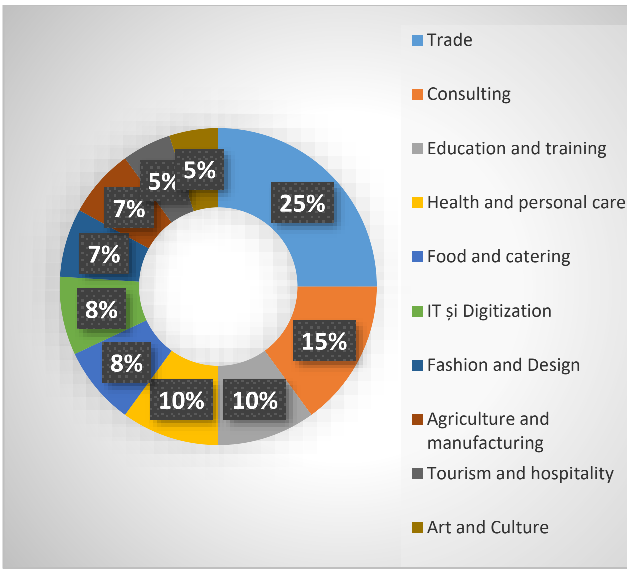

Fig. 1. Percentage structure of business led by women in Călăraşi county
Source: own processing.

Regarding these challenges, it is essential the development of an entrepreneural ecosystem to support woemn through easy access to funding, mentoring and professional development programs.

The analysis of the organizational culture in feminine entrepreneurship in Călăraşi county offers a unique perspective on how cultural values, norms and attitudes influence the conduct of businesses led by women, highlighting the particularities that contribute to the creation of a distinct and favorable entrepreneurial area for feminine leaders.

The organizational culture in feminine entrepreneurship in Călăraşi is structured in a way that values diversity and collaboration, while addressing specific challenges, such as combating gender stereotypes and promoting an inclusive and egalitarian area, as shown in Table 4, built based on the information received through the unstructured interview with women entrepreneurs.

These values are reflected in the leadership styles adopted by feminine entrepreneurs, which tend to place more emphasis on cooperation and personal development than on fierce competition. This approach helps create a positive work area that encourages innovation and employee committment.

Table 4. Correlation of organisational cuturle elements with feminine entrepreneurship features

Organisational culture elements	Features
Leader communication	Feminine leaders emphasize open and transparent communication, facilitating dialogue and collaboration within teams.
Leader values	The promoted values include cooperation, flexibility, communication and equality, reflecting an orientation towards personal development, teamwork, supporting creativity and innovation.
Leader behavior	Behavior is influenced by local cultural traditions and the needs of an ever-changing business sector, with a focus on adaptability and inclusion.
Working conditions	Flexible organizational policies that allow for a healthy work-life balance, contributing to employee satisfaction and loyalty.
Professional development	Investments in training and professional development programs to improve the skills and increase the self-confidence of women entrepreneurs.

Source: Carried out by authoris based on information received at interview with women entrepreneurs.

One of the major challenges in businesses led by women is balancing cultural traditions with the needs of an ever-changing business area. Women entrepreneurs often face prejudice and gender stereotypes, which can influence perceptions of their ability to run successful businesses.

In order to strengthen the organizational culture in businesses led by women in Călăraşi, it is essential to implement strategies that support their development and success, such as investments in training and professional development programs.

The organizational culture in female entrepreneurship in Călăraşi county plays an essential role in defining and supporting the success of businesses led by women and by adopting strategies oriented towards development, collaboration and inclusion, it is possible to create a dynamic and sustainable entrepreneurial environment that values and promotes women's contribution to the local economy.

Table 5 classifies and presents the leadership styles identified among the companies participating in the study, grouped by their fields of activity. Leadership styles are divided into three categories: Authoritarian (12-18 points), Collaborative (19-30 points), and Facilitative (31-36 points). The number in each column represents the number of persons in that company who fit into each leadership style.

Table 5. Leadership styles of women leader participating in the study

	Activity field	Authoritarian	Collaborative	Facilitative
1	Food Retail	3	6	1
2	Food production	3	1	1
3	Architecture	1	2	4
4	Textile Production	1	2	4
5	Food and Catering	1	2	1
6	Health	1	1	2
7	Interior Design	1	4	2
8	Renewable energy	1	2	2
9	Farmacy	3	2	1
10	Education	2	8	1
11	Beauty & Wellness	2	2	2
12	IT/Consulting	1	12	2
13	Agriculture	4	2	1
14	Fashion	1	2	2
15	Technology	1	1	2
16	Legal Services	1	2	2
17	Tourism	2	2	2
18	Consulting in Management	2	3	2
	TOTAL	**32**	**56**	**32**

Source: Centralization of information obtained based on questionnaire [6].

Each field of activity in the table is evaluated according to the responses of women entrepreneurs to the questionnaire, thus providing an insight into the prevailing trends in management approaches in various economic sectors. This organization of data helps identify leadership patterns and adapt organizational strategies to optimize leadership and performance in different business sector.

Figure 2 shows the share of leadership styles specific to o feminine entrepreneurship in Călărași county. We find that 46.7% of respondents identify themselves as having a collaborative style, this category dominating the sample, reflecting a trend towards participative leadership models in feminine entrepreneurship in the region. The authoritarian and facilitative styles are equally represented, each with 26.7%, indicating a diversity in the leadership approaches of female entrepreneurs. This distribution suggests a balance between more direct approach and more permisive or supportive in business management.

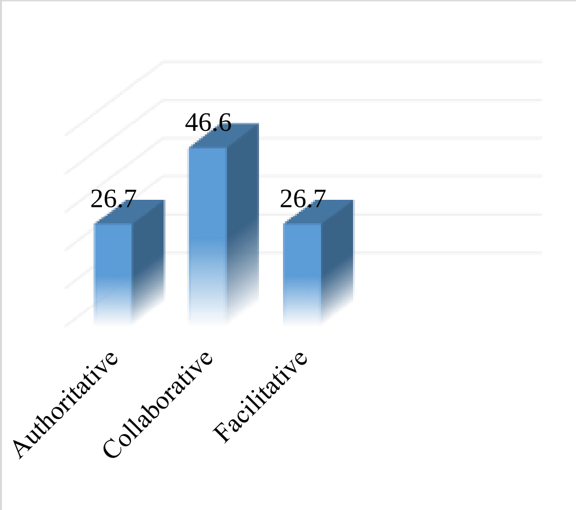

Fig. 2. Percentage distribution of leadership in the sample of women entrepreneurs in Călărași county
Source: Centralization of information obtained based on questionnaire [6].

The most frequent leadership style identified in the sample is the collaborative one, with 46.7% of the participants adopting this approach. This style is characterized by an emphasis on teamwork, effective communication, and sharing power and responsibility with team members. The prevalence of the collaborative style reflects a trend towards creating inclusive and supportive work environments that value the contribution of each member and encourage innovation and active involvement in decision-making processes.

Authoritative and facilitative styles are equally represented in the sample, each with a percentage of 26.7%. The authoritarian style, characterized by centralized decision-making and firm control over organizational direction and activities, can be effective in situations that require quick decisions and clear direction. On the other hand, the facilitative style, which emphasizes the development and support of team members, highlights a concern for the personal and professional growth of employees, being appropriate in contexts that require adaptability and continuous learning.

Table 6 shows the correlation between the leadership style and the respondent age. It is found that, by age category, in the categories 20-30 years, 31-40 years and 41-50 years, the weight is owned by the collaborative style, while in the age category, over 50 years, the weight it is owned by the authoritarian leadership style.

Table 6. Evaluation of correlation between leadership styles and respondents age

Age	**MU**	**Leadership style**			**Total**	
		Authoritative	Collaborative	Facilitative	No.	%
Between 20- 30 years old	No.	9	16	7	32	26.7
Between 31-40 years old	No.	11	18	11	40	33.3
Between 41-50 years old	No.	5	20	13	38	31.6
Over 50 years old	No.	7	2	1	10	8.4
TOTAL	No.	32	56	32	120	100
	%	26.7	46.6	26.7	100	X
CHIINV (Chi theoretical)	≥	15.7	17,9	19.2		
CHIINV (Chi calculated)	18.03	**				

Source: Own calculations.

Analyzing the collected data it results that there is a difference (**) of leadership style and the respondents age that is appreciated statistically as being significant by value of 18.03 of Chi calculated.

Table 7. Evaluation of correlation between leadership style and respondents residence area

Residence area	**MU**	**Leadership style**			**Total**	
		Authoritative	Collaborative	Facilitative	No	%
URBAN	No.	11	30	27	68	56.7
RURAL	No.	21	26	5	52	43.3
TOTAL	No.	32	56	32	120	100
	%	26.7	46.6	26.7	100	X
CHIINV (Chi theoretical)	≥	14.3	17.1	20.4		
CHIINV (Chi calculated)	21.11			***		

Source: Own calculations.

Table 7 shows the correlation between the leadership style and the residence area of the respondents. It is found that feminine entrepreneurs from rural area hold the weight in the authoritarian style category, while the weight reverses in the facilitative style.

Analyzing the data collected, it appears that there is a significant differentiation (***) of the leadership style practiced and the residence area of the respondents which is statistically assessed as very significant by the value of 21.11 of the calculated Chi. From the analysis carried out in Tabel 8, it is find out that, as the study level increases, the respondents leadership styles is included in the collaborative category. Related to preuniversity studies, the authoritarian style is the predominant one. Analyzing the collected data it results that there is a difference (**) of leadership style practiced and respondents education level, that is appreciated statistically as significant with value of 20.28 of Chi calculated.

Table 8. Evaluation of correlation between leadership style and study level of respondents

Residence area	**MU**	**Leadership style**			**Total**	
		Authoritative	Collaborative	Facilitative	No	%
Preuniversitary (highschool)	No.	11	6	7	24	20,0
Universitary	No.	13	18	9	40	33.3
Postuniversitary	No.	8	32	16	56	46.7
TOTAL	No.	32	56	32	120	100
	%	26.7	46.6	26.7	100	X
CHIINV (Chi theoretical)	≥	16.5	18,4	20.9		
CHIINV (Chi calculated)	20.28			**		

Source: Own calculations.

In Tabel 9, it is presented the correlation between leadership style practiced and commercial company type, legally, coordinated by the respondent.
It was found that, in the category of limited liability commercial companies (SRL) all three leadership styes are found, while in share companies (S.A.) we do not see facilitative leadership style.
At sole enterprises individuale (I.I) and aurtohirsed natural persons (PFA) we do not find the authoritarian leadership style.
Analyzing the collected data it results that there is a major difference (***) of leadership style practiced and the legal status of organisations led by women entrepreneur that is appreciated statistically as being distinctly significant by value of 16.21 of Chi calculated.

Table 9. Evaluation of correlation between leadership style and commercial company type

Residence area	**MU**	**Leadership style**			**Total**	
		Authoritative	Collaborative	Facilitative	No	%
S.R.L.	No	27	52	31	110	20,0
S.A.	No	5	1	0	6	33.3
I.I./PFA	No	0	3	1	4	46.7
TOTAL	No.	32	56	32	120	100
	%	26.7	46.6	26.7	100	X
CHIINV (Chi theoretical)	≥	11.2	13.3	15.1		
CHIINV (Chi calculated)	16.21			***		

Source: Own calculations.

CONCLUSIONS

The analysis of the business sector in Călărași county, in particular, of feminine entrepreneurship, requires a complex approach that takes into account a series of internal and external factors essential for understanding the economic landscape and the challenges and opportunities encountered by feminine entrepreneurs. At internal level, human resources, including the skills and training of feminine entrepreneurs, play a crucial role in business development and success. Local infrastructure, access to basic services and financing, as well as the entrepreneurial culture prevailing in the county directly influence women's ability to start and lead successful businesses.
Externally, the legislative and political framework, the local and global economy, market trends are factors that determine the environment in which women's businesses evolve. The diversity of leadership styles among female entrepreneurs in Călărași county emphasizes the importance of adaptability and flexibility in the leadership style approach, it should be influenced by the specific context, organizational objectives and team needs, with an inclination towards the collaborative style that promotes the employees participation and commitment.
The analysis of feminine leadership in entrepreneurship in Călărași county highlights

both the valuable contribution of women leader to economic and social development, and multiple challenges encountered. These challenges include flight against gender stereotypes, difficulty of accessing the necessary resources and challenges of balancing the professional with personal life. In this context, it is vital to create a favourable area that support and promote the feminine entrepreneurship. Feedback received following the questionnaire application and interview regarding the challenges of business area for women entrepreneurs was extremely valuable. Many feminine leaders appreciated the clarity of questions and remarked that this exercise provided the opportunity to reflect on own methods of leading. Also, the results allowed leaders to identify the specific needs for their training and development.

The study highlighted the crucial role that women leaders play in the economic and social developmnet of the region, bringing valuable skills as empathy, flexibility and a participatory approach. These features contribute to the creation of some positive and and innovative working areas, but, at the same time, women leader face significant challenges, including gender stereotypes, limited access to resources and difficulty of balancing professional and personal responsibilities.

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ANALYSIS OF THE PERCEPTION OF CONSUMERS IN ROMANIA TOWARDS THE USE OF INSECTS AND ARTIFICIAL MEAT IN PUBLIC FOOD

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Abstract

Recently, the European Commission approved mealworms as a food product in the European Union. Following this authorisation, mealworms are considered 'novel foods'. Lab-grown meat is regulated in the EU as "novel food", a legal definition that includes products not significantly present in Europeans' diets before May 1997. In this context, the paper aimed to analyze the perception of the Romanian consumers towards the use of insects and artificial meat in public food. For this purpose, it was applied a questionnaire with 6 questions to a number of 1,200 people over 16 years old. The results pointed out that of the 1,200 questioned individuals, only 30% would consume edible insects. This aspect is due to the fact that in Romania the consumption of insects is not a habit as in other countries, where insects are consumed almost daily. Also, artificial meat is not highly rated by consumers. A very small proportion of those who took part in the survey agree with the production and consumption of artificial meat.

Key words: *public food, edible insects, food, artificial meat, consumers, mealworms*

INTRODUCTION

Recently, the European Commission approved mealworms as a food product in the European Union - a first decision in the field.
Why are insects authorized as food products?
Following a recent authorisation, mealworms are considered 'novel foods' - this designation refers to any food that was not widely consumed by EU citizens before 15 May 1997, when the first food regulation came into force us [25].
In 2023, the EU also developed a strategy on food sustainability, entitled the Farm to Consumer Strategy, which aims to create a sustainable food system that ensures food security, protecting nature and individuals [11] [21]). The UN appreciates that, in principle, sustainable consumption depends on sustainable production, aiming to facilitate the satisfaction of basic needs and ensure a high quality of life [13] [22]. Minimizing the use of natural resources and toxic materials, reducing emissions of pollutants and reducing the amount of waste in order not to endanger society as a whole [3] [6]. According to the OECD, sustainable consumption is achieved by making the consumption of energy and other resources more efficient, minimizing food waste and developing among consumers a mindset and behavior responsible for nature [16] [20] [29].
Of course, it is up to consumers to decide whether they want to eat insects or not, but eating insects is nothing new, as they are already part of the diet in many parts of the world [2].
The draft legislation establishes labeling requirements for food products that will contain novel foods. This requirement is in addition to the provisions of the labeling regulation.

The EU is strongly committed to transparency [7] [18].

According to the FAO, insects as food will play a major role in addressing the many problems we face today and will face in the future [14] [24]. These include the rising cost of animal protein.[4] [23].

Insects are found in abundance all over the world. They are high in protein and account for less than 1% of the animal's carbon footprint [30]. They are the ideal food alternative that facilitates the transition to a healthy and sustainable diet and contributes positively not only to our health, but also to that of the environment and therefore our future [10]. According to FAO, more than 1,900 species of insects are used as food in the world [26][27].

In Romania, Law 411/2023, which applies from January 18, 2024, regulates the use of insects (insect flour) in the preparation of food products, as well as the way in which these products can be labeled and sold.

Economic operators are prohibited from including new foods in the preparation of the products provided for in the National Register of Traditional Products and the National Register of Sacred Recipes.

The reporting committees (agricultural and economic) in the Senate replaced the phrase "insect meal" with new authorized foods in the project.

According to an amendment introduced by the reporting committees and appropriated by the plenary, the European Regulations are listed in whose annexes the forms of use (frozen, paste, dry, powder, partially defatted), the conditions under which new foods can be used in food products, the specific categories of food in which they can be used and the maximum proportions allowed.

On the label of the food products, the name of the newly authorized food will be found as follows: dried, frozen or powdered yellow mealworm, depending on the form used; flour beetle larvae in frozen or paste form; partially defatted homemade cricket powder; frozen/dried/powdered/whole locusts.

The law also states that the labels of food products containing novel foods must state that this ingredient may cause allergic reactions to consumers with known allergies to mites and/or crustaceans and products derived from them. The mention must appear in close proximity to the list of ingredients. An article, kept in the form proposed by the initiators, provides that the food products that are/contain insect species authorized to be introduced on the market as new foods, coming from the European Union area, will be presented in the classic direct sales areas, in a stand separately, delimited by the stands containing consecrated products that do not contain insects.

The topic of lab-grown meat has sparked controversy over the past five years, as promises have been made to lessen the environmental impact of conventionally produced meat. On the other hand, this industry is facing problems due to diminishing investments, difficulties in reaching a high level of production, as well as hostile reactions in some countries [17].

Review of the scientific literature

The research methodology on the systematic analysis of specialized literature, includes specific tools for bibliometric studies considered popular and rigorous methods for exploring and analyzing large volumes of data [8] [12]. The data collection stage is very important for the relevance of the research results, and that is why it was paid more attention to it [9] [19]. The Web of Science (WoS) was used as an academic database because it is considered one of the most important scientific information source in the world [15]. To emphasize the relevance of the final database, we also used VOSviewer, as an IT tool, this being a software product made by Van Eck and Waltman, which allowed us to develop some suggestive bibliometric maps [28].

In order to create the bibliometric maps with the help of VOSviewer, it was necessary to export the WoS database in tab delimited file format [1] [5].

Through this software we were able to perform an analysis of the relevance of the keywords used in the WoS query process, as can be seen in Figure 1.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

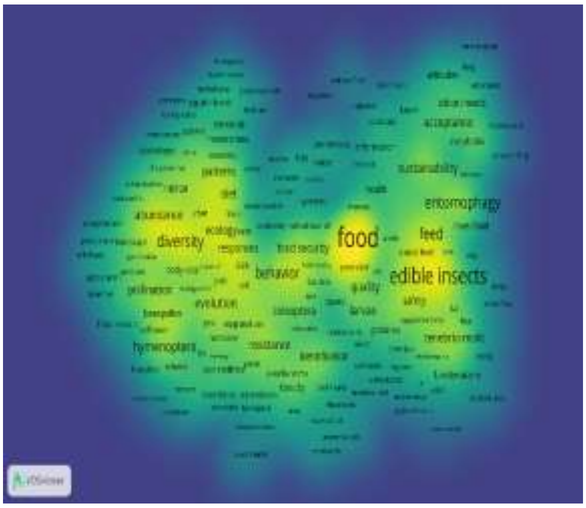

Fig. 1. The relevance of keywords used in the WoS query process.
Source: VOSviewer.

The map generated by VOSviewer highlights the frequency of use of keywords by the authors and, from its analysis, it can be seen that among the most used keywords are those used by us in the query process.

Using the same scientific method, there were also identified university networks, clusters, that study issues related to the use of insects and artificial meat in human nutrition (Figure 2).

A very important element of our research concerned the identification of the most cited authors who addressed these topics and the collaboration between them (Figure 3).

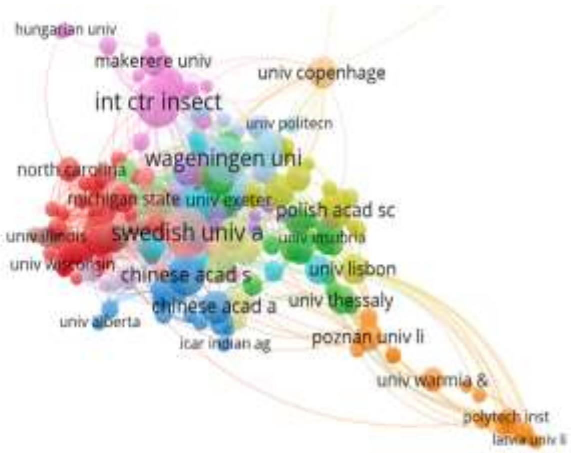

Fig. 2. University networks.
Source: VOSviewer.

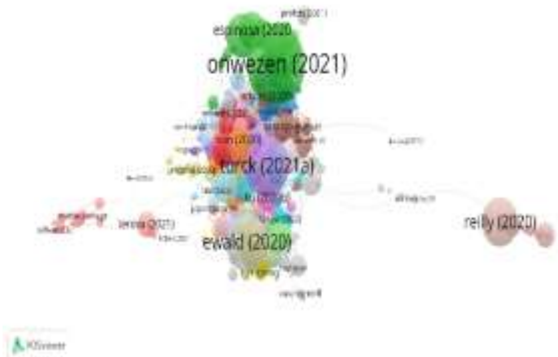

Fig. 3. The most cited authors
Source: VOSviewer.

Also very interesting is the map showing the main publications that dealt with these topics and the collaboration between them (Figure 4).

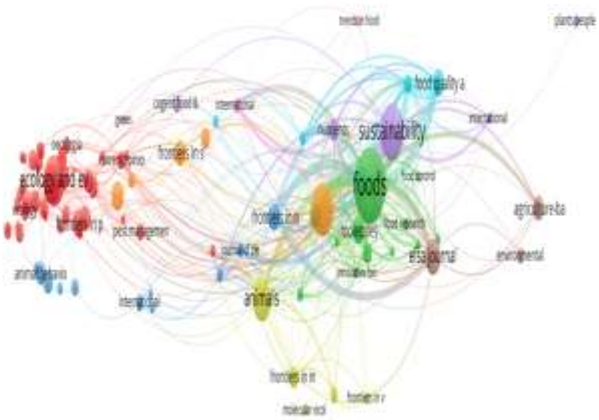

Fig. 4. Main publications
Source: VOSviewer.

MATERIALS AND METHODS

In this paper it was analyzed the perception of Romanian consumers towards the use of insects and artificial meat in public food.

For the study, a questionnaire with 6 questions was applied to a number of 1,200 people over 16 years old.

When applying the questionnaires, the research team was helped by 2 students from the master's degree in Quality and Innovation Management from our faculty.

The questions are presented in Table 1.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 1. The questions in the questionnaire

1	**Would you eat edible insects?**
2	Would you be willing to eat meal or other insect products?
3	Can eating insects become dangerous to health?
4	What would make you eat edible insects?
5	Can insect flour replace regular flour?
6	Do you agree with the production of artificial meat?

Source: Own contribution.

RESULTS AND DISCUSSIONS

According to our analysis, it turned out that out of a sample of 1,200 people, only 30% of them would consume edible insects. This aspect is due to the fact that in our country the consumption of insects is not a habit as in other countries, where insects are consumed almost daily (Figure 5).

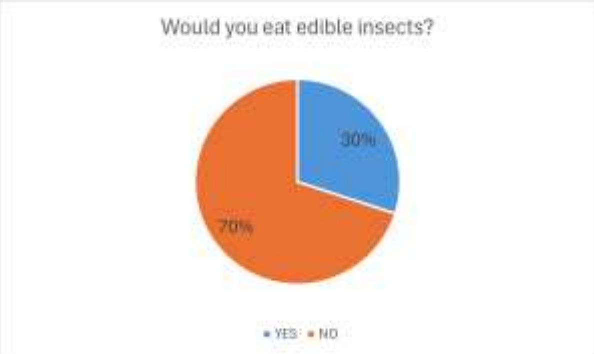

Fig. 5. People willing to eat edible insects
Source: Own contribution.

According to the survey, the consumption of flour or other products resulting from insects, such as powder, has a rather large weight, almost 40% of people answered the question affirmatively.
This result is due to the fact that the insects in the form of flour or powder are subjected to a process that gives a different appearance and taste to the final product compared to the actual eating of the insect (Figure 6).
Referring to the survey, the consumption of insects can become dangerous to health if we do not pay more attention to how they are prepared or the species of insects consumed (Figure 7).

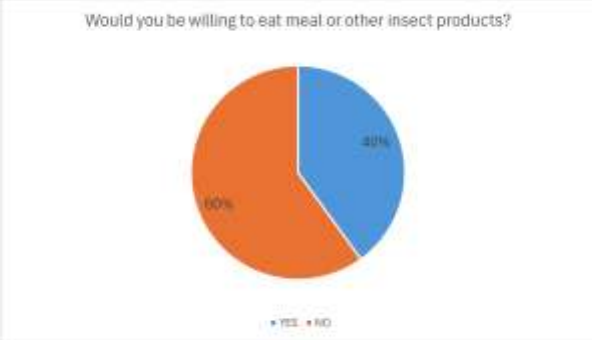

Fig. 6. People willing to consume insect meal.
Source: Own contribution.

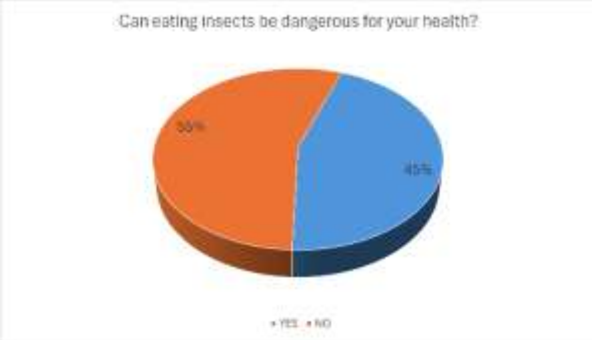

Fig. 7. Can eating insects become dangerous to health?
Source: Own contribution.

Among the Romanians, insects whether edible are looked down upon and not regarded as a source of food or protein. The result shows that only 30% of those surveyed would eat insects at least once out of curiosity.
Most of them wouldn't be driven by anything to even try insects (Figure 8).
Insects as a whole or in the form of flour or powder are not valued so much in Romania.

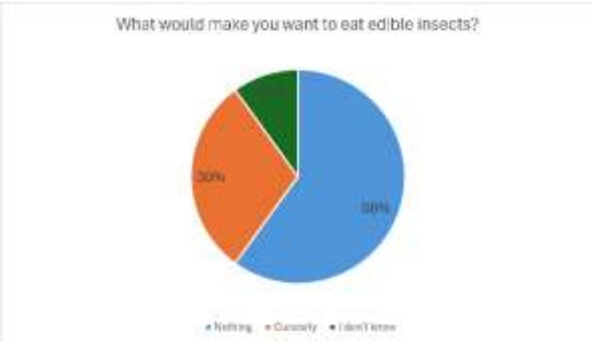

Fig. 8. The reason why people would be willing to consume insects.
Source: Own contribution.

The survey shows that even insect meal is not valued and cannot replace the flour we normally use. 75% of people who participated in the survey do not agree that insect flour can replace normal flour (Figure 9).

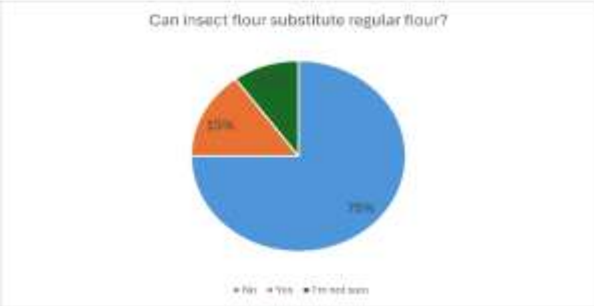

Fig. 9. The consumption of meal from insects.
Source: Own contribution.

Artificial meat is not highly rated by the Romanian consumers. A very small share of those who participated in the survey agree with the production of artificial meat (Figure 10).

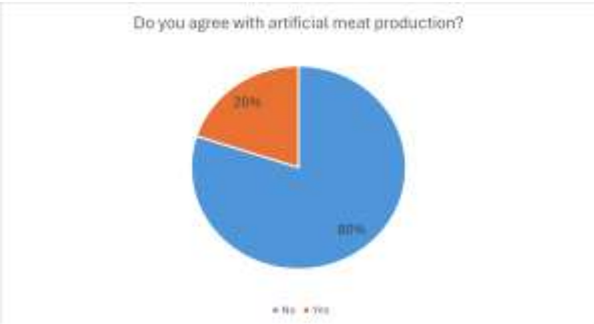

Fig. 10. The opinion of consumers towards the production of artificial meat.
Source: Own contribution.

In a year and a half we could eat laboratory-produced meat in restaurants in Romania. A company in France has already submitted an application to the European Union's regulatory authorities for authorization to sell cultured meat in all 27 states of the Union.
French company Gourmey has applied for the first EU pre-market authorization for lab-grown foie gras amid a heated debate between European governments over food innovation.
On July 26, Gourmey, a Paris-based cultured food company, announced that it has submitted an application for its cell-based duck product to food safety authorities in the EU, Switzerland, the UK, Singapore and the US United. The sale of mealworms in the EU has to meet a number of requirements imposed by EFSA - European Food Safety Authority, so an economic process model for the production of this type of material - mealworms flour, incorporated in an ERP - SAP system using smart technologies as presented in Figure 11.
Mainly the adaptation of the ERP system for this particular type of production is aimed to go through some steps that will be related to the following modules of the integrated ERP SAP system - PP - production planning, MM - material management, CO - controlling, EWM - extended warehouse management, QM - quality management.
The model proposed in this paper will use AI - artificial intelligence, through iRPA - intelligent Robotic Process Automation, to solve the repetitive tasks (tasks).
Sensors and video cameras can also be used to monitor the stages of evolution existing in the growth of these worms (raw material) used for the type of edible flour discussed - these transmit data in SAP for decision making regarding - worm growth (selection of controlled growth environments, control of environmental conditions, etc.), harvesting (and here we can have a range of data that the ERP system can store for various analyses), worm pre-processing, dehydration (the ERP system can monitor and transmit the necessary information for the respective process - drying methods, temperature control, etc.), milling, packaging (airtight packaging, labeling) and storage (controlled storage) and QM - quality management (various analyzes performed and which are attached in the SAP system for use in the economic production process).

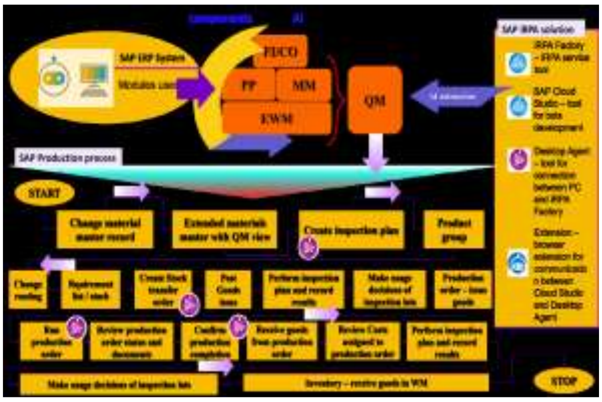

Fig. 11. ERP SAP system.
Source: Own contribution.

CONCLUSIONS

The conclusions regarding the desire of Romanians to consume insects or insect flour are very interesting and differ from other countries.

In Romania, according to the analysis above, it turned out that out of a sample of 1,200 people, only 30% of them would consume edible insects.

This aspect is due to the fact that in Romania the consumption of insects is not a habit as in other countries, where insects are consumed almost daily. Many, 55%, believe this is dangerous to health.

These consumer perceptions are not based on data from specialized studies, but rather from the mass media and social networks.

According to the survey, the consumption of flour or other products resulting from insects, such as powder, has a greater weight, 40% of the 1,200 people surveyed answered the question affirmatively.

Regarding the consumption of artificial meat, Romanian consumers are very conservative and traditional, compared to those from other countries. It is very difficult to change some 2000-year-old gastronomic habits.

In Romania, artificial meat is not highly rated by consumers. A very small share – 20% of those who participated in the survey agree with the production of artificial meat.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

USING REMOTE SENSING TECHNIQUES TO ESTIMATE ACTUAL EVAPOTRANSPIRATION IN THE NILE DELTA, EGYPT

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Abstract

With 755 million tonnes consumed as a cereal grain in 2020, rice is the most consumed crop in the world. Estimating rice's water requirements is crucial since the crop often grows under flood conditions and water serves a number of vital purposes for it. This study uses the Penman-Monteith (FAO 56-PM) method to assess and estimate evapotranspiration, whereas the METRIC model is used to calculate surface enrage balance. The estimation and monitoring of field agricultural water use has shown to be a successful application of remote sensing technology. Using remote sensing techniques, this work aimed to develop a method for estimating crop coefficient and actual crop evapotranspiration (ETc). for rice using METRIC model within the Google Earth Engine (GEE) based on Landsat-8 satellite imagery. The average seasonal ETo (FAO56) resulted 469 mm for crop rice and the water productivity (WP) was 0.42 kg m-3. Good correlations were found between the crop coefficients (Kc) proposed by FAO and (Kc) sat, with R^2 0.92. The Kc_{FAO} used to validate Kc_{Sat}. Linear relationship between Kc_{FAO} and Kc_{Sat} was established and R^2 was 0.96. Normalized Deference Vegetation Index (NDVI) used to estimate crop coefficient according to satellite data (Kc_{Sat}). Landsat TM and Landsat ETM+ data were used to outline the growth of vegetation cover, and these data were coupled with land surface temperature (LST) taken from Landsat8 satellite data and air temperature (Tair) acquired from ground stations. The findings indicated that as cultivated area expanded during rice development, (LST) declined by around 2.3°C and (Tair) reduced by roughly 1.6°C.

Key words: *Evapotranspiration (ET0),water productivity (WP), Land Surface Temperature (LST), crop coefficient (Kc), remote sensing*

INTRODUCTION

Rice is generally recognized as the most important crop for human sustenance since it feeds more than half of the world's population and is the most commonly consumed cereal grain [5]. Due to its lower production costs compared to other summer field crops like maize, cotton, and rice is Egypt's most significant crop in the Nile Delta. About 50% of Egyptians depend on it as their primary source of sustenance, particularly in the Nile Delta and Northern Egypt [8]. According to the Ministry of Agriculture, Egypt's 510,649 acres of rice field produced 326,429 tons of rice in 2015 [10]. A total of 1,100–1,500 mm of water are needed for the rice crop [11, 32]. Comparing this amount to other grain crops throughout the growing season, it is considered to be significant. The mechanism of evapotranspiration is essential to the water cycle. It contributes around 15% of the water vapour atmosphere. The absence of it would result in a significantly colder atmosphere and reduced precipitation. Conversely, nevertheless, the expression Conversely, the term "water productivity" describes the proportion of crop production, or agricultural output, to water intake. Stated differently, it assesses the effectiveness of water usage in farming. Usually, it is stated as the volume of water used to produce one unit of agricultural output. Increasing water productivity is essential for sustainable agriculture, particularly in areas with little water resources. It requires undertaking tasks including improving irrigation efficacy, choosing drought-resistant agricultural varieties, and implementing improved water management strategies. Understanding both evapotranspiration and water production is crucial for efficient management of water resources, especially considering climate change and increasing water shortages.

This is due to the fact that additional factors related to water use, such as percolation (the vertical movement of water in the soil beyond the root zone), lateral flow losses, and surface drainage are taken into account in addition to evapotranspiration, which takes into account both water evaporation and plant transpiration. Rice has a water use efficiency that is comparable to other cereals when just evapotranspiration is taken into consideration [33, 26]. The Food and Agricultural Organisation of the United Nations (FAO) divides the reference evapotranspiration (ETo) by the crop coefficient (Kc) to determine the actual evapotranspiration (ETa) of a given crop [2]. Since ETa is a crucial component of the decision support tools used in field management, it is necessary to construct effective irrigation systems at the field size. Understanding the hydrological cycle, which is directly impacted by global warming, is further aided by the measurement of ETa [31]. Numerous investigations have concentrated on determining Kc using crops experimentally measured ET. The relationships between variations in leaf area, plant height, crop features, irrigation technique, crop development rate, crop planting date, canopy cover %, canopy resistance, soil and environmental variables, and management techniques are illustrated by the Kc values [23]. Applications for the single- and dual-crop coefficient techniques are many. The impacts of soil evaporation and crop transpiration are combined into a single coefficient known as the single crop coefficient [20]. On the other hand, the soil surface evaporation is represented by the coefficient of transpiration and soil evaporation (Ke), whereas the dual crop coefficient indicates Kc. According to Allen and others [2]. The dual crop factor is typically used in research, real-time irrigation scheduling, additional irrigation scheduling, and in-depth analyses of the soil balance and hydrologic fluid. The single crop coefficient is utilised for irrigation planning and design, basic and real-time scheduling of shorter-term water applications, and irrigation management. These researchers used both single-crop and dual-crop techniques to present the crop coefficients of various crops grown with unlimited irrigation, noting that Kc can be affected by soil evaporation, crop type, atmospheric variables (like rainfall, wind velocity, and relative humidity), as well as the growth of the crops [22]. Despite several attempts to establish it empirically for numerous crops, regional variability in Kc is very challenging to define. This is due to the fact that it depends on several management inputs such as irrigation techniques, soil moisture, the availability of nutrients, and plant morphological traits, as well as variables such as climate, soil type, crop type, and variety [2; 15]. An option to determining Kc by employing vegetative indices (VIs) generated from satellite data is the Remote Sensing (RS) approach. One of the most used vegetation indexes in agriculture is the Normalised Difference Vegetation Index (NDVI). While soil reflectivity and the saturation effect may have an effect on the NDVI [29]. The primary cause of selecting this index was to maintain the consistency of past investigations that have been reported in the scientific literature [13,11]. This index benefits from the high reflectance of plant materials in the red spectrum channel (0.62-0.69 m) and the NIR band (0.75-1.3 m). pigments from chloroplasts absorbed. (NIR RED)/(NIR + red) is the normalised ratio of the red and NIR wavelength bands, which is used to construct the index [30,14]. Since increased levels of photosynthetic activity lead to Smaller reflectance coefficient values in the red area of the spectrum and large values in the NIR region allow for a clear separation between vegetation and several other natural components. NDVI normally falls between 0.1 and 0.2 for bare ground and between 0.2 and 1 for vegetation. This is because vegetation has a strong NIR reflection and a low red band reflectance [34].

The NDVI, which helps with the study of the dynamics of the vegetation during the growth season, is closely connected with plants' ability to employ photosynthetic activities to absorb energy [25]. The capacity to keep an eye on changes in the vegetation during the growth season is made possible by the NDVI, which is directly related to plant canopies' capability for photosynthesis and energy absorption [19]. In a separate experiment, Kc was calculated using a linear correlation between Kc and VI, the linear connection between Kcb and VI, a calibrated model of Kc-VI, and a verified model of Kcb-VI based on Landsat 7 data. The findings demonstrated that variations in the NDVI across all techniques could adequately account for variations in Kc [21]. It is possible to produce ETc maps at various scales using remote-sensing-based estimations of ET was calculated using Surface Energy Balance models based on multispectral satellite images [3, 27]. Among the several surface energy balance models, METRIC (Mapping Evapotranspiration at High Resolution with Internalised Calibration) [4].

The aims of this paper were to estimate Eta using Landsat data in summer season 2022, and bio physical variables such.as NDVI, LST, surface albedoand surface emissivity wh ich are useful for the estimation of spatiotemporalvariations in evapotranspiration (ET) using METERIC model and FAO56.

MATERIALS AND METHODS

The study area has a dry arid climate, according to the Köppen Climate Classification System, with rainfall being less than 50 % of the region's estimated evapotranspiration. The location of its UTM coordinates is between latitudes 31° 6′ 10.89 " N to 31° 4′ 7.10" N and 31° 5′ 57.85" E to 30° 59′ 56.16" E.

The whole study area is about 997ha.

A uniform clay-silt soil with a high clay content and low organic matter (1.2%), the soil in the study region has a field capacity of 44 % and a permanent wilting point of 21% and a Mediterranean climate with hot, dry summers and cool, wet winters characterize the research region.

As showed in Fig. 1, this study was conducted in El-Gharbia main drain irrigated area in the Kafr El-Sheikh governorate of Egypt’s North Nile Delta.

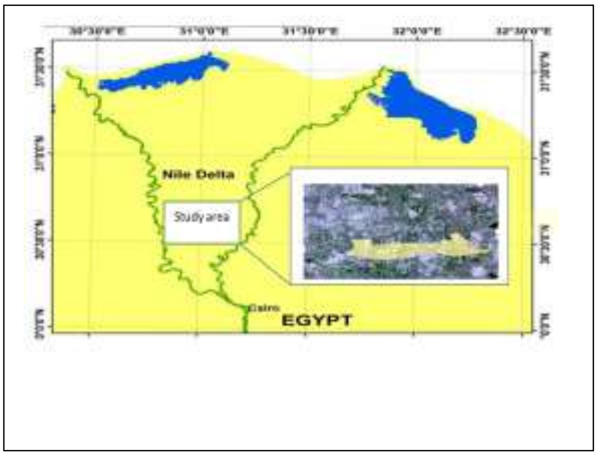

Fig. 1. Location Map of the studied area
Source: designed by authors.

The average yearly temperature is around 19° C.

The annual average rainfall is about 22 mm. The month of January typically records the highest rainfall totals (7 mm on average).

The month with the highest average high temperature is Aug (40 C), while the coldest month on record is January (12 C).

The minimum temperature varies from 12 °C in January to 21 °C in August.

Table 1. meteorological data in 2022 for Kafr El-Sheikh

Month	Min Temp. ° C	Max Temp. ° C	Wind speed km/h	Relative humidity %	ETo monthly
June	19.9	38	6.7	44	232
July	20	39	4.3	50	284
August	20	40	2.2	55	469
September	19	38	2.3	56	327
October	17	37	2.7	57	258
November	11.7	25.3	2.7	89	200
December	7.5	20.9	3.1	84	110
January	7.58	19.23	4.2	80.6	68
February	8.5	20.5	4.9	89.5	86
March	12.4	24.6	4.7	81.5	84
April	16.4	26.4	4.4	75.8	100
May	19.8	31.4	5.3	72.9	127

Source: Data from Sakha Station.

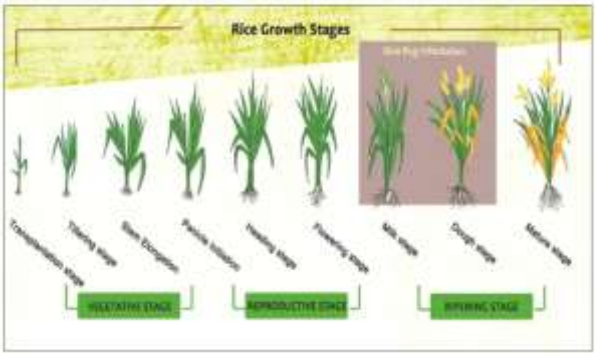

Fig. 2. Rice crop growth stages
Source: Own conception.

Remote Sensing Data Availability

The Landsat 8 data (path 176/row 039) with a 30 meter ground resolution that was acquired during the summer at 10 a.m. The Sallite images were collected on July 26, 2022, August 11, 2022, August 27, 2022, and September 19, 2022. The majority of the study's data came from GEE collecting using Python.

Landsat 8 satellite data were used to calculate NDVI. The United States Geological Survey (USGS) contributed images captured by the Landsat satellite, which is equipped with a functional land imager (OLI) and a thermal infrared sensor (TIRS). A thermal infrared sense (TIRS) with a resolution of 100 m and an operational land imager (OLI) with a resolution of 30 m make up Landsat pictures, which are frequently utilized for managing water resources. The program releases Albedo, vegetation index, land surface temperature, and other surface data are used in conjunction with Landsat's thermal and shortwave channels to calculate ETa [28].

Crop coefficient

Due to differences in evapotranspiration throughout various growth stages, the Kc for a certain crop varies at the growing season. The rice season of cultivation was divided into main three distinct growing stages: Fig. 2 shown the rice growth stages are vegetative stage, reproductive stage, and ripening stage. The Kc curve must be constructed using three typical Kc values: Kc- Veg at the start of the season, Kc-rep.at midseason, and Kc-Rip at late season's finish. According to the FAO-56 method's recommendations, under a typical climatic condition, Kc-Veg., Kc-Rep., and Kc-Rip should be 1.05, 1.2, and 0.9, respectively [2]. It is clear that NDVI and Kc are related. Due to parallels between the Kc curve and a vegetation index generated from satellite data, modelling Kc as a function of vegetation index shows potential. Therefore, it was investigated to see if Kc could be directly estimated from a crop's satellite reflectance [6]. The formula below can be used to generate NDVI data using Landsat8 bands 4 and 5, which provide R and NIR measurements such as:

NDVI = (Band 5 - Band 4) / (Band 5 + Band 4)……………………......................(1)

Kc is combined with ETo to estimate ETc. The value that is calculated (ETc) is obtained by multiplying the dimensionless number Kc by the ETo value, which normally lies between 0.1 and 1.2. The produced ETc can be used by an irrigation manager to schedule when to irrigate and how much water needs to be returned to the land. The link between Kc_{Sat} and NDVI is represented by the equation.

$$Kc_{Sat}=\frac{1.02}{0.6}(NDVI-0.2) \quad \dots\dots\dots\dots \quad (2)$$

where: 1.02 is the greatest Kc for rice under Egyptian environment; 0.2 is the smallest NDVI value for vegetation; and 0.6 is the variance across the minimum and maximum NDVI value for vegetation.

Crop evapotranspiration

According to Jenson's proposed equation [16], the actual crop water use was calculated:

$$ETa=ETo\times K \quad \dots\dots\dots\dots\dots\dots\dots\dots \quad (3)$$

Meteorological data were utilised to compute ETo using the FAO-Penman-Montieth method. The aforementioned equation was created using an empirical approach to estimate ETo. The crop coefficient (kc) was then added to obtain ETc. The Sakha meteorological station provided the meteorological characteristics utilised in this calculation. The equation that was applied was:

$$ETo=\frac{0.408\Delta(R_n-G)+\gamma\left[\frac{900}{T+273}\right]U_2(e_s-e_a)}{\Delta+\gamma(1+0.3442U_2)} \quad \dots\dots\dots\dots (4)$$

where: Rn, the net radiation at the crop surface [MJ m-2 day-1], and ETo, the reference evapotranspiration [mm day-1], G, the density of soil heat flow (MJ m-2 day-1) U2, or wind speed at a height of two metres, and T, or mean daily air temperature at two metres [°C] Δ, slope vapour pressure curve [kPa °C-1],γ, psychrometric constant [kPa °C-1], es, saturation vapour pressure [kPa], ea, actual vapour pressure [kPa], and es - ea, saturation vapour pressure deficit [kPa]. The land surface temperature (LST) is calculated using equations:

$$T = T_{61} + [1.29 + 0.28(T_{61} - T_{62})](T_{61} - T_{62}) + 45(1 - \varepsilon_4) - 40\Delta\varepsilon \ldots (5)$$

$$\varepsilon_4 = 0.9897 + 0.029 \ln(NDVI) \ldots\ldots (6)$$

$$\Delta\varepsilon = 0.01019 + 0.01344 \ln(NDVI) \ldots\ldots (7)$$

where: T_{61} , T_{62} are the brightness temperature of the thermal bands (T_{61} and T_{62}) of remote sensing data, ε_4 the surface emissivity of T_{61} channel, and Δε is the differences in surface emissivity between the T_{61}, T_{62} channels.

Water productivity (WP)

Water productivity is defined as the field obtained per unit of water applied. Water productivity was calculated using the following equation:

$$WP\left(\frac{kg}{m^3}\right) = \frac{Y}{WR} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

where:
Y= yield ($kg.fed^{-1}$), and
WR= the total amount of water applied in the field ($m^3.fed^{-1}$) to determine the rice and wheat $1m^2$ of plants per each plot were harvested manually.

RESULTS AND DISCUSSIONS

The daily reference evapotranspiration for Penman-Monteith rice ranged from 4 to 15 mm day-1. August was the month with the highest daily ETo levels, as the temperature, sun radiation, and VPD were at their highest levels. Daily From May until August, ETo increased before declining in the last months of the year. ETo daily values ranged from 6 to 15 mm day-1 from tillering to maturity stages, respectively. The maximum values in booting and elongation ranged from 216 to 200 mm for ETo monthly values. For sustainable water management and to apply agricultural A study on long-term developments in climatic parameters should be suggested within the context of changing climates in order to preserve and advance food production in a research area under water shortage.

NDVI

Figure 3 shows the NDVI values at different growth stages.

In 2022, the difference between the five stages was more noticeable for the first two stages. At the end of July (Tillering stage), the NDVI values ranged between 0.21 to 0.35. At the beginning of August, the curve intersected, showing a homogeneous distribution. The NDVI decreased towards the end of September after reaching its peak in the middle of the month (about 0.83). The NDVI curve stayed superposed, peaking at the end of August at around 0.80. In 2022, it stayed almost exactly overlapping for the duration of the cultural cycle. Up to the end of August, the NDVI displayed a higher level of vegetative vigour (the whole first phase). At heading 29, the NDVI peak (between 0.78 and 0.83) was attained for all the plants as showed Figure 3.

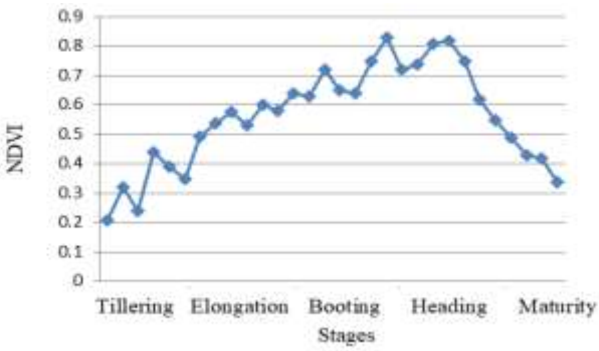

Fig. 3. NDVI for different rice growth stages.
Source: Own research results.

The first rice crop cultivation stage produced the lowest NDVI values (less than 0.3), which were attributed to plant flooding. The greatest NDVI values, around 0.75 and 0.83, were attained in the middle phase, which also reflects the various sowing dates, at the conclusion of booting and the start of heading, respectively. As the growing season came to a conclusion, the NDVI values dropped until the plant was fully mature and harvested at the end of September.

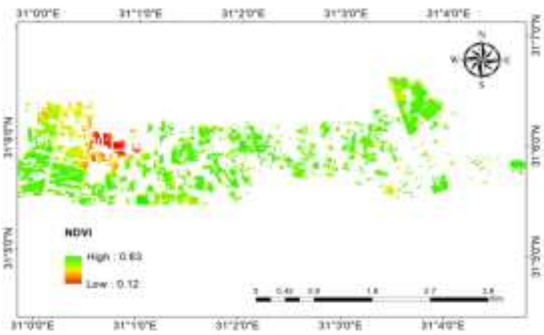

Fig. 4. NDVI extracted from Landsat 8 in heading stage
Source: Own research results.

Land surface temperature and Air Temperature

Due to specific physical factors, the relationship between Temperature of air (T-air) and LST in the thermodynamics of the biosphere is always rather elusive. This relationship was applied to forecast T_{air} from LST as showed Table 2. LST at night was lower than Tair, however on the day it was the opposite due to the increased surface emitted energy, wind speed, and air humidity affecting T_{air}. The relation between LST and T_{air} is positive relationship where the slope is 0.3946, the intercept is 16.327 and R^2 is 0.87 as showed in Fig. 5 and 6.

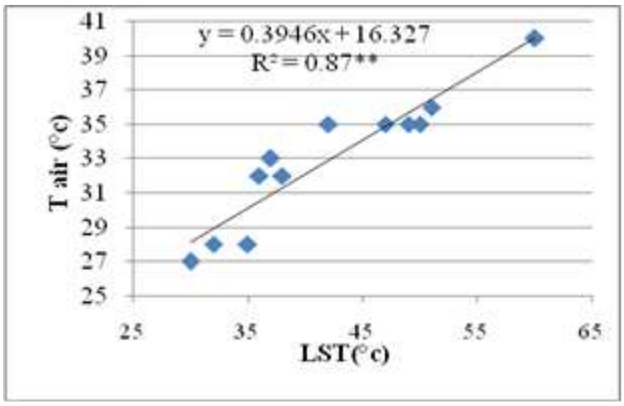

Fig. 5. Relationship between Land surface temperature and air temperature (excel)
Source: Own research results.

Table 2. Illustrates KcSat and Kc FAO simple model description

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std Eror	Beta		
(Constant) Kc FAO	.015 1.034	.087 .110	.983	0174 9.412	.873 .003

Source: Own research results.

Kc coefficient

The canopy height, crop development, layout, and plant cover affect Kc [2]. The NDVI was correlated to Kc in a positive. The Red and NIR bands of the Landsat8 data were used to calculate NDVI of landsat8 data acquired on 26 Jul, 11 Aug, 27 Aug,12 sept and 28 sept respectively.

Figure 6 shows the variation in Kc values in the study region based on Landsat8 data. Kc varied in the sample area from 0.6 to 1.02 as showed in Table 3.

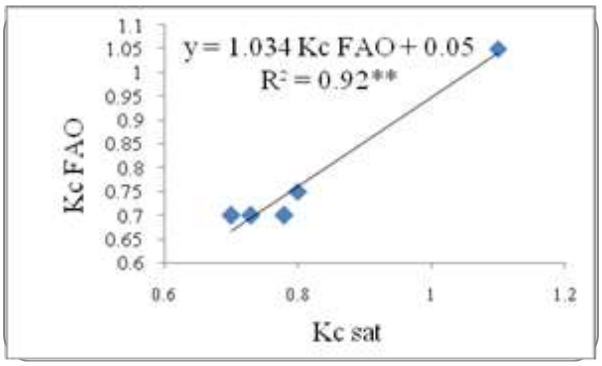

Fig. 6. Relationship between Kc sat and Kc FAO.
Source: Own research results.

There is a strong correlation between Kc and NDVI. Because empirical Kc values vary depending on the environment and crop stage in which they were derived, they have faced criticism for their significance and applications. When the regression strength of the association between the two variables is analyzed, the diagram shows that the developed model has a significant correlation between the Kc Sat and Kc FAO, as showed in Fig. 7.

The model parameters are shown in Table 2, R^2 value is 0.92. The method we present in this study is based on the calibration of the equation shown below.

Kc sat= $\frac{1.02}{0.6}$(NDVI-0.2) equation.

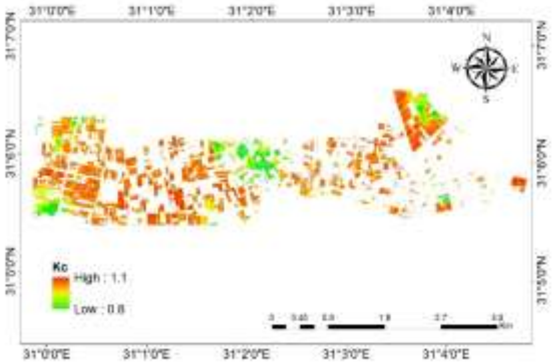

Fig. 7. Kc various in different sites for booting.
Source: Own research results.

It was adjusted for our specific rice crop and local conditions with the goal of further applying it to a temporal series of satellite photographs and replicating a range of crop scenarios under varying management approaches, resulting in a diversity of ETa values. Figure 8 shows a comparison between the ETosat values and estimated EToFAO from methodologies, for the dates with availabilities of Landsat 8 images, for the five campaigns. The satellite derived NDVI data effectively captures this variability. The FAO56 methodology, which assigns uniform crop coefficient for all plants or surface conditions without making a distinction based on planting dates, does not take this into consideration.

Rice actual evapotranspiration (ETc)

Evapotranspiration accounts for the biggest flux in the hydrological cycle, and as data collection is essential for assessing land-use governance and predicting how plants will respond to climate change, daily estimates of ET are important for managing water resources. It's vital to remember that evapotranspiration is influenced by a range of environmental conditions and plant features, such as plant morphology and growth stage. For 2022, ETc daily growth stages varied from 4 to 15 mm, with booting stages having a greater value of 15 mm. ETc monthly growth stages ranged between 129.7 to 467.2 mm for 2022 which was higher value467.2 mm for booting stage, Lower value 129.7 mm for Tillering stage because high the atmosphere evaporative demand was brought on by conditions of high sun radiation, temperatures, and vapor pressure deficit as well as by the plant's steady growth, which makes it consume more water as the temperature rises towards August. Conversely, low the atmosphere evaporative demand was brought on by conditions of low sun radiation, temperatures, and VPD as well as by the plant's steady growth, which makes it utilize less water as the temperature increases towards August as a showed Fig. 9, Fig. 10 and Table 3.

Contrarily, throughout the vegetative and reproduction phases of the crop and decreased during the maturity phase during the WS, the actual daily evapotranspiration of rice altered less. Data also revealed that the ETc peaked in August before declining till harvest. The existing agronomic and meteorological conditions may have caused these results [17, 18, 1].

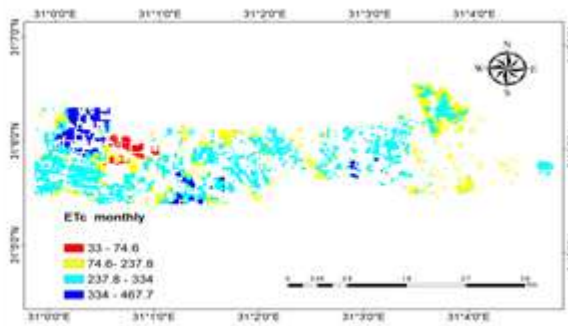

Fig. 8. Monthly actual evapotranspiration Booting stage extracted from Landsat 8.
Source: Own research results.

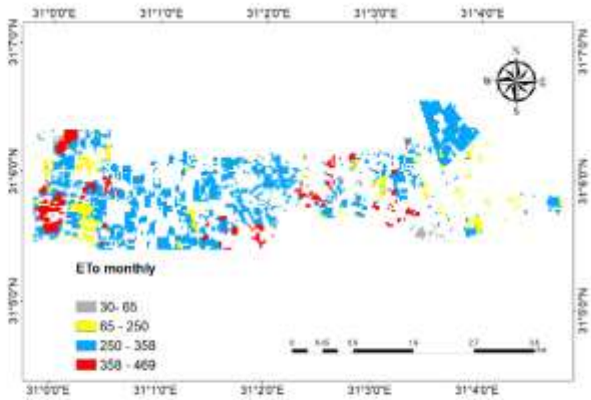

Fig. 9. Monthly evapotranspiration for Elongation stage extracted from Landsat 8.
Source: Own research results.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 3. Evapotranspiration and Kc coefficient at the experimental site for rice for different growth stages

Stages	ETo daily	ETo monthly	ETc daily	ETc monthly	Kc
Tillering 26/July	6.4-8.6	216-284	4.1-5.4	129.7-170.4	0.70
Elongation 11/August	11-15	358-469	9-11.8	281-366.3	0.78
Booting 27/August	9-13	301-425	10.7-15	334-467.2	1.02
Heading 12/September	5.7-7.7	193-258	5.7-7.7	173-232	0.9
Maturity 28/September	6.9-10.9	207-327	4.8-7.6	146-229.2	0.7

Source: Own research results.

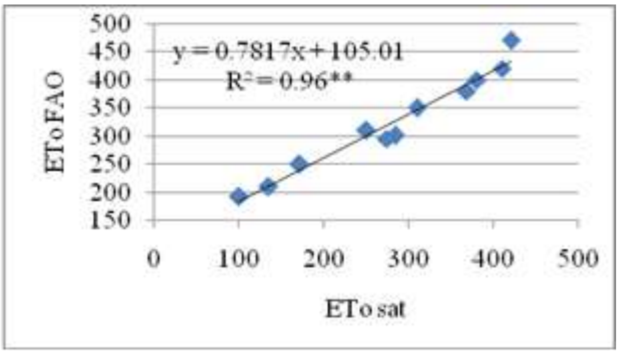

Fig. 10. Relationship between ETo FAO and EtosatSource: Own research results.

Land surface temperature and Air Temperature

Due to specific physical factors, the relationship between Temperature of air (T-air) and LST in the thermodynamics of the biosphere is always rather elusive. This relationship was applied to forecast T_{air} from LST as showed in Table 4.

Table 4. Water productivity and land surface temperature (LST) at the experimental site for rice

Stages	WP m^3/ton	LST
Tillering	1.1	24-28
Elongation	0.7	33-39
Booting	0.4	24-27
Heading	0.8	22-27
Maturity	0.9	26-28

Source: Own research results.

LST at night was lower than Tair, however on the day it was the opposite due to the increased surface emitted energy, wind speed, and air humidity affecting T_{air}.

The relation between LST and T_{air} is positive relationship where the slope is 0.3946, the intercept is 16.327 and R^2 is 0.87as a showed Fig. 11 and Fig. 12.

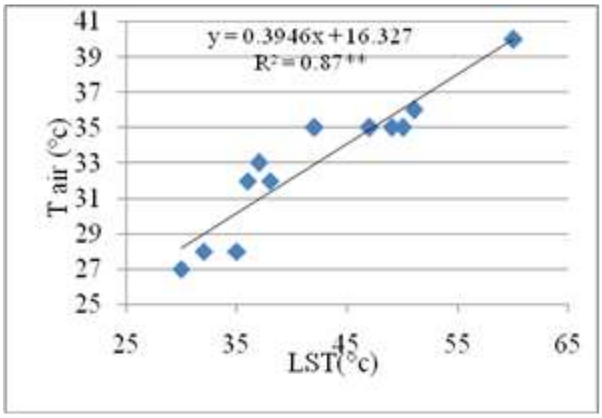

Fig. 11. Relationship between Land surface temperature and air temperature
Source: Own research results.

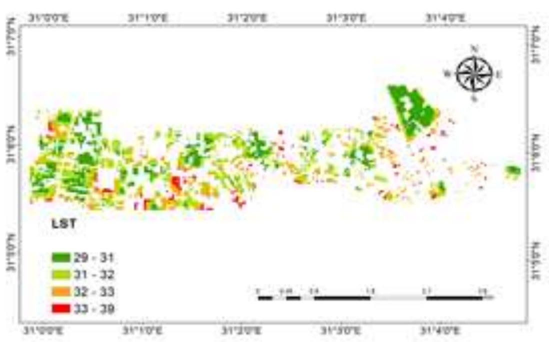

Fig. 12. Land surface temperature (LST) °C, Elongation extracted from Landsat 8
Source: Own research results.

Crop Production and Productivity of Irrigation Water

A comparison of the rice yield (kg/fed) and WP (kg/m3) may be shown in Figure 13. The yield outcomes are related to the amount of water used. It was feasible to link both factors to determine the WP after samples of mature plants were gathered and examined. For each of the rice growing seasons, the findings produced with the ETo sat technique matched the predicted ETc from the FAO56 extremely well. In 2022, there was a larger yield of rice grains. (4.9t/fed), the lowest and higher WP were (0.41, 0.53) Kg/m^3. A WP of rice of around 0.4 kg/m3 has been observed by certain researchers based on the total water input (rainfall + irrigation) [9]. These statistics (an average value of 0.47 kg/m3) are consistent with those found in the current investigation. Reaching this WP challenge may be accomplished in one of two ways: (i) by increasing crop production while lowering applied water usage, or (ii) by increasing productivity (growing crop yield) while using the same quantity of water. According to Blatchford et al. [7], the first approach is preferable for developing strategies for lowering water usage while preserving food production at the basin size where water is the top issue. Farmers ought to be urged to save water if the objective is to lower the amount used. But regardless of the effects on the environment, farmers—especially smallholders with difficult financial circumstances—generally prefer to focus on yields over water use [24].

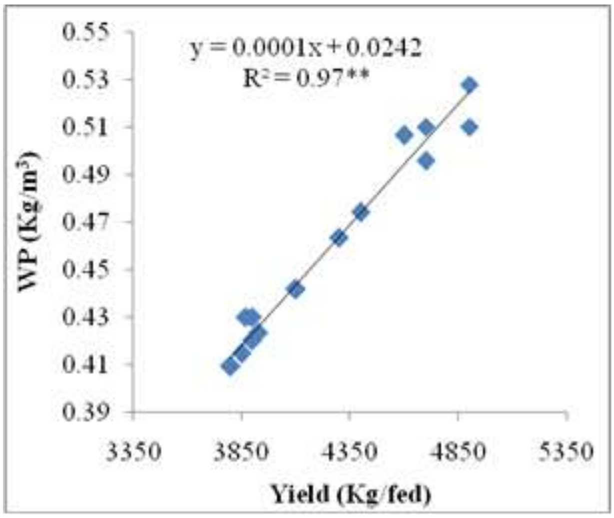

Fig. 13. Relationship between Yield (Kg/fed) and WP (Kg/m^3)
Source: Own research results.

CONCLUSIONS

In order to evaluate the effect of the growth of agricultural areas on the air temperature, a case study in KafrElshiekh was conducted. LST, NDVI, Yield, and Kc were generated using data from Landsat 8. To evaluate LST, tair data from Sakh ground station were used. The research of ETo allowed for a thorough investigation of the water condition of the plants over the study period, ETc and WP. The WP boundaries in each district reveal that there is great potential to improve water use efficiency and productivity. $Kc_{Sat} = \frac{1.02}{0.6}(NDVI - 0.2)$ represented the relation between crop coefficient (Kc) and NDVI.

Linear relationship between KcFAO and KcSat was established (y = 1.034 Kc FAO + 0.05) and R^2 was 0.92. Crop actual evapotranspiration (ETc) varied from 129.7 to 469.7 mm with the highest ETc obtained during the hot and dry seasons. The results of this study can be used as a guideline for rice water use and irrigation water requirement by the irrigation designers, agricultural project managers, consultants, universities, producers, and other stakeholders within rice value .

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THE IMPACT OF THE BAN ON NEONICOTINOID SEED TREATMENT ON AGRICULTURE IN ROMANIA

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Abstract

In the context of growing concerns about the impact of neonicotinoids on bee populations and biodiversity in general, the European Union has implemented measures to ban these substances. The paper studies the impact of the prohibition of neonicotinoid treatment on the main crops in Romania: sunflower, autumn cereals and corn. The analysis sought to identify the effects of the ban through a rigorous methodological approach, using data from a wide range of sources, including official EU reports, published scientific studies and national agricultural statistical data. Field data obtained through direct observation in various regions of Romania were also included. Through the Regulations it has adopted over time, the European Union has tried to reach an agreement both with beekeepers and especially with European farmers, who, year after year, face the attacks of soil pests for the main crops namely: sunflower, corn and cereals. The main results and conclusions of our study demonstrate the effectiveness of the neonicotinoid ban in protecting bee populations and biodiversity but also highlight the complexity of the transition to alternative agricultural practices. Our results suggest the need for integrated policy and support strategies to ensure a sustainable transition without compromising agricultural productivity.

Key words: *neonicotinoids, agriculture, seed treatment, bees, European Union*

INTRODUCTION

The European Union (EU) has taken a decisive action on the use of neonicotinoids, given their negative impact on the environment and, in particular, on the populations of bees and other pollinators [3, 7].
In 2009, the European Commission adopted the Regulation (EC) no. 1107/2009 regarding the introduction of phytosanitary products on the market, a regulation including new rules for the use of phytosanitary products but, at the same time, the risks that may exist if the recommendations proposed in this document are not followed. It is very clearly specified in the document that vegetable production occupies a very important place within the Community [19].
In 2013, the European Commission adopted Regulation (EC) no. 485/2013, which imposed a ban on the use of three substances from the category of neonicotinoids, namely imidacloprid, thiamethoxam and clothianidin, in the treatment of sunflower, corn and rape seeds [16, 2]. The decision was made based on scientific assessments that highlighted serious risks to pollinators [8]. To begin with, the restriction was valid for 2 years, to evaluate the impact of the substances on bee populations.
The European Commission's decision to ban the three substances from the neonicotinoid class was adopted following investigations carried out in 2012 by the European Food Safety Authority (EFSA). These investigations have shown that the insecticides imidacloprid, thiamethoxam and clothianidin, used by farmers to treat seeds, harm pollinating insects. However, the use of these substances remains permitted in protected areas [13].
EFSA played a crucial role in assessing the risks associated with the use of neonicotinoids. EFSA published several scientific reports that served as the basis for EU regulatory decisions.
In 2018, by Regulation (EU) 2018/784 implementing the amendments to Regulation (EU) no. 540/2011 regarding the approvalconditions of the active substance clothianidin, the European Commission prohibits the sale of insecticides containing

clothianidin, but also of seeds treated with it, except crops grown in protected areas [11, 20].
Despite all these regulations that the European Commission drew up due to the pressures of farmers and certain Member States, exemptions were issued regarding treating sunflower and corn seeds with neonicotinoids, more precisely with imidacloprid. The latter is the most used substance in the neonicotinoid category for seed treatment.
EU decisions were preceded by public consultations and discussions with member states, thus ensuring a transparent and participatory process. Farmers, beekeepers, non-governmental organisations and other stakeholders could express their views and concerns.
The bans imposed had a considerable impact on farmers who relied on neonicotinoids to protect their crops from pests. Despite this, the European Union has actively promoted the transition to safer solutions and sustainable agricultural practices. Among these measures are the adoption of environmentally friendly alternatives such as biopesticides and the implementation of crop rotation techniques to reduce reliance on harmful chemicals and help maintain ecological balance.
Under the influence of the pressure exerted by beekeepers and in the context of the numerous exceptions granted to neonicotinoids, the European Court of Justice decided that Article 53, paragraph (1) of Regulation 1107/2009 no longer gives Member States the authority to allow the placing on the market of phytosanitary products intended for the treatment seeds or the marketing and use of seeds treated with certain products, in situations where these products have been prohibited by an implementing regulation. The decision emphasizes the strictness of European regulations regarding the protection of the environment and public health, thus strengthening existing prohibitions and limiting the flexibility of member states in derogating from them [14].
In this context, the research aimed to analyze the effects that the ban on the use of neonicotinoids had on the main crops in Romania. The study was particularly focused on corn, sunflower and rapeseed crops, which represent some of the most important crops from an economic point of view for Romanian agriculture. Through this approach, it was aimed not only to quantify the economic impact but also to identify changes in agricultural practices and how farmers had to adapt to the new regulations imposed at the European level. The evaluation also looked at aspects related to plant health and possible alternatives used to protect these crops, trying to provide a complete picture of the consequences of the ban on neonicotinoids in Romanian agriculture.

MATERIALS AND METHODS

In this sense, the main crops in Romania were presented, where neonicotinoids from seed treatment are of great interest to farmers, but also the negative effects their use could have on the environment. The data on the areas and crop production were obtained from the National Institute of Statistics of Romania.
The paper also presents the main pests fought with neonicotinoids, their influence on bee flocks, and the European Union Regulations that were the basis for banning these substances in EU member countries.

RESULTS AND DISCUSSIONS

Neonicotinoids are a class of insecticides with neuro-active action, having a chemical structure similar to that of nicotine. These substances act specifically on the central nervous system of insects, disrupting its normal functioning. Because of their mode of action, neonicotinoids are highly effective in controlling agricultural pests, but this high effectiveness has also raised concerns about their impact on other species, including pollinating insects essential to natural ecosystems and crops [2, 6, 21].
They are a class of insecticides widely used in agriculture to protect crops from major soil pests. These insecticides were developed by Shell and Bayer in the 1980s [15].
The prohibition of neonicotinoid seed treatment has a significant impact on the main crops in Romania.

The main crops for which Romanian farmers do not want to give up the use of neonicotinoid treatments are sunflower, corn (wheat and barley) and rape. These crops in our country represent a significant share of the cultivated area of each farm (Table 1).

Table 1. Cultivated area and production of the main crops

	Cultivated area Ha (K)		Total production Tons (K)		2023 compared to 2022	
	2022	2023	2022	2023	Ha	Tons
Cereals for grains	5,184	5,238	18,861	20,571	54	1,710
-wheat	2,169	2,208	8,684	9,635	39	951
-barley	426	501	1,707	2,001	75	294
-corn	2,431	2,373	8,037	8,522	-58	485
Oil plants	1,701	1,859	3,584	4,122	158	538
-sunflower	1,093	1,089	2,107	2,028	-4	-79
-rape	469	625	1,230	1,787	156	557

Source: National Institute of Statistics [12].

The prohibition of the treatment of seeds with neonicotinoids has a significant impact on agriculture in Romania [5]. Neonicotinoids, a class of insecticides, have been widely used to protect crops against pests. However, these substances have been associated with negative effects on the environment, particularly on populations of bees and other pollinating insects.

The prohibition of treatment with neonicotinoids presents a series of negative effects, experienced over time by farmers, among which we mention:

-significant decreases in yield for corn and sunflower crops. These crops are particularly vulnerable to attacks by insect pests such as *Tanymecus dilaticollis* (maize beetle). Without the protection afforded by neonicotinoids, crop losses can be substantial, affecting production and farm incomes;

-neonicotinoids are known for their effectiveness in combating a wide spectrum of insect pests, but without them, crops can become more vulnerable to attack, which can lead to more pressure on everyone involved (producers, distributors and farmers) in agriculture to find alternative solutions.

In parallel, certain associated advantages include aspects related to the conservation of biodiversity, by protecting ecosystems, which are essential for maintaining a healthy natural balance. At the same time, special emphasis is placed on improving soil and water quality, recognizing the crucial role these resources play in the long-term sustainability of agriculture. By using sustainable agricultural practices, the aim is not only to increase efficiency in production but also to reduce the negative impact on the environment, thus ensuring a harmonization between economic activities and environmental protection. These measures reflect a deep commitment to developing agricultural systems that are resilient, regenerative and capable of sustaining human communities responsibly and equitably.

-one of the main reasons for banning neonicotinoids is to protect bees and other pollinators, which are essential for the health of ecosystems and the pollination of many crops. Reducing the use of these pesticides can help halt the decline in populations of bees and other beneficial species [9, 10].

-furthermore, neonicotinoids are said to contaminate soil and water, adversely affecting aquatic organisms and soil health. Banning them can lead to a reduction of these contaminants and improve the quality of the environment.

-banning neonicotinoids may encourage farmers to adopt more sustainable agricultural practices such as crop rotation, use of natural pest predators, organic products and other environmentally friendly methods of managing pest attacks.

The multiple exemptions obtained by the Ministry of Agriculture and Rural Development, which allowed Romanian farmers to use imidacloprid as an insecticide for the treatment of the main field crops, were justified by the presence of specific soil pests, which certain regions of the country face. These exceptions were invoked against the background of an urgent need to protect crops against infestations that could have seriously compromised agricultural production in the affected areas. The decision to request these exemptions reflects the complexity of phytosanitary challenges in Romanian agriculture and the need for quick and efficient solutions to maintain stability and productivity in the agricultural sector. These are: *Zabrus tenebrioides*, *Agriotes spp* and *Tanymecus dilacotillis*.

We find *Zabrus tenebrioides* (the ghebos beetle) spread all over Europe and in Romania we find it in all the areas where wheat and barley are mainly cultivated, but more frequently in the Bărăganului Plain but also Dobrogea [Photo 1]. It is a dangerous pest because it can cause losses of 80% or even 95% in years of invasion [1]. The ghebos beetle overwinters as a larva and when the soil temperatures exceed 3 degrees Celsius, it comes out of the ground and eats the leaves of the plants, until they are destroyed [17].

Photo 1. Larva of *Zabrus tenebrioides*
Source: Original own photo.

Agriotes spp. (wireworms) are widespread in all the territories of our country, but we find them mainly in SE Romania (Photo 2). They have multiplied mainly due to the farmers' practice of monoculture but also due to the non-observance of rotations. Unlike other soil pests that have one generation per year or even more, wireworms have a generation of 3 – 4 years.

If we have a drought, the larvae migrate into the soil, at depth, looking for moisture. But if there is precipitation outside, the larvae move to the surface of the soil where the agricultural plants are found and attack them. Agriotes spp. is a common pest for sunflowers, and autumn cereals, but especially maize [18].

Photo 2.*Agriotes spp.*
Source: Original own photo.

Tanymecus dilacotillis, the corn borer, appears in late April and early May [Photo 3]. We find it in most areas of Romania, being reported for the first time in 1904 [4].We find it especially where corn and sunflower culture predominate.

Photo 3. Adult *Tanymecus dilacotillis*
Source: Original own photo.

When the plants have 2-4 leaves then they attack the hardest, cutting the plants from the parcel and a mass attack can compromise the entire crop. If the plants are attacked when they are in a more advanced phase of vegetation, the plants recover but we see a delay in growth.

CONCLUSIONS

Banning neonicotinoids in Romania has both advantages and challenges. Although the measure protects the environment and the health of pollinators, it forces farmers to find alternative solutions, which may be more expensive and difficult to implement in the short term. Investments in agricultural research and education are essential to help the agricultural sector transition to more sustainable and efficient practices.

In recent years, the use of neonicotinoids in Romanian agriculture has been an intensely disputed topic between farmers and beekeepers. Each of them came up with convincing arguments to support their cause and the businesses they own. Numerous articles have been written in the press and numerous studies and documentation have been done regarding the impact of neonicotinoids on bee colonies.

The point of view of beekeepers is to ban neonicotinoids for treating sunflower and corn seeds because, they say, these substances affect the ability of bees to search for food, can cause increased mortality among bee populations, reduced colony development, increased risk of disease but also the decrease in honey production.

On the opposite side, come the farmers who claim that, together with the manufacturers who sell neonicotinoids, if the substances are used as the manufacturer writes in the technical sheet and the seeds are treated in appropriate spaces and by those approved, controlled by the Phytosanitary Directorates, the risks for the livestock of bees decreases.

Regarding the future of pesticide regulation, the EU continues to monitor the use of pesticides and their impact on the environment and human health.

The regulations are periodically reviewed based on new scientific evidence and technologies, to ensure sustainable agriculture and protecting biodiversity.

In conclusion, the EU has taken a cautious and proactive stance on the use of neonicotinoids, based on sound scientific evidence and the need to protect the environment and pollinators vital to agriculture. The banning decisions reflect the EU's commitment to sustainable agriculture and biodiversity conservation.

In Romania, the last exemption in this case is from November 16, 2023 and came into force from January 22 - May 21, 2024. All products or seeds treated with imidacloprid that were not used by May 21, 2024, had to be destroyed.

At this moment, due to climate change and especially the spread of soil pests that cause significant damage to sunflower and corn crops in our country, the Ministry of Agriculture and Rural Development is trying, together with relevant organizations, to find a long-term solution for using of neonicotinoids in our country to be able to treat sunflower and corn seeds and Romanian farmers to obtain satisfactory productions.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY ON THE INFLUENCE OF ALUMINOSILICATES USED AS FEED ADDITIVES ON THE QUANTITY AND QUALITY OF MEAT: A BIBLIOGRAPHIC ANALYSIS

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Abstract

Aluminosilicates, including zeolites, have garnered attention in animal husbandry due to their diverse applications for improving meat quality. This review synthesizes research findings on the impact of zeolites on various meat quality parameters, covering performance analysis, meat composition, sensory aspects, and technological parameters. Notably, zeolites influence carcass weight differently, with varying effects observed across different animal species. Additionally, zeolite supplementation alters meat composition by affecting fatty acid profiles and water-holding capacity. Sensory parameters such as colour and texture are also influenced by zeolites, with particle size and coating with nanosilver playing significant roles. Moreover, zeolites affect technological parameters like pH and cooking loss, highlighting their multifaceted impact on meat quality.

Keywords: *zeolites, meat quantity, meat quality parameters, meat technological parameters, carcass traits*

INTRODUCTION

Aluminosilicates are a broad class of minerals composed of aluminium, silicon, and oxygen, often with other elements incorporated into their structure. These minerals are abundant in the Earth's crust and have diverse uses in ceramics, construction materials, and as catalysts[14].
Zeolites are hydrated crystalline aluminosilicates that contain other cations such as calcium, strontium, sodium, potassium, barium, and magnesium. They were discovered and named by the Swedish mineralogist Cronstedt in 1756, and currently, they can be natural or synthetic [11].
Clinoptilolite is a specific type of zeolite mineral characterized by its high adsorption capacity and ion exchange properties. It has applications in agriculture, environmental remediation, and animal feed additives due to its ability to capture toxins and improve nutrient absorption [35].
The Zeolit Production group of companies from Romania exploits the existing volcanic tuffs in the Rupea area, BrașovCounty. They sell a wide range of zeolite-based products, some of which directly contribute to the welfare and health of animals and birds. They help to detoxify the body, prevent, and combat gastrointestinal problems, increase the resistance of the eggshell, etc. Products based on zeolites that are for zootechnical use also help to protect the environment by reducing the level of pollution with gases resulting from the exploitation of animals. The products in the Zeco range are used either as feed additives for feeding different species of farm animals, or as ecological litter [35].
Mordenite is another type of zeolite mineral with a porous structure like clinoptilolite. Mordenite is used in various applications such as catalysts, adsorbents, and molecular sieves. These can be used as additives in animal feed or as materials for food packaging [15, 34].
According to the Scientific Opinion of the EFSA Panel on Additives and Products or Substances used in Animal Feed (FEEDAP), clinoptilolite (hydrated calcium aluminosilicate) is not absorbed, not degraded

through feed metabolism, and consequently, it is excreted. For this reason, it is considered to pose no risk to consumers. The FEEDAP Panel considers that for all animals, a maximum addition of 10,000 mg clinoptilolite/kg complete feed does not present risks [13].

This paper aims to provide a bibliographic study on the effect of zeolites on the quantity and quality of meat from animals that have received feed with zeolites.

To achieve the stated objective, three research questions (RQ) are chosen:

• RQ1. What has been the evolution of the scientific literature on the effect of the use of zeolites in animal feed on the quantity and quality of meat?

• RQ2. How do zeolites used as feed additives influence the results obtained at slaughter (carcass weight, weight of different parts of it and meat quality)?

• RQ3. How do zeolites used as a feed additive influence meat quality parameters?

MATERIALS AND METHODS

From the academic databases Web of Science (WoS) and Scopus, 327 documents were collected in English. These were published between 1976 and 2023 inclusive. The query used two binary operators: "AND" and "OR", and the query strings used to collect the database were: (Zeolite OR Aluminosilicate OR Clinoptilolite OR Mordenite) AND (Meat OR Carcass OR Slaughter). This resulted in 450 articles. Articles present in both databases were manually eliminated. For bibliometric analysis, the Biblioshiny program provided by the Bibliometrix R-package(http://www.bibliometrix.org) was used [2].

RESULTS AND DISCUSSIONS

RQ1. How has the literature dealing with the influence of zeolites in poultry and livestock feed on meat production evolved so far?

Performance analysis

Following the query of the two databases WOS and Scopus, 327 documents were obtained, of which 236 are articles, 18 are proceedings papers, and only 5 are reviews. The annual production, within the period of 1976-2023, is presented in Figure 1.

The number of scientific articles published on this topic has registered a continuous upward trend, with variations depending on the year. Most scientific articles on this topic have been published in 2023, with 22 articles published.

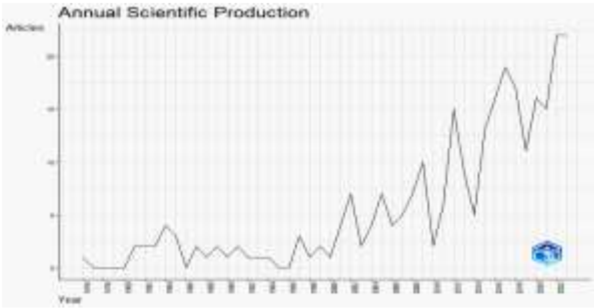

Fig. 1. Number of annual scientific articles from the WOS and Scopus databases, addressing the use of zeolites in feed, published between 1976-2023.
Source: Biblioshiny.

Table 1. Most relevant and most locally cited sources

Most relevant source		Most Local Cited Sources	
Sources	Articles	Sources	Articles
Poultry Science	12	Poultry Science	824
Nutrition Reports International	8	Journal Anim Science	287
Animals	7	Brit Poultry Science	184
Asian-Australasian Journal of Animal Sciences	6	Animal Feed Science and Technology	167
Journal of Animal Science	6	Meat Science	110
British Poultry Science	5	Asian Austral J Anim	97
Toxins	5	Res Vet Sci	87
Cuban Journal of Agricultural Science	4	J Appl Poultry Res	82
Environmental Science and Pollution Research	4	Bioresource TECHNOL	79
Journal of Animal and Veterinary Advances	4	J Agr Food Chem	78

Source: Biblioshiny, based on the WOS and Scopus dataset.

Table 1 identifies the most significant scientific journals in which articles on this topic were published, as well as the journals in which the most citations of articles on the effect of zeolites used as feed additives were registered.

In the both cases, Poultry Science ranks first, which can be explained by most of the research being conducted on poultry.

Is noticeable that only two journals in Table 1 predominantly focuses on meat or food characteristics in general, rather than on poultry and live animals.

These journals have had a variable number of articles on this topic over time (Figure 2).

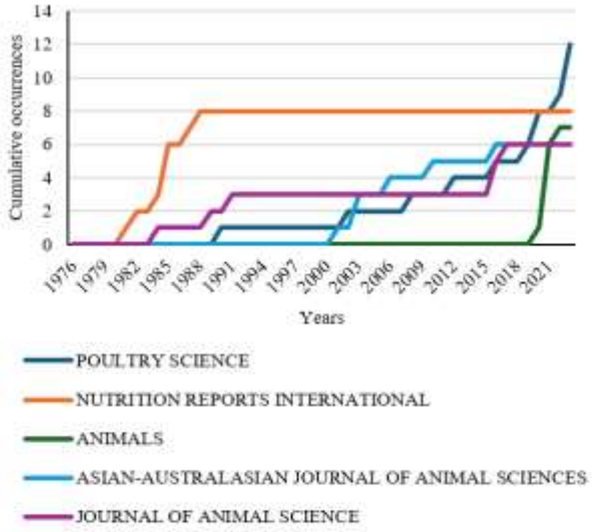

Fig. 2. Sources of articledproduction over time
Source: Biblioshiny, based on the WOS and Scopus dataset.

It can be observed that initially articles were published in Nutrition Reports International, but as new journals appear, they will publish more and more articles. In this scenario, the journal Animals stands out, publishing the first article on this topic in 2020.

Regarding the authors, annual production and the impact of articles can be considered. In this regard, an overview for the studied period is presented in Figure 3.

For the initial period studied, Pond WG is notable (with 3 articles in 1984 and 1985, and 1.6 citations in 1984) and Yen JT (with 2 articles in 1981 and 1983, and the highest number of citations being 1.3 in 1983). After 2012, Huang G and Kong X, along with Dastar B and Hassani S, stand out, while after 2021, Adamski M, Banaszak M, and Biesek J can be mentioned, each having 4 articles in 2021 and 2022 respectively.

The authors' activity can be assessed by the total number of published scientific articles (NP) and the number of accumulated citations (TC). Some indexes can also be used, such as: h-index (n articles with at least n citations), g-index (n articles that have at least n^2 citations) and m-index (which shows the ratio between the h-index and the number of years that have passed from the first published article).

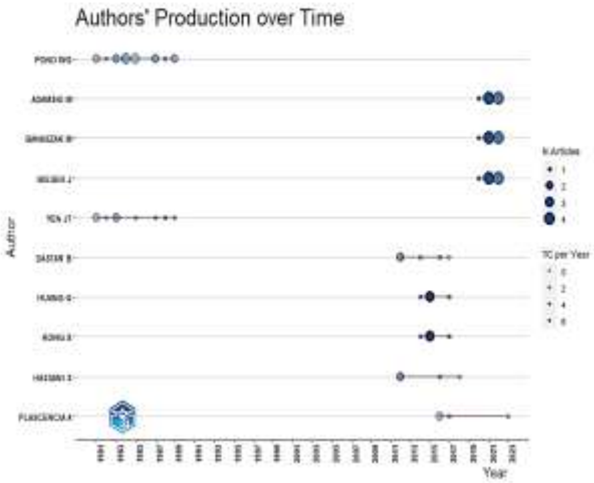

Fig. 3. The evolution of the number of scientific articles published by authors in a year and the number of citations received in that year
Source: Biblioshiny, based on the WOS and Scopus dataset.

From the data presented in Table 2, it can be observed that Pond not only has the highest values for NP and TC but also stands out with high values of h-index and g-index, followed by Yen.

Table 2. The 10 most relevant authors

Element	H index	g index	m index	TC	NP	PY start
Pond WG	11	16	0.25	279	16	1981
Yen JT	7	9	0.16	151	9	1981
Huang G	5	5	0.45	106	5	2014
Kong X	5	5	0.45	106	5	2014
Adamski M	4	7	0.8	54	9	2020
Banaszak M	4	7	0.8	54	9	2020
Biesek J	4	7	0.8	54	9	2020
Dastar B	4	5	0.31	56	5	2012
Alexopoulos C	3	3	0.13	132	3	2002
Hassani S	3	4	0.23	44	4	2012

Where: TC - total number of citations; NP - total number of publications; PY start - year of the first article publication
Source: Biblioshiny, based on the WOS and Scopus dataset.

The two authors have 9 joint research studies in this field.

The studies carried out by them address various topics related to the effects of dietary supplements, especially clinoptilolite or zeolites, on various aspects of animal health and performance.

One objective pursued was the influence of clinoptilolite in feed on weight gain in pigs and lambs [24,25,31].

The following authors have relatively close h-index values, but Adamski, Banaszak, and Biesek have the highest m-index. These 3 authors have 9 joint articles, of which 7 have focused on the quality of meat resulting from animal feeding [3, 4, 5, 6, 7, 8, 9].

Production over time by main representative country is presented in Figure 4. The first concerns can be seen to have appeared in the USA, and after the 2000s they intensified. At the same time articles began to appear in Poland, Serbia, Iran, and China. In the last three years, China has the highest productivity.

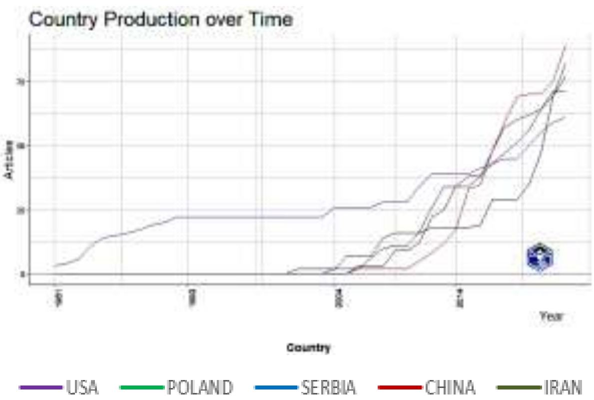

Fig. 4. Country production over time
Source: Biblioshiny, based on the WOS and Scopus dataset.

RQ2. To what extent can zeolites in poultry and animal feed influence the weight of carcasses/components resulting from slaughter?

The influence of zeolites on the carcass weight

The use of zeolites in animal husbandry, both as feed additives and to improve their welfare and the environmental protection, can contribute to the greening of the EU agriculture and the valorisation of natural resources, respectively, ensuring food security [26, 27].

So far, the influence of zeolites on carcass weight varies significantly. For example, Çabuk et al. (2004) found that supplementation of broiler feed with natural zeolite at doses ranging from 15 to 25 g/kg feed did not influence broiler live weight [10].

Similarly, supplementation with 5 g clinoptilolite/100 kg feed did not influence slaughter yield, carcass weight or carcass structure[18]. Other authors, such as Banaszak and colleagues (2022) observed an increase in muscle mass in the breast and legs, associated with overall body growth due to the addition of aluminosilicates in the feed. Moreover, an increase in liver weight was noted. The authors attribute these observations to the type of aluminosilicates used, as well as the composition and quality of the feed, alongside lipid metabolism and accumulation in the liver [6]. Prvulovic and Kojic found that the spleen increased in size with a 5% addition of zeolites, without affecting other organs [28].

Recently, Abdelrahman et al. (2023) tested the effect of using zeolites in different doses and with different particle sizes in the feed of broilers. The aim was to appreciate the evolution of body weight, the structure of the carcass meat and its technological quality. The presented conclusions show that supplementation with doses of maximum 10 g zeolite/kg feed positively influences the health of the birds and reduces mortality. At the same time, the use of zeolite as a feed additive above this dose has negative effects on productive performance [1].

Other authors show that adding zeolites to broiler feed nets or spreading them on permanent litter does not influence growth performance or slaughter yield. Addition of 5 g/kg natural zeolites to broiler feed had no effect on reducing NH3 concentration in the house or litter moisture [29].

Christaki-Sarikaki et al. (2006) included natural zeolite at a rate of 2% in combination with flaxseeds, leading to a significant increase in thigh meat weight and a reduction in abdominal fat [12].

In the case of ducks, Biesek (2021) observed that using 4% zeolite in feed resulted in decreased body weight gain and increased feed conversion rate, but they noted an improvement in breast meat quality [9].

For pigs, it was observed that zeolites influence metabolism but do not affect weight gain [31].

Furthermore, Fabijańska et al. (2001) concluded that a 3% proportion of zeolites in feed reduces loin surface area [16].

Results regarding lambs or sheep are controversial. Stojković et al. (2012) found a significantly positive influence in lambs fed zeolite rations [32], while Toprak et al. (2016) using rations with 2% and 3% zeolite in lamb feed found no significant differences[33]. Similarly, no positive effects were reported in cattle [21,30].

RQ3. How do zeolites in poultry and animal feed influence meat quality parameters?

Meat Quality Parameters

Meat composition

Herc et al. (2021) added zeolite to the diet of rabbits at a concentration of 0.2 g/kg of body weight and observed that in the Longissimus dorsi muscle, the water content (73.630 ± 0.270 g * $100g^{-1}$) was significantly higher compared to the control (72.480 ± 0.530 g * $100g^{-1}$), but no significant difference was observed in the Musculus Vastus lateralis muscle[19].

Mallek et al. (2012) show that adding up to 1% zeolites to poultry feed does not alter protein content but interferes with the gelling process of proteins[22]. Changes were also observed in amino acid levels, as the use of zeolites in rabbit feed led to a significant increase in cysteine content, at 0.2898 ± 0.007 g * $100g^{-1}$ compared to the control, which recorded only 0.2772 ± 0.011 g * $100g^{-1}$[19].

According to Banaszak and colleagues (2022), a higher amount of intramuscular fat was found in the breast of broiler chickens, while a lower amount was observed in leg muscles [6, 7]. Adding zeolites to cattle feed led to a significant increase in n-3 fatty acids in intramuscular fat. A doubling of the linolenic acid (C18:3) content was achieved with a 0.5% addition of zeolites. Additionally, the linoleic acid (C18:2) content increased. They explained this by the alteration of intestinal microflora in the presence of zeolites, resulting in reduced degradation of PUFA acids. At the same time, researchers observed an increase in oleic acid (C18:1) but a decrease in palmitoleic acid (C16:1) content, possibly due to reduced Δ9 desaturase activity [20].

Mallek et al. (2012) used ZeoFeed, a commercial product with a minimum of 84% clinoptilolite, and found that Tunisian broilers fed with 0.5% zeolite showed double the linoleic acid content compared to the control group[22].

Similar results were obtained by Hcini et al. (2018) in the case of Turkey poults. The same authors found a significant reduction in lignoceric acid (C24:0). When 2% zeolites were added to the basal diet, the lignoceric acid content was reduced to less than half of the value obtained in the control birds [18].

Herc et al. (2018), using zeolite in rabbit feeding at a ratio of 0.2 g zeolite/kg of body weight, observed a significant increase in linoleic acid content compared to the control group only in the *Longissimus dorsi* muscle, while no significant difference was recorded in the *Musculus Vastus lateralis*muscle[19].

Regarding saturated acids, their level decreased, possibly due to the increase in unsaturated acids [20, 22].

The oxidative stability of lipids was investigated by Hashemi et al. (2014). They observed that the concentration of malondialdehyde decreased insignificantly when using zeolites coated with silver nanoparticles [17].

Sensory parameters of meat

The colour of meat can be expressed using the CIELAB system, also known as CIE Lab*, which represents lightness (L*), redness (a*), and yellowness (b*). While Banaszak et al. (2021) observed that adding aluminosilicates to the diet did not lead to a change in the colour of bird breast and leg muscles [4-5], Abdelrahman et al. (2023) concluded that the proportion (0-20 g of zeolite per kg of diet) or particle sizes of zeolite (1mm and 2mm) did not significantly affect brightness and b* immediately after slaughter. However, they did impact the a* values both at the time of slaughter and 24 hours post-slaughter. Particle size affected the final b* colour, with birds receiving larger particles showing more yellow colour and lower L* values in breast muscles[1].

Hashemi et al. (2014) reported the change in the color of broiler thigh muscle when nanosilver-coated zeolites were added to the feed. Thus, the L* values were higher in the experimental group compared to the control group, obtaining the highest values when zeolites coated with nanosilver were used. The b* values for the same thigh muscle were also significantly higher only for birds fed nanosilver. The a* values for this muscle were lower in the experimental group (6.72 for the 1% zeolite diet), compared to the control group (7.02). In the presence of nanosilver, the recorded value of the a* indicator (5.46) was obtained in the case of using 1% zeolite and 75ppm nanosilver) [17].

In the case of broilers raised in Tunisia, the addition of 1% zeolites to the feed, compared to the control group, caused a sharp increase in the hardness of the thigh muscles, from 1.53 to 2.76N. Their elasticity also increased from 3.23 to 5.50 mm [22].

Hashemi et al., (2014) observed for broiler breast muscles the influence of diets with zeolites coated or not with nanosilver on hardness and gumminess (the lowest value was obtained for feeds with 1% zeolites not coated with nano silver), cohesiveness (higher values only for feeds with 1% zeolites coated with 50 ppm and 75 ppm nano silver), and chewiness values (lower than control in the case of feeds with 1% zeolites and 1% zeolites coated with 25 ppm nano silver). For broiler thigh muscles, hardness, stickiness, and cohesion were not influenced by dietary treatment. They observed significantly higher values for hardness, gumminess, and chewiness with a diet containing 1% zeolites [17].

Technologicalparameters of meat

After slaughter, pH decreases due to post-mortem biochemical transformations. The final pH value depends on several factors, including pre-slaughter stress. Banaszak et al. (2021 and 2022) were unable to observe changes in pH45 and pH24 in broilers fed with and without zeolites, nor if these zeolites are coated with nanosilver[4, 5, 6, 7].

Mallek et al. (2012) show that adding zeolite to broiler feed reduces the compactness of the protein gel network, allowing better water binding and making the meat tender[22].

Hashemi et al. (2014) show that adding 1% zeolites to the feed leads to a decrease in WHC (64.51% compared to a control with 70.06%), but if zeolites (1%) coated with nanosilver (50ppm and 75ppm) are added to the feed, better results are obtained (74.32% and 74.11%, respectively) compared to diets containing only 1% zeolites. A possible explanation is that nanosilver intervenes in the antioxidant system in muscle tissue, thus affecting the activity of calpains and proteolysis, and ultimately [17].The presence of nanosilver alongside zeolites prevents oxidative processes in proteins, resulting in better WHC values.

The addition of zeolites to the feed of ducks caused an increase in the water retention capacity of the pectoral muscle and limb muscles, respectively, their yellow color was intensified [8].

In the case of cooking loss, the highest values were obtained with an addition of 5 g of zeolite per kg of feed and for a particle size of 1mm, while a higher addition (15 g of zeolite per kg of feed) or larger particle sizes (2mm) resulted in greater cooking losses[1].

A study carried out on the efficiency of the use of Romanian zeolites shows that they improve the use of nutrients and the feed conversion rate [23].

CONCLUSIONS

Zeolites exhibit a complex influence on meat quality parameters, with their effects varying depending on factors such as dosage, particle size, and animal species. While zeolite supplementation generally improves water-holding capacity and alters fatty acid composition favourably, its impact on carcass weight and sensory attributes like colour and texture is nuanced. Future research should delve deeper into the mechanisms underlying these effects to optimize zeolite usage in animal feed for enhanced meat quality.

ACKNOWLEDGEMENTS

This work was supported by a project of the"Lucian Blaga" University of Sibiu, Contract:1809/11.05.2022.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ADAPTABILITY OF MAIZE HYBRIDS IN THE CENTRAL PART OF OLTENIA, ROMANIA, UNDER COMBINED DROUGHT AND HEAT CONDITIONS

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Abstract

Due to climate modifications, extremely dry years are becoming more frequent in Romania, the Oltenia region being one of the most affected areas. In this context, farmers must choose the most suitable hybrids for their farm, because the level of grain yield and its quality depend on this choice. This study was designed to compare the phenology, grain yield and associated traits of some maize hybrids belonging to two different maturity groups (4 semi-early and 4 semi-late), under the combined effect of drought and heat in 2022. Experiences were placed under field conditions at Agricultural Research and Development Station (ARDS) Simnic, the Oltenia region, Romania in a randomized block design on a reddish brown soil. The obtained results showed that the maize hybrids from the semi-early maturity group outperformed maize hybrids from the semi-late maturity group with a grain yield advantage of 865 kg/ha (+30%). The semi-early hybrids Magnus (4,334 kg /ha) and DKC 4598 (3,814 kg/ha), closely followed by HSF 1180-17 (3,719 kg/ha) were superior for grain yield compared to other hybrids, showing a good adaptability to extreme drought conditions in the central part of Oltenia.

Key words**:** *drought, growth stages, heat, yield***.**

INTRODUCTION

One of the basic cereals worldwide, including in Romania, is maize (*Zea mays* L.) crop, which plays an important role in ensuring food security.
For human nutrition, maize along with wheat and rice provides about 30% of the food calories for 4.5 billion people [23]. Globally, it is considered that about 56% of dry grain production is used for feed, 13% for food, and a fifth for non-food uses [9].
Although Romania occupies a constant place among the largest maize producers in the European Union, due to drought, heat and limited irrigation, the maize harvest fluctuates significantly [11, 20]. For example, in Romania, at the level of 2021 (a favorable year for maize crop), the national production of maize reached a level of 14.82 million tons, but in 2022, due to the extreme drought, the level decreased to 8.03 million tons [10].
Maize is a very sensitive plant to drought due to its high water requirements, but also its inability to reduce/stagnate growth under water stress conditions [19].
The simultaneous occurrence of drought and heat in the fields of farmers in Romania has become more and more common. The most recent extremely dry years from 1900-2022 were 2007, 2015, 2019, 2020, 2022, and the summer of 2022 was the third warmest summer since 1961 to date, with high temperatures associated with insufficient precipitation exacerbating the drought stress [16]. The variation of weather from one area to another and from one year to another is very different, presenting serious risks to the production of agricultural crops. In this context of current climate changes, emphasis is placed on improving the ability of maize to adapt to adverse climatic conditions [12].
Oltenia is an agricultural region in southwestern Romania, important for maize crops. The frequent occurrence of drought in this area has shown serious consequences on maize yield [2, 3, 8].

Grain yield is the objective with the greatest contribution to the economic efficiency of maize crop, to its increase contributing the tolerance to abiotic, biotic and technological factors, balanced development of plants, and expression of yield traits [7].

Depending on the time of occurrence, duration and intensity of the drought, yield losses in maize vary between 15-70% [2, 3, 17]. Therefore, information is needed on the evaluation of maize hybrids to select the best adapted to drought.

The Romanian market includes a wide range of maize hybrids and the choice of the right ones for each crop area represents a real challenge for farmers, because the level of yield and its quality depends on their choice.

The increase in the frequency of extremely dry years in most areas of Romania has attracted the attention of researchers from research institutes, to develop and transfer to farmers improved maize hybrids for drought and heat tolerance.

Previous studies have shown that a viable and sustainable strategy from an economic point of view is the development and expansion in cultivation of earlier maize hybrids (depending on the cultivation area), hybrids that have a better adaptation capacity to the conditions of drought and heat [13, 14, 19].

Based on these considerations, this study aimed at the behavior of some maize hybrids belonging to two different maturity groups (semi-early and semi-late) in terms of growth stages, grain yield and some related attributes, with implications for agricultural practice in the central part of Oltenia area.

MATERIALS AND METHODS

This study was carried out at ARDS Simnic, Craiova (the central part of Oltenia, Romania), in the combined drought and heat conditions of 2022 (Figure 1).

The biological material tested consisted of eight maize hybrids belonging to two groups of different maturity: FAO 301-400 (Oituz, Magnus, DKC 4598, HSF 1180-17) and FAO 401-500 (F 423, Felix, P0216, P0023).

The experiment was carried out in a randomized block with two replications having a net plot size of 6.72 m^2, on reddish-brown soil.

Complex fertilizers (NPK 20:20:20) were applied before sowing with 250 kg/ha and ammonium nitrate at the stage of 10-12 leaves with 150 kg/ha.

Sowing was carried out on April 12, 2022, at a density of 55,000 plants/ha.

For chemical protection against diseases and pests, Dual Gold 1 l/ha was applied in pre-emergence and at the 6-8 leaf stage, as well as the herbicides Click Pro 2-2.3 l/ha and Crew Ace 0.8 l/ha. Also, 2 mechanical and one manual hoeing were done. Harvesting was done on August 31, 2022.

Data were collected for plant height (cm), ear height (cm), days to 75% emerged plants, days to 50% flowered and silked, days to physiological maturity, grain yield (kg/ha) adjusted to 15.5% moisture, sterile plants (%), 1000-grain weight (g) and test weight (kg/hl).

Data collected for yield were statistically analyzed with analysis of variance (ANOVA) and Duncan multiple range test (p=0.05), first separately for each maturity group and then combined, for both groups.

Weather data (precipitation and temperatures) comes from Craiova Meteorological Station [6].

Fig. 1. View from the experimental field, ARDS Simnic, 2022
Source: Original.

RESULTS AND DISCUSSIONS

For Romania, the summer of 2022 was the third driest and warmest since 1961 until now [16].

The climatic factors (precipitation and temperatures) recorded for the study area (Craiova, Oltenia region from southwest Romania) during the maize growing period (April-August) of 2022, showed an extreme, long-lasting drought with many hot days and nights (Figures 2 and 3).

From April to July, precipitation was below the multiannual average, the lowest precipitation being recorded in June and July (-55.5 mm, respectively, -36.6 mm) (Figure 2).

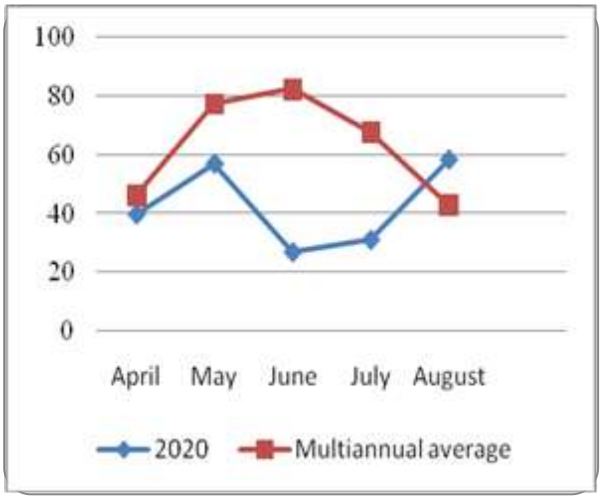

Fig. 2. Monthly precipitation durind the maize growing period (April-August) at ARDS Simnic, 2022.
Source: Own design and processing based on the data from [6].

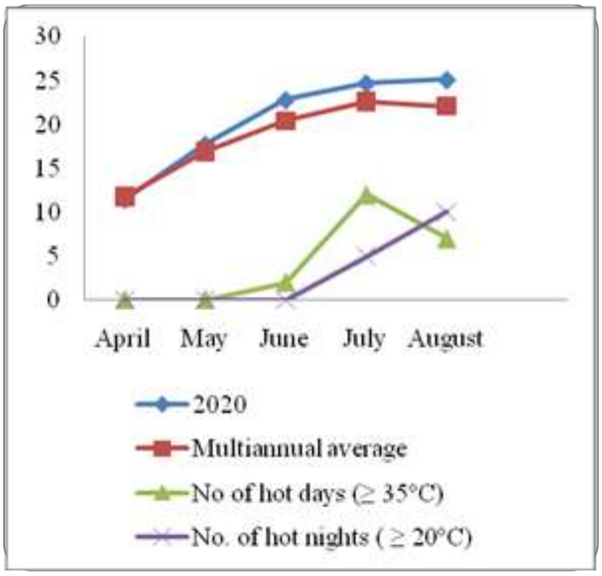

Fig. 3. Average monthly temperatures during the maize growing period (April-August) at ARDS Simnic, 2022
Source: Own design and processing based on the data from [6].

Average monthly temperatures throughout the growing period, except for May, exceeded the multi-year average. The high number of hot days (≥ 35°C) and hot nights (≥ 20°C) in June, July and August combined with low amounts of precipitation exacerbated drought (Figure 3).

Therefore, at ARDS Simnic, drought and heat set in from June (the most critical period for maize/flowering and silking) and continued throughout all reproductive stages.

Insufficient precipitation and high and long-lasting temperatures during the flowering and reproductive stages negatively affected the grain yield of the hybrids studied, which was an average of 3320 kg/ha. From FAOSTAT data [10] it can be seen that it is almost at the same level as the national average yield obtained in 2022 (3,298 kg/ha), but it is lower than that of 2021 (5,801 kg/ha).

Previous studies have shown that combined stress (drought and heat) had a greater impact on maize grain yield than individual stresses [25, 26], and maize is more sensitive to stress in the reproductive stages compared to the vegetative growth stages [5, 21, 22].

According to [18], high temperatures between 33°C-36°C during pre-flowering and post-flowering reduce grain yield by 10-45%. Maize yield reduction percentages due to high temperatures (above 30°C) are of 1% under optimal precipitations conditions, of 1.7% under drought conditions and up to 40% under combined drought and heat conditions [17].

In our study, the results of the analysis of variance for grain yield showed significant differences between hybrids both within maturity groups and between groups ($P<0.05$) (Table 1). From the semi-early maturity group (FAO 301-400), the Magnus hybrid achieved the highest grain yield (4,334 kg/ha) being at the same level of significance as the DKC 4598 hybrid (3,814 kg/ha), while the old hybrid Oituz (released in 1999) achieved the lowest yield (3,142 kg/ha).

From the semi-late maturity group (FAO 401-500), the P0216 and Felix hybrids achieved the highest yields (3,166 and 2,954 kg/ha, respectively), while the F 423 hybrid achieved the lowest yield (2,560 kg/ha).

Combined analysis of variance for grain yield showed that the hybrids Magnus and DKC

4598, closely followed by HSF 1180-17 were superior compared to other hybrids.

The group of semi-early hybrids exceeded the group of semi-late hybrids by 865 kg/ha (+30%) (Table 1, Figure 4).

The Magnus maize hybrid is a modern hybrid, recently released (2021) by NARDI Fundulea (Romania) that has been improved for drought tolerance [15].

Modern maize hybrids improved for drought tolerance together with improved field management represent the best solutions for managing drought losses [15].

Table 1. Grain yield of the maize hybrids studied at ARDS Simnic, 2022

Hybrid	Grain yield				
	kg/ha	% to average group	Duncan test	% to general average	Duncan test
1. FAO 301-400 group (semi-early hybrids)					
Oituz	3,142	-16.3	C	-5.4	C
Magnus	4,334	+15.5	A	+30.5	A
DKC 4598	3,814	+1.6	AB	+14.9	A
HSF 1180-17	3,719	-0.9	B	+12.0	B
Average group 1	*3,752*				
LSD5%	529	14.1			
2. FAO 401-500 group (semi-late hybrids)					
F423	2,560	-11.3	B	-22.8	D
Felix	2,954	-2.3	A	-11.0	CD
P0216	3,166	+9.7	A	-4.6	C
P0023	2,867	-0.7	AB	-13.6	CD
Average group 2	*2,887*				
LSD 5%	353	12.2			
General average	*3,320*				
LSD 5%	623			18.7	

The same letter shows that there is no significant difference based on the Duncan test α = 5%
Source: Own calculation.

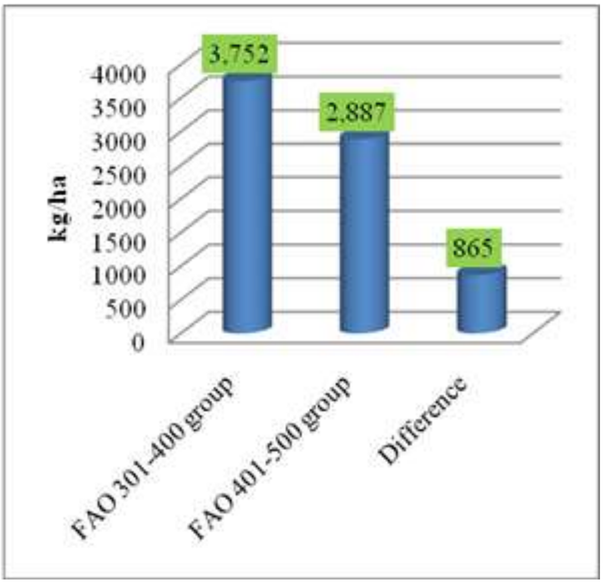

Fig. 4. Yield difference (kg/ha) between maturity groups, ARDS Simnic, 2022
Source: Own calculation.

The number of days to emergence, for most hybrids, was 22 days. Regarding the precocity of flowering, the group of semi-early hybrids recorded an advance of 4 days compared to the group of semi-late hybrids (Table 2).

According to [5], maize plants exhibit three mechanisms of resistance to combined drought and heat conditions, namely, avoidance, escape and tolerance, and hybrids precocity is one of the responses related to escape.

There was no difference between the two maturity groups regarding the attainment of physiological maturity (118 days), but the number of days from silking to physiological maturity (the period of grain filling) was lower for the semi-late maturity group, the group that recorded a lower grain yield.

Our results were consistent with previous studies that showed that grain yield is closely related to grain filling duration [4, 21].

Table 2. Growth stages of the maize hybrids studied at ARDS Simnic, 2022

Hybrid	Growth stages (days from sowing to)				
	emergence	Flowering	silking	physiological maturity	silking-physiological maturity
1. FAO 301-400 group (semi-early hybrids)					
Oituz	22	76	79	116	37
Magnus	21	76	78	119	41
DKC 4598	21	76	78	116	38
HSF 1180-17	22	76	78	121	43
Average group 1	*22*	*76*	*78*	*118*	*40*
2. FAO 401-500 group (semi-late hybrids)					
F 423	22	80	82	118	36
Felix	22	79	82	119	37
P0216	22	80	84	118	34
P0023	24	80	84	118	34
Average group 2	*22*	*80*	*83*	*118*	*35*

Source: Own calculation.

Plant height is an important trait for both grain yield and green and dry matter production. This is determined by the expression and interaction of several genes but also by climatic conditions [3].

In our study, the plant height had a general average of 203 cm, the Magnus and P0216 hybrids recording the maximum plant height of 210 cm (+3%), and the Felix hybrid the minimum plant height of 193 cm (-5%) (Table 3).

Table 3. The agronomic traits of the maize hybrids studied at ARDS Simnic, 2022

Hybrid	Plant height		Ear height		Sterility		1,000-grain weight		Test weight	
	cm	% to general average	cm	% to general average	%	% to general average	g	% to general average	kg/hl	% to general average
1. FAO 301-400 group (semi-early hybrids)										
Oituz	206	100	103	116	1	20	200	105	65.4	99
Magnus	210	103	87	98	7	140	210	110	66.4	100
DKC 4598	207	102	93	105	0	0	171	90	66.6	100
HSF 1180-17	203	100	88	99	0	0	184	96	71.6	108
Average group 1	*207*		*93*		*2*		*191*		*67.5*	
2. FAO 401-500 group (semi-late hybrids)										
F 423	193	95	70	79	13	260	205	107	67.0	101
Felix	198	97	89	100	7	140	166	87	65.7	99
P0216	210	103	94	106	3	60	208	109	63.8	96
P0023	198	97	89	100	9	180	186	97	63.2	95
Average group 2	*200*		*86*		*8*		*191*		*65.0*	
General average	*204*	*100*	*89*	*100*	*5*	*100*	*191*	*100*	*66.3*	*100*

Source: Own calculation.

Ear height between 70 and 103 cm, with a general average of 89 cm, makes hybrids suitable for mechanized harvesting. According to [1], a very high ear height could be susceptible to stock and root lodging. The percentage of sterility was higher in the semi-

late maturity group (8%) compared to the semi-early group (2%). The highest percentage of sterility was recorded in F 423 (+160%) compared to the general average (Table 3).
A previous study found that the drought and heat during flowering led to an increase in the number of sterile plants and also to a reduction in yield [2] .
For 1,000-grain weight, the values were similar for the two maturity groups (191 g), the HSF 1180-17 hybrid registering the highest value of 210 g (+10%) compared to the general average.
The weight of the grains is an important component of the yield having a decisive role in highlighting the production potential. Our results were consistent with previous studies that showed that high temperatures (heat) during the reproductive stages shorten the duration of grain filling leading to a reduction in the number of grains, their size and weight [1, 24].

CONCLUSIONS

The preliminary results obtained in combined conditions of drought and heat throughout the flowering and reproductive stages showed a different response of the studied hybrids from the two maturity groups. This difference between hybrids is due to both genetic variation and their difference in adaptability to combined drought and heat conditions.
Maize hybrids from the semi-early maturity group (FAO 301-400) outperformed maize hybrids from the semi-late maturity group (FAO 401-500) with a grain yield advantage of 865 kg/ha (+30%).
Three semi-early hybrids namely, the modern hybrid Magnus released in 2021 (4,334 kg/ha) and DKC 4598 (3,814 kg/ha), closely followed by the perspective hybrid HSF 1180-17 (3,719 kg/ha) were superior for grain yield, compared to other hybrids. These better-adapted maize hybrids can be a solution to the problems caused by extreme drought for farmers in the Oltenia region.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

FACTORS AFFECTING THE DECISION TO PURCHASE BIO-ORGANIC FERTILIZER FOR RICE PRODUCTION IN THE MEKONG DELTA, VIETNAM

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Abstract

Using industrial bionitrogen fertilizer for crops is a new trend to improve the quality and value of agricultural products while helping to improve the soil environment and can completely replace traditional chemical nitrogen. Industrial bionitrogen fertilizer is gradually being produced and consumed in Vietnam and the Mekong Delta. However, the level of industrial bionitrogen fertilizer consumption is still limited for many reasons. This study interviewed 250 rice farmers in the Mekong Delta provinces who consumed industrial bionitrogen fertilizers, then used exploratory factor analysis to evaluate the influence of factors on their decisions of purchasing industrial bionitrogen fertilizer. The results show that there are at least 5 factors that have a positive impact on purchasing decisions, arranged according to their importance: consumer awareness, subjective standards, product quality, distribution system and sales promotion. On this basis, some policy implications and solutions have been proposed.

Key words: *awareness, bionitrogen fertilizer, consumer, decision, exploratory factor analysis*

INTRODUCTION

The Mekong Delta (MD) is a key agricultural production region of Vietnam, mainly producing rice and fruit trees. The abuse of inorganic fertilizers and chemical pesticides, increasing production costs, affecting the health of users, polluting the environment, and leaving residue on agricultural products is ongoing [15]. At the conference "Current situation and solutions for managing the use of fertilizers and pesticides and growing areas and packaging facilities for agricultural products in the MD provinces" in 2021, the agricultural authority revealed a lot of related information and problem of using fertilizers on crops. The average amount of fertilizer used in the MD is over one ton of fertilizer per cultivated hectare, of which inorganic fertilizer is 754 kg/ha and followed by 392 kg/ha of organic fertilizer, accounting for about 36.6% of the total amount of fertilizer used [12].

The Ministry of Agriculture and Rural Development (MARD) has had a strategy to develop organic fertilizers to increase the value of agricultural products and protect the environment. The program to develop the production and use of organic fertilizer has been implemented by the sub-ministry unit of Plant Protection Department since 2017. By 2020, the country had 4,798 organic fertilizer products recognized for circulation, and there were 265 fertilizer production manufacturers with a capacity of 4.04 million tons/year. The MARD has also organized cooperation with businesses and trained farmers on how to use fertilizer effectively, aiming to use more organic fertilizer. Data up to 2020 show that there are 124 models and 6,683 hectares of models trained to use organic fertilizer. In the Mekong Delta, there are 909 classes and 30,273 farmers trained to use organic fertilizers.

On the market there are two types of traditional organic fertilizer and industrial organic fertilizer. Traditional organic fertilizers are often limited in popularity on a large scale due to problems in collecting raw materials, transporting and distributing them. Meanwhile, industrial organic fertilizers overcome these limitations and can be promoted in the future. However, the level of use of organic fertilizers, especially industrial organic fertilizers, in the MD is still limited. There are currently pilot models and trained farmers who are acting as really adopters to spread the organic fertilizer use strategy. Practically, many problems are arising in encouraging producers to use organic fertilizers to meet the goals of the agricultural sector towards sustainable development in the future.

N. Humate + TE is a product of PetroVietnam Ca Mau Fertilizer Joint Stock Company (PVCFC) and is a form of bio-industrial organic fertilizer. This product is a complex of Urea and organic Humic Acid creating Humate in associated with micro-mineral elements of Zinc and Boron... Commonly it can be called a new generation organic fertilizer since it can provide nutritional solutions for plants, combining sufficient chemical nitrogen fertilizer and biological ingredients to stimulate the growth of beneficial microorganisms and supplement nutrients. Organic matter in the fertilizer increases soil fertility, and helps completely replace chemical nitrogen fertilizers in farming [9]. With its ingredients and uses, the product N. Humate + TE 28-5 can be abbreviated as Ca Mau Fertilizer brand and is a microbial organic (MBO) fertilizer.

Although MBOF fertilizer has been traded on the market in recent years, its widespread use in agriculture to replace the long-standing practice of completely using chemical fertilizers is a task that requires time and a lot of effort from all related parties. The amount of MBOF consumed on the market in the period 2018 - 2022 is still quite low. Data from Ca Mau Fertilizer Company shows that the average amount of this fertilizer consumed is 3,449 tons/year and is much lower than chemical nitrogen fertilizer (urea) sold by the same company with 348,366 tons/year [13].

In the context of the MD regarding the limited use of organic fertilizers on crops, as well as the specific case of PVCFC's MBO fertilizer consumption, research to find solutions to increase the use of organic fertilizers is necessary. This study therefore has the purpose of analyzing the factors that affect consumers' decisions to purchase and use so that it can supplement useful solutions for the process of spreading MBO fertilizer use in the domestic market in the following years. The study applied theories of consumer behavior in the context of agricultural production, specifically purchasing MBO fertilizer for rice production in some provinces in the MD.

MATERIALS AND METHODS

Theoretical model of factors influencing consumer decisions

Consumers choose and decide to buy a product on the market are influenced by many factors that represent characteristics of product quality, brand, price, marketing, and customer perception etc., …. In this study, consumers are rice farmers and the product they decide to buy is the MBO fertilizer. Many studies have proposed theoretically hypotheses about factors that influence consumer decisions that can be inherited in this study.

(a) Product quality

Previous studies have concluded that product quality has an important influence on the choice to buy bio-organic fertilizer products such as Sumbayak [15], Kusumah [7] or deciding to buy food in Vietnam like Hung [4]. This study inherits the above studies and hypothesizes as follows:

Hypothesis 1: Product quality has a positive (+) correlation with the decision to buy biofertilizer products.

(b) Price

The selling price of a product represents the value of the product and also shows the competitiveness of the product when compared to similar products from the consumer's perspective. Studies on consumer product purchase decisions as above cited also hypothesize the influence of price and can be inherited for this study.

Hypothesis 2: Price has a negative (-) correlation with the decision to buy biofertilizer products.

(c) Supply system

The product distribution or supply system in general and biofertilizer in particular is a bridge between manufacturers and consumers. In this study, there is a system of biofertilizer dealers or stores in the research provinces. A rich and convenient product distribution system will help consumers easily choose and positively influence their decision to buy fertilizer [3]. Authors such as Sumbayak et al. [15] argued that the distribution system has an influence on product purchase decisions. This study also hypothesizes inheritance.

Hypothesis 3: The distribution system has a positive (+) correlation with the decision to buy biofertilizer products.

(d) Sale promotion

Sales promotion is convincing customers to buy products, can be considered an art of sales and can make customers increase their level of satisfaction when buying products [2], [4]. Some studies show that this factor affects the decision to buy products and services such as Sumbayak et al. [15] for biofertilizers. This study also has a similar hypothesis.

Hypothesis H4: Sales promotion has a positive (+) correlation with the decision to buy biofertilizer products

(e) Personal characteristics

Consumers' personal factors represent internal characteristics of consumers due to cultural factors, social relationships or even human characteristics. Personal characteristics can also be influenced by the surrounding community where consumers live and interact on a daily basis such as family, friends, neighbours, and colleagues [6]. Some authors have shown that social influence has an impact on the decision to apply technical advances in rice production [14], or accept organic agricultural production [8]. This study inherits the following hypothesis.

Hypothesis H5: The personal factor has a positive (+) correlation with the decision to buy biofertilizer products.

(f) Trademark

A trademark or brand is a relatively abstract concept as it has commercial value. Customers' brand knowledge includes brand awareness and brand impressions [5], [19]. The hypothesis is set out as follows.

Hypothesis H6: Trademark has a positive correlation (+) with the decision to buy biofertilizer products.

(g) Consumer perception

Perceived usefulness of a product is the degree to which customers believe it will improve work performance when they consume that product. Venkatesh and Davis [20] suggested that perceived usefulness and perceived ease of use have an impact on behaviour intention to use. The higher the perceived usefulness of a product, the easier it will be for consumers to make purchasing decisions. The hypothesis of this study is inherited as follows.

Hypothesis H7: Consumer perception on the usefulness of fertilizer has a positive (+) correlation with the decision to purchase biofertilizer products.

Thus, the theoretical model of this study is a collection of all seven hypotheses mentioned above, all of which influence the decision to buy biofertilizer products in different directions and levels. These hypotheses will be evaluated through factor analysis and regression methods in the following section.

Observation sample

This study employs the method of exploratory factor analysis (EFA) to reduce a large number observed variables into smaller representative variables, thereby determining the factors influencing the decision to buy biofertilizers. Subsequently, the study uses multivariate regression to determine the magnitude and direction of influenced factors on the decision to buy biofertilizers.

The observed sample size is determined based on the number of observed variables, with a minimum of 5 observations for each observed variable to ensure reliability [3]. With 34 observed variables, the minimum size required of the observation sample is $n \geq 5*34$ equivalent to ≥ 170. In fact, we randomly selected 3 farmers on each of the 93 agents of the fertilizer distribution system scattered in different rice-produced provinces in the MD namely Can Tho, Hau Giang, Soc Trang, Bac Lieu and Ca Mau. A total of 279 farmers were interviewed, however, after eliminating those with incomplete information, 250 observations remained and were used for the analysis.

Data interviewed

Primary data was collected through questionnaires and direct interviews with farmers who purchased fertilizer. The questionnaire consists of information showing basic characteristics of buyers such as name, age, gender, rice land area and factors affecting the decision to buy fertilizer. For asking about factors influencing the decision to buy fertilizer, the questionnaire was designed with a 5-level Likert scale from 1 to 5, whereby level 1 corresponds to "strongly disagree", level 2 is "disagree". ", level 3 is "neutral", level 4 is "agree" and level 5 is "strongly agree" to evaluate the level of influence on the decision to buy fertilizer. The factor analysis model includes 7 scale groups including 34 observed independent variables (Table 1) and a scale on purchasing decisions including 3 observed dependent variables (Table 2).

Table 1. Scales and observed independent variables affecting the decision to buy fertilizer

Scale	Coding	Description
Product quality (PQ)	PQ1	Biofertilizer is of good quality
	PQ2	Fertilizer content is clearly shown on the packaging
	PQ3	The packaging quality is good and waterproof
	PQ4	The fertilizer grain are black and uniform, with good solubility
	PQ5	Instructions for use are clear, easy to read and understand
Product price (PP)	PP1	Selling price is reasonable
	PP2	Competitive selling price compared to other products
	PP3	The selling price is corresponding to the quality of the fertilizer
	PP4	Selling price is stable
Distribution system (DS)	DS1	The product is easy to buy at the dealer
	DS2	Product is delivered quickly
	DS3	There is a large network of distributors
	DS4	Products can be ordered easily over the phone
	DS5	Products can be purchased online
Sale promotion (SP)	SP1	There are gifts included when buying fertilizer
	SP2	There are gifts when participating in fertilizer consulting sessions
	SP3	Participate in sales seminars at dealerships with promotions
	SP4	Regular promotions and discounts when the season comes
	SP5	Receive technical support after purchasing fertilizer
Trademark (TM)	TM1	The Ca Mau Fertilizer brand is of good quality
	TM2	The Ca Mau Fertilizer logo has a familiar impression
	TM3	The Ca Mau Fertilizer brand creates trust in customers
	TM4	Ca Mau Fertilizer products are as good as the nitrogen fertilizers used before
	TM5	Ca Mau Fertilizer products stand firmly in the market
Personal characteristics (PC)	PC1	Know the product through acquaintances and neighbors
	PC2	Get to know the product through referral distributors
	PC3	Know the product through advertisements on TV and YouTube
	PC4	Know the product through sales seminar
	PC5	Know products from local agricultural authorities
Perception (PE)	PE1	Using this fertilizer is less costly than conventional use
	PE2	This fertilizer has organic content that is good for the soil
	PE3	Hard and round fertilizer granules are easy to use and mix
	PE4	The product has beneficial properties for plant growth
	PE5	The product has multi-nutrients that are good for agricultural products

Source: Author’s research design.

Table 2. Scales showing the decision to buy fertilizer

Decision	DE1	I am completely satisfied when choosing to buy and use biological nitrogen fertilizer
	DE2	I faithfully use biological nitrogen fertilizer
	DE3	I advise my friends and neighbours to use biological nitrogen fertilizer

Source: Author’s research design,

Analytical method

This study firstly employs the EFA method and then runs multivariate regression to evaluate the influence of factors on the decision to buy biofertilizers. The analysis steps are performed on SPSS statistical software version 26, in the following:

Step 1: Evaluate the quality of the scale through Cronbach's Alpha coefficient

Evaluate the quality of the scale are based on the total variable correlation coefficient and Cronbach's Alpha [1], according to which variables with a total variable correlation coefficient less than 0.3 will be eliminated [16], and at the same time, the selected variables must have a Cronbach's Alpha coefficient greater than 0.6 [10], [11], [18]. After eliminating variables that do not meet the requirements, if any, the evaluation of the scale will be continued for the remaining variables to determine the total variable correlation coefficient and Cronbach's Alpha coefficient until all variables remained meet the requirements.

Step 2: EFA exploratory factor analysis for the independent variable

EFA analysis is performed to reduce a set of many interdependent observed variables into a smaller group of variables called meaningful factors and still contain most of the information of the original set of variables. head. The KMO (Kaiser-Meyer-Olkin) and Bartlett's test methods were used to measure the compatibility of the surveyed sample. The factor analysis is meaningful whenever the KMO value > 0.5 and the sig value < 0.05; The factor loading factors must be > 0.5. In case an observed variable loads on both factors, the factor loadings must be greater 0.3 different and this observed variable is included in the factor that it has the highest loading with the condition that it must satisfy loading factor > 0.5.

Eigen value is the criterion used to determine the number of factors in EFA analysis, according to which only factors with Eigen value ≥ 1 are retained in the analytical model [3]. At the same time, the total explained variance of the factors must be greater than 50% or better than 60% [3], this value explains the percentage of variation of observed variables in the model.

Step 3: EFA exploratory factor analysis for the dependent variable

Similar to the EFA analysis procedures for the independent variable above, this study also performed EFA analysis for the dependent variable. Use the KMO value > 0.5 and the statistical significance level of the Barlett test to confirm the appropriateness of EFA for the dependent variable.

Step 4: Multivariate regression analysis and hypothesis testing

The least squares (OLS) multivariate regression model was used to analyze the influence of the independent variables determined through the EFA analysis above on the dependent variable (decision intend to buy biological fertilizer). The regression model has the form:

$$DE = \beta_0 + \beta_1F_1 + \beta_2F_2 + \beta_3F_3 + \beta_4F_4 + \beta_5F_5 + \beta_6F_6 + \beta_7F_7 + \varepsilon \quad .... \quad (1)$$

where:
DE: dependent variable
$F_1, F_2, F_3, F_4, F_5, F_6, F_7$: independent variables
$\beta_0, \ldots, \beta_7$: coefficient
ε: residual

The variables in the regression model are created according to the factor score method based on the loading factor in the factor analysis above. The appropriateness of the regression model is determined through the F test with the hypothesis H_0 that the determining coefficient $R^2 = 0$. At the same time, the "t" (student) test is also used to determine the significance level of the regression coefficients with H_0that the $\beta n = 0$. At the same time, to avoid multicollinearity, the variance inflation factor (VIF) values of the variables are considered, so that the VIF must be less than 2 [16]. At the same time, in order to avoid correlation in the residuals of the model, the value of the Durbin-Watson coefficient (DW) is determined so that this value must range from 1.50 to 2.50 ($1.50 \leq DW \leq 2.50$) according to Yahua [21].

RESULTS AND DISCUSSIONS

Consumer's characteristics

The basic characteristics of farmers who decided to buy biofertilizers are shown in the survey sample of 250 farmers as shown in Table 3. Farmers are mainly male, their average age is 52.3 years old, of which the majority are over 40 years old (88.4%), which also means they have a lot of experience in agricultural production. Up to 40% of farmers have primary school education, nearly 50% have lower secondary education and just over 10% have high school education. The average agricultural land area is 1.8 hectares/household, of which 54.4% have an area of 1 to 3 hectares and 38% have an area of less than 1 hectare/household. In general, farmers who buy MBO fertilizers are people who have a lot of production experience and are mature enough in their production decisions as well as buying and using fertilizers on their farms. Survey data show that, on average, each farmer household used general fertilizers at 1,611 kg/ha (ranging from 200 to 8,000 kg/ha), of which MBO fertilizer was 349 kg/ha (ranging from 100 kg/ha to 2,000 kg/ha).

Table 3. Main characteristics of consumers

Characteristics		Frequency	Rate (%)
Gender	Male	231	92.40
	Female	19	7.60
Age (year)	< 40	29	11.60
	40 – 50	63	25.20
	>50	158	63.20
	Mean	52.3	
Land area (ha/household)	< 1	95	38.00
	1 – 3,0	136	54.40
	> 3 – 5	15	6.00
	> 5	4	1.60
	Mean	1.8	
Education (level)	Primary school	100	40.00
	Secondary school	123	49.20
	High school	27	10.80
	University	0	0

Source: Data surveyed in 2023.

Evaluation of quality of the scale using Cronbach's Alpha coefficient

The results of evaluating the scale quality of the independent and dependent variables are shown in Table 4.

Based on the total variable correlation coefficient must be greater than 0.3 and Cronbach's Alpha value greater than 0.6, the scales of the independent variable group are all appropriate.

However, through screening, the scales of Product Quality (PQ) and Distribution System (DS) have eliminated two variables PQ4 and DS5 respectively because they did not meet the requirements.

After eliminating the above two variables, the evaluation of the scales was performed again and showed that the scales had Cronbach's Alpha coefficients greater than 0.6 and at this time the total number of observed variables of the remaining scale of independent variables was 32 instead of 34 as initially.

Similarly, evaluating the dependent variable scale shows that the total correlation coefficient and Cronbach's Alpha both meet the requirements.

Table 4. Results of evaluating the quality of the scale using the Cronbach Alpha coefficient

No.	Scale	Observed variable	Number of appropriated variables after evaluation	Cronbach's Alpha
Independent variable				
1	Product quality (PQ)	PQ1, PQ2, PQ3, **PQ4**, PQ5	4	0.832
2	Product price (PP)	PP1, PP2, PP3, PP4	4	0.885
3	Distribution system (DS)	DS1, DS2, DS3, DS4, **DS5**	4	0.901
4	Sale promotion (SP)	SP1, SP2, SP3, SP4, SP5	5	0.830
5	Trademark (TM)	TM1, TM2, TM3, TM4, TM5	5	0.899
6	Personal characteristics (PC)	PC1, PC2, PC3, PC4, PC5	5	0.914
7	Perception (PE)	PE1, PE2, PE3, PE4, PE5	5	0.906
Dependent variable				
1	Decision (DE)	DE1, DE2, DE3	3	0.970

Note: the observed variables with bold highlight (PQ4, DS5) are eliminated variables due to Corrected Item-Total correlation value <0.3.
Source: Author's analysis.

EFA analysis results

Exploratory factor analysis is considered satisfactory with the data when the analysis results satisfy the following conditions: (i) KMO value ranges from greater than 0.5 to less than 1 (0.5). < KMO < 1), (ii) Bartlett test is statistically significant (Sig. < 0.05) and (iii) the cumulative of variance > 50%.

Table 5. Rotated loading factor matrix

Observed variables	Factors						
	1	2	3	4	5	6	7
PC1	0.823						
PC2	0.820						
PC3	0.787						
PC4	0.741						
PC5	0.596						
DS1		0.850					
DS2		0.813					
DS3		0.793					
DS4		0.781					
TM1			0.845				
TM2			0.829				
TM3			0.674				
TM4			0.591				
TM5			0.569				
PE1				0.908			
PE2				0.850			
PE3				0.686			
PE4				0.680			
PE5				0.612			
PQ3					0.827		
PQ5					0.768		
PQ2					0.737		
PQ1					0.710		
PP3						0.882	
PP2						0.856	
PP1						0.842	
PP4						0.828	
SP5							0.856
SP3							0.589
SP2							0.566
SP4							0.536
SP1							0.530
Eigenvalues	1.102						
Total cumulative variance	76.827						
KMO value	0.872						
Sig. value	0.000						

Source: Author's analysis.

The results of the above tests are shown in Table 5, whereby we see that the KMO value is 0.872, the Eigen value is 1.102, leading to the total cumulative variance being 76.827 (%), this represents 76 82% of the variation in factor results is explained by observed variables in the model. The Bartlett test is statistically significant (Sig. = 0.000), so the calculation results show that the observed variables are linearly correlated with the representative factor with 99% confidence.

Through the rotated factor matrix in Table 5, the original factor groups were rearranged into 7 factor groups (Table 6), including:

Group 1 includes 4 variables PQ1, PQ2, PQ3, PQ5, this group is named Product Quality, with the representative variable symbol F_PQ.

Group 2 includes 4 variables PP1, PP2, PP3, PP4. This group is named Product Price, with the representative variable symbol F_PP.

Group 3 includes 4 variables DS1, DS2, DS3, DS4, this group is named Distribution System, with the representative variable symbol F_DS.

Group 4 includes 5 variables SP1, SP2, SP3, SP4, SP5, this group is named Sale Promotion, with the representative variable symbol F_SP.

Group 5 includes 5 variables TM1, TM2, TM3, TM4, TM5, this group is named Trademark, with the representative variable symbol F_TM.

Group 6 includes 5 variables PC1, PC2, PC3, PC4, PC5, this group is named consumer Personal Characteristics, with the representative variable symbol F_PC.

Group 7 includes 5 variables PE1, PE2, PE3, PE4, PE5, this group is named Personal Perception, with the representative variable symbol F_PE.

On the basis of grouping the variables into 7 representative variables as above, the next step is multivariate regression analysis to see the level of impact of the variables on the decision to buy MBO fertilizer.

Table 6. Factors and representative variables used in multivariate regression

Factors	Observed variable	Factor name	Representative variables
1	PQ1, PQ2, PQ3, PQ5	Product Quality	F_PQ
2	PP1, PP2, PP3, PP4	Product Price	F_PP
3	DS1, DS2, DS3, DS4	Distribution System	F_DS
4	SP1, SP2, SP3, SP4, SP5	Sale Promotion	F_SP
5	TM1, TM2, TM3, TM4, TM5	Trademark of Product	F_TM
6	PC1, PC2, PC3, PC4, PC5	Personal Characteristics	F_PC
7	PE1, PE2, PE3, PE4, PE5	Perception of consumer	F_PE

Source: Author's analysis.

Determination of factor influence

In order to quantify the level and direction of impact of the factors identified above, a multivariate regression model was set up as in formula [1] above and performed. The regression results were performed twice, the first time was performed with 7 independent variables as above. However, this first result occurred multicollinearity in the variable F_TM with VIF value = 2,458 (>2), so this variable was eliminated to perform the second time with the remaining 6 variables. The later regression results are shown in Table 7. We see that the regression equation is statistically significant (Sig. value = 0.000), the value of the adjusted determined coefficient R^2 is 0.716, which means there are up to 71.6% of the variation in the dependent variable is explained by the variation in the independent variables. Besides, the Durbin-Watson value = 1.637 is within the limit, showing that the residual correlation phenomenon of the model does not occur, and the VIF values of the independent variables are all less than 2, proving that this multicollinearity phenomenon does not occur between independent variables. The above parameters show that the regression model is statistically significant and completely appropriate.

The regression results also show the impact of independent variables on the decision to buy fertilizer. Accordingly, up to 5 out of 6 independent variables had a statistically significant impact including F-PQ, F_DS, F_SP, F_PC, F_PE and 1 variable was not statistically significant, F_PP. The impact coefficients after standardization show that the variable F_PE (buyer's perception) has the highest contribution to the decision to buy fertilizer with 31.27%, followed by the variable F_PC (personal characteristics) with 21.79%, variable F_PQ (product quality) with 20.88%, variable F_DS (distribution system) with 13.76% and variable F_SP (sale promotion) with 12.31%.This result also proves that all the hypotheses set out above are correct, except for the hypothesis that product price does not have a meaningful impact on the decision to buy fertilizer.

Table 7. Regression results of factors influencing the decision to buy MBO fertilizer

Factors/ variables	**Unstandardized β**	**t**	**Sig.**	**VIF**	**Standardized β**	**Absolute value of standardized β**	**Level of distribution (%)**
Constant	-2.427	-8.431	0.000				
F_PQ	0.384	5.717	0.000	1.404	0.229	0.229	20.88
F_PP	**0.013**	**0.736**	**0.463**	**1.109**	**0.026**	-	-
F_DS	0.180	3.425	0.001	1.714	0.151	0.151	13.76
F_SP	0.132	3.213	0.001	1.548	0.135	0.135	12.31
F_PC	0.399	5.100	0.000	1.935	0.239	0.239	21.79
F_PE	0.470	7.364	0.000	1.906	0.343	0.343	31.27
						1.097	100.00
Dependent variable: Decision to buy MBO fertilizer (DE) Observation: 250 F = 105.884 Sig. value = 0,000 R^2 = 0.723; R^2 adjusted = 0.716 Durbin-Watson = 1,637							

Source: Author's analysis.

Policy implication

Policy implications are drawn from the results of factor analysis as well as multivariate regression above. There are 5 factors that positively influence the decision to buy and use MBO fertilizer and the price of fertilizer does not affect the purchase of fertilizer, in other words, the decision to buy fertilizer is not influenced by the price of fertilizer. The upcoming policy implication is to deploy solutions related to the above five factors to attract buyers and promote the decision-making process of producers to buy MBO fertilizer. The proposed policy solutions are as follows:

(i) Raise awareness for producers

Changing the perception of producers about the usefulness of MBO fertilizer in production is the most important factor, accounting for nearly 1/3 of the decision to buy MBO fertilizer. Local agricultural extension agencies, governments as well as multimedia systems need to do a better job of propagandizing about the usefulness of MBO fertilizer such as improving the ecological environment, increasing the quality of agricultural products while meeting the tastes of domestic and export markets.

(ii) Enhance community relations and access to information for consumers

MBO fertilizer factories and distribution networks, supplier facilities and input supply companies need to create better opportunities for farmers to access information and MBO product designs through many different means, thereby helping to change consumer thinking.

(iii) Maintain product quality

The quality of MBO products as announced on the market recently needs to be guaranteed honestly and strictly, creating solid trust for consumers. Related measures such as protein content and micronutrients need to be guaranteed and clearly stated on the packaging. At the same time, printing techniques to prevent counterfeit and counterfeit goods can reduce the reputation of genuine fertilizers.

(iv) Upgrade distribution system

The MBO fertilizer distribution system through agents as well as agricultural input material stores needs to be maintained and expanded to make it easier for farmers in communities to access. In addition, online ordering and delivery of fertilizers to consumers is also a measure that needs to be considered to improve the level of convenience and competitiveness to attract a greater number of consumers to buy MBO fertilizers.

(v) Maintain and upgrade sales promotions

Sales skills as well as promotions in recent times have had an effect and influenced the decision to buy MBO fertilizer. Therefore, these measures and skills need to be maintained and promoted to an optimal level to attract more customers and consumers' intended purchase.

CONCLUSIONS

Using organic fertilizers as well as MBO fertilizers is a progressive trend in the process towards sustainable development of the agricultural industry as well as the rice industry in the Mekong Delta. The amount of MBO fertilizer being used for rice production in this area is quite limited.

There are 5 factors that affect consumers' decisions to buy MBO fertilizers in order of importance including awareness, personal characteristics, product quality, distribution system and sales promotion.

In order to increase the number of consumers buying MBO fertilizer products, the above proposed solutions need to be taken into consideration and have better measures by managers, manufacturing plants as well as MBO fertilizer distribution systems in the coming years.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STERILIZE AQUACULTURE WASTEWATER BY UTILIZATION LOCALLY UV UNIT AS A WAY TO SUSTAIN CIRCULAR ECONOMY

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Abstract

Water shortage is a global problem, especially in the Arab Republic of Egypt. The aim of this study was the effect of ultraviolet sterilizers on the bacterial load in the water of the aquaponic system, especially coliform bacteria. To determine the state of food safety, by conducting some engineering studies affecting the microbial load in the water of fish farms used in aquaculture, in order to produce healthy food for humans. Providing quantities of water and fertilizers. Microbial analysis of the total number of bacteria and coliforms was conducted in the water company's laboratories and the prevalence of the total number of bacteria and coliforms in the systems in three replicates. The study parameters were for different flow rates over time at 2, 4, 6 and 10 minutes with water heights of 2.5, 5, 7.5 and 10 cm at lamp heights of 10, 20 and 30 cm. Water quality and the total number of bacteria and total coliforms in the water were measured before and after treatment using a UV sterilization unit. The results showed that the ultraviolet sterilizer gave lower results for the microbial load of coliform bacteria in the treatments under study compared to the treatments before using the sterilizer.

Key words**:** *aquaculture, aquaponic system, water quality, ultraviolet sterilizer, bacteria, coliforms, wastewater*

INTRODUCTION

The ever-increasing demand for food to meet the needs of a growing population combined with the challenges of resource scarcity and the need for high-quality foods with excellent nutritional properties demonstrates the importance of efficient, intensive and sustainable food production systems [12]. Aquaponic is a soil-less agricultural system that synergistically combines aquaculture with hydroponics in a closed cycle. Since a few years ago, aquaponics, as a sustainable production alternative to traditional aquaculture, has attracted increasing attention worldwide [5], [9]. Aquapnic has become popular and attractive conceptual agricultural technology and been considered as a potentially sustainable method of industrialized food production [7]. Alternative cultivation systems that can restrict chemical fertilizer use by replacing it with more sustainable nutrient sources are required. Aquaponics is a promising solution that addresses all the above-mentioned issues by turning waste into resource under the circular economy concept [1], [13]. This approach is especially promising for urban area to meet the needs of food nearby as the urbanization develops rapidly [8]. The technique combines fish production in recirculating aquaculture systems (RAS) and crop cultivation through hydroponics [11]. The factors that influence the water quality in the system include the stocking density of the fish, feeding rate, fish growth rate, and environmental conditions [15]. Water quality is an essential factor in aquaculture. Unlike terrestrial animals, aquatic organisms are immersed in water. Therefore, all of their important metabolic processes occur in water, including feeding, digestion, excretion, and growth. These organisms are sensitive to any change in water quality, especially in high stocking densities. The importance of controlling these pathogenic bacteria is highlighted by the fact that the aquaponics industry is growing globally, and the number of aquaponics producers [7]. Light emitting diodes (LED) and UV-A are two main safe sources of lights for photodynamic inactivation which have been used to improve sanitation of food products Thus, to address the potential challenges in water sanitation in Recirculating Aquaculture Systems (RAS) and aquaponics [2], [14]. RAS is a healthy and environmental option for food production which has encouraged research into many different aspects One of the main difficulties related to aquaponics system is the potential dissemination of pathogens Diseases control is mainly based on disinfecting water methods at various points of the aquaponics systems, depending on the method [10], because water recirculation and controlled parameters such as temperature provides the perfect environment for pathogen proliferation [4]. Microbes perform the important role of fundamental biological filtration of water to provide the required nutrients for plant growth Therefore, microbes in aquaponics may affect the system performance, water quality, and the growth and quality of the plants and fish [6]. Bacteria also have direct implications for the fish, as they are highly abundant in the water and in constant contact with the mucosal surfaces of the skin, gills and gut. Bacteria can give positive effects through metabolic and immunological relations, such as improved utilization of nutrients in the gut and protection against in the microbial community structures in RAS are shaped by physicochemical variables and competition for nutrients and space, and this selection has consequences for the composition of the microbial communities as ion of pathogens [3]. This approach compromises the environmental footprint of the system, nullifying its main advantage, which is nutrient recovery, and re-use among the three components (i.e., fish, bacteria, plants). Additionally, the closed loop aquaponics operation is primarily based on the maintenance of an equilibrium among the above-mentioned components [17]. For example, a series of studies conducted in California and New York examined the transfer of E. coli from wildlife feces to pre-harvest lettuce by spraying during irrigation. Similar field studies have been conducted to examine pathogen survival and transfer to production from soil, irrigation water, and other environmental sources. However, the majority of research has focused on soil-based field and greenhouse environments, and there is limited data on food safety risks in soilless production environments, such as hydroponics (i.e., producing plants in a liquid medium rather than soil) [16]. The main objective of this study was reducing the microbial load for aquaculture wastewater by using UV sterilizing unit locally manufactured.

MATERIALS AND METHODS

The UV sterilizer unit

The two units were made from local materials. Everyone was designed in the form of a cuboid cross-section. Its dimensions are 63 * 56 * 15 cm. It has a number of holes with a diameter of 5 cm for lamp and holes of outlet water with a diameter of 1 cm as presented in Photo 1 which shows a photograph of the structure unit. A schematic diagram of the unit is shown in Fig. 1, for front view, side view and plan view of the unit. The UV sterilizer is a robust unit used for the disinfection of water. Disinfection of the water takes place when the water flows past the built-in UV Lamp. There are various models for different flow rates, all easy to install and made to the highest quality with a stainless-steel housing and external control box with monitoring capabilities. The UV lamp was used for sterilizer of water. It blows on three heights different 10, 20 and 30 cm from water surface with in unit. The UV lamp (Philips Lightning IBRS 10461 – 5600VB NL ' TL' 20 W/ 52, is a type of UV lamp manufactured by Philips. It operates at a power of 20 watts and has a model designation of TL 20 W/52. This UV lamp emits ultraviolet light with a wavelength of around 365 nanometers, which is effective for killing or deactivating microorganisms and for inducing fluorescence in certain materials. Table 1 shows the manufacturing specification for the UV lamp.

Microbiological Analysis

Sampling analysis has been conducted in KafrEl-Sheikh Company for water and waste water - Central Laboratory for Drinking water. The sample was taken after each transaction and saved in an ice tank to save the samples, then send it to the laboratory to conduct the microbial analysis for them, where the total number of bacteria count/ ml (T. B. CFU/ml) and total coliform count/ 100 ml (T. C. CFU/100 ml) were measured.

Photo 1. A photo reflecting the structure of the unit
Source: Photography by the author's camera.

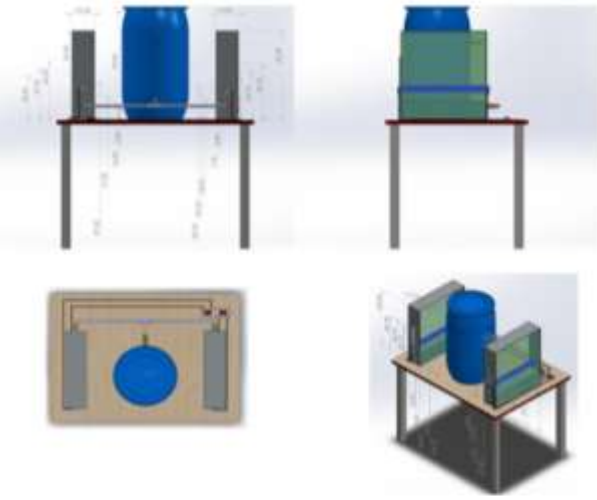

Fig. 1. A schematic of diagram isometric for the structure of the unit
Source: Author's schematic drawing.

Experimental Procedure

The main experimental work was carried out from July 2021 to October 2021. When experimental system was constructed, each component was checked and the water temperature and quality were set at the desired levels. The water used was brought in the experiment from the experimental units of intensive fish pond of *Nile Tilapia, Oreochromis Niloticus* attached to the Faculty of Aquatic and Fisheries Science, KafrEl-Sheikh University, on October 1, 2021. The analyze of the most important physical and chemical characteristics of the study of water quality have been performed. Then the tank connected to the sterilizer unit of ultraviolet rays was filled with water, and various study transactions were conducted from the height of the lamp (H.L, cm), the height of the water (H.W, cm) and the duration (time, min) of the survival water flow rate (Q L/min). Samples were collected in an ice tank to save physical and chemical characteristics and sent to the laboratory to conduct the basic microbial analyzes on them (the total number of bacterial count CFU/ ml and total coliform count CFU/ 100 ml) on the same day.

Table 1. specification of UV lamp according to Philips Company.

General Information	Controls and dimming
	
Useful Life (Nom) 2,000 hour(s)	Mechanical and Housing
Light Technical	
Color Code 52	Approval and Application
Luminous Flux 318 lm	Mercury (Hg) Content (Nom) 8.0 mg
Order product name TL 20W/52 SLV/25	
Operating and Electrical	Full product name TL 20W/52 SLV/25
Power Consumption 19.3 W	Full product code 871150064302540
Lamp Current (Nom) 0.36 A	Order code 928003505203
Voltage (Nom) 59 V	Material Nr. (12NC) 928003505203
Voltage (Nom) 59 V	Numerator - Quantity Per Pack 1

Source: The manufacture company.

Rate of change Percentage %:

To find out the relationship between the factors that affected the total number of bacteria and total coliform that were measured in the study samples, it was calculated the rate of change using the equation (1).

$$\textbf{Rate of change \%} = \frac{N_0 - N_t}{N_0} \quad ....(1)$$

where:
N_0 = the initial concentration
N_t = the concentration after a specific UV exposure time, of total bacteria (CFU/mL) and total coliform (CFU/100 mL).

Statistical Analysis

The bench-scale experiments were conducted based on a laboratory, full-factorial design. All experiments were duplicated independently with three method replicates for each sample. The data was analyzed statistically by two software, the first one was Smart-PLS version (4), smart-pls is a software with graphical user interface for variance-based Structural

Equation Modeling (SEM) using the Partial Least Squares (PLS) Path Modeling method, the second was the latest version of XLSTAT, it is a powerful yet flexible. The data was conducted two different types of analysis and they are partial least square (PLS) path model for the main effect of height of lamp (H L) and flow of water (Q) for the total number of bacterial (CFU/ml) and the total number of coliform (CFU/100 ml), with mediating factor height of water (H L) and time (t). The direct effect of the parameters under the study and the non – significant results were studied, another analysis was made using the indirect effect using mediation variable and the type of mediation was determined based on the positive values the path coefficient, so it would be complementary mediation and the negative values the path coefficient, so it would be competitive mediation. The total effect has also been studied.

RESULTS AND DISCUSSIONS

Effect of UV-LED Sterilizer for all Parameters under Study

Fig. 2 shows the number of total bacterial count (CFU / ml) and the total number of coliform count (CFU/100 ml) for all study parameters such as time (min), H.L (cm), H.W (cm). The highest value of number of total bacteria count was 415 CFU/ml at the parameter of study 2 min, 10 cm and 10 cm for t, H.W and H.L respectively, compared to the value of the total bacterial count which was 450 CFU/ml before treatment using the sterilization unit. The lowest value of rate of change percentage for total bacterial was 20 CFU/ml at the parameter of study 10 min, 2.5 cm and 20 cm for t, H.W and H.L respectively. The highest value of the total number of coliform count was 62 (CFU/100 ml) at the parameter of study 2 min, 10 cm and 30 cm for t, HW and H.L respectively, compared to the value of the total bacterial count which was 63 CFU/ 100 ml before treatment using the sterilization unit. The lowest value of the total number of coliform count was 5 (CFU/100 ml) at the parameter of study 10 min, 2.5 cm and 20 cm for t, H.W and H.L respectively.

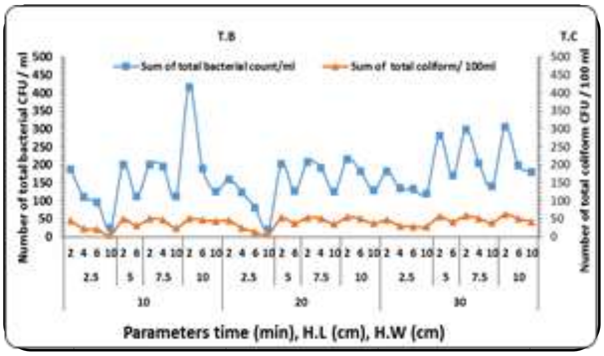

Fig. 2. The Number of total bacterial count (CFU/ml) and the total number of coliform count (CFU/100 ml) for all study parameters.
Source: Own calculation.

Rate of change Percentage

The preliminary analysis of the data by some descriptive statistics like the rate of change percentage of the total number of bacteria (CFU/ml) and the total number of coliform (CFU/100 ml), are represented graphically as shown in the Fig. 3. To find out the relationship between the factors that affected the total number of bacteria and total coliform that were measured in the study samples. It was calculated from the equation (1). UV exposure flow of water, of total number of bacteria (CFU/mL) and total number of coliform (CFU/100 mL).

Fig. 3 shows the rate of change percentages for the total number of bacterial (%) and the total number of coliform (%) calculated from equation (1). The values in the Figure 3 under the x – axis, the direction of the arrow is down and the values are all negative, this means that all the values for bacterial counts before the study are lower than their numbers after the study. The highest value of rate of change percentages for total bacterial was 95.56 % at the parameter of study 0.2 L/min, 10 min, 2.5 cm and 20 cm for Q, t, H.W and H.L respectively. The lowest value of rate of change percentages for total bacterial was 7.78 % at the parameter of study 4.2 L/min, 2 min, 10 cm and 10 cm for Q, t, H.W and H.L respectively. The highest value of rate of change percentages for total coliform was 92.06 % at the parameter of study 0.2 L/min, 10 min, 2.5 cm and 10 cm for Q, t, H.W and H.L respectively. The lowest value of rate of change percentages for total coliform was 1.59 % at the parameter of study 4.2

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

L/min, 2 min, 10 cm and 30 cm for Q, t, H.W and H.L respectively.

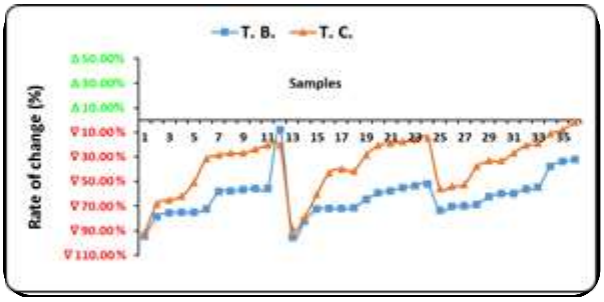

Fig. 3. The rate of change % for T. B. and T. C. for all study samples.
Source: Own calculation.

Fig. 4 shows the average rate of change percentage the total number of bacterial (CFU/ml) and the total number of coliform (CFU/100 ml) for all flow rates of water.

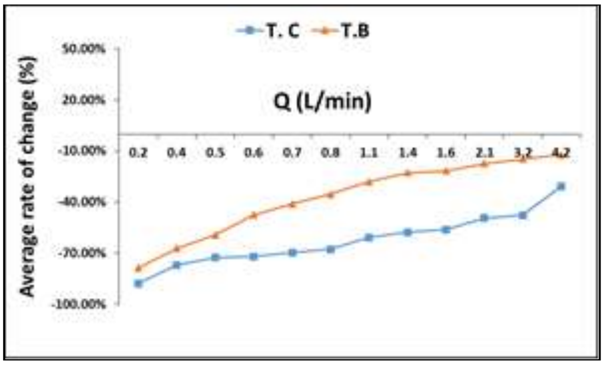

Fig. 4. Average rate of change % for total number of bacterial (T. B.) and total number of coliform (T. C.) for all flow rates of water.
Source: Own calculation.

The values in the Fig. 4 under the x – axis, the direction of the arrow is down and the values are all negative, this means that all the values for bacteria counts before the study are lower than their numbers after the study. The highest value of average rate of change percentages for total bacterial was 87.85 % at flow rate 0.2 L/min. The lowest value of average rate of change percentages for total bacteria was 30.74 % at flow rate 4.2 L/min. This means that the relationship between average rate of change percentages of bacteria and flow rates are positive. The highest value of average rate of change percentages for total coliform was 78.84 % at flow rate 0.2 L/min. The lowest value of average rate of change percentages for total bacterial was 12.17 % at flow rate 4.2 L/min. This means that the relationship between average rate of change percentages of coliform and flow rates are positive.

The first one Analysis for PLS Path Model for Total Bacteria count

The first one analysis for PLS Path Model was conducted. The first model for total bacteria (T.B) was conducted as shown in Fig. 5 and Table 2. The path coefficients for the height of lamp and water flow factors (0.172 and 0.349) respectively weren't statistically significant whereas the p-values were equal to (0.091 and 0.161) respectively which was greater than the level of significance (0.05) for the total number of bacterial. Regarding to the path coefficients for the height of water factor was equal to (0.362) with p-values was equal to (0.017) which means the path coefficient for total bacterial was statistically significant. Whereas the second value for total coliform was statistically significant. The second main effect in this table was water flow factor, the path coefficients were equal to (-0.668 and 0.540) with p-values (0.00 and 0.00) respectively, which means they were statistically significant in time and height of water. The last main effect in this table was time factor, the path coefficients was equal to (-0.442) with P-values (0.029) which means it was statistically significant in total bacteria. The statistical analysis indicated that there was a statistically significant for mediation role only with water flow factor because the p-value in case total indirect effect was equal to (0.016) less than (0.05) with path coefficient (0.491) which means the water flow affect positively on T.B with path coefficient (0.349) and the mediation was complementary mediation. The total effect of Q factor on T.B in this table was a statistically significant the path coefficients were equal to (0.839) with p-values (0.00).

The Fig. 5 showed that the flow chart of PLS Path Model for total bacterial count for (Q, H.L) component with mediation (T, H.W) factors. The direct, indirect and total effects of parameters under study are shown in the figure and coefficient of determination $R^{2,}$ so its value was 0.795 the highest of total effect from data analysis.

The second model for total coliform (T. C) was conducted as shown in Figure 6 and Table 3.

The path coefficients for the water flow factors (-0.196) weren't statistically significant whereas the p-values were equal to (0.242) which was greater than the level of significance (0.05) for the total number of coliforms. Regarding to the path coefficients for the height of lamp, the height of water and time factors were equal to (0.248, 0.774 and -0.783) with p-values was equal to (0.00, 0.00 and 0.00) respectively, which means the path coefficient for total coliform was statistically significant. The second main effect in this table was water flow factor, the path coefficients were equal to (-0.668 and 0.540) with P-values (0.00 and 0.00) respectively, which means they were statistically significant in time and height of water. The statistical analysis indicated that there was a statistically significant for mediation role only with water flow factor because the p-value in case total indirect effect was equal to (0.00) less than (0.05) with path coefficient (0.941) which means the water flow affect positively on T. C. with path coefficient (-0.196) and the mediation was competitive mediation. The total effect of Q factor on T. C. in this table was a statistically significant the path coefficients were equal to (0.745) with p-values (0.00).

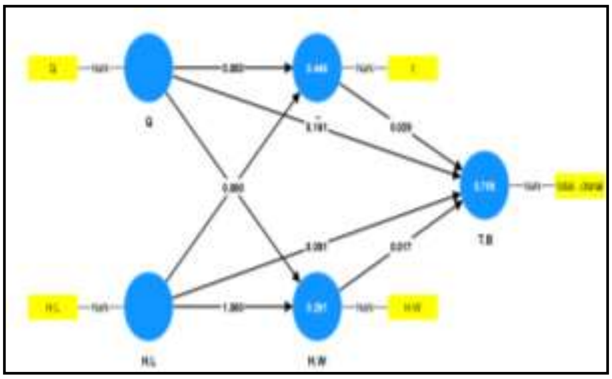

Fig. 5. Flow chart of PLS Path Model for total bacterial for (Q, H.L) component with mediation (T, H.W) factors.
Source: Own calculation.

Table 2. PLS Path Model for total bacteria for (Q, H.L) component with mediation (T, H.W) factors.

Path Direction (Total Bacterial)	Path Coefficient	CI (97.5) %	T-Test	P-value P < 0.05	Mediation
Direct Effect					
H.L -> T.B.	0.172	[0.003 – 0.386]	1.691	0.091	
H.W -> T.B.	0.362	[0.104 – 0.704]	2.395	0.017	
Q -> T.B.	0.349	[(-0.164) – 0.801]	1.403	0.161	
Q -> T	-0.668	[(-0.785) – (-0.544)]	10.889	0.00	
Q -> H.W.	0.540	[0.315 – 0.734]	5.106	0.00	
T -> T.B.	-0.442	[(-0.884) – (-0.103)]	2.178	0.029	
Total Indirect Effect					
Q -> T.B.	0.491	[0.125 – 0.925]	2.417	0.016	Complementa
Total Effect					
Q -> T.B.	0.839	[0.721 – 0.946]	14.473	0.00	

Source: Own calculation.

The second model Analysis for PLS Path Model for Total Coliform count

The Figure 6 showed that the flow chart of PLS Path Model for total coliform count for (Q, H. L) component with mediation (T, H.W) factors.

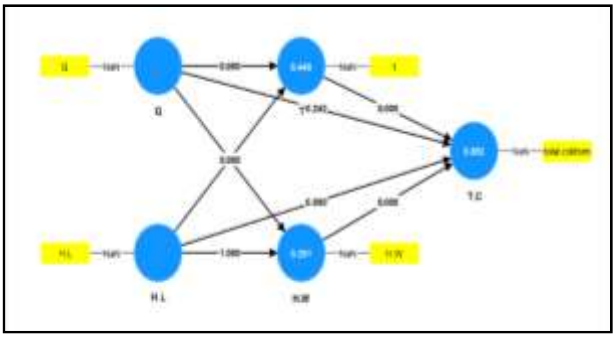

Fig. 6. Flow chart of PLS Path Model total coliform for (Q, H.L) component with mediation (T, H.W) factors.
Source: Own calculation.

The direct, indirect and total effects of parameters under study are shown in the figure and coefficient of determination $R^{2,}$ so its value was 0.853 the highest of total effect from data analysis.

Table 3. PLS Path Model for (Q, H.L) component with mediation (T, H.W) factors

Path Direction (Total Coliform)	Path Coefficient	CI (97.5) %	T-Test	P-value P < 0.05	Mediation
Direct Effect					
H.L -> T.C	0.248	[0.112 – 0.380]	3.630	0.00	
H.W -> T.C	0.774	[0.570 – 1.065]	6.188	0.00	
Q -> T.C	-0.196	[(-0.529) – 0.138]	1.170	0.242	
Q -> T	-0.668	[(-0.785) – (-0.544)]	10.889	0.00	
Q -> H.W.	0.540	[0.315 – 0.734]	5.106	0.00	
T -> T.C	-0.783	[(-1.132) – (-0.489)]	4.818	0.00	
Total Indirect Effect					
Q -> T.C	0.941	[0.647 – 1.279]	5.994	0.00	**Competitive Mediation**
Total Effect					
Q -> T.C	0.745	[0.672 – 0.835]	18.267	0.00	

Source: Own calculation.

UV sterilizers have positively affects water quality in recirculating aquaculture systems (RAS) without altering its chemical composition. UV treatment contributes to sustainable aquaculture practices by providing a chemical-free method of maintaining water quality. This approach aligns with environmental conservation efforts and the water remains safe and healthy for the species being cultured, without the risk of chemical build up in the system. This process helps to prevent the spread of infections among the selected species, leading to healthier, more robust growth and higher survival rates. This approach aligns with water conservation efforts in the world.

CONCLUSIONS

This study showed that the homemade experimental unit, which is a sterilizer using ultraviolet rays to reduce the microbial load in aquaponic water, was effective compared to treatment before use. It is hoped that the unit used in this study will contribute to the development of standard experimental procedures and validation protocols for UV water disinfection. Finally, a more holistic approach to the design and implementation of UV disinfection systems will enable the development of "fit-for-purpose" technologies. This will then encourage the identification of wide-ranging UV applications that take advantage of the unique advantages Technology offers. Identifying specific disinfection applications for UV lamps as a solution will also serve as a catalyst for further innovation and development. This work presents a new paradigm for the use of UV lamps for disinfection and more broadly the role of UV light on the inactivation of human pathogens of clinical importance.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDIES ON TRENDS IN THE EVOLUTION OF THE GLOBAL SHEEP MEAT MARKET 2010-2022

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Abstract

This article aims to explore the changes that occurred in the global sheep meat market between 2010 and 2022. The study examines aspects such as the evolution of the global sheep herd, global production, consumption and geographical distribution of trade. The foundation of this article relied on a series of statistical data obtained from the online statistical service of the Food and Agriculture Organization (FAOSTAT) as well as from the Organisation for Economic Co-operation and Development (OECD). During this studied period, the global sheep meat market has been influenced by a multitude of factors such as fluctuations in demand and supply, demographic and economic changes, shifts in dietary consumption patterns, urbanization growth, developments in livestock technology and so forth. In this complex global context, sheep meat-producing and importing countries had to adapt to new conditions and challenges, contributing to shaping a dynamic commercial landscape. In those twelve years, global sheep meat production increased by 23%, with China being the main producer. China accounted for 24.9% of the total production between 2010 and 2022. Other high-production countries included Australia (7.1%) and New Zealand (5%). China also stood as the primary importer (25.7%), followed by France (8.8%) and the USA (8.7%). Concerning exports, Australia and New Zealand nearly equally occupied the top two positions, accounting for over 70% of global exports during those years.

Key words: *sheep meat, sheep herds, production, consumption, geographical distribution of trade*

INTRODUCTION

Consuming sheep meat brings multiple benefits to human health. It is a rich source of nutrients, including proteins, lipids and minerals, essential for maintaining metabolic functions [10]. Sheep meat also contains bioactive compounds with beneficial effects on human health [12]. The fatty acid profile of sheep meat is favorable, with high levels of polyunsaturated fatty acids [2]. These fatty acids have been associated with various health benefits, such as reducing the risk of cardiovascular diseases [3]. Additionally, incorporating sheep meat into the diet has been observed to increase antioxidant levels in the blood and enhance meat oxidation resistance, contributing to overall health maintenance [8].
Globally, sheep and goat meat consumption grew more slowly in contrast to poultry and pork consumption. This was due to a slower evolution of the sheep herd and the consolidation of production and exports in a limited number of countries [9]. Significant changes occurred in the global sheep market between 2010 and 2022, and this article aims to explore them. The analysis encompassed the evolution of the global sheep population, alongside an examination of global production and consumption patterns, as well as the geographic distribution of trade.

MATERIALS AND METHODS

The basis for the elaboration of this article was a series of statistical data obtained from public databases on the websites of international organizations. Information regarding livestock, production and world trade were obtained from the online statistical service of the Food and Agriculture Organization (FAOSTAT). Consumption data, on the other hand, were obtained from the website of the Organisation for Economic Co-operation and Development (OECD).
To facilitate a clearer observation of trends in the global sheepmeat market, processed statistical data were visually represented through graphs, maps and tables.
The research included the analysis of data on

the evolution of the global sheep meat market in both absolute and relative terms.

The bibliographic documentation mainly included scientific articles.

RESULTS AND DISCUSSIONS

Evolution of sheep herds

The first step in analyzing global sheep meat trends involves studying the changes in global sheep herds. Statistical data illustrates that from 2010 to 2022, the global sheep population exhibited an upward trend (Fig. 1).

The global sheep population has increased from 1.24 billion heads in 2010 to 1.52 billion heads, representing a growth of 21.8%. Sheep experienced the highest percentage increase in livestock, followed by goats (20.6%), cattle (8%), and pigs (-0.6%). The significant growth in the sheep population can be attributed to their adaptability to various climatic conditions and lower economic requirements, making them a suitable choice for small-scale farmers [13].

Additionally, the rising demand for animal products in the Arab region, driven by a growing population, urbanization, and economic development, has contributed to this trend [1].

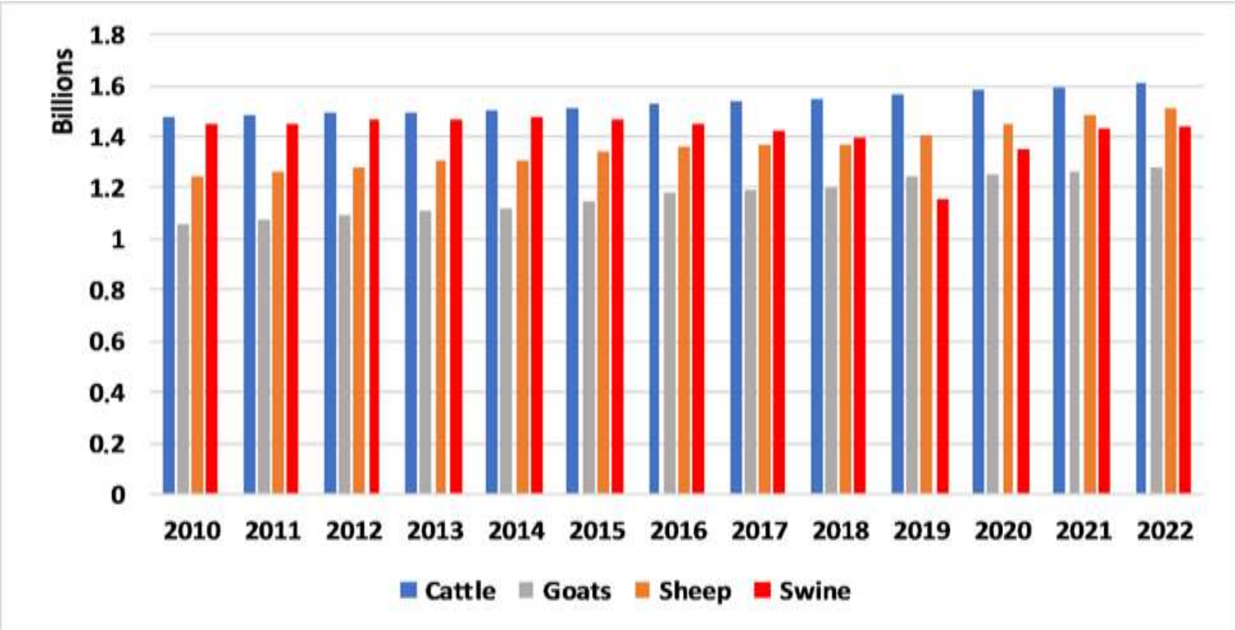

Fig. 1. Evolution of sheep herds worldwide compared to other animal species during the period 2010-2022.
Source: Own calculation based on FAOSTAT data [5].

Production of sheep meat

Globally, from 2010 to 2022, the production of fresh or chilled sheep meat has also followed an overall upward trend (Figure 2). From the analysis of the data regarding meat production, it resulted in a global increase of 23% in 2022 compared to 2010. However, it is anticipated that the future global production of sheep meat will fall short of market demand, generating strong demand and rising prices. High-value markets are expected to be favorable for sheep meat consumption, especially for lamb meat [4].

Figure 3 illustrates the global production of fresh or chilled sheep meat between 2010 and 2022, expressed in million metric tonnes. According to FAO data, the majority of sheep meat production was concentrated in a small number of countries. These values show that a total of 153 countries contributed less than 1% to global production of fresh or chilled sheep meat worldwide.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

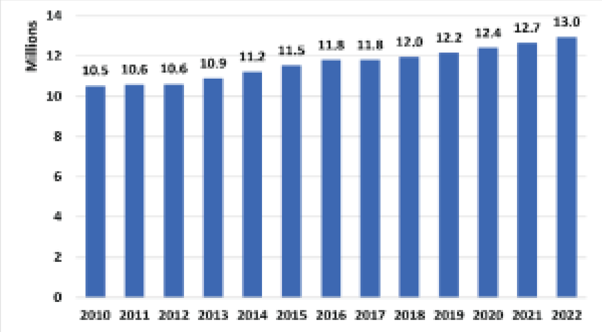

Fig. 2. The production of fresh or chilled sheep meat worldwide, during the period 2010-2022 (million tons).
Source: Own calculation based on FAOSTAT data [5].

Analyzing the cartogram (Figure 3), it can be observed that the highest sheep meat production between 2010 and 2022 corresponds to states in Asia and Africa, as well as Australia and New Zealand. In Asia, the highest production was achieved by China with 30.1 million tons (24.9% of the total), followed by Turkey with 3.6 million tons (3%), India with 3.3 million tons (2.7%), Iran with 3.1 million tons (2.6%), Pakistan with 2.5 million tons (2.5%), and so on.

African countries with the highest productions include Algeria with 3.9 million tons (3.2%), Sudan with 2.9 million tons (2.4%), South Africa with 2.1 million tons (1.7%), Morocco with 2 million tons (1.7%), Nigeria with 1.9 million tons (1.6%), and so forth.

Australia stood out with a production of 8.6 million tons (7.1%), making it the second-largest sheep meat producer globally. New Zealand also made a significant contribution with a production of 6 million tons (5%), ranking as the third-largest sheep meat producer worldwide.

In Europe, the United Kingdom stood out with a production of 3.8 million tons (3.2%). Other European countries with significant productions, exceeding one million tons, include Spain with 1.6 million tons (1.2%) and France with 1.3 million tons (1.1%).

Both in North America and South America, the production was lower compared to other continents. The United States had the highest production in North America, reaching 0.91 million tons (0.75%).

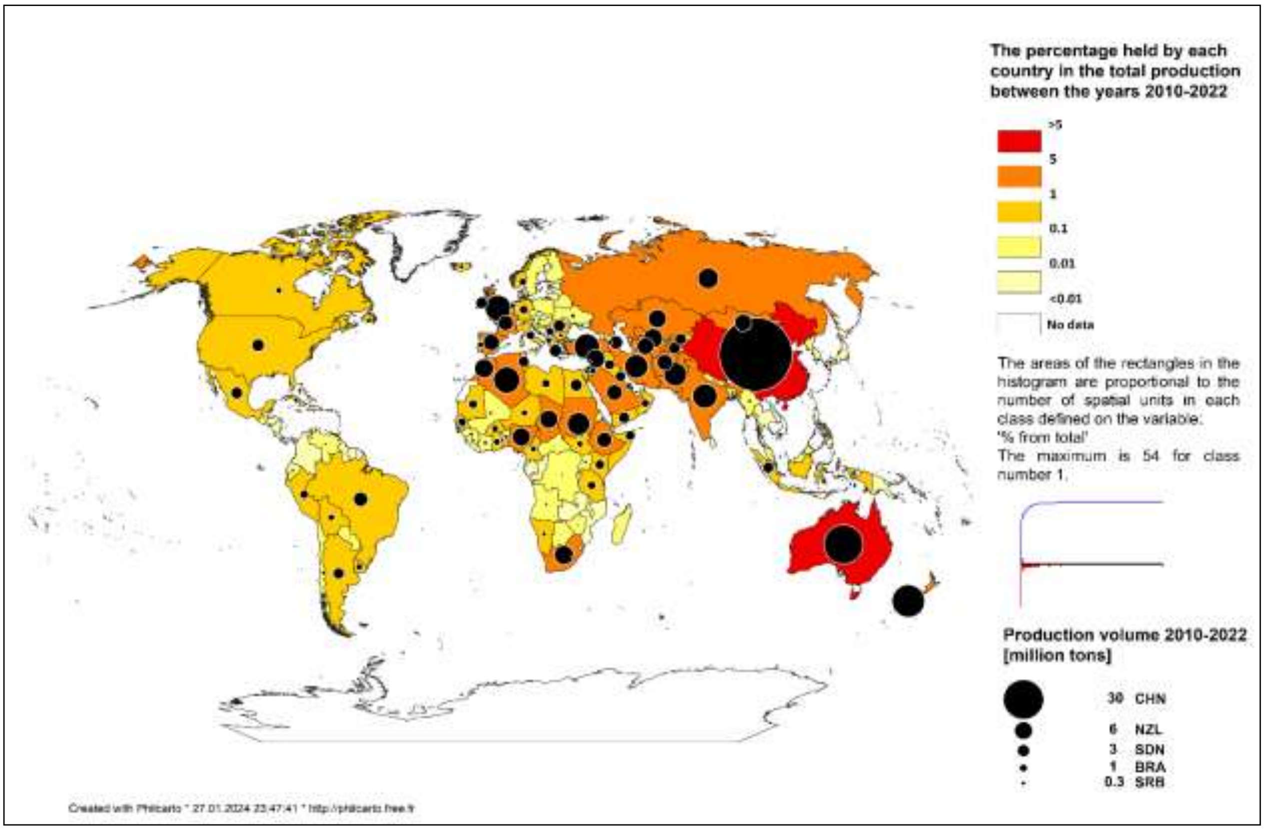

Fig. 3. Distribution of world production of fresh or chilled sheep meat obtained in the period 2010-2022.
Source: Created with Philcarto based on FAOSTAT data [5].

Asia dominates in the production of sheep meat during the period between 2010 and 2022, according to the map presented. According to the chart below (Figure 4), Asia accounted for 63% of world production, followed by Africa (15.5%), Australia and Oceania (9.7%), Europe (8.2%), South America and North America (both having 2.1%).

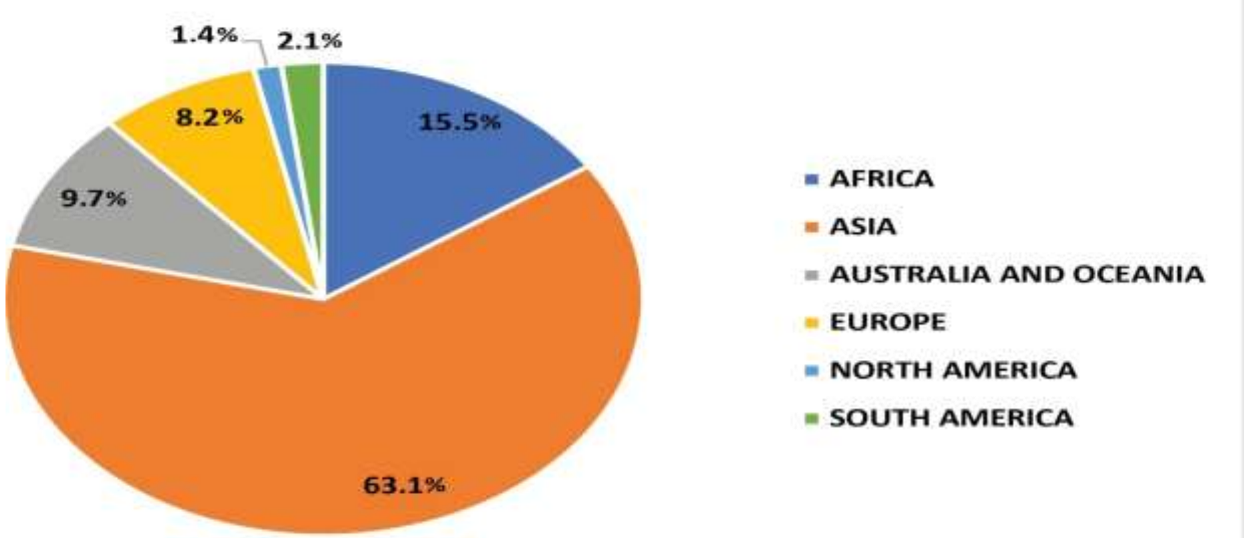

Fig. 4. Sheep meat production at the continental level in the period 2010-2022. Source: Own calculation based on FAOSTAT data [5].

Analysis of the global evolution of sheep meat consumption.

From 2010 to 2022, global sheep meat consumption grew steadily year on year. The growth rate of sheep meat consumption was 31.1%.

Consumption increased from 13.2 million tonnes in 2010 to 16 million tonnes in 2022 (Figure 5).

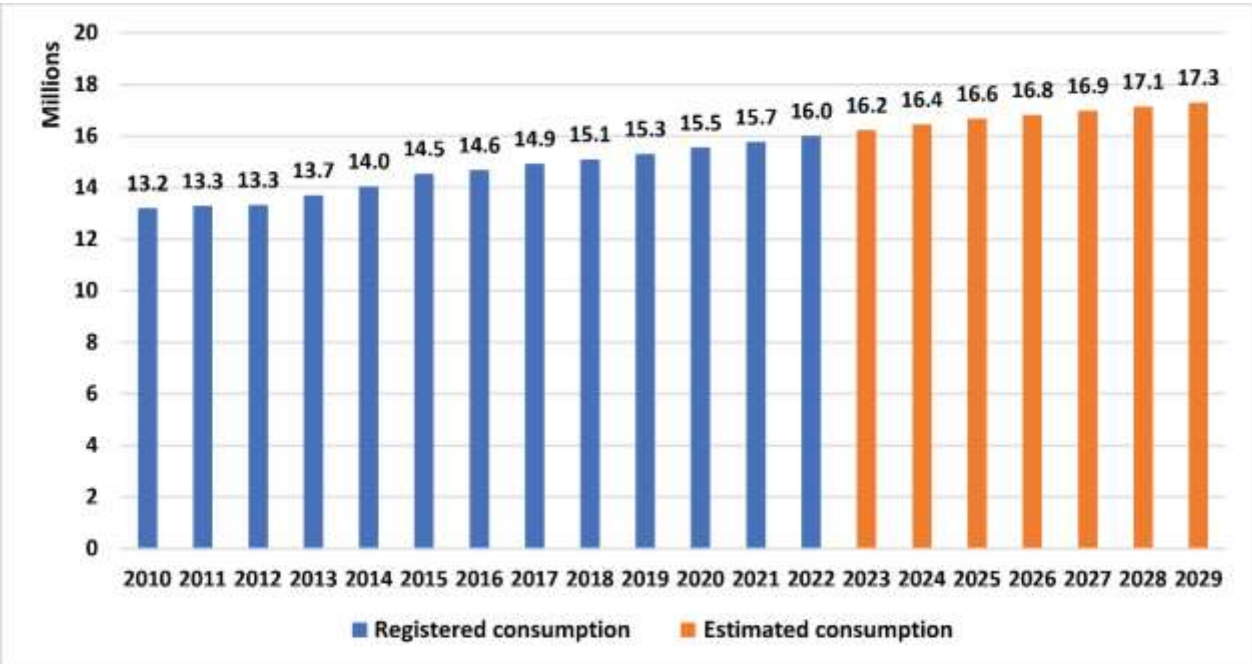

Fig. 5. Global sheep meat consumption between 2010 and 2029.
Source: Own calculation based on OECD data [11].

Global sheep meat consumption is expected to grow steadily by 2029, according to statistics from the Organisation for Economic Co-operation and Development (OECD). Consumption is expected to increase from 16 million tonnes in 2022 to 17.3 million tonnes by 2029. This increases to 8.1% by 2029.

There are several factors contributing to this steady increase in global sheep meat consumption through 2029. These factors include changing dietary habits, increased purchasing power, significant urbanization, and heightened awareness of the importance of a protein-rich diet for health. All these aspects have led to a higher demand for meat in the market, including sheep meat [6]. Additionally, the preference for meat due to religious beliefs has also contributed to the consumption growth [7].

Major sheep meat consumers globally

Table 1 provides data on the top ten countries worldwide in terms of sheep meat consumption per capita.

The table presents data on per capita consumption in the year 2022 as well as estimates for the year 2029.

The data suggests that sheep meat consumption is expected to remain relatively stable or slightly decrease in certain countries between 2022 and 2029.

In 2022, the top three consumers of sheep meat were Kazakhstan, Australia, and Norway, with per capita consumption of 8.4 kg, 5.9 kg, and 4.4 kg, respectively. The estimated consumption for the year 2029 indicates that Kazakhstan is projected to remain the largest consumer with 8.7 kg per capita, followed by Australia with 5.8 kg per capita. It is anticipated that Turkey will increase its consumption from 4.2 kg per capita in 2022 to 4.2 kg per capita in 2029, surpassing Norway. Other countries such as Saudi Arabia, Iran, and China are also expected to experience slight decreases in consumption between 2022 and 2029.

Table 1. Top 10 major sheep meat consumers globally recorded in 2022 and 2029 (kilograms per capita)

	Country	Consumption of sheep meat in 2022 (kilograms/capita)	Country	Estimation of sheep meat consumption in 2029 (kilograms/capita)
1.	Kazakhstan	8.4	Kazakhstan	8.7
2.	Australia	5.9	Australia	5.8
3.	Norway	4.4	Turkiye	4.2
4.	Saudi Arabia	4.3	Saudi Arabia	4.1
5.	Turkiye	4.2	Norway	4.0
6.	Iran	4.1	Iran	4.0
7.	United Kingdom	3.9	United Kingdom	3.8
8.	China (People's Republic of)	3.4	China (People's Republic of)	3.6
9.	New Zealand	3.3	New Zealand	2.9
10.	South Africa	2.6	South Africa	2.6

Source: OECD data [11].

Global exports of sheep meat between 2010 and 2022 have seen some fluctuations, but the overall trend has been upward (Figure 5). The volume of exports increased from 0.98 million tonnes in 2010 to 1.23 million tonnes in 2022, reflecting a growth of 25.4%. The lowest level of exports was recorded in 2011 (0.83 million tonnes), while the highest level was recorded in 2018 (1.25 million tonnes). The global exports and imports of sheep meat have experienced fluctuations, with an overall upward trend. Imports have grown from 1 million tons in 2010 to 1.60 million tons in 2022, resulting in a 60% increase.

The lowest import quantity was recorded in 2011 at 0.98 million tons, while the highest was in 2019 at 1.63 million tons.

In 2010, the exported quantity was only slightly less than the imported one, resulting in a modest trade deficit of only 0.02 million tons.

However, the increasing demand has led to a more pronounced growth in imports compared to exports, and the trade deficit has intensified, reaching -0.37 million tons in 2022.

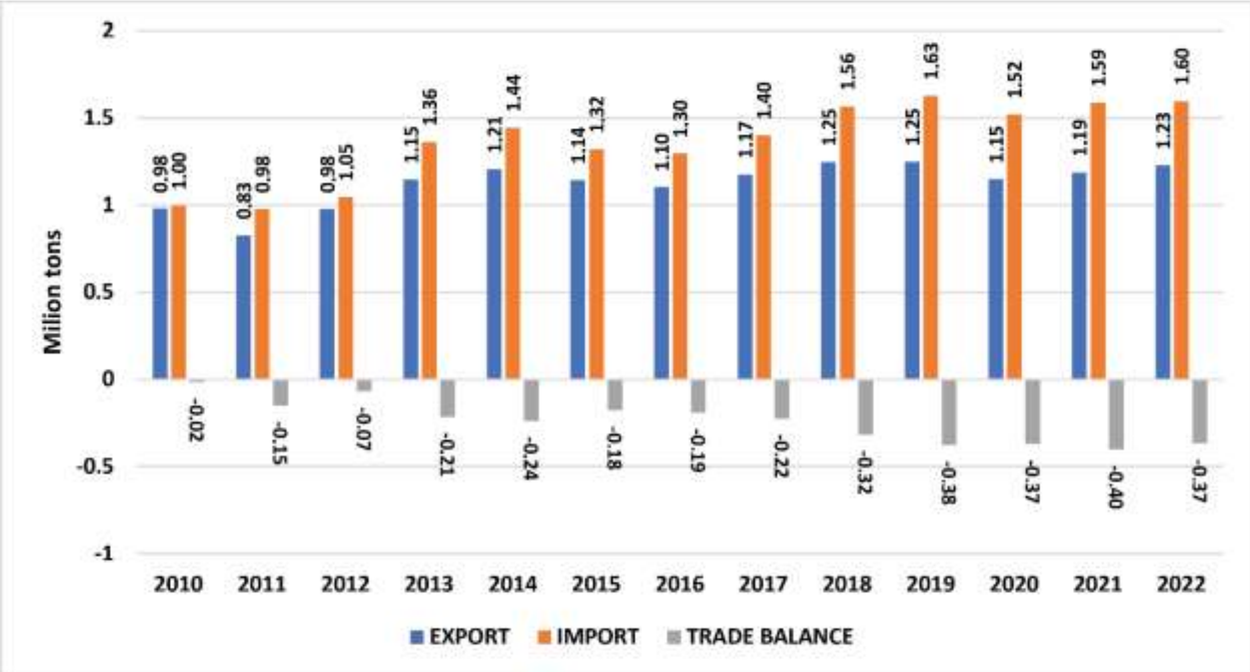

Fig. 6. Evolution of international trade balance in sheep meat from 2010 to 2022. Source: Own calculation based on FAOSTAT data [5].

Analyzing the import situation (Figure 7) over the studied period, we can observe a relatively uniform distribution worldwide, with major importing nations located on nearly every continent. The most significant importing country is China, with 3.7 million tons (25.7% of the global total), followed by France with 1.27 million tons (8.8%), the USA with 1.25 million tons (8.7%), and the United Kingdom with 1 million tons (7%). Importing nations are predominantly located in the northern hemisphere (East Asia – China, Malaysia, Japan, South Korea; Europe – the United Kingdom, France, Germany, Italy, BeNeLux; North America – USA, Canada; Middle East – UAE, Saudi Arabia, Qatar, Jordan).

A distinctive situation can be observed in the case of certain countries such as China, the UK, France, or the United States of America. Despite having significant domestic production, it doesn't fully cover their internal needs. These countries are among the top importers due to high demand from the population and the processing industry seeking raw materials. In contrast, some economically challenged countries with high domestic demand have significant production but minimal imports, aiming to maintain trade balance stability. Prolonged negative trade balances could severely destabilize their already fragile economic situation. Among such countries are India, Pakistan, Afghanistan, Sudan, Nigeria, Chad, and even Turkey. Another category of importing nations includes those in the Islamic world, traditionally using sheep meat in their cuisine. Due to arid climates, these countries cannot entirely fulfill their needs through domestic production. Middle Eastern countries such as UAE, Saudi Arabia, Iran, Jordan, and Egypt fall into this category. Regarding the total exports of sheep meat from 2010 to 2022, a significant disparity is evident among countries (Figure 7). While 27 countries surpass 1 million tons in production, only three countries exported more than 1 million tons during the analyzed period.

The top two positions are almost equally dominated by Australia and New Zealand, exporting 5.25 and 4.97 million tonnes respectively, together accounting for more than 70% of global exports.

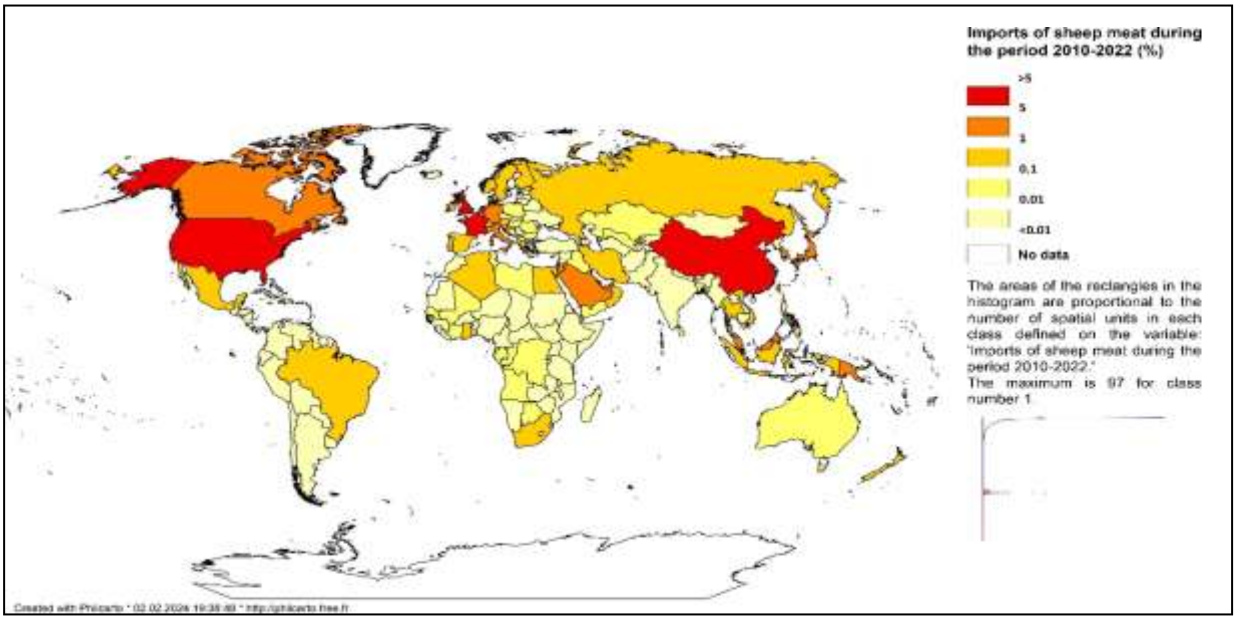

Fig. 7. Cartogram illustrating global sheep meat imports during the period 2010-2022
Source: Created with Philcarto based on FAOSTAT data [5].

The next country in terms of export volume, although significantly lower, is the united Kingdom, with 1.14 million tons (7.8 of the total).

On a regional level, aside from Australia and New Zealand, there is a notable concentration of exporting countries in Europe (the United Kingdom, Ireland, Spain, the Netherlands, France, Belgium, Germany, Romania, Greece) and the Americas (Uruguay, Argentina, Chile, USA).

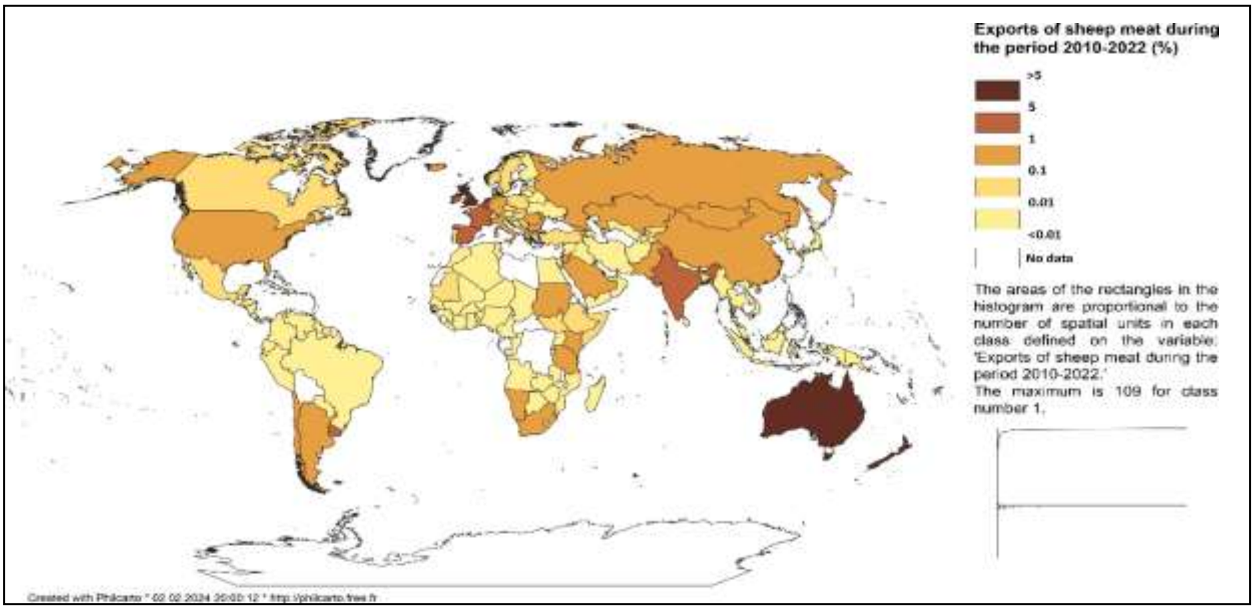

Fig. 8. Cartogram illustrating global sheep meat exports during the period 2010-2022
Source: Created with Philcarto based on FAOSTAT data [5].

CONCLUSIONS

After examining the main aspects of the global sheep market from 2010 to 2022, several important conclusions were drawn:

-demographic and economic changes, fluctuations in supply and demand, and changes in food consumption behaviour have had a significant impact on the global sheepmeat market over the past twelve years. Advances in livestock farming and increasing urbanisation have also been relevant factors in

market developments;
-the global sheep population has increased from 1.24 billion heads in 2010 to 1.52 billion heads in 2022, resulting in a growth of 22%;
-over the past twelve years, global sheep meat production has increased by 23%, with China dominating as the primary producer. FAO data indicates that 153 countries contributed less than 1% to global production, underscoring a concentration of production in a limited number of states. China accounted for 24.9% of production between 2010 and 2022, followed by Australia (7.1%) and New Zealand (5%);
-by 2029, sheep meat consumption is expected to increase by 8.1%
-in terms of exports, their volume increased by 25.4% until 2029. Only three countries exported more than one million tonnes during the period under review. The top two positions are occupied almost equally by Australia and New Zealand, accounting for over 70% of global exports combined. They are followed by the United Kingdom, which contributes 7.8% of total exports.
-despite significant domestic production, countries such as China, the United Kingdom, France or the United States do not fully cover their domestic needs. They are among the leading importers due to the high demand from the population and the processing industry in search of raw materials. In the case of imports, a more balanced overall distribution can be observed, with large importing countries located on all continents.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

INTEGRATING IMAGE PROCESSING TECHNIQUES WITH VEGETATION INDICES FOR MONITORING GROWTH STAGES AND GENERAL HEALTH FOR FABA BEAN CROP

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Abstract

The measurable value of vegetation cover resulting from image RGB bands was used in monitoring the growth stages of faba bean crop as well as obtaining information about the accuracy of vegetation analysis. In addition, this process takes little time while field measurements give results on small spatial scales with high temporal data. Usually requires a lot of measuring and sampling. In addition, this process takes a long time. The highest accuracy and the shortest time to extract color characteristics, it was advised to utilize an assistant programming program Matlab with using digital picture to verify the color vegetation indices during growth periods of faba bean crop from November 2021 to February 2022. The results showed an increase in the percentage values of green band, intensity, Hue, EXGR, GVI, VARI, NDI, EXG, VEG, CIVE, and MEXG through (budding, to podding) stages were 4.65, 7.13, 24.54, 24.12, 28, 11.24, 15.11, 83.66, 60.79, and 15 % respectively. RGB Vegetation Indices which used accurately to distinguish and monitor the condition of the plant GRVI (Green Red Vegetation Index) VARI (Visible Atmospheric Resistance Index) GLI (Green Leaf Index) TGI (Triangular Greenness Index)To describe of crop health and growth rates

Key words: *faba bean,vegetation indices, RGB bands, monitoring*

INTRODUCTION

Grain legume crops like faba beans play essential roles within the farming system. Faba beans, both large and small-seeded varieties, are considered the most significant grain legumes. They serve as a vital source of nutrition for both humans and animals alike [2].

The faba bean stands out as the foremost food legume crop globally and serves as the primary cool-season food and feed legume in numerous countries. Its adaptability to diverse soil types and environmental conditions further enhances its significance. With over 4.1 million households cultivating this crop across nearly 0.5 million hectares of land, it yields a remarkable one million tonnes of grain [3].

In recent years, there has been a rising interest in enriching food products through the inclusion of plant proteins in their formulations. Faba bean, boasting a protein content of around 29% and a well-balanced amino acid profile, holds promise as an excellent source of plant-derived protein [16]

In 2024, digital image analysis (DIA) has become an indispensable tool in modern agriculture, revolutionizing the way farmers and agronomists monitor, manage, and optimize crop production. By leveraging advancements in technology and machine learning algorithms, DIA enables the extraction of valuable insights from high-resolution satellite imagery, aerial drone footage, and ground-based sensors. These insights encompass a wide range of agricultural applications, including crop monitoring, disease detection, yield prediction, soil health assessment, and precision farming. DIA empowers farmers to make data-driven decisions at every stage of the growing season, from field planning and planting to irrigation and harvesting. Through the analysis of spectral indices, such as NDVI (Normalized Difference Vegetation Index) and NDRE (Normalized Difference Red Edge), DIA provides real-time information on crop health and vigour, allowing for timely interventions to optimize inputs, reducing costs, and maximizing yields [15].

The average of faba bean for the Red color band was 133.63, in Blue color band was 43.68, and in Green color band was 97,94 while Hue was 0. 626.Also the intensity and the browning index was 91.75, 16.25 respectively [1].

Precision Agriculture, also known as Smart Farming, seeks to enhance crop yield, minimize production expenses, and mitigate environmental repercussions. Within this realm, a prominent research focus centres on automating the identification of crops in digital imagery to facilitate plant classification, growth monitoring, and the detection of issues like water stress, nutrient deficiencies, or plant health concerns. This endeavour is particularly challenging in open-field cultivation settings, where factors such as varying natural lighting, weather conditions, and diverse agricultural practices adopted by farmers complicate the task [8].

Image-based RGB bands employ image processing and machine learning techniques to derive quantitative measurements of plants' structural and functional characteristics. This method enables the monitoring of plant growth, health, and physical attributes directly from images, offering a quicker and more precise evaluation of field areas [14].

Image processing involves converting RGB color units to Lab* values (segment labelling) required for graphics and analysis purposes. This conversion from the RGB color space to the CIE Lab color space is achieved in two steps. The initial step entails the RGB to XYZ transformation, followed by the second step which involves the XYZ to Lab* transformation [7].

The analysis of strawberry fruit images, along with their chemical properties, was conducted using the ENVI software package. Various applications of gibberellic acid and citrate potassium were explored. Chemical properties such as total soluble solids and anthocyanin content were assessed under different treatment conditions and correlated with image indices. RGB values (red, green, blue) were derived from each image, leading to the determination of color indices including the Red/Green ratio (R/G), hue, and intensity (I). The findings revealed significant correlations between certain chemical parameters and color indicators [6].

Utilizing color indices offers the advantage of enhancing specific color of interest, thereby emphasizing certain visual attributes. In the images under analysis, the predominant spectral signature is typically green, representing plant foliage. Consequently, for the purpose of accentuating greenness, indices such as ExG, CIVE, ExGR, VEG, NDI, and ExR were chosen due to their observed effectiveness in yielding favourable results [12].

Nowadays, techniques for extracting data from images are gaining traction due to their simplicity, cost-effectiveness, and speed. These methods often involve the utilization of software programs such as Matlab for analysing plant images [21].

The objective of this study was to possibility of integrating image processing techniques with vegetation indicators to monitor the faba bean crop during growth periods and determine the vegetation indices with RGB bands of faba bean crop growth starting from agriculture to harvesting and describe of crop health and growth rates.

MATERIALS AND METHODS

A field experiment was conducted to grow faba bean in November 2021 to February 2022 (5-27/11/2021 budding, 2-26/12/2021 branching,3-23/1/2022 flowering, and 26/1/2022 to 22/2/2022 podding) to verify the color vegetation indices from planting to end.The experiments field located between 30°48'15.9"N 30°58'56.2"E as shown in Photo 1.

Photo 1. The experiments field (Faba bean crop)
Source: Author's' determination.

Image Processing Techniques

MATLAB software was used to determine the three additive primary colours of faba bean

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

plant, referred to as RGB. The 'R' value indicates the red band; the 'G' value represents the green band; and the 'B' value represents the blue band.

Xiaomi Redmi Note 10 Camera

The picture was taken by mobile "Xiaomi Redmi Note 10 Camera" to get RGB bands, the main and the ultra-wide are pretty much the standard too - 48MP main unit with f/1.8 aperture. The sensor itself is 1/2.0" big and offers 0.8μm pixels and, outputs 12MP images by combining four adjacent pixels into one.

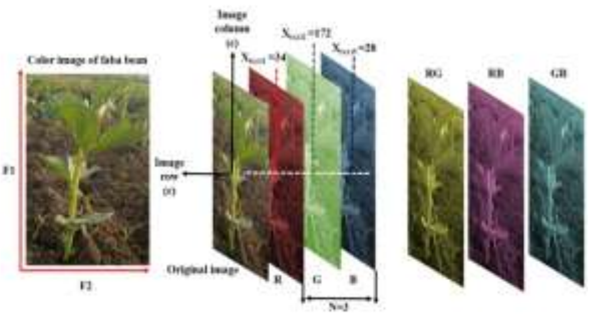


Photo 2. Color image interpretation in the RGB color domain
Source: Author's determination.

As for the ultra-wide, it's the popular 8MP, 1/2.0", 1.12μm pixels sensor paired with f/2.2 aperture that everyone uses. This particular implementation promises a 118-degree field of view (Photo 2).

Acquisition and Processing of RGB-Based Data

The RGB images were pre-processed in MATLAB software, and the steps included picture calibration, picture cropping, background removal, plant area selection, field canopy coverage extraction as shown in Photo 3. The R, G, and B channels of an image are determined by its design. They are characterized by their spectrum sensitivities, giving the distinct wavelengths, the greatest values of the spectral sensitivities for the red, green, and blue bands of the picture were 163, 235, and 153 with wavelength ranges between 350 and 400 nm. Also, the minimum values of same indices were 118, 143, and 58 with wavelength ranges between 80 and 100 nm respectively.

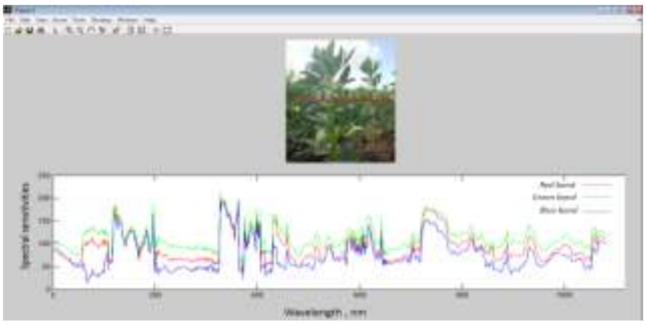


Photo 3. Relationship between spectral sensitivities and wavelength of faba bean crop
Source: Author's ' determination.

Vegetation Indices

RGB vegetation index were summarized in Table 1.

Table 1. The RGB vegetation index were using in assessing the crop's growth stage and general crop health

Acronym	Indices	Formula	Author and year
GR	Simple red–green ratio	$\frac{R}{G}$	Gamon et al 1999 [9]
GRVI	Green–red vegetation index	$\frac{G-R}{G+R}$	Tucker et al 1979 [17]
RGBVI	RGB-based vegetation index	$\frac{G^2-(BXR)}{G^2+(BXR)}$	Bendig et al 2015 [4]
MGRVI	Modified green–red vegetation index	$\frac{G^2-R^2}{G^2+R^2}$	Bendig et al 2015 [4]
VARI	Visible atmospherically resistant index	$\frac{G-R}{G+R-B}$	Gitelson et al 2002 [10]
BGI2	Simple blue–green ratio	$\frac{B}{G}$	Zarco-Tejada et al 2005 [20]
VEG	Vegetative	$\frac{G}{R^2XB^{(1-a)}}$; $a=0.667$	Hague et al 2006 [11]
GLI	Green leaf	$\frac{2G-R-B}{2G+R+B}$	Woebbecke et al 1995[18]
ExG	Excess green index	2G-R-B	Du et al 2017 [5]
NGBDI	Normalized green-blue difference index	$\frac{G-B}{G+B}$	Du et al 2017[5]
RGBVI2	RGB-based vegetation index 2	$\frac{G-R}{B}$	Proposed
RGBVI3	RGB-based vegetation index 3	$\frac{G+B}{R}$	Proposed
Hue	Hue	$COS^{-1}(\frac{(2R-G-B)/2}{(R-G)^2+(R-B)(COSG-B)^{0.5}})$	Khojastehnazhand et al., 2009[13]

I	Intensity	$\frac{1}{3}(R+G+B)$	
I_2	Intensity	(R-B)/2	
ExR	Excess Red Index	$2*G - R - B$	Du et al 2017 [5]
NDI	Normalized Difference Index	$128 * ((G - R)/(G + R)) + 1$	Du et al 2017 [5]
CIVE	Colour Index of Vegetation Extraction	$0.441*R - 0.811*G + 0.385*B + 18.78745$	Hague et al 2006 [11]
ExGR	Excess Green Minus Excess Red Index	ExG – ExR	Du et al 2017 [5]
COM1	Combination of green indices	ExG + CIVE + ExGR + VEG	Bendig et al 2015 [4]
COM2		$0.36*ExG + 0.47*CIVE + 0.17*VEG$	Bendig et al 2015 [4]
MExG	Modified Excess Green Index	$1.262*G - 0.884*R - 0.311*B$	Bendig et al 2015[4]
GB	Green minus Blue	G-B	Bendig et al 2015[4]

Source: Author's synthesis.

RESULTS AND DISCUSSIONS

The most vegetation indices increased , during the first, second, third, and fourth stages of growth periods. From Fig. 1 to Fig (5) and Table 2.

The results showed Intensity increased to (79.13, 80.13, 82.2, and 83) related to the color's overall brightness. Also EXGR increased to point out positive ExGR values suggest areas with more green than red, To estimate plant health and biomass point to VARI, GR indicesthe Simple Red-Green Ratio and Green–Red Vegetation Index is a fundamental vegetation metric., Green band expressed in excess to (0.06, 0.12, 0.14, and 0.2) during the first, second, third, and fourth stages The green band measurement provides valuable information about the characteristics of vegetation, as chlorophyll, the pigment responsible for photosynthesis in plants, strongly absorbs red and blue light while reflecting green light, Hue increased to (2.1, 2.22, 2.24, and 2.26) during the first, second, third, and fourth stages the "Hue" component refers to the characteristic of colour that separates one colour from another, such as red, green, blue, GRVI It increases (0.66, 0.74, 0.77, and 0.87) during the first, second, third, and fourth stages used to estimate plant health and biomass.

BGI2 in excess to (0.21, 0.23, 0.24, and 0.28) during the first, second, third, and fourth stages it reflects of plant vigor and density because healthy vegetation absorbs more blue light for photosynthesis while reflecting more green light owing to chlorophyll content. Also GLI It stands out more to (0.64, 0.65, 0.68, and 0.73) to analyze the chlorophyll concentration and health of green plants. It is very useful for assessing crop health and vigor. The signal from RGBVI2 was increased to (3.14, 3.88, 4.26, and 4.54) during the first, second, third, and fourth stages it focuses on the contrast between green and red reflectance, which can be indicative of vegetation presence. Also RGBVI3 indicator shows an increase (4.2, 5, 5.15, and 6.49) It captures the contrast between red and non-red features in RGB imagery, which can be useful for identifying vegetation against backgrounds with low red reflectance, EXG (264.5, 276.9, 297, and 311.6) during the first, second, third, and fourth stages it measures the quantity of green in a picture relative to red and blue. Also ExG emphasizes the distinction between green and non-green components in a picture,. NDI indicator shows a clear increase to (212.7, 223.4, 227.4, and 239.6) during the first, second, third, and fourth stages it Determines the normalized difference between the red and green band, which aids in enhancing certain aspects or qualities of interest in the images

NGBDI indicator that shows a steady increase to (0.55, 0.61, 0.63, and 0.66) during the first, second, third, and fourth stages it measures the relative difference between green and blue reflectance. Higher NGBDI values indicate areas with higher green reflectance than blue reflectance,

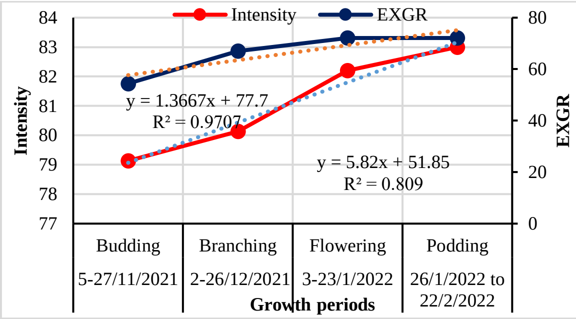
VEG indicator of an increase to (0.58, 1.02, 1.27, and 3.55) uses RGB bands to quantify several aspects of plant cover and health, Also COM1 and COM2 indicators of a high range increase and both indices were beginning points for determining greenness, GB increased to (120.7, 137.8, 138, and 140.8) during the first, second, third, and fourth stages used in image processing to evaluate plant properties based on the reflectance difference between green and blue spectral bands, CIVE increases the contrast between vegetation and non-vegetation regions by emphasizing the green color of the vegetation. It accomplishes this by eliminating the red component and adding the blue component, EXR An indicator of a high range increase to (192.4, 204.8, 230, and 257.2) during the first, second, third, and fourth stages Higher values imply a greater proportion of red pixels compared to green and blue pixels, which are often associated with vegetation, and MEXG 175.9, 177.5, 195.7, and 207) during the first, second, third, and fourth stages it computes the difference between green reflectance and the mean of red and blue reflectance. By removing the average of red and blue from green. From Fig. 6 to Fig. 12 whereas the highest values were in February 2022, and the lowest values were in November 2021 for the previous indices.

In Table 2 showed Percentage of increase and decrease of RGB vegetation index value during faba bean growth stage during growth periods of faba bean crop during November 2021 to February 2022.

The results showed an increase in the percentage values of green band, intensity, Hue, EXGR, GVI, VARI, NDI, EXG, VEG, CIVE, and MEXG through (budding, to podding) stages were 4.65, 7.13, 24.54, 24.12, 28, 11.24, 15.11, 83.66, 60.79, and 15 % respectively.

Some of RGB Vegetation Indices which used accurately to distinguish and monitor the condition of the plant GRVI (Green Red Vegetation Index)VARI (Visible Atmospheric Resistance Index) GLI (Green Leaf Index) TGI (Triangular Greenness Index) To describe and give an indicator of crop health and growth rates.

In Table 3 showed the linear regression equations was performed to predict the RGB vegetation index were using in assessing the crop's growth stage and general crop health.



FFig. 1. Relationship between intensity and excess green minus excess red index during growth periods of faba bean crop.
Source: Authors' determination.

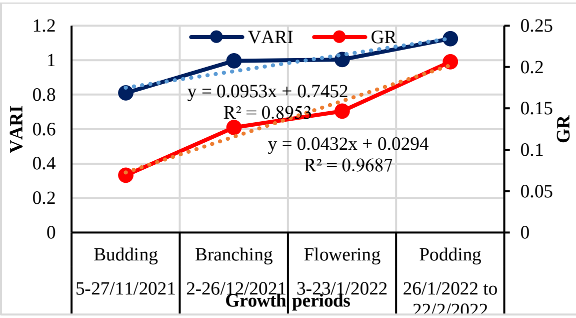


Fig. 2. Relationship between visible atmospherically resistant index and Simple red–green ratio during growth periods of faba bean crop.
Source: Authors' determination.

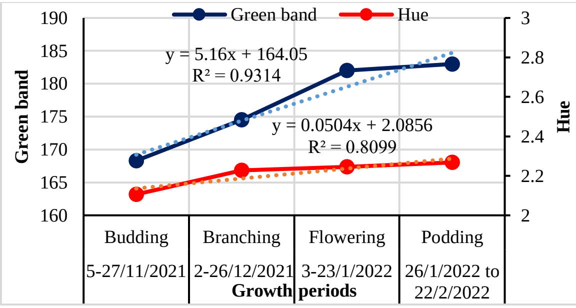


Fig. 3. Relationship between green band and hue during growth periods of faba bean crop
Source: Authors' determination.

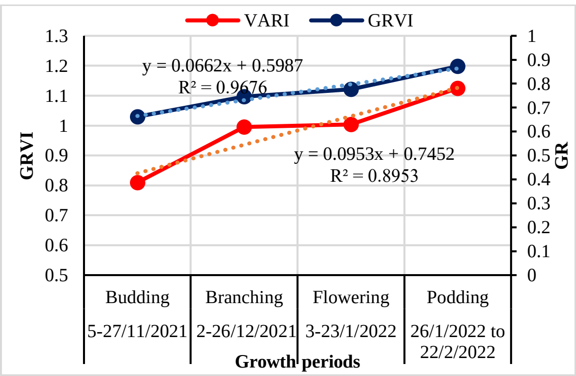


Fig. 4. Relationship between green–red vegetation index and visible atmospherically resistant index during growth periods of faba bean crop.
Source: Authors' determination.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

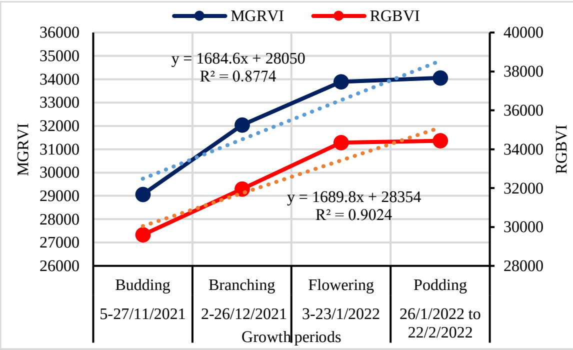


Fig. 5. Relationship between modified green–red vegetation index and RGB-based vegetation index during growth periods of faba bean crop.
Source: Authors' determination.

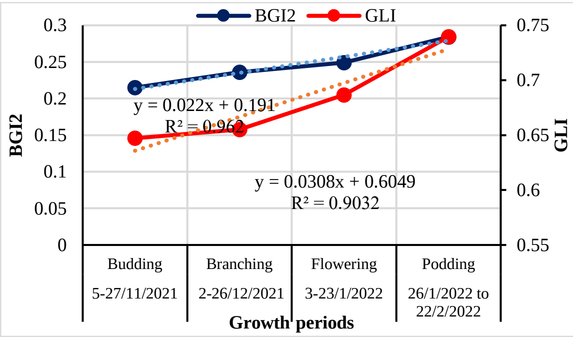


Fig. 6. Relationship between simple blue–green ratio and green leaf during growth periods of faba bean crop
Source: Authors' determination.

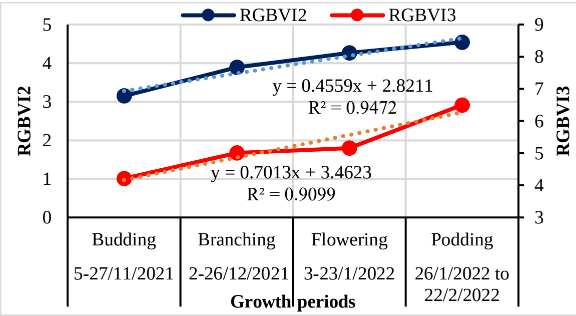
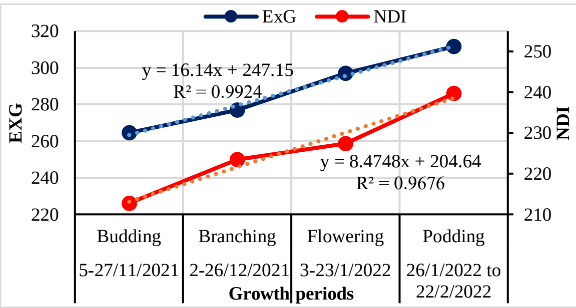


Fig. 7. Relationship between RGB-based vegetation index 2 and RGB-based vegetation index 3 during growth periods of faba bean crop.
Source: Authors' determination.



FFig. 8. Relationship between excess green index and normalized difference index during growth periods of faba bean crop.
Source: Authors' determination.

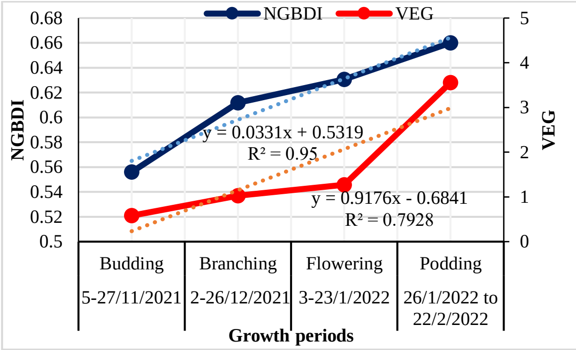


Fig. 9. Relationship between normalized green-blue difference index and vegetative during growth periods of faba bean crop
Source: Authors' determination.

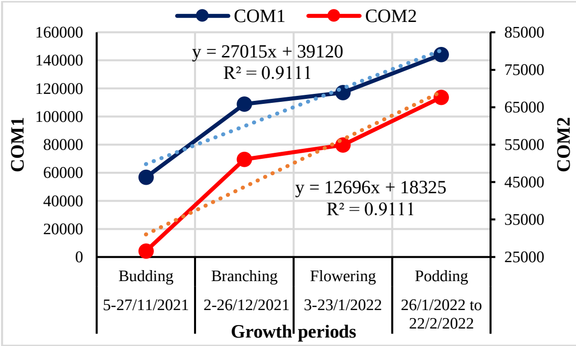


Fig. 10. Relationship between combined indices 1 and combined indices 2 during growth periods of faba bean crop
Source: Authors' determination.

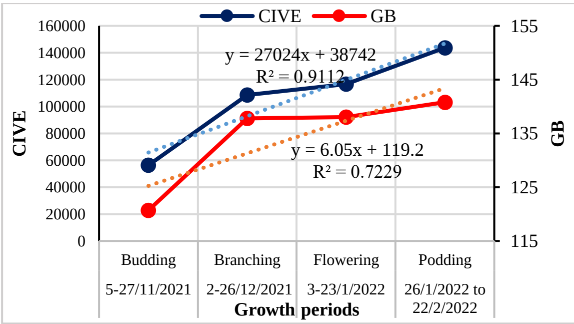


Fig. 11. Relationship between green minus blue and color index of vegetation extraction during growth periods of faba bean crop
Source: Authors' determination.

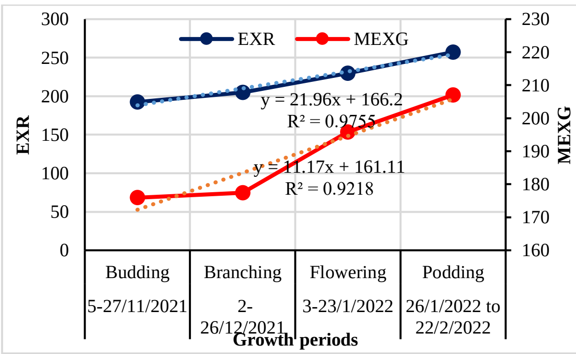


Fig. 12. Relationship between excess green index and modified excess green index during growth periods of faba bean crop
Source: Authors' determination

Table 2. The RGB vegetation index value during faba bean growth stage

Vegetation indices	Growth periods							
	Germination	Branching	Flowering	Podding	GB%	BF%	FP%	GP%
GR	0.06	0.12	0.14	0.20	50	14.28	30	70
GRVI	168.30	174.50	182.00	183.00	3.55	4.12	0.5464	8.03
RGBVI	0.66	0.74	0.77	0.87	10.81	3.89	11.494	24.13
MGRVI	29,594.85	31,950.2	34,335.66	34,432.48	7.37	6.94	0.2812	14.04
VARI	29,061.97	32,033.65	33,890.78	34,058.19	9.27	5.47	0.4915	14.66
BGI2	0.80	0.99	1.00	1.12	19.19	4.80	1.7857	28.57
VEG	0.214	0.23	0.24	0.28	6.95	4.16	14.286	23.57
GLI	0.58	1.02	1.27	3.00	43.13	19.68	57.667	80.66
ExG	0.64	0.65	0.68	0.73	1.53	4.41	6.8493	12.32
NGBDI	264.50	276.90	297.00	311.60	4.47	6.76	4.6855	15.11
RGBVI2	0.55	0.61	0.63	0.66	9.83	3.17	4.5455	16.66
RGBVI3	3.14	3.88	4.26	4.54	19.07	8.92	6.1674	30.83
Hue	4.20	5.00	5.15	6.49	16	2.91	20.647	35.28
I	2.10	2.22	2.24	2.26	5.40	0.89	0.885	7.07
ExR	79.13	80.13	82.20	83.00	1.24	2.51	0.9639	4.66
NDI	192.40	204.80	230.00	257.20	6.05	10.95	10.575	25.19
CIVE	212.72	223.48	227.41	239.66	4.81	1.72	5.1114	11.24
ExGR	56,343.80	108,519.024	116,628.052	143,721.64	48.00	6.95	18.851	60.79
COM1	54.40	6.70	72.10	72.13	18.80	7.07	0.0416	24.58
COM2	56,713.36	108,884.29	116,965.68	144,071.22	47.91	6.90	18.814	60.63
MExG	26,594.36	51,111.00	54,910.57	67,648.95	47.96	6.91	18.83	60.68
GB	175.93	177.71	195.26	207.07	1.00	8.98	5.7034	15.03
GR	120.70	137.80	138.00	140.80	12.40	0.14	1.98	14.27

Source: Author's determination.

Table 3. Model performance comparison vegetation index value during faba bean growth stage

Indices	Model performance
Simple red–green ratio	$y = 0.0432x + 0.0294$ $R^2 = 0.9687$
Green–red vegetation index	$y = 0.0662x + 0.5987$ $R^2 = 0.9676$
RGB-based vegetation index	$y = 1689.8x + 28354$ $R^2 = 0.9024$
Modified green–red vegetation index	$y = 1684.6x + 28050$ $R^2 = 0.8774$
Visible atmospherically resistant index	$y = 0.0953x + 0.7452$ $R^2 = 0.8953$
Simple blue–green ratio	$y = 0.022x + 0.191$ $R^2 = 0.962$
Vegetative	$y = 0.9176x - 0.6841$ $R^2 = 0.7928$
Green leaf	$y = 0.0308x + 0.6049$ $R^2 = 0.9032$
Excess green index	$y = 16.14x + 247.15$ $R^2 = 0.9924$
Normalized green-blue difference index	$y = 0.0331x + 0.5319$ $R^2 = 0.95$
RGB-based vegetation index 2	$y = 0.4559x + 2.8211$ $R^2 = 0.9472$
RGB-based vegetation index 3	$y = 0.7013x + 3.4623$ $R^2 = 0.9099$
Hue	$y = 0.0504x + 2.0856$ $R^2 = 0.8099$
Intensity	$y = 1.3667x + 77.7$ $R^2 = 0.9707$
Excess Red Index	$y = 5.82x + 51.85$ $R^2 = 0.809$
Normalized Difference Index	$y = 8.4748x + 204.64$ $R^2 = 0.9676$
Colour Index of Vegetation Extraction	$y = 27024x + 38742$ $R^2 = 0.9112$
Excess Green Minus Excess Red Index	$y = 21.96x + 166.2$ $R^2 = 0.9755$
Combination of green indices	$y = 27015x + 39120$ $R^2 = 0.9111$
	$y = 12696x + 18325$ $R^2 = 0.9111$
Modified Excess Green Index	$y = 11.17x + 161.11$ $R^2 = 0.9218$
Green minus Blue	$y = 6.05x + 119.2$ $R^2 = 0.7229$

Source: Author's determination.

CONCLUSIONS

The research showed the possibility of RGB vegetation index is valuable in assessing the crop's growth stage and general crop health.

The vegetation index can reflect the growth conditions of crops with using integrating image processing techniques with vegetation indicators to monitor the faba bean crop during growth periods as well as obtain information about the accuracy of vegetation analysis. The results showed increased values of color vegetation indices during fourth stages of faba bean growth from 3.55 to 8% for green band, 1.24 to4.65% for intensity, 5.4 to 7.13% for Hue, 18.8 to 24.5% for EXGR, 11.26 to

24.12% for GRVI, 18.6 to 28% for VARI, 4.8 to 11.24% for NDI, 4.47 to 15.11% for EXG, 43.48 to 83.66% for VEG, 48 to 60.7% for CIVE, and from 5.82 to 14.31% for MEXG respectively.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

PREDICTION OF MASS PRODUCTION OF FABA BEAN CROP USING DIGITAL IMAGE ANALYSIS

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Abstract

Accurate estimation of crop biomass is essential for assessing crop growth, yield potential, and optimizing agricultural management practices. Digital image analysis has emerged as a promising tool for non-destructive and efficient biomass prediction in crop production. In this study examine the predictive capabilities of digital image analysis for faba bean biomass estimation. Utilizing RGB (Red, Green, Blue) and vegetation indices image analysis techniques, the digital images was analyses of faba bean plant in fields to extract relevant biomass characteristics and quantify biomass. Through computational modelling and simulation, it assess the accuracy and reliability of these models across 100 days of growth and environmental conditions. The test analysis were conducted in the laboratory of the Agricultural Engineering Department. The results showed varying with the green biomass with the color indicators used, through which the green mass can be predicted. A linear equation appears relationship between normalized difference index and mass production during days of faba bean growth it was $y = 6.0166x + 215.85$ *with* $R^2 = 0.9495$ *.*

Key words: *prediction, modelling, biomass, digital image*

INTRODUCTION

Faba bean, a significant member of the legume family, stands out for its high protein content and promising developmental prospects. Seeds have special physical properties closely connected with their quality and yield [1, 6].

Yield is an important phenotypic trait of crops, and early yield estimates can inform field management decisions. To quickly and accurately estimate faba bean yield, this study collected and analyzed dual-sensor data (RGB and multispectral) acquired using an unmanned aerial vehicle (UAV). This study explores the potential of integrating RGB and multispectral sensor data as well as data from different growth stages to build a faba bean yield estimation model. Additionally, the impact of different machine learning algorithms and plant species on the accuracy of these models was examined [3], [4]. Yield, a significant phenotypic trait representing the ultimate goal of crop breeding, has spurred the emergence of spectroscopy as a crucial technology. Spectroscopy, which involves generating spectra from diverse substances and their interactions, has been adapted by agricultural researchers into a discipline known as agricultural spectroscopy. This discipline quantifies phenotypic traits by analyzing interactions between plant traits and spectra [5]. The application of digital image analysis techniques in predicting faba bean biomass is pivotal for evaluating crop growth and estimating yield potential, alongside refining crop management practices. This review delves into diverse methodologies and strategies employed in digital image analysis for biomass prediction, encompassing image segmentation, feature extraction, and machine learning algorithms. Furthermore, it explores the benefits, hurdles, and potential advancements associated with the integration of digital image analysis in predicting faba bean biomass [11]. Estimating aboveground biomass (AGB) accurately and quickly is essential for monitoring crop growth status and predicting grain yield. It serves as a vital indicator for assessing crop nutrition status and refining crop management strategies [12].

Faba bean (*Viciafaba*) stands as a crucial leguminous crop, boasting substantial economic and nutritional significance. The precise anticipation of faba bean biomass holds paramount importance in refining crop management techniques, gauging yield potential, and ensuring crop health monitoring. The advent of digital image analysis presents a promising avenue for non-invasive and effective biomass estimation in faba bean cultivation. This review presents a comprehensive exploration of ongoing research endeavours focused on predicting faba bean biomass through the utilization of digital image analysis technique [14].

Accurate assessment of crop biomass holds paramount importance in evaluating crop growth, potential yield, and enhancing agricultural management strategies. The emergence of digital image analysis presents a promising avenue for non-invasive and effective biomass prediction in crop cultivation. This review delves into the present research landscape surrounding the prediction of crop biomass through the utilization of digital image analysis techniques. It investigates various methodologies, hurdles, and future opportunities within this domain [15]. The utilization of RGB (Red, Green, Blue) image analysis techniques in forecasting crop biomass, a pivotal factor in evaluating crop growth and yield potential, is explored in this review. RGB image analysis provides a non-invasive and effective means of estimating biomass by harnessing color data from digital images of crop fields. The review investigates diverse methodologies, encompassing color segmentation, feature extraction, and machine learning algorithms, applied in the prediction of crop biomass using RGB image analysis [16]. Leaf-area index (LAI) and biomass are critical parameters in understanding ecosystem dynamics and biogeochemical processes. LAI represents the amount of leaf surface area relative to the ground area, providing insights into vegetation structure, productivity, and energy exchange. Biomass, on the other hand, quantifies the total mass of living vegetation per unit area, indicating the amount of organic matter produced by plants [13].

The reflected light is analyzed by vegetation indices to detect plants and assess their status. The healthy plants were riched in chlorophyll and reflect near-infrared and more green light than those with stressed or dead leaves.

Vegetation indices, such as the Normalized Difference Vegetation Index (NDVI) or Enhanced Vegetation Index (EVI), quantify these spectral characteristics to provide valuable insights into plant health, biomass, and productivity. By measuring the ratio of reflected light in specific spectral bands, these indices can distinguish between healthy and stressed vegetation, aiding in early detection of plant diseases, nutrient deficiencies, or environmental stressors [17].

The aim of this study was to predict biomass of a single plant correlate with color indices based on RGB bands during faba bean growth period.

MATERIALS AND METHODS

Simulation models was constructed by C^{++} to predict of faba bean biomass during growth faba bean crop (10, 30, 55, 80, and 100 days) as shown in Photo 1, the color vegetation indices from planting to end to reflecting production of faba bean crop.

Photo 1. Growth stages of faba bean plants within 100 days of planting
Source: Author's' determination.

Image Processing technique and RGB bands

750 photo was taken during the plant's life and MATLAB software was used to extract the Red, Green, and Blue bands from an image of faba bean plant, Photo 2 showed the sequence to extract the image and RGB bands

Vegetation indices and biomass of faba bean crop

The relationship between vegetation indices and the increase in biomass of plants can vary depending on several factors, including the specific index used, the stage of plant growth, and environmental conditions.

However, a positive correlation between vegetation indices and biomass increase:

1-Greenness Indices (GR, GRVI, VEG, GLI, ExG, RGBVI, MGRVI, VARI):

These indices typically measure the amount of green vegetation present.

As biomass increases, there is usually more green foliage, leading to higher values of these indices.

2-*Redness Indices* (ExR, NDI, CIVE, ExGR, COM1, COM2):

These indices assess variations in red reflectance, which can be related to changes in biomass density, especially in mature or senescent plants.

Higher biomass may lead to alterations in red reflectance due to changes in leaf structure or pigment content

3-Blue-Green Indices (BGI2, NGBDI, GB):

Blue-green indices measure the relationship between blue and green reflectance, which can be influenced by factors such as leaf area and chlorophyll content.

An increase in biomass may lead to changes in these indices due to variations in leaf density and chlorophyll concentration.

4- Combined Indices (RGBVI2, RGBVI3, Hue, Intensity)

These indices consider multiple bands or color spaces, capturing additional information about vegetation characteristics.

Changes in these indices with increasing biomass may reflect alterations in plant structure

Flowchart presented in Photo 3 showed the calculation of color vegetation indices based RGB bands.

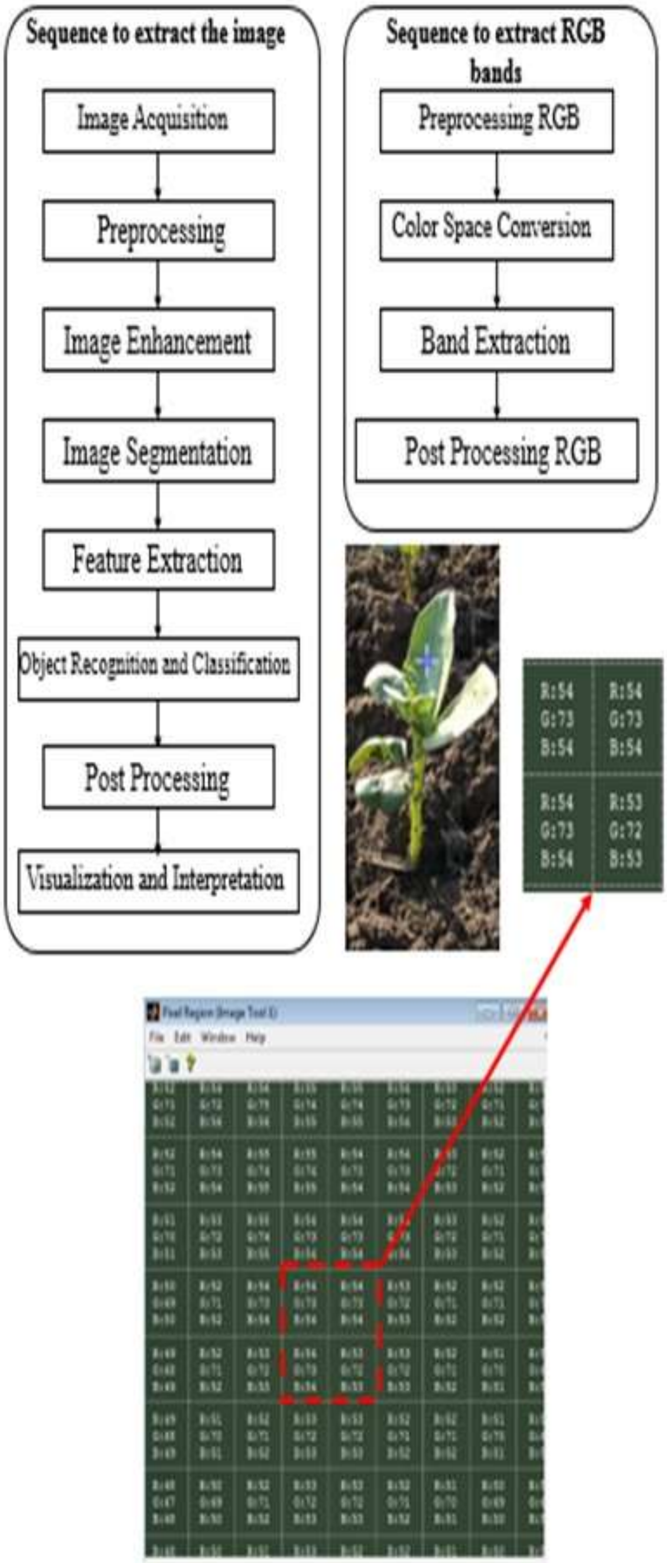

Photo (2): Flowchart showing the sequence to image and RGB bands in Matlab software
Source: Author's prepared.

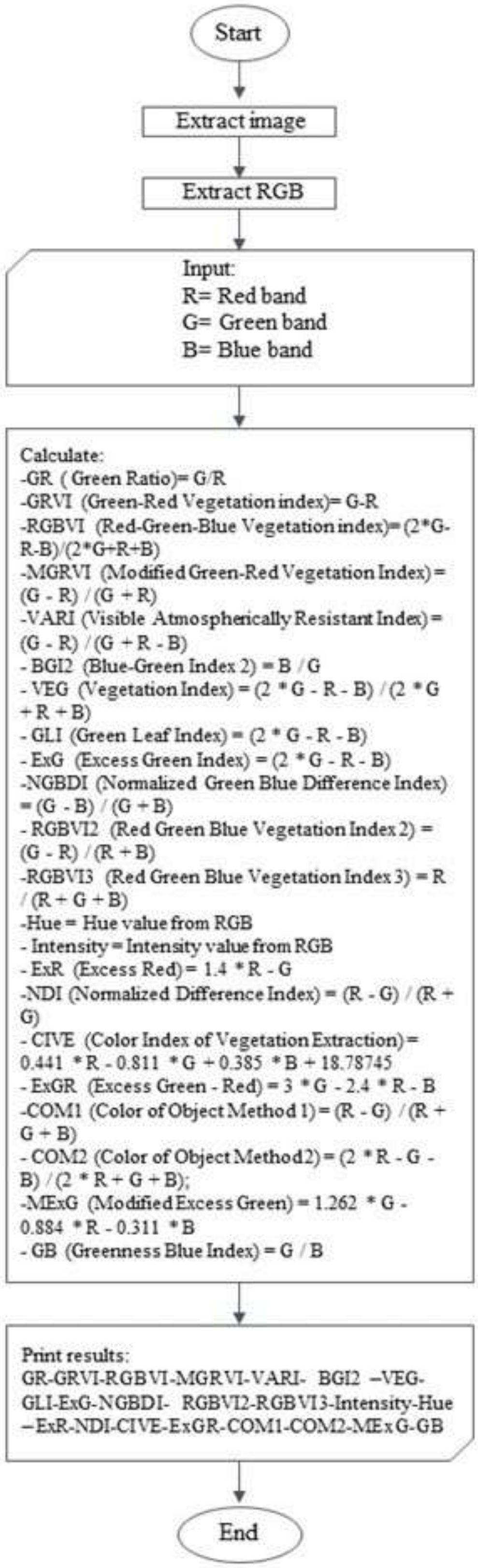

Photo (3): Flowchart showing the sequence to estimate the color vegetation indices
Source: Author's prepared
Source: [1], [3], [5], [6], [7], and [8].

RESULTS AND DISCUSSIONS

The most vegetation indices increased for mass production and green pods.

Figure 1 showed the maximum values of simple red–green ratio, green leaf, visible atmospherically resistant index, normalized green-blue difference index, and simple blue–green ratio recorded to 0.265, 0.781, 1.239, 0.811, and 0.366, with the mass production value was 508.75 g.

Figure 2 showed when mass production increased from 7.67 to 508.75 g. the intensity increased from 61.66 to 85.35. Also the same trend showing in the excess green minus excess red index, increased from 52.00to 91.00, green band from150,to 205, normalized difference index from 223.481, to 245.331, green minus blue from 113 to 172, excess red indexfrom146 to 300, and modified excess green indexfrom178.238,to 231.431.

Figure 3 showed the maximum values of RGB-based vegetation index, modified green–red vegetation index and combination of green indices 2 gives slightly increased in difference values with mass production of faba bean crop while with colour index of vegetation extraction and combination of green indices 1 it gives a clear increase in the difference values with mass production.

Figure 4 showed the maximum values of Hue Gives slightly increased in difference values with mass production of faba bean crop while with RGB-based vegetation index 2, and 3) it gives a clear increase in the difference values with mass production.

Figures 5 and 6 showed the linear regression analysis run to derive equations to predict the relationship between normalized difference index and mass production during of faba bean growth. The following equation represented the relationship.

$$y = 6.0166x + 215.85 \quad R^2 = 0.9495$$

Also, the relationship between the colour index of colour Index of vegetation extraction and mass production during faba bean growth is represented by the following equation.

$$y = 20717x + 78293 \quad R^2 = 0.9448$$

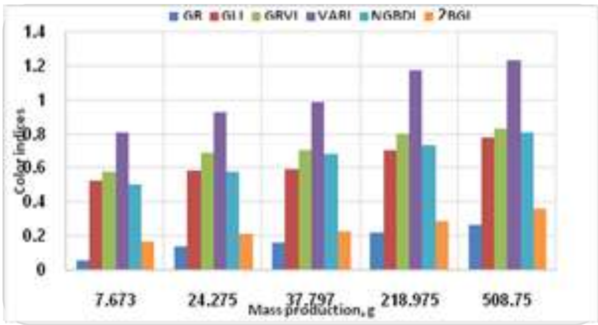

Fig. 1. Relationship between color indices and mass production of faba bean crop
Source: Authors' determination.

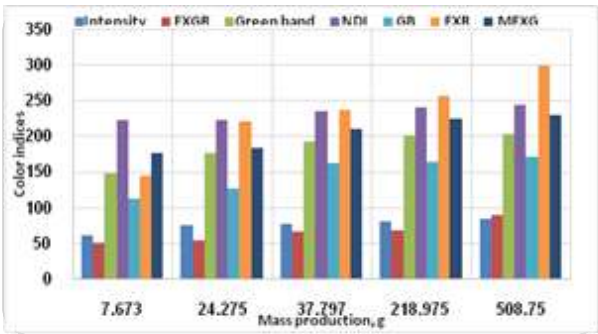

Fig. 2.. Relationship between color indices and mass production of faba bean crop
Source: Authors' determination.

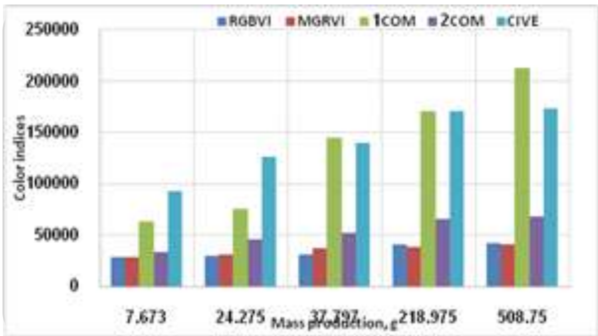

Fig. 3. Relationship between color indices and mass production of faba bean crop
Source: Authors' determination.

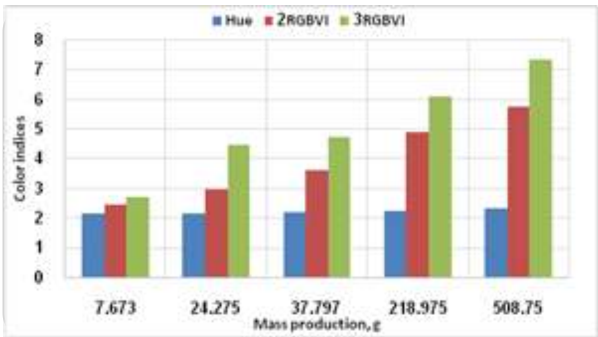

Fig. 4. Relationship between color indices and mass production of faba bean crop
Source: Authors' determination.

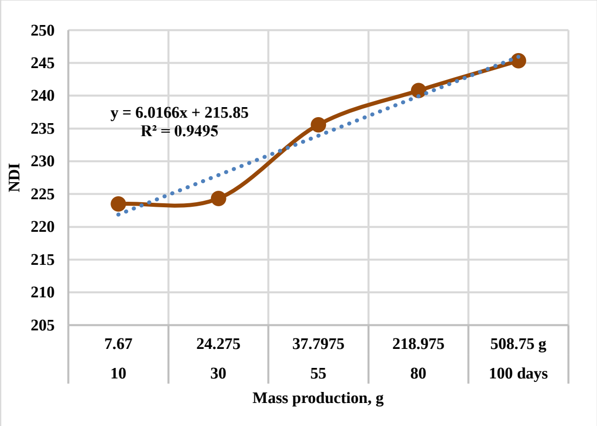

Fig. 5. Relationship between normalized difference index and mass production during of faba bean growth
Source: Authors' determination.

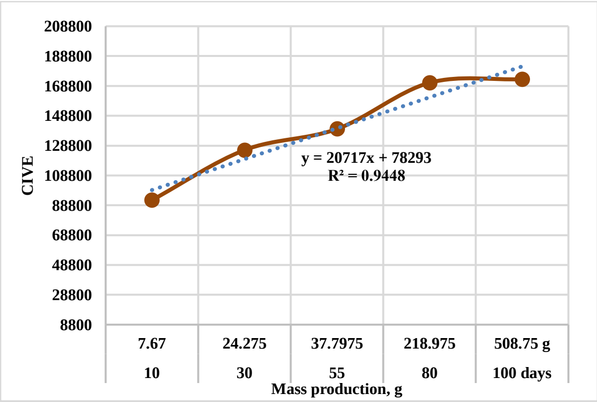

Fig. 6. Relationship colour index of colour Index of vegetation extraction and mass production during faba bean growth
Source: Authors' determination.

Table 1. The color indices values of mass production and green pods of faba bean crop

Vegetation indices	mass production
	8-100 days
GR	16%
GRVI	3%
RGBVI	3%
MGRVI	6%
VARI	5%
BGI2	20%
VEG	61%
GLI	10%
ExG	21%
NGBDI	9%
RGBVI2	15%
RGBVI3	17%
Hue	4%
Intensity	4%
ExR	14%
NDI	2%
CIVE	11%
ExGR	24%
COM1	19%
COM2	4%
MExG	2%
GB	4%
GR	16%
Green band	1%

Source: Authors' determination.

Table 1 shows the differences of color indices values with mass production of faba bean crop. When mass production increased from 7.67 to 508.75 g. the color indices values increased by 16,19 and 24% with GR , COM1 and ExGR.

CONCLUSIONS

The research results demonstrate the effectiveness of color indices which extracted from RGB images for estimating biomass of faba bean crop during growth period. Additionally, the utilization of image processing techniques and extraction of vegetation indices from these images. The values of color vegetation indices were measured during 100 days.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

VISUALIZATION AND MEASUREMENT OF SKILLET TEMPERATURE PROFILEUSING INFRARED THERMOGRAPHY

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Abstract

This paper presents a possibilities of infrared thermography especially focused on temperature measurement as a non-destructive to monitor temperature profile during potato frying With using three different, easily accessible skillet materials stainless steel Wock Skillet, Stainless steel with PTFE polytetrafluoroethylene material and Tefal Skillet .The thermal imaging cameras and software to read skin surface temperature and calculate an estimated core body temperature. The results recorded the internal and external temperatures at the three Skillet materials, the temperature of air, oil, fire, and potatoes, for the Wock Skillet before frying 29.8, 36.9, 21.7, 45.9, 216.7 and 17.2Cº while after frying 50.9, 61.9, 23.1, 111.9, 204 and 31.8 Cºrespectively. as they were for the Teffal Skillet before frying 131, 154.9, 25, 94.2, 206.1 and 17.2 Cºwhile after frying 200.7, 201.3, 27.8, 161.1, 260.7 and 40.1Cº respectively. as they were for the Wock Skillet before frying 59.7, 51.6, 26.7, 65.6, 129.8 and 17.2Cº while after frying 99.4, 126, 28.8, 120.1, 197.4 and 35.1Cº respectively. Therefore, the best temperature profile of frying with typesSkillet for the least heat emission, and the lowest temperature recorded for oil and potatoes, were in the Wock Skillet, followed by the Teffal Skillet, and finally the EL RAMLAY Skillet.

Key words*: *chips, French fries, frying, potato, infrared thermography

INTRODUCTION

For numerous apparent reasons, including lowering the risk of food-borne infections and improving flavor, texture, palatability, digestibility, and shelf life in both domestic and commercial settings, cooking is an essential aspect of daily living. Food-related energy demand is estimated by FAO to be 75% for cooking and food preparation, 10% for primary production, and 15% for food transportation and processing [3].

A Skillet is a physical delivery mechanism that transfers heat to the contact surface of food that is meant to be cooked from a source such as an electrical coil, natural gas, or induction. The way that food cooks is determined by the conduction of thermal energy via the food contact surface. Heat is transferred through the Skillet 's materials and from the heat source (the cooktop) to the Skillet 's base by a process known as conduction of heat. How thermal energy is delivered from the Skillet to the food is mostly determined by the materials used in the Skillet 's construction. Taking into account the aforementioned, this study examines the properties of heat transfer for Skillet s with varying compositions on different cooktops [8].

One of the oldest and most widely used food processing techniques, frying provides fried food its distinct flavour, texture, and taste. Due to their crispy texture, affordable price, and portability, fried potato strips and chips make up a sizable share of the fried food goods. But fried potatoes and other foods typically have a high oil content—between 35 and 45 percent. Consuming such fried food in excess can raise your risk of obesity, hypertension, heart disease, diabetes, and other conditions [15].

One of the most popular methods for preparing food is deep-oil frying, which is thought to be a billion-dollar industry globally. To ensure the ultimate quality of the fried food products, it is crucial to simulate and monitor the temperature time distribution in the food during frying. Frying can remove all or some of the moisture from food, depending on how intensely it is processed. In actuality, while frying, heat from hot oil is absorbed, causing a phase shift from liquid to vapor. As a result, mass transfer and heat transfer phenomena occur concurrently when food is frying [4].

Because they are readily available, affordable, convenient, and have a delicious flavour, deep-fried potatoes are among the most often consumed food items. A number of scientists have created mathematical models to explain how potatoes fry. Based on either single-phase or two-phase systems, these models have been constructed to represent the heat and mass transmission mechanism for frying potatoes. Dincer developed an analytical correlation for heat and moisture transfer coefficients based on various potato geometries, assuming that heat and mass transfer processes occur independently. Dincer employed a single-phase model, solving the diffusion equation for both the heat and mass transfer phenomena, without coupling the two phases together [9].

When potato slices or strips are fried, heat can produce certain chemical pollutants like acrylamide and furan, which can end up in the final fried pieces in significant levels. In industrial frying procedures, the variables that can be controlled are often the kind of oil, frying temperature, frying time, and potato variety. Because of this, it is essential to analyze how quality changes during frying. By understanding kinetics parameters, one can forecast the ultimate quality of fried potatoes and increase the value of the final product by carefully choosing the processing settings [10].

Over time, there has been a significant increase in interest in frying process optimization. This method has improved our comprehension of the entire process, including the food, fryer, oil, and overall operation. The degree to which the heated fat undergoes chemical reactions such as oxidation, polymerization, and hydrolysis, which change its chemical and physical properties, determines how complex the frying process is. Maintaining ideal frying conditions and estimating the degree of each factor's influence are challenging tasks [6].

Plant and animal items have been cooked, baked, roasted, or fried from the beginning of time to increase their palatability and digestibility. Heat can be delivered to the product by conduction (Skillet-frying), convection (deep-frying), or radiation (microwave) from the medium, such as air, water, or oil. Food has been cooked using deep-fat frying on an industrial, catering, and home scale. Traditionally, based on their precise volume, several final goods might be prepared: I item that are wet and have a crisp, dry crust, like fried chicken, French fries, and doughnuts; and ii) products that are entirely dry and brittle, like potato chips (also known as crisps [13].

The range of temperatures utilized for frying is 150–200°C. Elevated temperatures stimulate the interplay between dietary ingredients such as proteins and carbohydrates, as well as the crust's surface dehydration and oil absorption. When food is heated to high degrees, it acquires a desired colour, crispness, flavour, and taste as opposed to boiling it in hot water [11].

Due to its speed and ease of use, frying is a highly popular procedure in the restaurant and industrial sectors, outperforming other cooking processes in terms of efficiency. Despite being a long-standing and widely used method, deep-frying remains little understood. Experience usually dictates the best frying oil to use as well as the correct cooking technique. A thorough understanding of the frying process aids in the optimization of the production processes with reference to food quality, fat use life, and energy consumption. Installing a management system that covers all crucial frying process points is required to provide a high-quality final product [14].

A food is a solid body that has pores and holes in it that are full of air and water. Traces of free water at the surface evaporate quickly after being submerged in the heated oil, causing the surface to violently bubble and dry out. The heat resistance of the steam evaporating from the surface means that the heat transfer rate from oil to food surface is zero when the vaporization of water occurs more quickly than the surrounding oil's capacity to remove the steam by convection. A violent bubbling is caused by the food being added to the heated oil and the food's quick evaporation of moisture. The area of interaction between oil and bubbles increases.As a result, the rate of heat transfer between oil and air rises, hastening the oil's oxidative deterioration [1].

Rapid evaporation of water from the food's surface and severe bubbling can be prevented by lowering the oil temperature, reducing the amount of food to be fried, or pre-drying the food. As the oil cooks, the number of bubbling decreases and the protective effect of the evaporating water steam increases. This reduces headspace air flow and creates a steam blanket over the oil surface, protecting it from oxidation by preventing air contact [12].

Convection from the oil to the product's surface and conduction to the product's centre are the two ways that heat is transported. There is more pressure inside the product because the water is heated to the boiling point. Water at the product's surface consequently evaporates, and as a result, water from the food's inside moves from the centre radially outward to the walls. After the first frying phase, this water transport is in charge of chilling the product's outside and preventing the food from burning or scorching. The inner portion of the meal to be fried is heated to a boiling point, which causes the starch to gelatinize and the proteins to denaturize [2].

You can utilize deep-fat frying as a substitute for other high-temperature, typically more complicated techniques like: Before pressing to extract oil, oil-rich materials (such as avocados, coconuts, and catering wastes) are dried and texturized. Forming and drying wood for outdoor usage. Coffee and cocoa are roasted and dried. Fried foods have been accused of exposing customers to health hazards including excess weight and toxicologic or mutagenic consequences because frying oils undergo chemical changes at high temperatures and stick to the product after it is taken out of the fryer. Therefore, the main areas of research have been fat chemistry and the potential health implications of fried foods [7].

The processes by which the oil impregnates fried goods and the internal alterations in the frying material have received far less attention. In fact, heat and mass transfer during the frying process have been inadequately explained and frequently restricted to a specific type of product (French fries, potato chips, fried chicken) or raw material (starchy materials, vegetables, fruit, etc.), despite a considerable amount of important work over the last ten years [5].

The main objectives of this study using infrared image to monitor temperatures distribution during potato frying and tocompare the heat transfer and energy efficiency across the various cooktops, it is important to comprehend the overall performance of the Skillets, including heating, the rate of heating that is impacted by the heating source, and the rate of heating that is influenced by the material composition of the Skillets.

MATERIALS AND METHODS

Potato tubers (Sponata) with a water content of 80% were used. The potatoes were cut into thin slices (10 mm thick and 55.1*10.33mm in diameter).

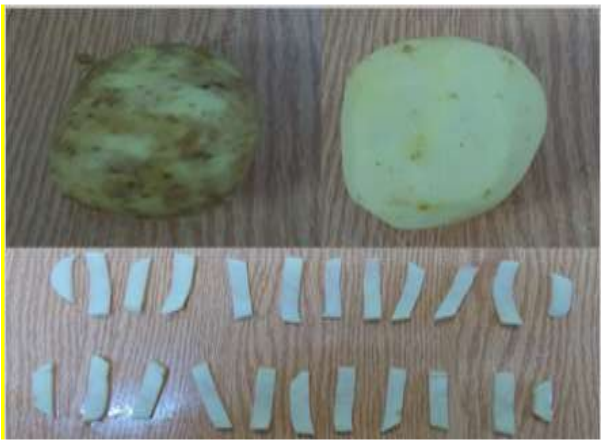

Photo 1. Potato tubers (Sponata)
Source: Photography by Authors.

Then slice into sticks (thickness 10mm and diameter 59.9*10.33mm) which were cut using manual French fry cutter.

Raw potato density was calculated from the weight and volume of potato samples. Samples were weighed on an analytical balance (Photo 1).

We used materials Stainless steel, sheet metal (steel) and Tefal skillets (Table 1).

Table 1. Skillet Properties

Properties	Stainless steel	Tefal	sheet metal (steel)
Elastic Modulus (N/m^2)	2e+11	400	190 to 210
Poisson's Ratio (N/A)	0.28	0.4 to 0.5.	0.27 to 0.30.
Shear Modulus (N/m$^{2)}$	7.7e+10	300 to 500	77 to 82
Mass Density (kg/m^3)	7,800	2,320	7,750 to 8,050
Tensile Strength (N/m^2)	513,613,000	7,580,000	300
Compressive Strength (MPa)	170 to 310	20 to 40	200
Thermal conductivity (W/mK)	18	0.25 to 0.35	15 to 60
Hardness (Rockwell)	95	50 to 65	120 to 200
Thermal Expansion Coefficient (µm/(m·K))	1.1e-05	80 to 135 x 10^{-6}	10 to 13 x 10^{-6}
Specific Heat (J/(kg·K))	460	0.5 to 0.55	0.46 to 0.51

Source: Authors' determination.

The Thermal camera characteristics

Image quality with 160 x 120 pixel infrared resolution (320 × 240 pixels using testo Super Resolution technology).

Photo 2. Thermal imaging camera- testo 865s
Source: Authors' determination.

Table 2. The specification of Thermal imaging camera-testo 865s

Infrared resolution	**160 x 120 pixels**
Thermal sensitivity	**<0.1 °C (100 mK)**
Field of view	**31° x 23°**
Minimum focus distance	**<0.5 m**
Geometric resolution (IFOV)	**3.4 mrad**
Super Resolution (Pixel)	**320 x 240 pixels**
Super Resolution (IFOV)	**2.1 mrad**
Spectral range	**7.5 to 14 µm**
Measuring range	**-20 to +280 °C**
Accuracy	**±2 °C, ±2 % of mv**
Emissivity	**0.01 to 1**

Source: From catalogue.

0.1 °C thermal sensitivity, automatic hot and cold spot detection, and free analytical software for the creation of expert reports.

Quick measurement with a fixed focus and ± 2 °C measurement accuracy.

Table 2 and Photo 2 demonstrates and providesan explanation of the Thermal Imaging Camera and its Technical Data (Testo 865s).

IRSoft · PC-Software

The testo thermal imager's captured images are processed, analyzed, and archived using the IRSoft software. Moreover, integrated reporting is included to provide data in an understandable manner. The instrument control can be used to adjust the parameters on the linked thermal imager.

System requirements

Operating system: The following operating systems are supported by the software: OS X (32-bit and 64-bit) Windows 10 (32- and 64-bit versions).

Workstation

The computer meets the specifications set forth by the relevant operating system.

USB 2.0 or higher interface. Internet Explorer version 6.0.

Intel Pentium Dual Core E2220 2.4 GHz, Intel Core i3-2310M 2.1 GHz RAM of 4 GB. 500 GB of accessible disk space. Device for graphics: DirectX 9c.

User interface

Ribbon, work area, and status bar are the three components of the interface that detect thermal images. Photo 3 presents IRSoft software interface.

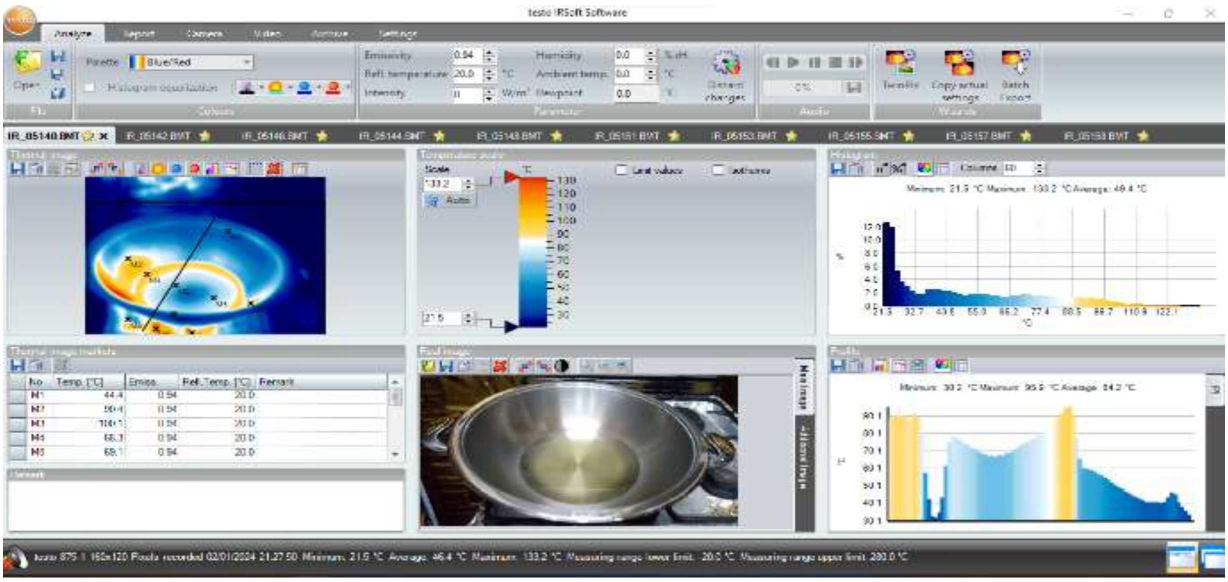

Photo 3. IR soft interface, ribbon, work space and status bar
Source: Authors' determination.

MATLAP PC-Software

The MATLAP application was used with the Image Analysis system. Digital cameras were used to take samples, and a capture card was used to transfer and save the data on a PC. The photos of Skillets were examined using the MATLAP software program. For every image, three bands—RGB—were obtained in order to get color indices.

User interface

The MATHAP Interface features a ribbon, a work area, and a status bar for image detection. The ribbon, work area, status bar, and Envi program interface are displayed in Photo 4.

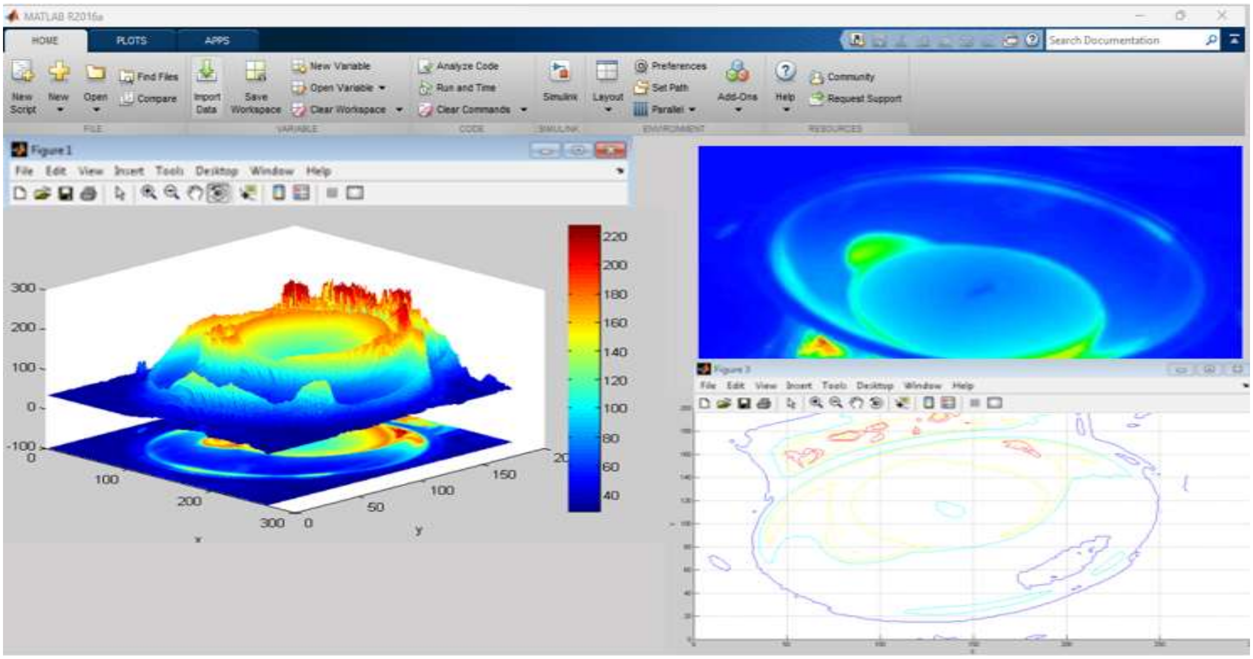

Photo 4. MATLAP interface, ribbon, work space and status bar
Source: Authors' determination.

RESULTS AND DISCUSSIONS

Photo 5 to 13 are shown using MATLAB software, where 3D images were extracted from thermal images to measure the effect of temperature on a different type of frying material when frying potato sticks.

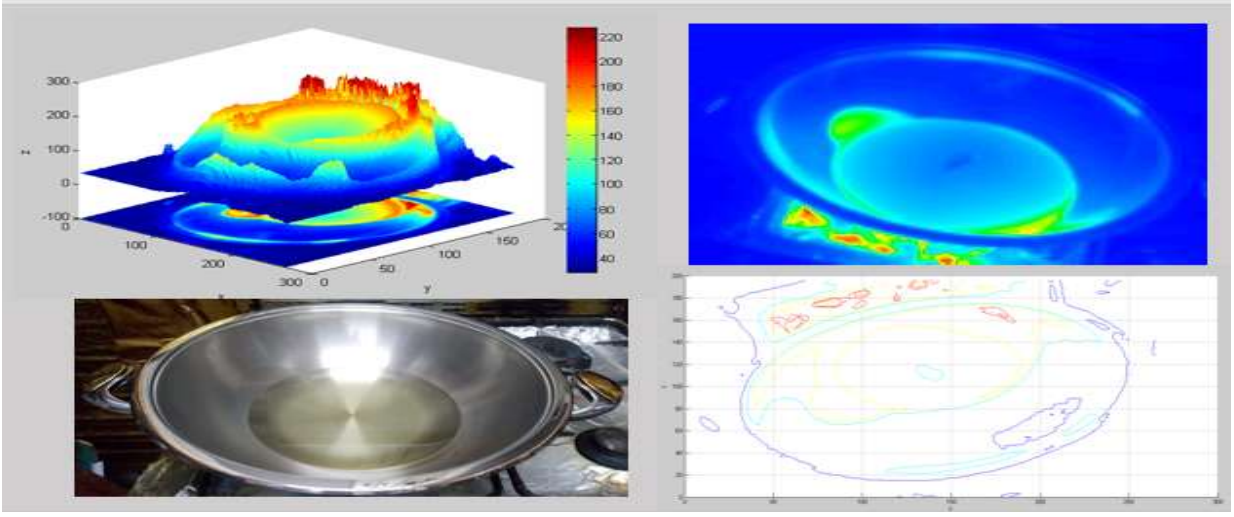

Photo 5. The Stainless steel (Wock Skillet) temperature profiles before frying potato sticks
Source: Authors' determination.

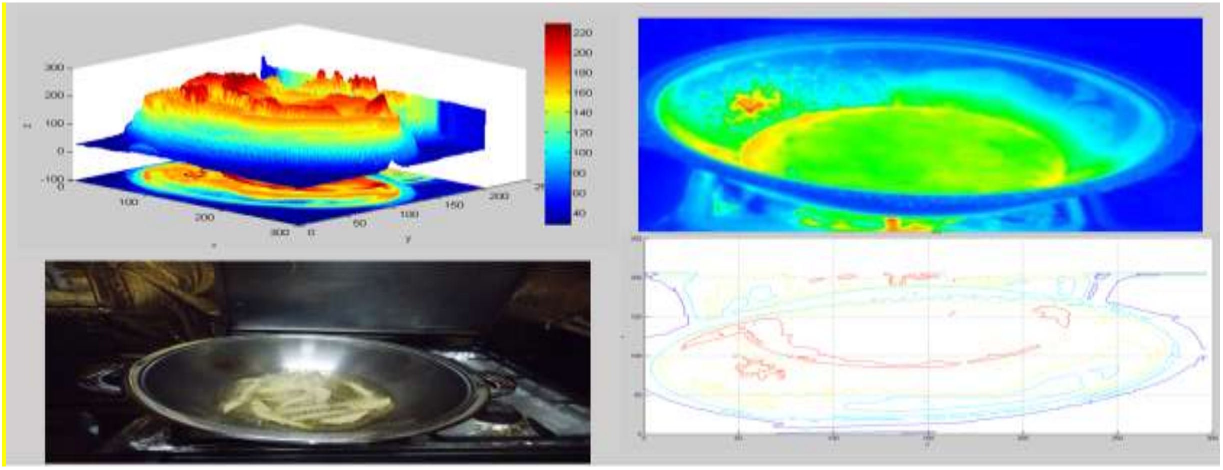

Photo 6. 6. The Stainless steel (Wock Skillet) temperature profiles during frying potato sticks
Source: Authors' determination.

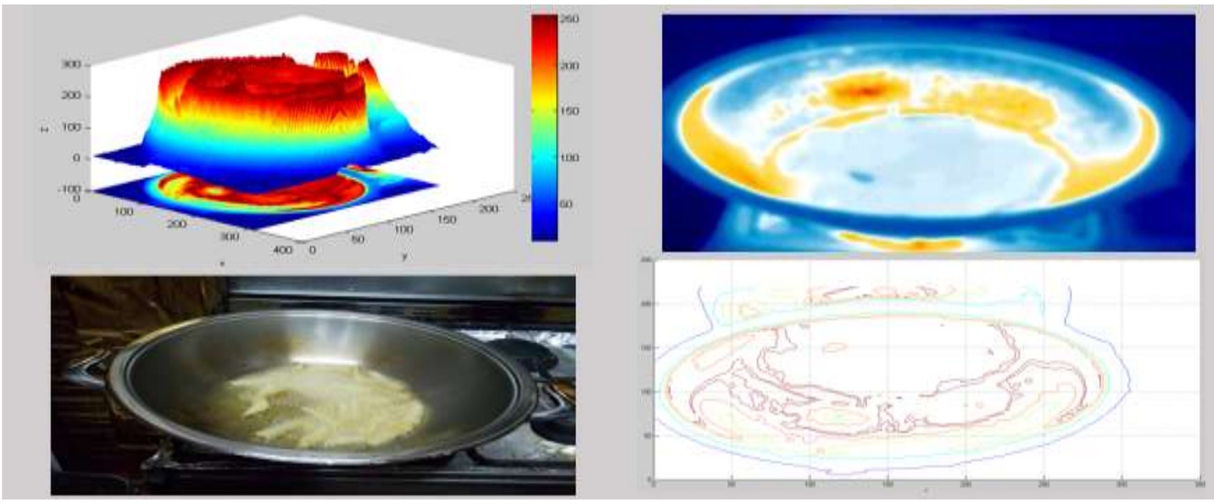

Photo 7. The Stainless steel (Wock Skillet) temperature profiles after frying potato sticks
Source: Authors' determination.

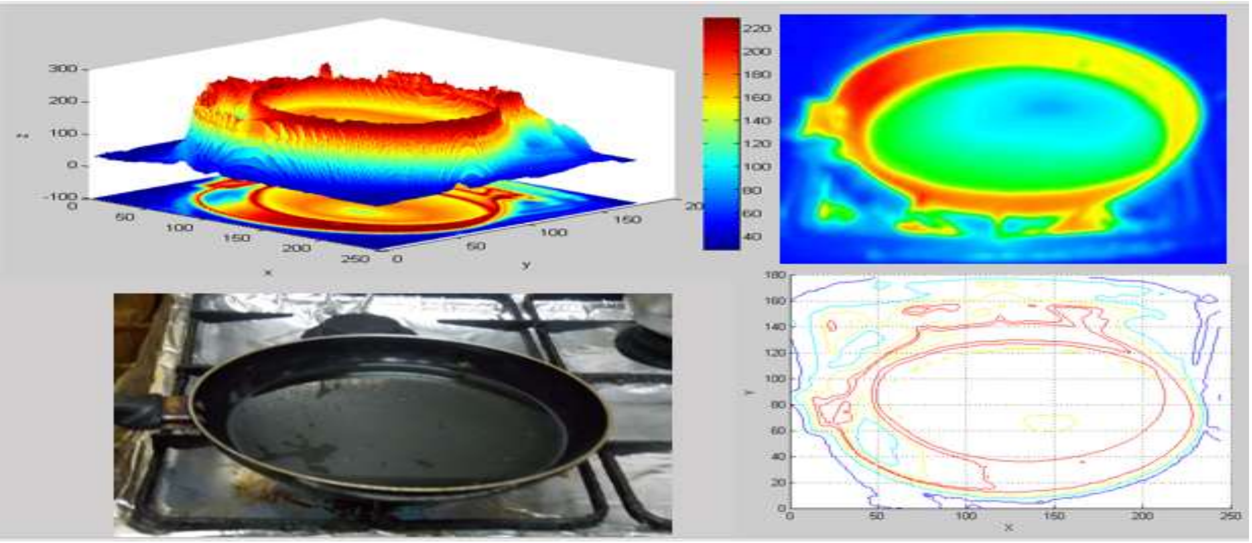

Photo 8. The material (Tefal Skillet) temperature profiles before frying potato sticks
Source: Authors' determination.

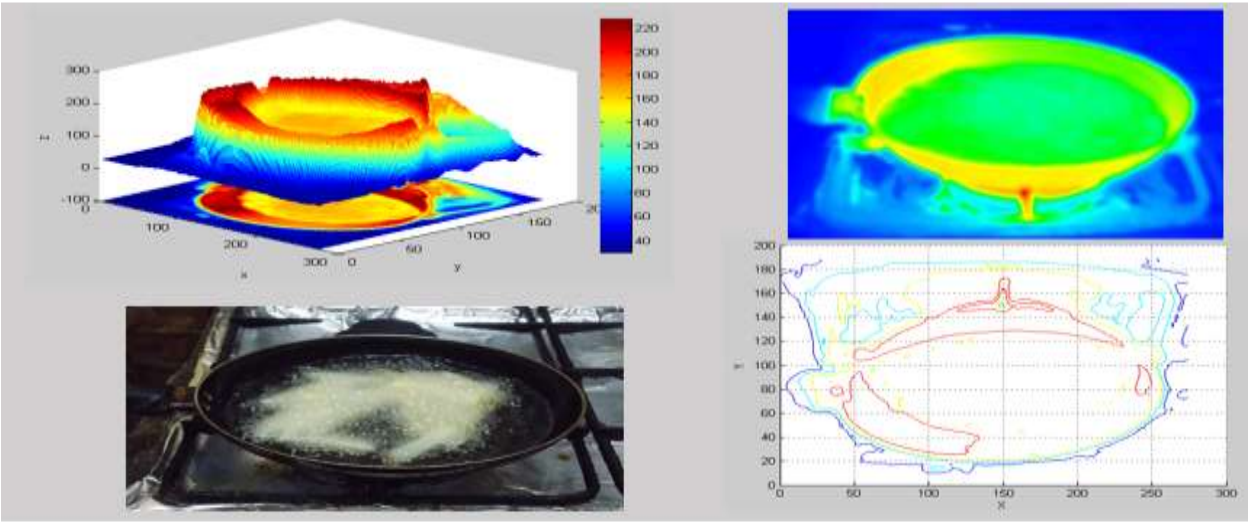

Photo 9. The material (Tefal Skillet) temperature profiles during frying at 4 min potato sticks
Source: Authors' determination.

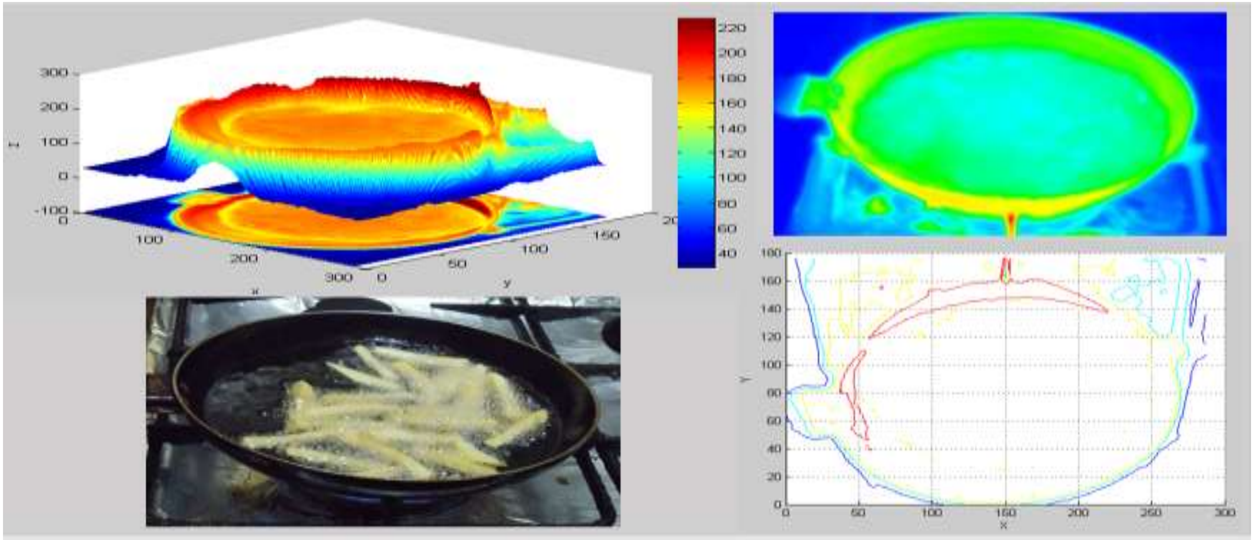

Photo 10. The material (Tefal Skillet) temperature profiles after frying potato sticks
Source: Authors' determination.

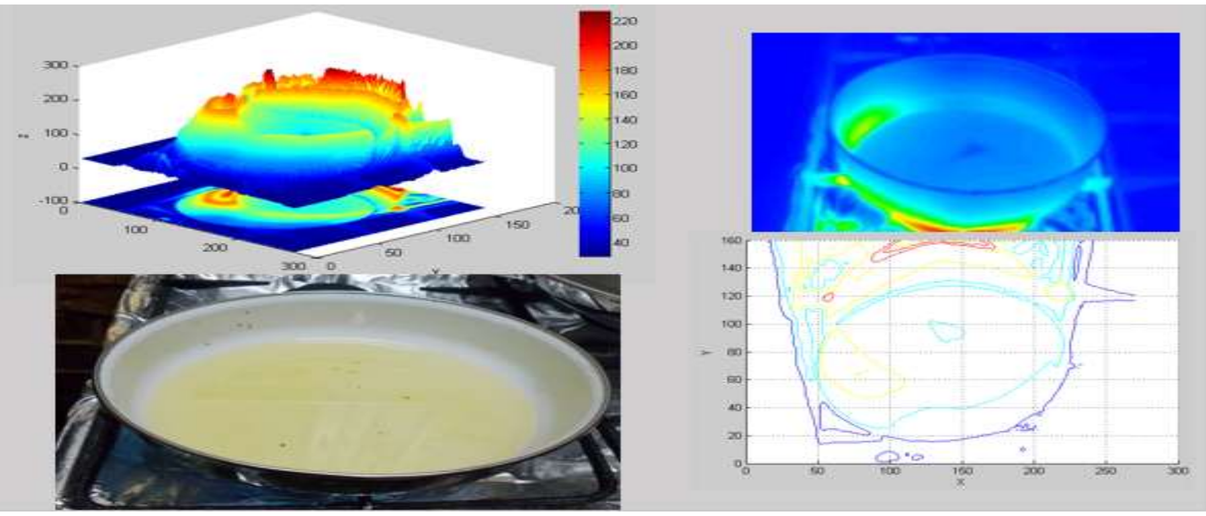

Photo 11. The sheet metal (steel) material (Ramlawi frying Skillet) temperature profiles before frying potato sticks
Source: Authors' determination.

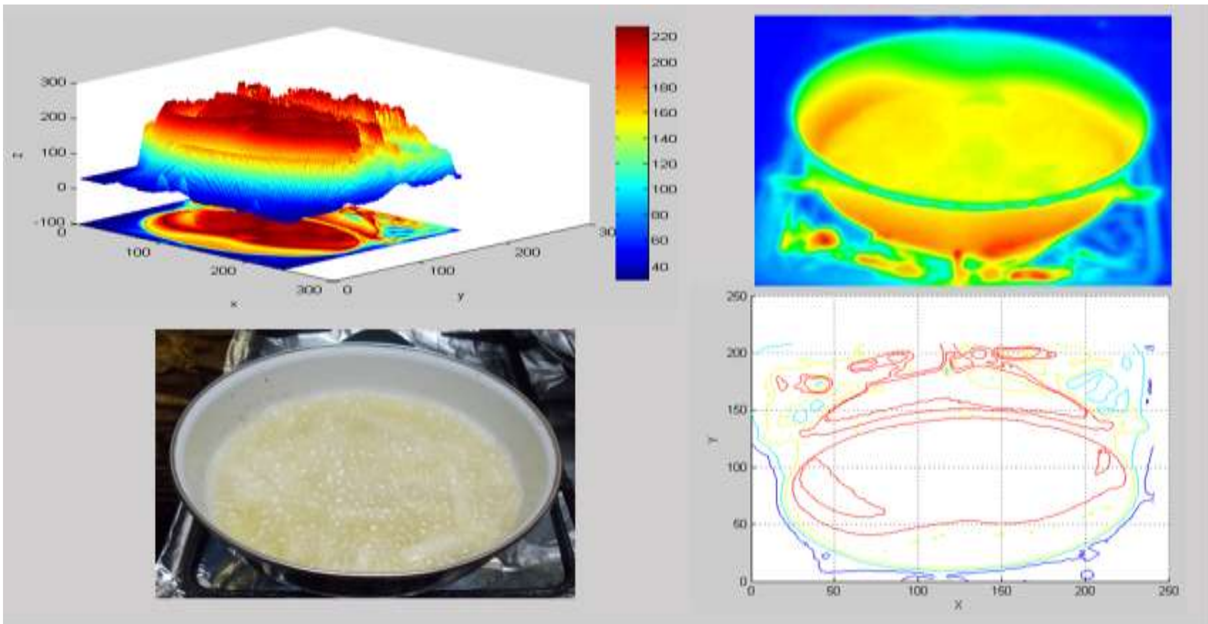

Photo 12. The sheet metal (steel) material (Ramlawi frying Skillet) temperature profiles during frying potato sticks
Source: Authors' determination.

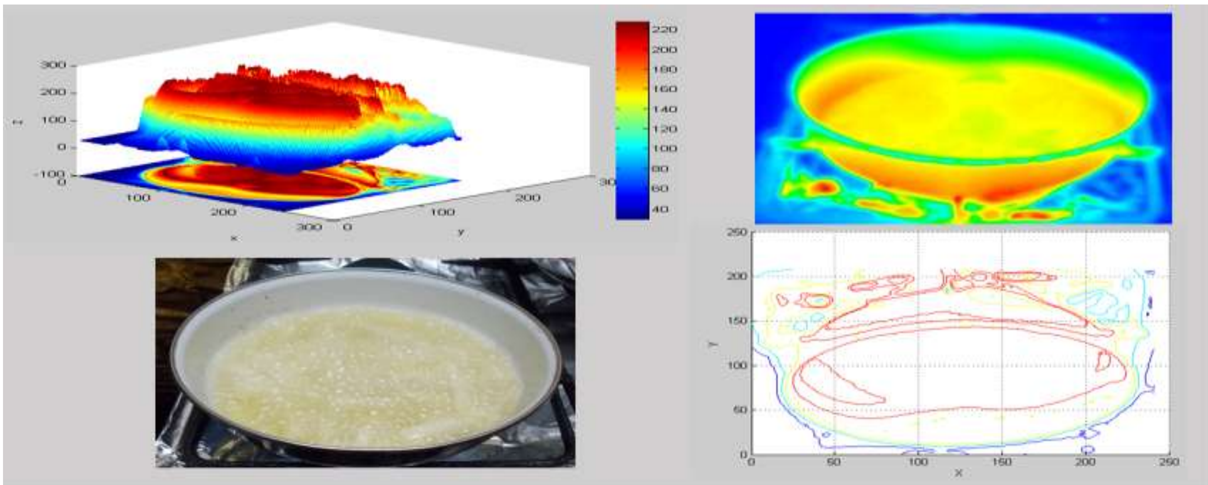

Photo 13. The sheet metal (steel) material (Ramlawi frying Skillet) temperature profiles after frying potato sticks
Source: Authors' determination.

Using infrared image to measure the internal temperature of the fryer material, the temperature of air, oil and potato in Photos 14 to 16 the external temperature of the fryer material and the temperature of fire in Photos 17 to 19 were affected by different type of fryer material when frying potato sticks by IRSoft software (Table 3).

Table 3. The internal and external temperature of the fryer material, the temperature of air, oil, fire and potato before and after frying potato sticks

Time	Wock Skillet						Teffal Skillet						EL RAMLAY Skillet					
	Before frying	2	4	6	8	After frying	Before frying	2	4	6	8	After frying	Before frying	2	4	6	8	After frying
Tair	21.7	22.6	24	25.2	26.7	23.1	25	27.5	28	29.7	31.7	27.8	26.7	27.3	30.6	34	39.1	28.8
Tin	29.8	40	64.4	73.6	117.6	50.9	131	197	204.9	201.9	234.9	200.7	59.7	66.4	185.4	186.6	192	99.4
Tout	36.9	56.4	68.7	53.3	48.9	61.4	154.4	168.9	232.7	237.8	252.3	201.3	51.6	61.4	173.8	233	345.6	126
Toil	45.9	123.2	104.8	153.4	193.2	111.9	94.2	168.7	154.3	173.1	192.5	161.1	65.5	127.9	110	189.1	209.1	120.1
Tfire	216.7	269.9	298.4	302	355	204	206.1	217.8	298.8	291.8	344.7	260.7	129.8	132.6	243.2	338.5	355	197.4
Tpotato			108.2	151.4	184.5				146.5	179.7	195.9				164.3	179.6	216.3	
Tpotato (out)	17.2				61.3	31.8	17.2				102.9	40.1	17.2				80.7	35.1

Source: Authors' determination.

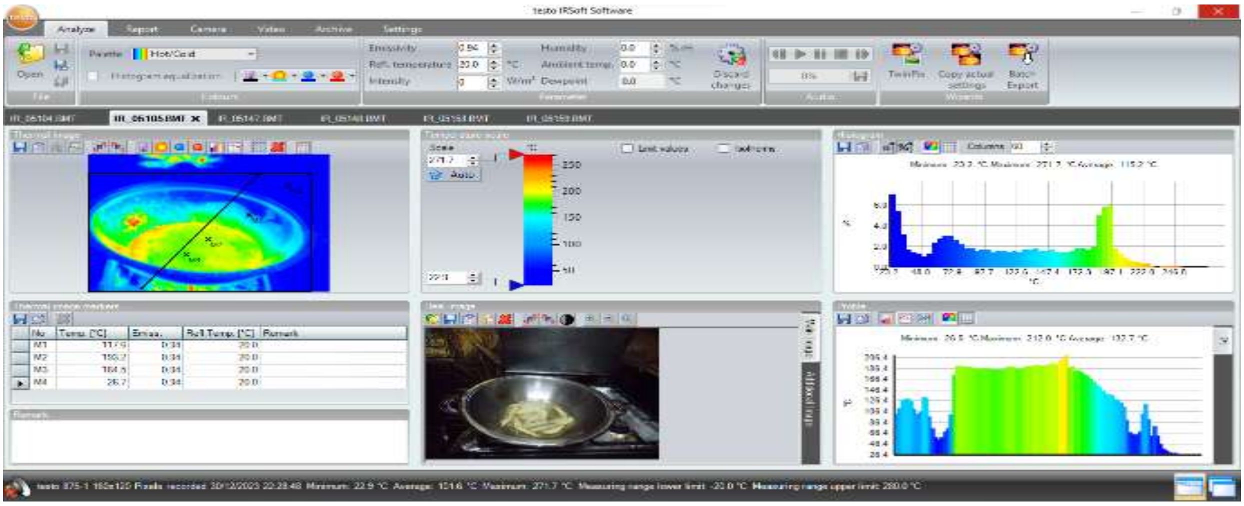

Photo 14. The internal temperature of stainless steel (Wock Skillet), the temperature of air, oil and potato by IRSoft software
Source: Authors' determination.

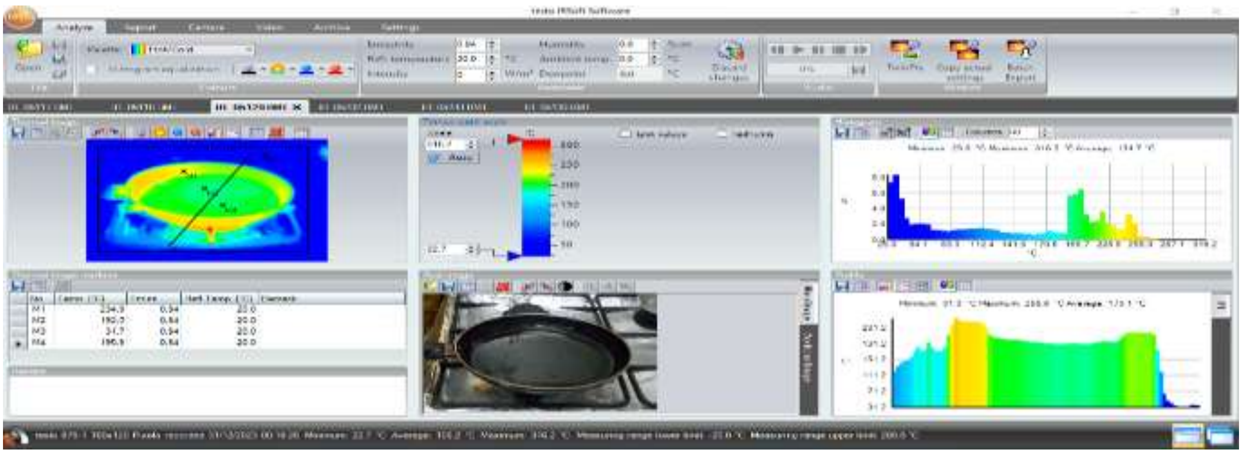

Photo 15. The internal temperature of Tefal Skillet, the temperature of air, oil and potato by IRSoft software
Source: Authors' determination.

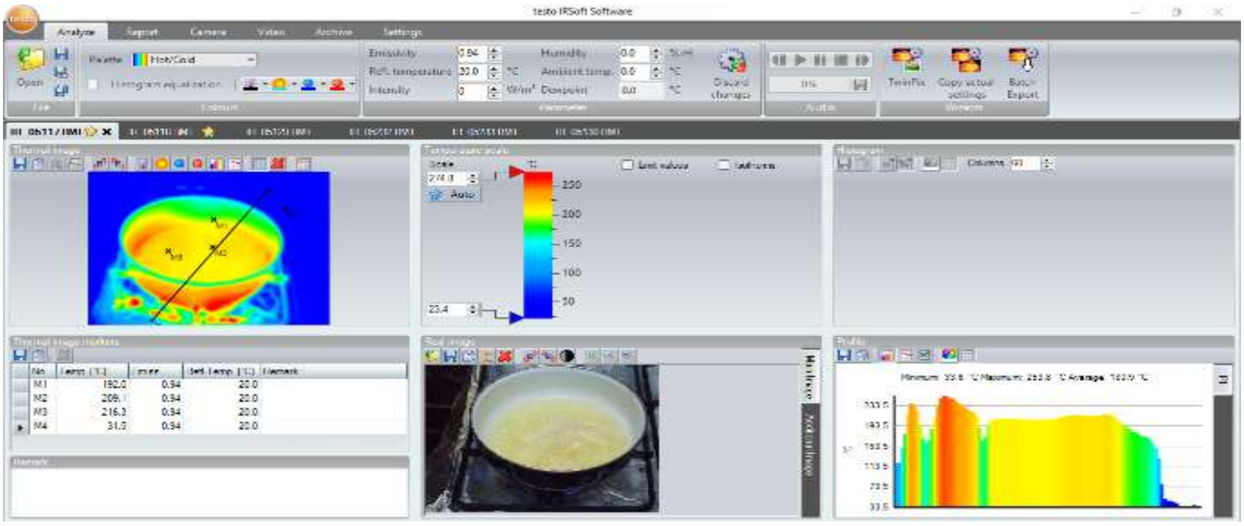

Photo 16. The internal temperature of sheet metal (steel) material (Ramlawi frying Skillet), the temperature of air, oil and potato by IRSoft software
Source: Authors' determination.

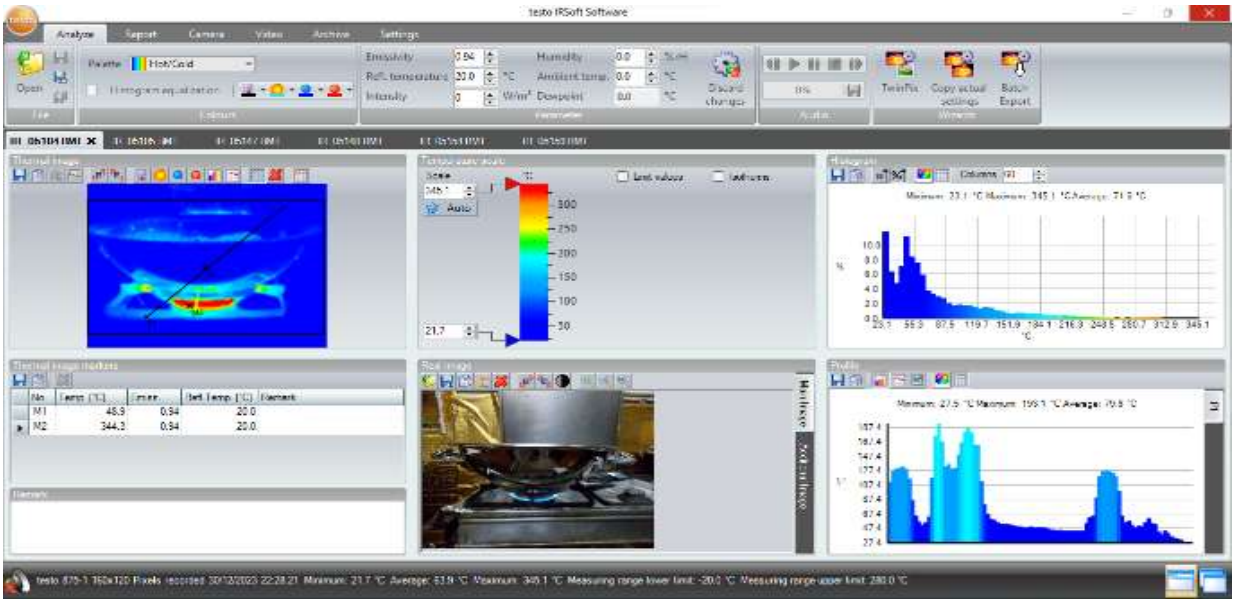

Photo 17. The external temperature of stainless steel (Wock Skillet) and the temperature of fire by IRSoft software
Source: Authors' determination.

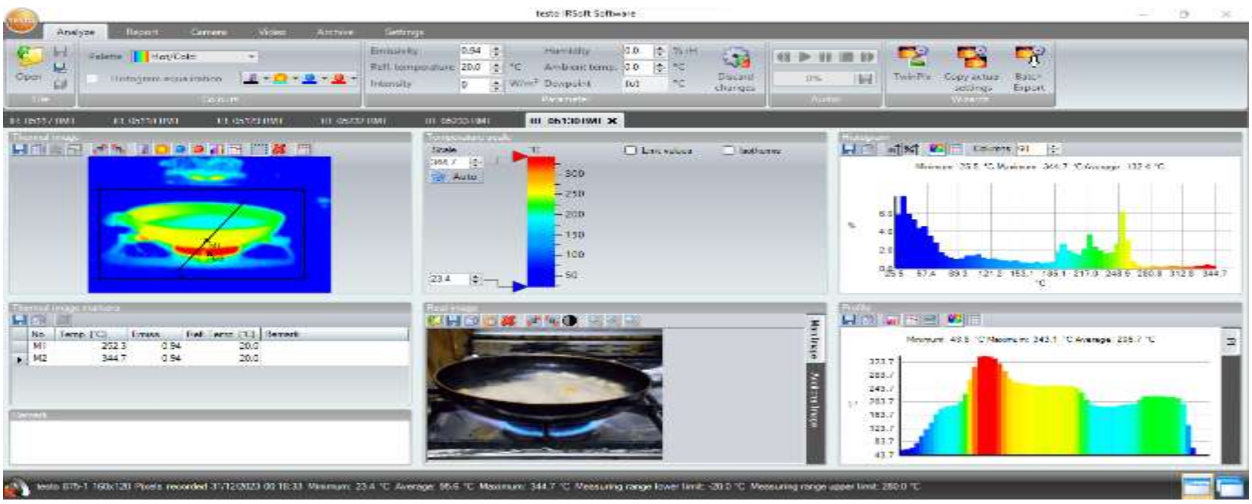

Photo 18. The external temperature of Tefal Skillet and the temperature of fire by IRSoft software
Source: Authors' determination.

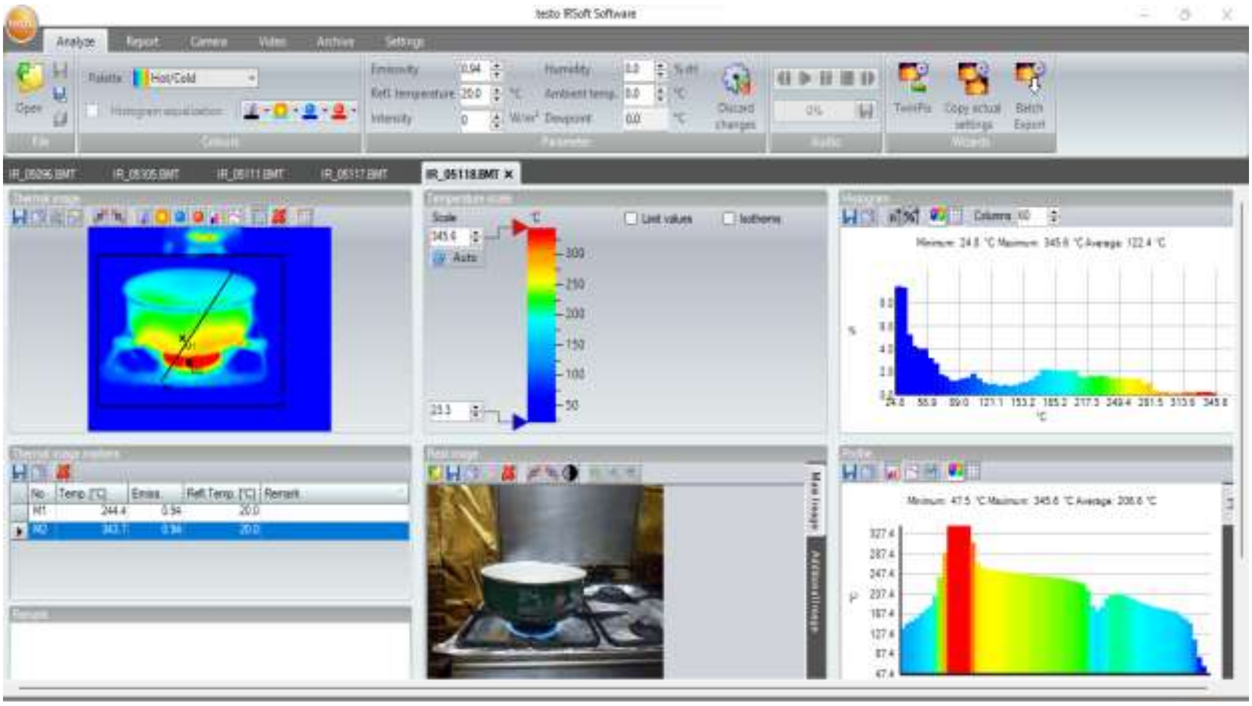

Photo 19. The external temperature of sheet metal (steel) material (Ramlawi frying Skillet) and the temperature of fire by IRSoft software
Source: Authors' determination

The effect of the type of SKILLET material on the temperaturesfor potato sticks

Figure 1 shows the effect of temperature on the stainless-steel material (Wock Skillet) during frying potato sticks in oil. The air temperatures surrounding the Skillet risefrom 21.7 to 23.1ºC, the internal and external temperatures of the Skillet rise from 29.8 and 36.9 ºC to 50.9 and 61.4 ºC, respectively.

While oil, its temperature rises from 45.9 to 123.2 ºC after two minutes of frying, then it decreases temporarily in the fourth minute to 104.8 ºC,then it returns to rise again in the last four minutes from 153.4 to 111.9 ºC, respectively. Also, the fire temperature which the frying Skillet is exposed increases from 216.7 to 204 ºC. As for the potato sticks, they are placed starting from the fourth minute and their temperature is raised from 108.2 to 184.5.

Figure 2 shows the effect of temperature on the material (Tefal Skillet) during frying potato sticks in oil. The air temperatures surrounding the Skillet rise from 25 to 31.7 ºC. The internal and external temperatures of the Skillet rise from 131 and 154.4 ºC to 234.9 and 252.3 ºC, respectively. While oil, its temperature rises from 94.2 to 168.7 ºC after two minutes of frying, then it decreases temporarily in the fourth minute to 154.3ºC, then it returns to rise again in the last four minutes from 173.1 to 192.5 ºC. Also, the fire temperature which the frying Skillet is exposed increases from206.1 to 344.7ºC. As for the potato sticks, they are placed starting from the fourth minute and their temperature is raised from 146.5 to 195.9ºC.

Figure 3 shows the effect of temperature on the sheet metal (steel) material (Ramlawi frying Skillet) during frying potato sticks in oil. The air temperatures surrounding the Skillet rise from 26.7 to 31.5 ºC. The internal and external temperatures of the Skillet rise from 59.7 and 51.6 ºC to 192 and 345.6 ºC respectively.

The oil temperature rises from 65.5 to 127.9 ºC after two minutes of frying, then it decreases temporarily in the fourth minute to 110ºC, then it returns to rise again in the last four minutes from 189.1 to 209.1 ºC. Also, the fire temperature which the frying Skillet is exposed increases from 129.8 to 355 ºC. As for the potato sticks, they are placed starting from the fourth minute and their temperature is raised from 164.3 to 216.3ºC.

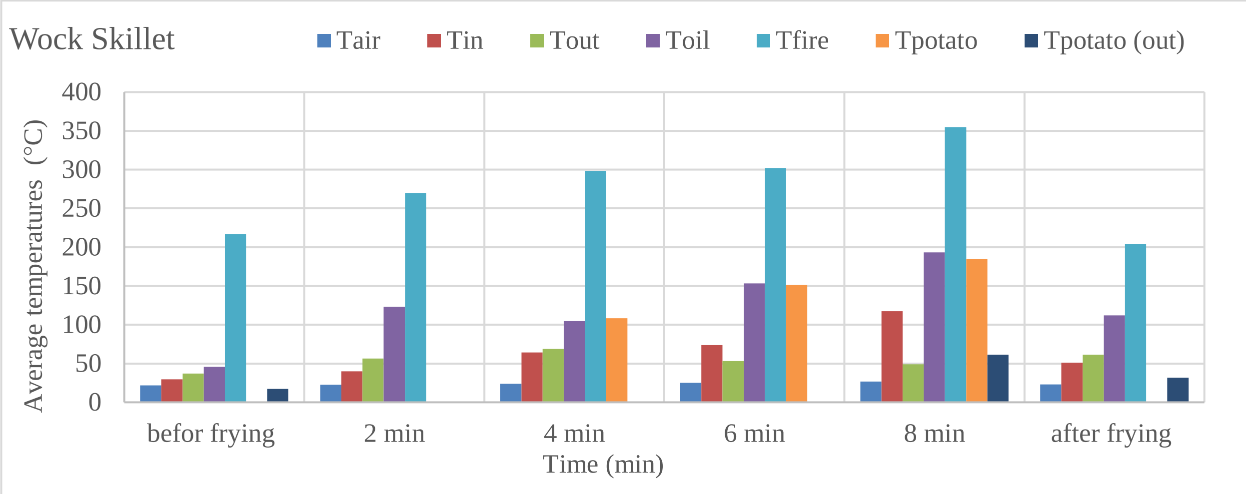

Fig. 1. The relationship between temperature and time for stainless steel (Wock Skillet) during frying potato sticks
Source: Authors' determination.

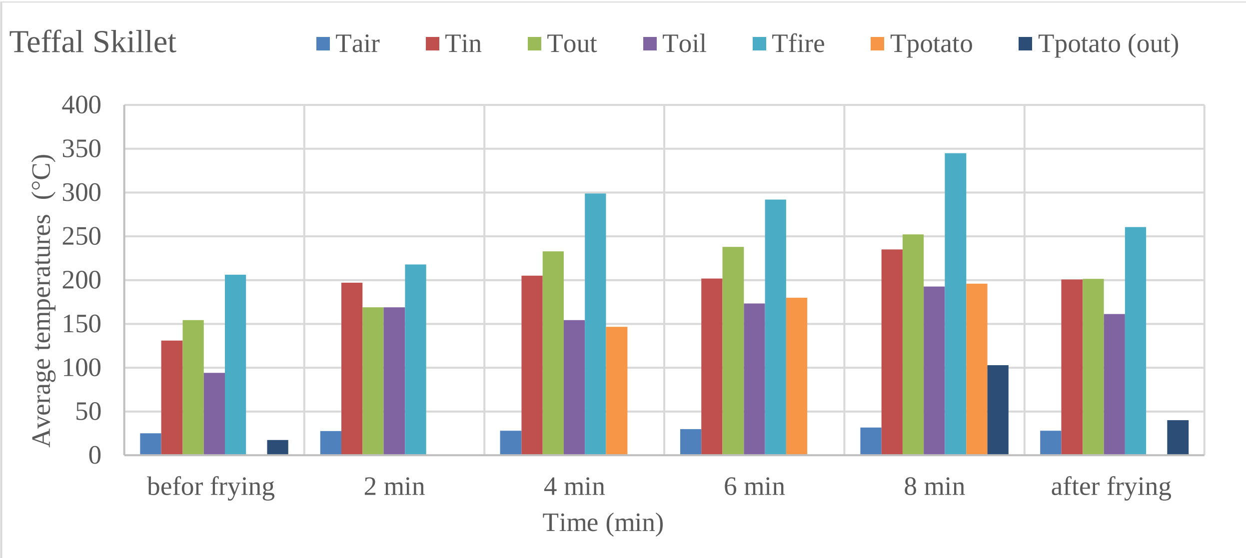

Fig. 2. The relationship between temperature and time (Tefal Skillet) during frying potato sticks
Source: Authors' determination.

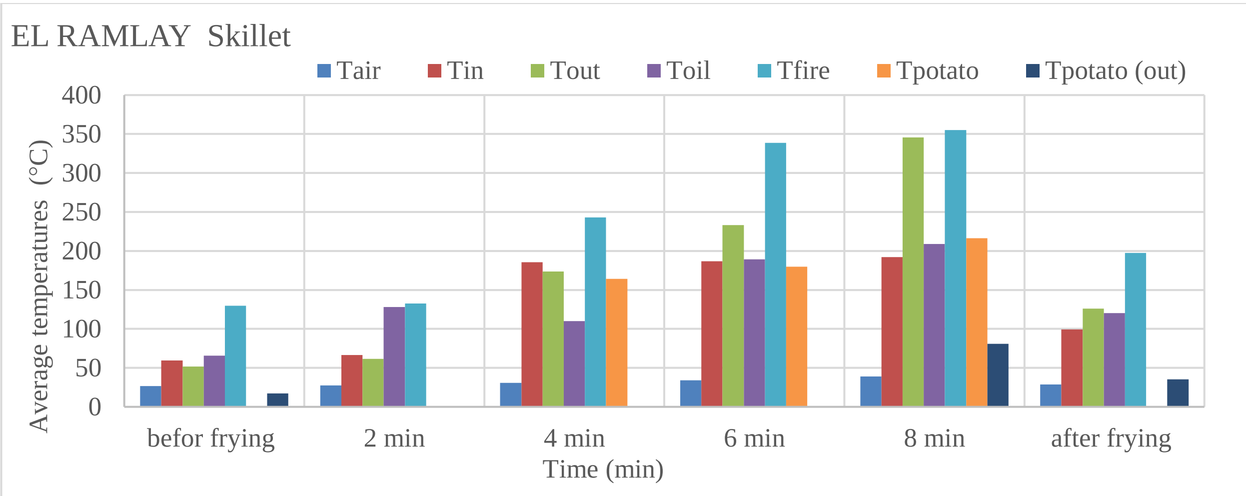

Fig. 3. The relationship between temperature and time for sheet metal (steel) material (Ramlawi frying Skillet) during frying potato sticks
Source: Authors' determination.

CONCLUSIONS

The results showed that the Wock Skillet recorded the lowest temperatures in the air surrounding the Skillet, the oil, and the French fries, and the lowest internal and external temperatures of the Skillet compared to the rest of the types mentioned, followed by the Teffal Skillet, and then the EL RAMLAY Skillet that recorded the highest temperatures.

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MEASURING THE COLOR CHANGE OF POTATO STICKS AND PLANT OIL DURING FRYING PROCESSES

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Abstract

The aim of this study is measuring the differences in color properties of potato sticks and oil by frying using Wock Skillet during three separate frying sessions. The measurements indicators were optical properties, RGB Bands: (Red, Green, Blue Bands), Intensity, and browning index of potato sticks and oil. The research was conducted in the laboratory of the Agricultural Engineering Department. The results showed a clear color change in the potato slices with the time of frying, and they also showed a clear color change in the number of times the oil was fried. The relationship between the oil browning index and the frying duration were happened. the oil browning index increased from 67.81 at the beginning of frying to 72.24 at the second minute, then to 75.18 in the fourth minute, then to 82.35 in the sixth minute, then to 84.49 in the eighth minute until it reached 87.75 at the tenth minute it end of the first frying process. The second frying time increased from 75.97 at the beginning of frying to 77.15 in the second minute, then to 78.92 in the fourth minute, then to 83.52 in the sixth minute, then to 86.93 in the eighth minute until it reached 88.18 in the tenth minute. In the third time also, the values increased from 76.44, 78.72, 82.54, 84.91, 88.53 and 90.15 in minutes 2, 4, 6, 8 and 10, respectively. While it was predicted that there would be a direct relationship between the potato browning index and the period of frying. And also, a direct relationship between the potato browning index and the number of frying times. as it increased from 48.11 in the fourth minute, then to 54.24 in the sixth minute, then to 61.83 in the eighth minute until it reached 69.50 in the tenth minute at the end of the first frying process.

Key words: *French fries, frying, potato, colour properties*

INTRODUCTION

With the world population growing at a rapid pace, achieving the aim of food security will be extremely difficult and will call for great efforts to integrate more alternative food sources. Plant-based foods, which make up the majority of the daily diet of humans, have shown an annual development of more than 7%. Nevertheless, more work has to be done in the areas of research, production, and preservation technology [14].

One of the most important food crops in the world, potatoes (*Solanumtuberosum* L.) are grown in more than 100 nations in temperate, subtropical, and tropical climates. The plant was grown on over 22 million hectares, and in 2019 it produced near to 370 million tons worldwide. FAO, 2021. The potato plant is a staple food for a large number of people worldwide, coming in second only to rice in terms of global distribution. Asia accounts for about 34% of the world's potato crop production [5].

Potatoes (*Solanumtuberosum* L.) are the first important non-cereal crop and the fourth most important crop overall. Carbohydrates, the main source of energy for a person's daily diet, are abundant in potatoes. It also contains important phenols and antioxidants, as well as minerals (iron, potassium, phosphorus, calcium, and magnesium), vitamins B1, B3, and C, and other multinutritional components. Additionally, the resistant starch found in potatoes may have a hypoglycemic and prebiotic impact, protect against colon cancer, and prevent the accumulation of fat [8].

Global consumption of potato chips, a widely consumed potato snack, is evident. They are made by deep-frying thin potato slices in lard or oil. Compared to ware potatoes, potato tubers used in the production of chips must meet specific quality requirements. To prevent the Maillard reaction from forming melanoidins, they must have minimal levels of reducing sugars. Since sucrose is the substrate of the reducing sugars and can hydrolyze under the right conditions to produce more sugars, it is also a crucial characteristic to consider throughout the conditions of harvesting, storing, and processing [9].

Some researchers have studied and modelled the dynamics of changes in some important physical and chemical properties of potatoes during frying. Accurate measurement of the physical and chemical properties of food is critical to the food industry. In order to predict the behavior of vegetables during processing and storage, as well as the quality of processed vegetables and their acceptance by consumers, food engineers need to determine the physical and chemical properties of vegetables [10].

When it comes to the perception of food quality, color is thought to be the most significant visual quality factor. Often, consumers make their food choices only based on what they can see, and this is the only information they are given. The product's color, size, and shape are all combined to create the visual impression. First of all, color conveys vital information about the processing or manipulation used and is a quick indicator of whether a product is good or awful. The Maillard reaction, which is influenced by the surface-reducing sugar content, frying temperature, and time, is what causes color development in fried potatoes, which only starts once adequate drying has taken place. It also depends on the drying rate and heat transfer coefficient during the various stages of frying [1].

People have used potatoes as a major source of energy in their cuisine for a long time, most likely because of their high calorie content. Potato protein has a high biological quality and contains eight or nine different types of amino acids that the human body is unable to manufacture. Determining the potato's physical characteristics and how they change over time for long-term storage is crucial to producing a high-quality product that customers would accept. Following measurements of the potatoes' surface area, volume, weight, moisture content, and three main tuber diameters, other characteristics, including sphericity, roundness, geometric mean diameter, volume mean diameter, aspect ratio, effective diameter, and real density during storage, were computed [6].

Cooking is an indispensable part of daily life for many obvious reasons, including as reducing the risk of food-borne infections and enhancing flavor, texture, palatability, digestibility, and shelf life in both residential and commercial settings. According to FAO estimates, food-related energy demand is 15% for food processing and transportation, 10% for primary production, and 75% for cooking and food preparation [2].

A skillet is a physical delivery device that uses natural gas, induction, or an electrical coil to physically transmit heat to the surface of food that is intended to be cooked. The conduction of thermal energy through the food contact surface controls how food cooks. Conduction of heat is the process by which heat moves through the components of the skillet and from the heat source (the cooktop) to the base of the skillet. The materials used in the Skillet's construction primarily dictate how thermal energy is transferred from the Skillet to the meal [7].

The formation of the fried potato's desirable sensory qualities and key structural elements, such as density, porosity, and volume, is mostly due to the high heat transfer rates experienced during deep-fat frying. The thermal and physical-chemical characteristics of the food and oil, as well as the meal's shape, oil temperature, and pressure, all influence heat and mass transmission during frying. After frying, a significant amount of oil on the surface sticks to the food's surface because most of it did not enter the food's microstructure during the frying process. This happens during the post-frying or cooling phase [4].

More than 17.4 billion pounds of French fries are produced annually in the US, accounting for about 44% of all processed potato production. The two areas that make up a French fry are (1) an oil-filled, crispy, and dehydrated exterior and (2) a cooked, humid interior that is devoid of oil. The outside crust resembles the structure of a potato chip or fried potato slice quite a bit. In order to prepare raw potato strips for French fry processing, they must first be blanched in hot water and then dried in hot air until they have a moisture content of around 60% (total basis). After

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

being cooked in hot oil (160–190C), the dry potato strips are cooled, frozen, and packaged. Fry or bake the par-fried frozen potatoes one last time to complete the preparation. French fries have a final oil and moisture level of about 15 and 38%, respectively [12].

The measurement of fried potato color has started using digital image processing-based technologies. Browning on the surface of a fried potato is often a zero-order response at temperatures below 60°C. A brown pigment versus time plot will curve upward at increasing temperatures, just like in a first-order process. A first-order kinetics analysis of browning during frying is anticipated as deep-fat frying typically involves a brief period of time with a surface temperature below 60°C. The rate of color changes during the frying of potato strips was calculated on the assumption that the color parameters L, a, and b followed a first-order kinetics. believed that the color parameter a followed first-order kinetics to ascertain the rate at which the color of potatoes changed while they were being fried and discovered a strong relationship between the color of the chips and their acrylamide leve l[11].

Vegetable oil is necessary for many foods processing operations, including frying. The physical, chemical, nutritional, and psychological characteristics of the oil might alter during frying operations, which can impact how well it fries. French fries or potato chips are the most popular fried food item. The physical and chemical characteristics, fat content, water content, and a few other attributes are categorized as pertinent quality parameters for fried potatoes. Because of their chemical makeup, oils are susceptible to chemical alterations brought on by a variety of circumstances, which can be hazardous to one's health. Temperature, light, ventilation, metallic ions, and enzyme activity are some of these variables. They can cause oxidation, thermal polymerization, and au-toxidation in oils by acting singly or in combination. Fats may go rancid or a significant number of reaction products may arise as a result of a sequence of reactions in these occurrences [3].

Vacuum-frying improved the flavor and overall quality of potato chips while drastically lowering color and texture characteristics and increasing oil content. The physical qualities of the potato used to make the chips are one aspect influencing their quality, as not all potato varieties yield chips of a high caliber. Manufacturers of potato chips may come into significant variations in the physical attributes of the raw potatoes since they acquire their potatoes from various areas and during different seasons. These variations may have an impact on the efficiency of the manufacturing line and the quality of the finished chip [13].

The Maillard reaction that depends on the content of reducing sugars and amino acids or proteins at the surface, due to the difficulty of real-time measurements of these indicators, this research was focussed to measuring color changes with time of frying. Also measuring the differences in color properties of potato sticks and oil before and after frying by using Wock Skillet materials

MATERIALS AND METHODS

Three frying periods were performed for 10 minutes each, the initial frying (S1.), the second frying (S2.). The third frying (S3.). Potato tubers (Sponata) with a water content of 80% were used. Then slice into sticks (thickness 10 mm and diameter 59.9*10.33 mm).The skillet materials stainless steel Wock Skillet were used .The three primary colors of potato sticks and oil were measured using MATLAB software The values RGB denoted by 'R', 'G', and 'B' stand for the red, green, and blue bands, respectively. Hue, the intensity for Potato was also measured. Additionally, (La b) was measured using a digital colorimeter, and the browning index was computed as follows:

-Intensity, candela= lumen per Ste radian

$$I = \frac{1}{3}(R + G + B) \qquad (1)$$

$$I2 = (R-B)/2 \qquad (2)$$

-Browning Index

$$BI = \frac{100*(X-0.31)}{0.17} \qquad (3)$$

$$X = \frac{a+1.75L}{5.645L+a-0.3012b} \qquad (4)$$

where:

RGB Red, Green, Blue Bands

L= lightness of the colour, which range from 0 (dark) to 100 (white).

a = indicates green colour.

-b = indicates blue colour

+b = indicates yellow colour

RESULTS AND DISCUSSIONS

The optical properties, color indices, and browning index of potato sticks and oil during three separate frying wear displayed in Figures 1 through 6 and were statistically examined. The oil's color changed in the Wock Skillet at a rate of two minutes for ten minutes at each of the three frying times, according to the results.

The effect of frying periods on the color properties of oil

From Fig. 1 to 3. Showed that, the frying periods with the color properties of oil. During the initial frying time, the red band color ranged from 140 to166; Green band increased from 45to 63 the same trend with Blue band and Intensity. While Brown index decreased from 65.67 to 82.33.

In the second frying time: the red band color increased from 170to 179; G band increased from 45 to 64; the same trend with B band and Intensity. While Brown index decreased from 75.97 to 88.18.

The third frying time: the red band color increased from 175 to 185; G band increased from 50, to 65; B band and Intensity the same trend. While Brown index decreased from76.44 to 88.53.

In Fig. 4 The Brown index of oil decreases sequentially from 67.81 to 72.24, then to 75.18, then to 82.35, then to 84.49 until it reaches 87.75 at the end of the initial frying time. In the second frying time it decreases from 75.97 to 77.15, then to 78.92, then to 83.52, then to 86.93 until it reaches 88.18 at the end. The same trend with Brown index in the third frying time.

In Fig. 5 The Intensity increased sequentially from 65.67 to 67, then to 71.33, then to 75.33, then to 78.33 until it reaches 82.33 at the end of the initial frying time. In the second frying time it increased from 77 to 79, then to 80.67, then to 85.33, then to 86.67 until it reaches 89 at the end. The same trend with Intensity in the third frying time.

The effect of frying periods on the color properties of potato sticks

From Fig. 6 to 8. Showed that, the frying periods with the color propertieschanged of potato sticks.

The potatoes were placed into the Skillet after fourth minute of the frying stage, and the values are estimated at a rate of two minutes until ten minutes at each of the three frying times, according to the results.

During the initial frying time, the red band color ranged from 28 to 155; G band increased from38to58 the same trend with Brown index and Intensity. While B band decreased from 141 to 32.

In the second frying time: the red band color increased from30to157; G band increased from 40to 60; the same trend with Brown index and Intensity. While B band decreased from 143to34.

The third frying time: the red band color increased from34, to161; G band increased from 44to 64; the same trend with Brown index and Intensity. While B band decreased from 147to38.

In Fig. 9 The Brown index of potato sticks decreases sequentially from 48.11 to 54.23, then to 61.83 until it reaches 69.5 at the end of the initial frying time. In the second frying time it decreases from 50.83 to 58.26, then to 64.67 until it reaches 72.39 at the end. The same trend with Brown index in the third frying time

In Fig. 10 The Intensity increased sequentially from 51.38 to 58.26, then to 64.67 until it reaches 72.39 at the end of the initial frying time. In the second frying time it increased from 51.38 to 60.25, then to 66.11 until it reaches 73.39 at the end. The same trend with Intensity in the third frying time.

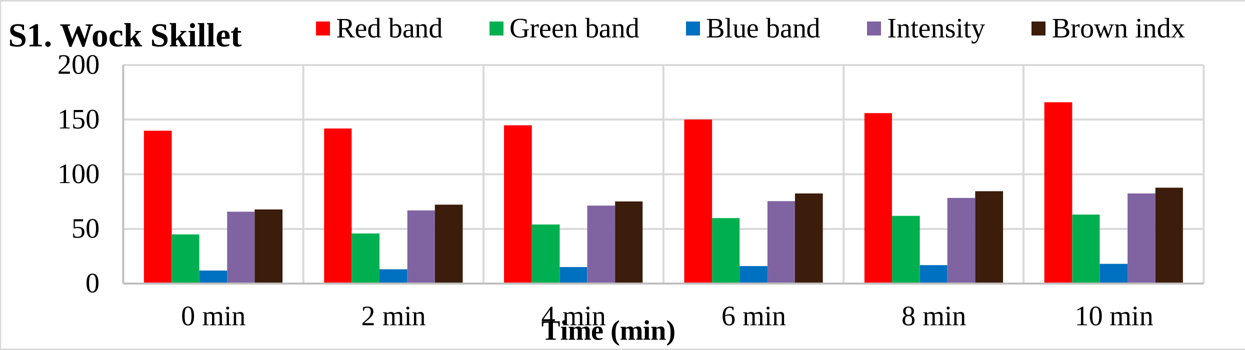

Fig. 1. The relationship between RGB bands, intensity, browning index and oil in (Wock Skillet) during the first frying time
Source: Authors' determination.

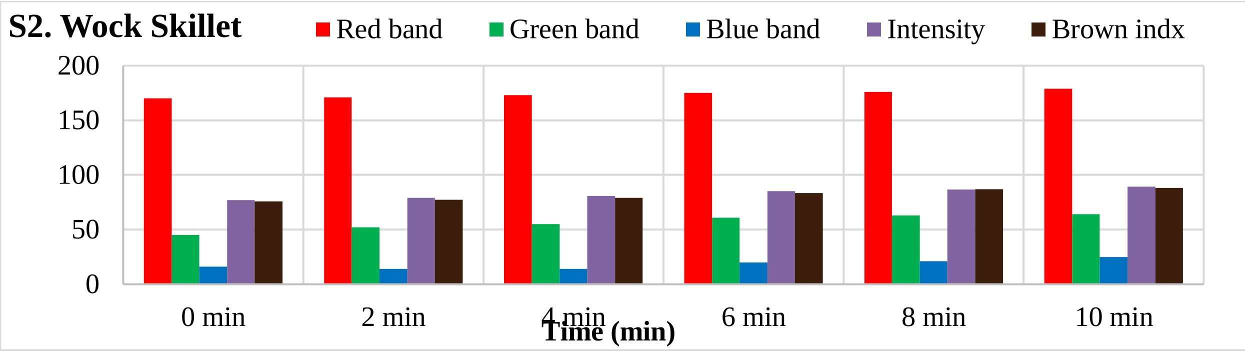

Fig. 2. The relationship between RGB bands, intensity, browning index and oil in (Wock Skillet) during the second frying time
Source: Authors' determination.

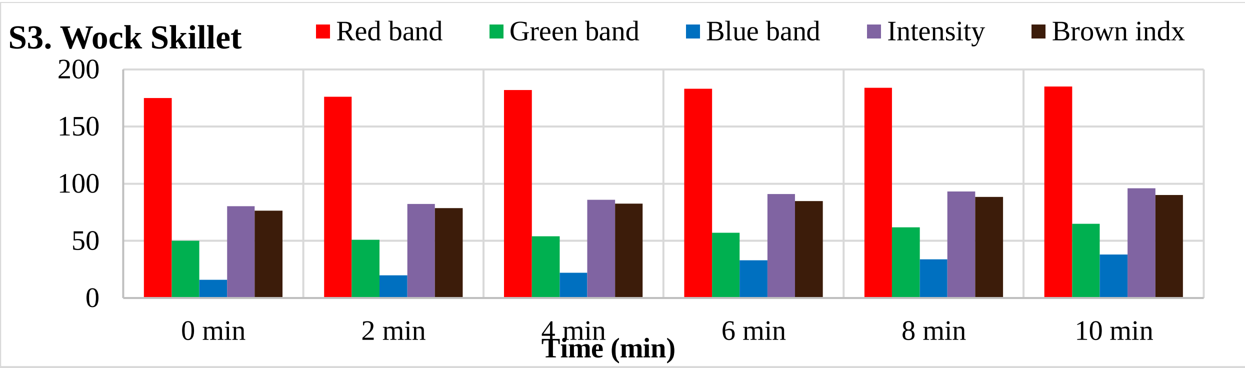

Fig. 3. The relationship between RGB bands, intensity, browning index and oil in (Wock Skillet) during the third frying time
Source: Authors' determination.

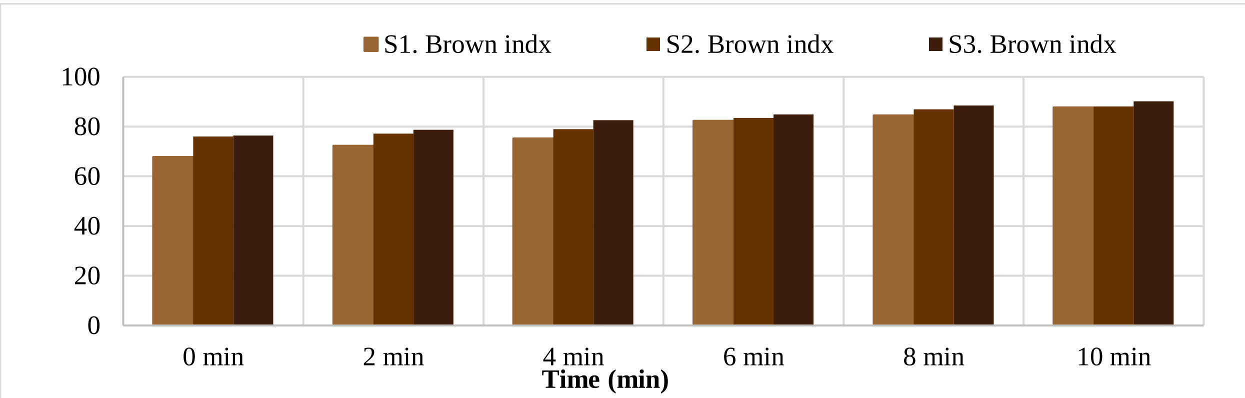

Fig. 4. The relationship between browning index and oil in (Wock Skillet) during the three frying times
Source: Authors' determination.

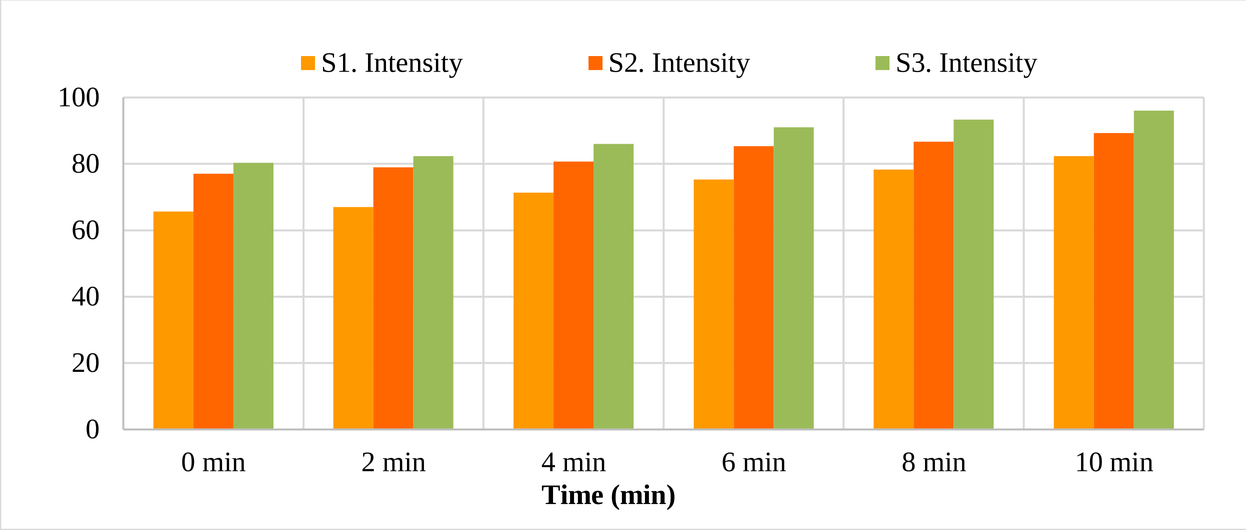

Fig. 5. The relationship between intensity and oil in (Wock Skillet) during the three frying times
Source: Authors' determination.

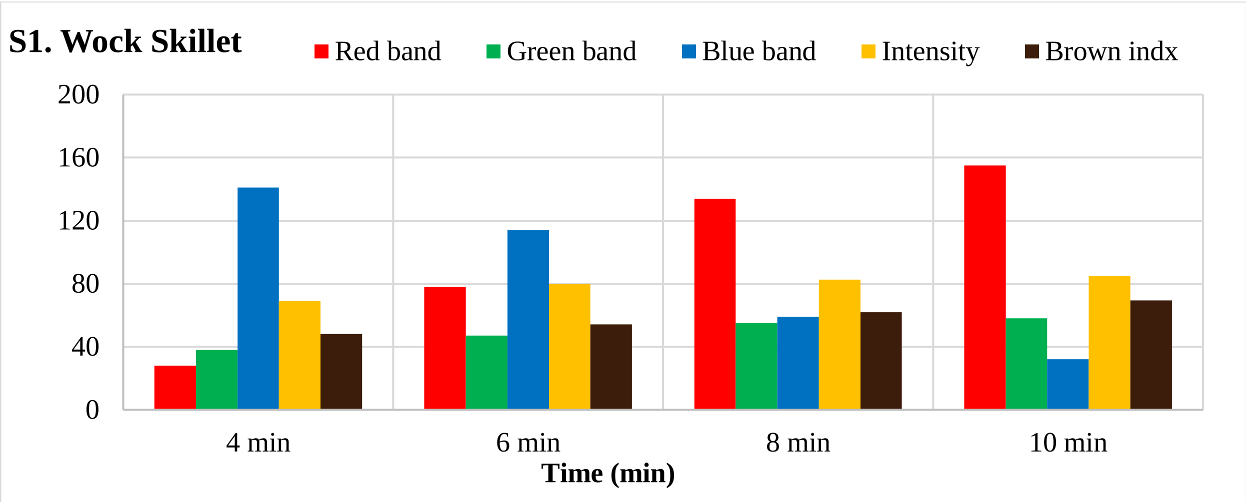

Fig. 6. The relationship between RGB bands, intensity, browning index and potatoesSticks in (Wock Skillet) during the first frying time
Source: Authors' determination.

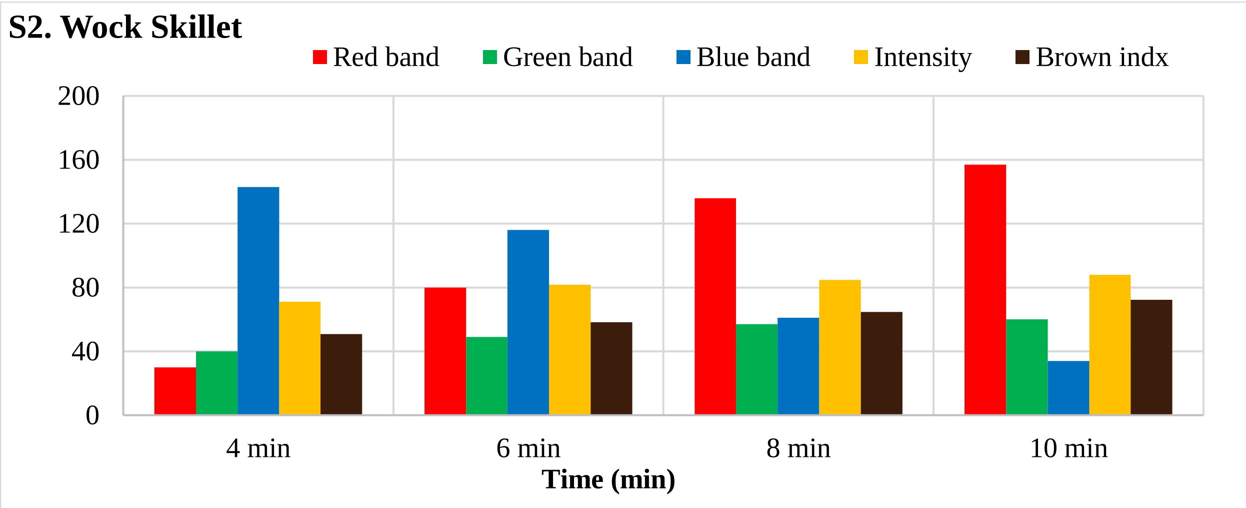

Fig. 7. The relationship between RGB bands, intensity, browning index and potatoesSticks in (Wock Skillet) during the second frying time
Source: Authors' determination.

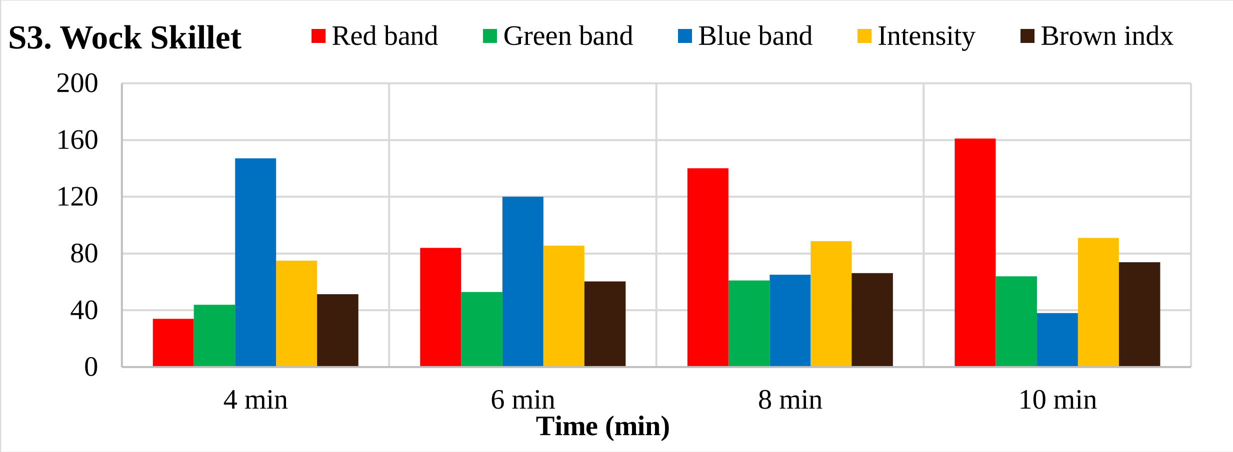

Fig. 8. The relationship between RGB bands, intensity, browning index and potatoesSticks in (Wock Skillet) during the third frying time
Source: Authors' determination.

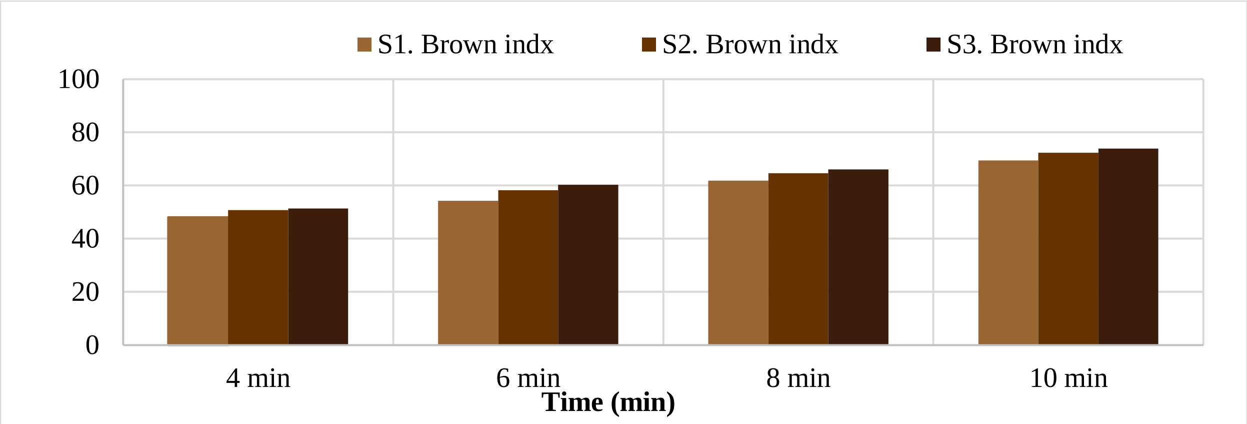

Fig. 9. The relationship between browning index and potatoesSticks in (Wock Skillet) during the three frying times
Source: Authors' determination.

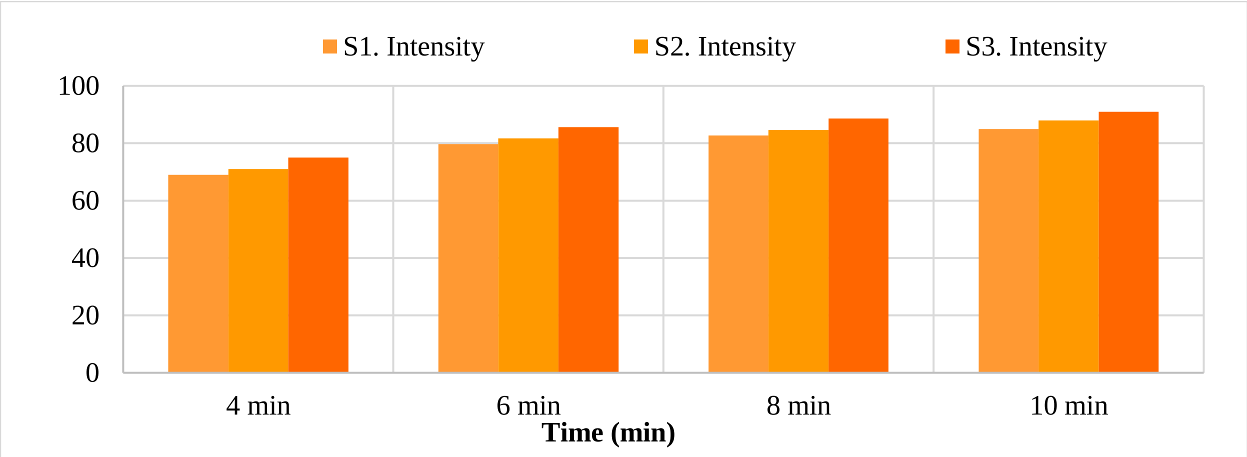

Fig. 10. The relationship between intensity and potatoesSticks in (Wock Skillet) during the three frying times
Source: Authors' determination.

CONCLUSIONS

Impact of frying time on color properties for fried potato chipsshowed with Wock Skillet recorded a clear color change appeared in the potato slices with frying time and successive periods of boiling the oil. There isrelationship between the oil browning index and the frying duration, as the longer the frying period, the greater the value of the oil browning index, and also a direct relationship between the oil browning index andpotato browning index with the number of frying times, where the values of the oil browning indexes in the third frying time are less than the oil browning indexes in the first frying time.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

FUTURE TRENDS IN MILK FAT CONTENT: A FIVE-YEAR FORECAST FOR ROMANIA AND THE EUROPEAN UNION

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Abstract

The present study investigates the trends and projections of milk fat content in Romania and the European Union (EU) from 2014 to 2029. The objective of this study was to employ time series analysis and regression modelling techniques in order to examine the evolution of milk fat content and evaluate the precision of predicted models. The findings from the research conducted in Romania indicate a consistent albeit moderate increase in milk fat content. The regression model adequately explains 90.81% of the observed variability. The predictive model exhibited a notable level of precision, as indicated by the low Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) values, which suggest a small disparity between the anticipated and observed values.Similarly, throughout the European Union, the milk fat content shown a more prominent and consistent increase, as indicated by the regression model which accounted for 99.16% of the variation. The reliability of the forecasting model is reinforced by positive statistical indicators, such as a narrow Mean Absolute Scaled Error (MASE) and Root Mean Squared Error (RMSE), indicating a strong predictive precision. The results indicate a persistent rise in milk fat levels in both Romania and the European Union, which may be linked to breakthroughs in dairy farming techniques, enhancements in feed quality, and genetic developments. It is anticipated that these patterns will persist, since the milk fat content in both locations is projected to remain within a steady and somewhat rising range during the extended prediction period. The findings of this study have significant implications for stakeholders within the dairy sector, presenting a dependable foundation for future strategic planning and decision-making pertaining to milk production and qualitative improvement.

Key words*: *milk fat content, tine series analysis, dairy sector trends

INTRODUCTION

The composition of milk fat, enclosed within the milk fat globule membrane, consists of polar lipids that have been found to have potential health advantages [8]. The variability of milk fat is influenced by a multitude of factors including nutrition, genetics, and environmental conditions [27, 23, 22]
The dairy industry is a vital sector on a global scale, with milk fat content playing a pivotal role in assessing the quality of dairy products and influencing both the economic and nutritional aspects of the industry [26]. The milk fat content also plays a crucial role in the breeding of dairy cattle, as it has a significant impact on the quantity and quality of dairy products [7]. Additionally, accurate measurement of milk fat content is crucial in maintaining the high standards of dairy products [17, 3].
Over the past few years, there have been major shifts in milk fat content in Romania and the European Union. These changes have been influenced by various factors, including consumer preferences, regulatory adjustments, and advancements in dairy farming techniques. The dairy industry has faced various challenges, one of which is milk fat depression. Moreover, there have been connections observed between dairy consumption, body composition, and cardiometabolic risk factors,

underscoring the intricate interplay between dairy intake and health outcomes [12, 26, 4].

The effective management of milk production is essential for the growth of the dairy industry and meeting consumer expectations [11]. Anticipating future trends in milk fat content is crucial for industry stakeholders to make well-informed decisions. Examining consumer behaviour analysis to forecast raw milk prices can offer valuable insights for the dairy industry [19, 14]. Monitoring the composition of milk products is crucial for the effective management of dairy farms and the industry as a whole [13]. Exploring the connections between dietary factors and milk fat composition can provide valuable insights into enhancing milk quality and production [16]. In addition, the stability of dairy products in relation to factors such as heat treatment is essential for guaranteeing the safety and quality of the product [1].

This research paper aims to foresee the future trends in milk fat content for the next five years and examine the potential implications for the dairy sectors in Romania and European Union.

MATERIALS AND METHODS

Data collection

The data on milk fat content for the present study were obtained from Eurostat (6). Data pertaining to Romania were acquired during a span of 10 years, namely from 2014 to 2023. Conversely, data regarding the European Union were obtained over a period of five years, specifically from 2014 to 2018.

Forecasting methodology

The study employed the forecasting model provided by Microsoft Excel to predict future trends in milk fat content. This tool utilises the Exponential Smoothing (ETS) method, which is highly efficient in handling time series data that exhibit seasonal patterns.

The forecasted values provided by the model included predicted milk fat content for the years 2024 to 2029, along with confidence intervals to assess the reliability and potential variability of the predictions. An analysis was undertaken on these numbers to detect prospective trends and shifts in milk fat content in Romania and the EU for the next five years.

Additionally, a comparison study was performed to get insight into Romania's position in relation to larger EU trends. It is crucial to acknowledge the constraints of this forecasting methodology. The precision of the forecasts relies on the quality and comprehensiveness of the historical data employed. Moreover, the model does not explicitly consider external variables such as policy modifications, economic fluctuations, or unexpected occurrences that may impact future trends in milk fat content.

Statistical measures

In the analysis and forecasting of milk fat content, several statistical measures are essential to evaluate the accuracy, reliability, and performance of the forecasting models. In this direction, the Mean Absolute Error (MAE), Root Mean Square Error (RMSE), Mean Absolute Scaled Error (MASE), Symmetric Mean Absolute Percentage Error (SMAPE), Alpha, Beta and Gamma Coefficients were determined.

RESULTS AND DISCUSSIONS

The Alpha, Beta, and Gamma parameters were set to 0.00, indicating that the model did not apply any smoothing for the level, trend, or seasonality components. This lack of parameter adjustment suggests that the model did not identify significant trends or seasonal patterns within the historical data, leading it to treat the data as relatively stable over time.

The MASE value of 1.05 implies that the forecast error is marginally higher than the in-sample average error derived from a simple one-step naive forecast. A MASE value near 1 typically indicates that the performance of the forecasting model is comparable to that of a naive approach, reflecting a reasonable but not superior level of forecast accuracy.

The SMAPE of 0.00, though atypical, indicates that the forecasted values are extremely close to the actual observations or might suggest a potential issue with the data or calculation process. Generally, SMAPE values approaching zero imply a highly accurate forecast, though this result should be interpreted cautiously.

The MAE of 0.01 signifies that, on average, the forecasted milk fat content deviates from the observed values by only 0.01 percentage points, indicating a very high level of forecast accuracy. Additionally, the RMSE of 0.01 corroborates this accuracy, showing that forecast errors are minimal, with larger deviations from actual values being infrequent. Taken together, these statistical measures suggest that the forecast for milk fat content in Romania is highly accurate, with very minimal error, as evidenced by the low MAE and RMSE values. The fact that the Alpha, Beta, and Gamma parameters are all zero suggests that the historical data did not exhibit pronounced trends or seasonality, prompting the model to predict relatively stable fat content levels throughout the forecast period. The forecasted values exhibit consistency, with slight incremental increases in milk fat content from 2024 to 2029, within a narrow confidence interval, which reinforces the projected stability of this trend.

The data indicate that milk fat content in Romania has been relatively stable over the past decade, with only minor fluctuations around the 3.8% to 3.81% range. The forecast suggests a modest upward trend in milk fat content, projected to rise by approximately 0.045% between 2024 and 2029. This gradualincrease could be attributable to factors such as improvements in dairy farming practices, enhancements in feed quality, or shifts in consumer preferences toward higher-fat dairy products.

The narrow confidence intervals associated with the forecast imply a high level of reliability, suggesting that the model anticipates minimal variability in future milk fat content values. This projected stability aligns with the historical data, which exhibit minimal year-to-year variations. Overall, the forecast predicts that milk fat content in Romania will remain stable with a slight upward trajectory over the next five years, reflecting continuity in production practices and consumer preferences.

The statistical analysis is further elucidated by the regression model given by the formula y=0.0067x+3.7412, with an R^2 value of 0.9081. This regression formula indicates a strong correlation between the observed data and the linear trend, with the R^2 value suggesting that approximately 90.81% of the variance in milk fat content over time can be explained by this linear relationship.

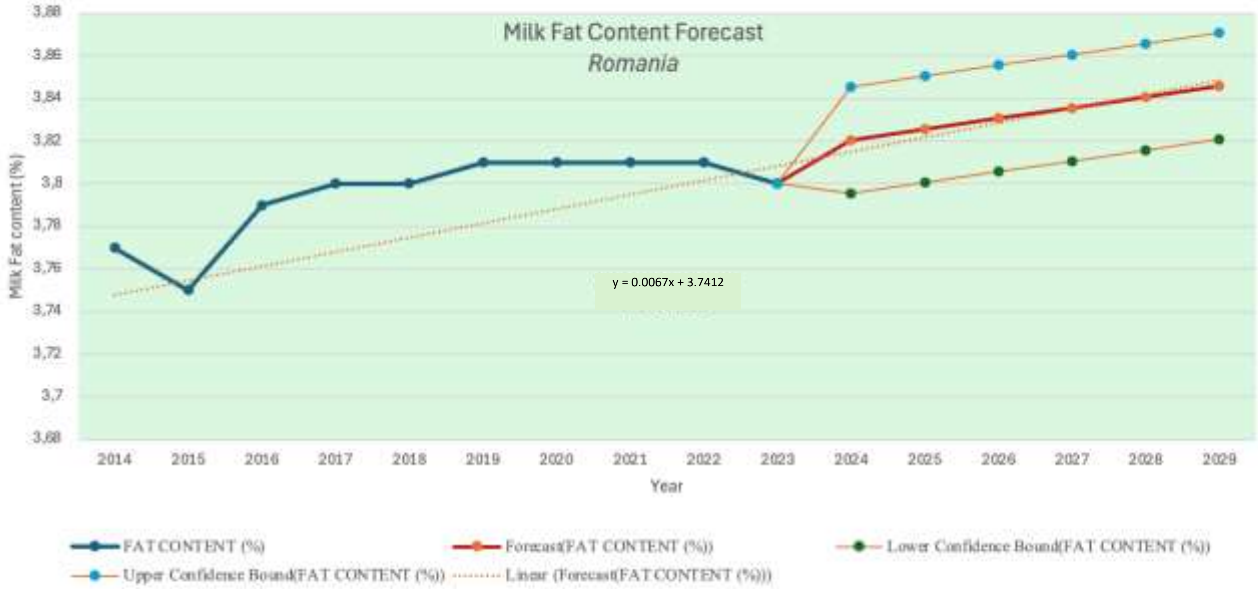

Fig. 1. Milk fat content forecast in Romania (2023-2029)
Source: Eurostat [5].

The statistical evaluation of the forecast model for milk fat content in the European Union reveals a high level of accuracy and stability. The Alpha parameter, set at 0.25, indicates a moderate level of smoothing applied to the level component of the model. This suggests that while recent observations are factored into the forecast, they do not overwhelmingly influence the overall prediction, allowing for a balanced consideration of historical data.

Interestingly, both the Beta and Gamma parameters are set to 0.00, indicating that the model does not account for any significant trend or seasonal variations in the data. This implies that the historical data does not exhibit strong trends or seasonal patterns, leading the model to treat the milk fat content as relatively stable over time.

The model's performance is further validated by the MASE value of 0.73. This figure indicates that the forecast error is 73% of the average error of a simple one-step naive forecast, demonstrating that the model outperforms basic forecasting methods and provides a reasonably accurate prediction.

The SMAPE is reported as 0.00, an unusual result that suggests the forecasted values are nearly identical to the actual values. While this could indicate an extremely accurate forecast, such a result should be interpreted cautiously, considering the possibility of calculation anomalies.

The MAE and RMSE both stand at 0.02, further underscoring the model's precision. These low values indicate that the forecasted milk fat content deviates from the actual values by only 0.02 percentage points on average, with few significant errors. The consistency between the MAE and RMSE values suggests that the forecast errors are uniformly small, with minimal large deviations.

Overall, these statistical measures suggest that the forecast model provides a reliable and accurate prediction of milk fat content in the European Union. The model's assumptions of stability in the data, combined with its minimal error rates, offer a strong foundation for future projections and planning in the dairy sector. The lack of significant trends or seasonal components aligns with the observed historical stability, reinforcing the model's credibility and the robustness of its predictions. The historical data reveal that milk fat content in the European Union has been relatively stable with minor fluctuations. The forecast indicates a steady and gradual increase in milk fat content from 2019 to 2029, with an overall rise of about 0.12% over the decade.

This increase could be attributed to a variety of factors, including improvements in dairy cow nutrition, breeding programs aimed at enhancing milk fat content, and possibly changes in consumer preferences for dairy products with higher fat content. The narrow confidence intervals suggest a high level of confidence in these forecasts, particularly in the near term, though some variability is expected as the forecast period extends further into the future.

The statistical analysis of milk fat content in the European Union is further supported by a regression analysis, with the formula $y=0.0107x+3.9865$ and an R^2 value of 0.9916. This linear regression model indicates a strong and almost perfect fit to the historical data, as evidenced by the high R^2 value, which suggests that approximately 99.16% of the variance in milk fat content over time can be explained by the linear relationship.

In the regression formula, y represents the forecasted milk fat content, while x represents the year or time variable. The slope of the equation, 0.0107, indicates a gradual annual increase in milk fat content by approximately 0.0107 percentage points. This aligns with the forecasted slight upward trend observed from 2024 to 2029, reinforcing the prediction that milk fat content in the EU is expected to continue increasing modestly over the coming years.

The intercept of the regression equation, 3.9865, suggests that the baseline milk fat content was around 3.9865% at the start of the observed period. This baseline value closely matches the recorded fat content in the earlier years, providing further validation for the model.

The near-perfect R^2 value of 0.9916 indicates that the linear regression model is highly effective at capturing the underlying trend in the data, with very little unexplained variance. This strong fit reinforces the reliability of the forecast model and suggests that the factors influencing milk fat content have remained consistent over time, allowing for accurate predictions based on historical trends.

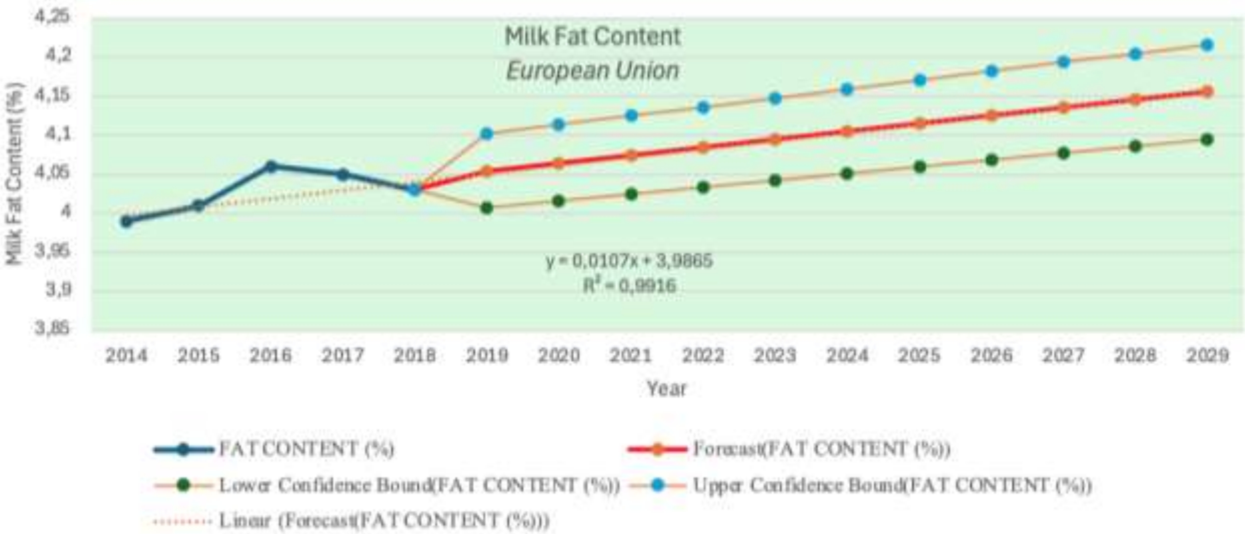

Fig. 2. Milk fat content forecast in the European Union (2018-2029)
Source: Eurostat [5].

The future evolution of milk fat content in Romania and European Union over the next five years is likely to be influenced by multiple factors. For example, environmental conditions such as temperature, humidity, and pressure have been identified as significant determinants affecting the fat and protein content of raw milk [21]. Additionally, the availability and quality of forage during the milking season are critical in shaping monthly variations in milk fat and protein content [17]. These findings suggest that changes in climate patterns and forage quality could potentially impact milk fat content.

Furthermore, the nutritional intake and body composition of dairy animals have been shown to influence milk fat content [9]. Advancements in feed quality and management practices, particularly with respect to the provision of protein-rich feeds like soybean cakes, could potentially lead to changes in the fat content of milk [24].

The adoption of automated robotic milking systems has been associated with increases in milk fat content [15, 10, 2], indicating that technological advancements in dairy farming practices may also play a role in shaping the future trajectory of milk fat content.

Moreover, genetic factors such as breed and lactation stage have been linked to variations in milk fat content [20]. Breeding programs aimed at enhancing milk quality traits, including fat content, could therefore influence the future evolution of milk fat. Additionally, the relationship between ruminal pH and de novo fatty acid synthesis in milk underscores the complex metabolic processes underlying milk fat production [6], suggesting that factors affecting rumen health and function may also impact milk fat content.

CONCLUSIONS

A comparative examination of milk fat content trends in Romania and the European Union demonstrates a continuous, if slight, rising trajectory across the analysed timeframe. The forecasting model in Romania demonstrates a high level of accuracy, as evidenced by its limited error and low values of statistical measures such as MAE and RMSE. The findings of the regression analysis provide evidence of a progressive rise in milk fat content, with an estimated 90.81% of the variance accounted for by the linear pattern. These findings indicate that the milk fat content in Romania has exhibited a somewhat consistent pattern, with a slightly increasing trajectory. This tendency is likely attributable to advancements in dairy farming techniques, enhancements in feed quality, and progress in genetic research.

In the context of the European Union, the observed tendency is more evident, since the regression model exhibits a more robust alignment with the observed data. Based on the statistical measurements, such as an Alpha coefficient of 0.25, as well as the low values of

MASE and RMSE, it can be inferred that the forecasting model has a high level of accuracy in capturing the underlying trends. The European model exhibits a higher R-squared value, indicating a greater degree of concordance with the empirical data. This suggests a more robust and consistent increase trajectory in milk fat content throughout the area.

Based on projections, it is anticipated that both Romania and the European Union would experience a gradual although consistent rise in milk fat content in the forthcoming years. The persistence of this trend is anticipated upon the sustained maintenance of current innovations in dairy farming and production processes. The robust correlation observed between historical data and predictive models serves to bolster the dependability of these projections, suggesting that forthcoming milk fat content will retain a stable and marginally rising trajectory. This, in turn, will enhance the overall quality and uniformity of dairy products within the geographic area.

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RESPONSE OF MAIZE (*Zea Mays* L.) GRAIN YIELD AND YIELD COMPONENTS TO INTEGRATED FERTILIZATION WITH GREEN MANURE AND NITROGEN

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Abstract

Green manures are an alternative to improve nitrogen availability for plant nutrition in a global context of declining soil fertility. To investigate the effects of green manure and nitrogen fertiliser on maize yield under the Braila Agricultural Development Research Station conditions, a bifactorial experiment with four replications was conducted for two years. The main factor was the use of green manures at four levels (control - without green mulch crop; winter pea (Pisum sativum L. var. arvense.); white mustard (Sinapis alba L); winter rye (Secale cereale L.), while the sub-factor was the application of N fertilizer at four levels (0, 60, 90 and 120 kg/ha of N active substance). Green manure application significantly influenced corn yield, with increases of 19.4% for winter pea, 16.9% for white mustard, and 9.8% for rye. The same significant influence was found on plant height and yield components. The application of different levels of nitrogen also had a very significant influence on yield results and yield components.

Key words: *maize, green manure crops, mineral fertilization*

INTRODUCTION

Maize is a significant worldwide commodity. It is used both as a direct food source and as an indirect feed for animal-sourced foods. The crop is highly adaptable and serves multiple purposes. Additionally, it has various non-food uses on a global scale. In recent decades, there has been a significant increase in global maize production. The global utilization of maize is projected to experience ongoing expansion. Currently, this grain holds the top position in terms of output volume and is projected to surpass all other crops in terms of cultivated area in the next ten years [8].

Romania has an internal use of fertilizers which cannot be covered in the coming years by domestic production and is dependent on the import of mineral fertilizers, and a solution may be to replace chemical fertilizers with natural fertilizers [3].

The application of mineral fertilizers leads to significant increases, but the unbalanced application of fertilizers chemical fertilizers can cause imbalances in the plant and yield increases be smaller as the amount applied increases above the useful limit [15].

Combining the application of organic and inorganic fertilizers appears to be a viable approach to address the crop's needs, enhance soil quality, and optimize nutrient usage efficiency. The correct timing and sequence of nitrogen application are crucial for its effective utilization [10].

Effective nitrogen fertilizer management plays a crucial role in agricultural activities, greatly enhancing crop output [6].

Nitrogen treatments improve the yield and quality of hybrid. Combining the utilization of urea with other manure tends to increase the yield and yield-related traits of maize hybrids. Higher yield performance of maize hybrids can be obtained by alternating mineral fertilizer with organic fertilizer to construct a more efficient farming cycle with an environmentally friendly or more sustainable system [10].

Research conducted by Boiko et al. (2024) between 2016 and 2022 showed that the highest yield in grain maize crops was obtained when an organo-mineral fertilization system was used, with an 18% increase compared to the unfertilized control variant [5]

According to Delibaltova (2014), the value of yield structural elements and grain yield of the studied genotypes increased as the amounts of nitrogen fertilization increased. The application of 240 kg N/ha resulted in the highest recorded values for the maximum number of rows per cob, number of grains per row, number of grains per cob, length of cob, cob weight, the weight of grains per cob, and thousand-grain weights, compared to other rates [7].

Marković et al. (2017) reported that the impact of N fertilization on maize was statistically significant for all variables examined in both years of the research. The application of nitrogen fertilizer resulted in a significantly greater grain output compared to the control treatment in both growing seasons. The yield components, including length, grain weight per ear, number of grains per ear, and 1,000-grain weight, exhibit a considerable increase as the nitrogen rate is increased from 0 to 200 kg N/ ha [12].

There is increased interest in organic fertilizers due to high prices, unavailability, or limited supply of mineral fertilizers. The importance of the use of green manure also derives from the decreasing production of organic fertilizers due to decreasing livestock numbers. The application of mineral nitrogen in conjunction with organic fertilizers has led to increased yields and yield components [1] [2] [11].

Enhancing the sustainability of intensive agriculture relies on achieving a high grain yield while also maximizing nitrogen use efficiency in crop production. The incorporation of green manure along with a 30% reduction in chemical fertilizer resulted in a considerable decrease in nitrogen losses through volatilization and leaching, while yet maintaining a high yield of maize [9]. The superior efficacy of this management technique can be linked to the optimization of nitrogen supply and enhancement of maize nitrogen uptake through the synergistic utilization of green manure and reduction in mineral nitrogen application [4]

Su et al. (2022) also showed that when green manure is incorporated, total and available nitrogen and phosphorus increase significantly, allowing the nitrogen dose to be reduced by 11.2% [16].

The positive effects of organic fertilizers, even green manure, were particularly noticeable at lower N rates. Therefore, they should be used to reduce the application rate of inorganic fertilizers and the resulting environmental risks [17].

Therefore, this study aims to evaluate the efficacy of several types of green manure and levels of nitrogen fertilizer on maize yield and its components in Northeast Baragan conditions.

MATERIALS AND METHODS

Field experiment was carried out in the 2022 and 2023 growing seasons on vermic chernozem soil with a medium humus content of 2.4 - 3.1% in the upper horizons and only 1.6% in the transition horizon, 0.14-0.25 % total nitrogen content at the trial site of Agricultural Research and Development Station (ARDS) Braila - Chiscani Experimental Center.

The experiment was designed in fully randomized blocks with 4 replicates. The main plot factor was green manure (GM) species (control – without green manure crop; winter pea (*Pisum sativum* L. var. arvense); white mustard (*Sinapis alba* L); winter rye (*Secale cereale* L.).

The sub-factor was nitrogen fertilizer which was applied at four levels (0, 60, 90 and 120 kg/ha of N active substance). The size of each test plot was 42 m^2 and the total surface area of the research plot was 4,032 m^2.

Green manure cultivation was done in early September in the two years of testing. The green manure was chopped and incorporated into the soil according to species: mustard at the onset of winter, and winter pea and rye species were chopped and incorporated in the spring, about one month before corn sowing.

Mineral fertilization was carried out by administering a 15:15:15 complex NPK fertilizer at the same time as the seedbed preparation, and fractional doses of urea were applied during the maize growing season. Thus, N doses of 60, 90, and 120 kg/ha and an agro-foundation of 40 kg/ha P and 40 kg/ha K were applied for all experimental variants.

Maize was sown on 04.05.2022 and 05.05.2023 with F423 hybrid at a density of 65,000 plants ha and harvesting was performed in the second decade of October in 2022 and 2023. During the growing season, weed and pest control treatments were applied and during the two years of experimentation, the maize was irrigated.

This paper's traits studied include plant height, grain yield and yield components. Plant height was determined in the field by biometric measurements on 10 plants from each experimental plot. For the determination of yield components, six ear for each experimental plot were analyzed.

The production was calculated after standardizing the moisture content of maize to 14%, which is the national standard of moisture content (STAS).

The statistical analyses of grain yield and yield component data included analysis of variance and Fisher’s least significant differences test (LSD), using the Polifact statistical software [18].

Table 1. Rainfall regime from 2021 to 2023 at the ARDS Braila

Year/Months	Rainfall—Monthly Amount (mm)												Annual average
	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	
2021-2022	33	27	44	7	12	14	25	24	33	9	27	32	287
2022-2023	6	31	20	64	7	13	66	40	26	106	55	5	439
Multiannual average	30	33	36	28	27	26	35	48	62	46	39	32	442

Source: Meteorological Stations Braila [14].

Table 2. Thermal regime from 2021 to 2023 at the ARDS Braila

Year/Months	Temperature—Monthly Average (°C)												Annual average
	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	
2021-2022	10.2	8.1	2.5	1.3	4.1	3.8	11.9	18	22.7	24.8	24.9	17.9	12.5
2022-2023	13	8.1	2.9	4.4	1.4	7.9	10.4	16.6	21.6	24.7	24.7	20.9	13.1
Multiannual average	11.5	5.6	0.6	-2.1	-0.2	4.7	11.2	16.7	20.9	22.9	22.1	17.3	10.9

Source: Meteorological Stations Braila [14].

RESULTS AND DISCUSSIONS

ARDS Brăila is located in the eastern part of the Northern Bărăgan, in one of the driest agricultural areas in Romania. The territory of Northern Bărăganului de Nord, as indeed the entire area of the Romanian Plain, is characterized by a temperate continental climate. Summers are hot and dry; rainfall is low, heavy, and unevenly distributed. Climatic data in this paper come from the Meteorological Station of Brăila, located near the Experimental Center Chiscani. The multiannual temperature regime has an average value of 10.9°C, and the rainfall regime records an annual average of 442 mm.

In the crop year 2021-2022, the average temperature recorded was 12.5.°C. This was a warm year, with a deviation of the mean annual temperature of +1.6.°C from the multi-year average. In addition, it was an excessively dry year, with a negative deviation of 155 mm from normal in terms of precipitation.

The 2022-2023 crop year was very warm; the average temperature recorded was 13.1 .°C, with a positive deviation from the multi-year average of 2.2.°C. In terms of rainfall, it was close to normal, with 439 mm recorded, but with an uneven distribution of precipitation.

Plant height

In terms of morphological characteristics, hybrid Fundulea 423 is characterized as a vigorous plant, with an average height of 265 cm [13].

A comparison of means showed that the application of winter pea green manure increased plant height by 6.63%, a highly significant difference from the control, and white mustard influenced plant height by 3.81%, a distinctly significant difference.

Winter rye had a significant negative influence on this parameter, reducing plant height by 2.94% (Table 3).

In addition, plant height also increased at the application of fertilizer levels with N. The highest plant height was observed in the 120 kg/ha N treatment, with a difference of 11% compared to the control.

The difference was highly significant as it was in the 90 kg/ha application rate.

The 60 kg/ha rate recorded a significant deviation from the control, but smaller compared to the other rates.

These results are due to the important role that green manures play in creating a nutrient space richer in organic matter, with also improved soil properties and increased nutrient availability.

Table 3. Effects of green manures and different nitrogen levels on maize. Average results 2022-2023

Treatment	Grain yield (kg/ha)	Plant height (cm)
	Green manure levels	
Control (without green manure)	5,946	249.53
Winter pea	7,101***	256.16***
White mustard	6,952***	253.34**
Winter rye	6,530**	246.59^{0}
	LSD (5%)= 375.26 kg/ha; LSD (1%)=521.09 kg/ha; LSD (0.1%)=728.21 kg/ha	LSD (5%)= 2.12 cm; LSD (1%)= 3.05 cm; LSD (0.1%)= 4.48 cm
	Nitrogen levels	
Control (0)	5,946	246.84
60 kg/ha	6,388**	248.63*
90 kg/ha	6,989***	252.31***
120 kg/ha	7,856***	257.84***
	LSD (5%)= 298.52 kg/ha; LSD (1%)=399.79 kg/ha; LSD (0.1%)=527.26 kg/ha	LSD (5%)= 1.77 cm; LSD (1%)= 2.37 cm; LSD (0.1%)= 3.12 cm

Source: Own results.

Grain yield

Variance analysis indicates that green manure and nitrogen fertilizers influence maize yield significantly. Comparison of yield means highlights that the application of green manure winter pea increased the yield by 19.4% compared to the control variant; in the case of the application of green manure white mustard, the yield increased by 16.9%, and the application of rye as green fertilizer influenced the yield by 9.8% compared to control variant, statistically the differences were highly significant. The same result was demonstrated for the application of N doses, with increases of 7% for N60, 17.5% for N90, and 32.1% for N120.

Figure 1 shows the interactions between the nitrogen dose factor and the green manure factor, the differences were highly significant compared to the control. The most significant interaction was N120 x white mustard GM, with a yield of 10,022 kg/ha.

Grain weight

From the average results of the year 2022 and year 2023, the analysis of variance shows that the effects of green manure and nitrogen fertilizer on grain weight per cob were distinctly significant and highly significant compared to the control variant (Table 4). The average grain weight per cob was 5.8% higher for winter pea-GM and 3.7% and 3.2% higher for white mustard- GM and rye-GM, respectively, compared to the control variant. When applying nitrogen doses, the results were also statistically highly significant, with the highest difference given by the control with the highest nitrogen dose, N120, and the difference recorded was 16.2.

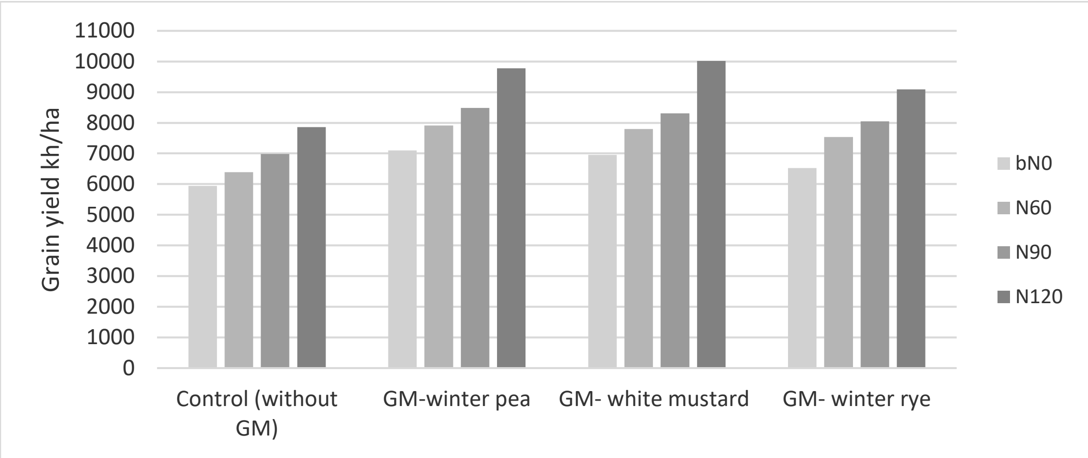

Fig. 1. The effect of nitrogen x green manure interaction on grain yield.
Average results 2022-2023.
Source: Own results.

Grain number/row

One of the most important components of yield is the number of grains per cob, which is affected by the plant's nutritional level. This indicator was very significantly influenced by the winter pea-GM application, significantly by the white mustard application, and insignificantly by the rye-GM application.

Cob length

Also, very significant differences were obtained for this indicator compared to the control version. For the application of green fertilizers, differences between 9.4-13% were obtained compared to the control, and for the application of nitrogen doses, differences between 2.2-7% were obtained.

Table 4. The effects of green manure and different nitrogen levels on yield components.Average results 2022-2023

Treatment	Grain weight (g)	Grain number/row	Cob length (cm)
Green manure levels			
Control (without green manure)	188.27	42.58	19.94
Winter pea	199.23***	44.47***	22.54***
White mustard	195.29**	43.49**	21.81***
Winter rye	194.36**	43.16^{-}	21.87***
	LSD (5%)= 3.91 g; LSD (1%)=5.62 g ; LSD (0.1%)= 8.27 g	LSD (5%)= 0.83 ; LSD (1%)= 1.19; LSD (0.1%)= 1.75	LSD (5%)= 0.40 cm ; LSD (1%)= 0.58 cm; LSD (0.1%)= 0.85 cm
Nitrogen levels			
Control (0)	179.11	41.66	20.85
60 kg/ha	192.24***	43.36***	21.31**
90 kg/ha	197.65***	43.96***	21.68***
120 kg/ha	208.14***	44.72***	22.31***
	LSD (5%)= 4.27 g; LSD (1%)= 5.72 g; LSD (0.1%)=7.55 g	LSD (5%)= 0.47; LSD (1%)= 0.63; LSD (0.1%)= 0.84	LSD (5%)= 0.26 cm ; LSD (1%)= 0.35 cm; LSD (0.1%)= 0.47 cm

Source: Own results.

CONCLUSIONS

The results of this study demonstrate the potential of winter pea, white mustard, and rye species to be used as green manures in integrated fertilization schemes with mineral fertilizers in maize.

When considering mineral N, the most promising interactions were given by the combination of white mustard x 120 kg/ha N, which obtained a yield of 10,022 kg/ha, and the combination of winter pea x 120 kg/ha N, which obtained a yield of 9,778 kg/ha, however, compared to the control variant without green manure, all the integrated variants obtained significant yields.

Fertilization of green manure also influenced plant height, application of green manure of winter peas increased plant height by 6.63% and white mustard influenced plant height by

3.81%. Winter rye had a significant negative influence on this parameter, reducing plant height by 2.94%.

The yield components were also influenced. The average grain weight per cob was 5.8% higher for winter pea-GM and 3.7% and 3.2% higher for white mustard-GM and rye-GM, respectively, compared to the control. The number of kernels per row was highly significantly influenced by winter pea-GM, significantly by white mustard-GM, and insignificantly by rye-GM.

In terms of cob length, compared to the control variant, there were differences between 9.4-13%, and differences between 2.2-7% were obtained for the application of nitrogen doses.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY ON CURRENT TRENDS ON THE VEGETABLE MARKET IN ROMANIA

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Abstract

The horticultural market in Romania is an unbalanced one, in which the demand is greater than the supply, as a result the phenomenon of price volatility appears for these categories of agri-food products. The objective of the paper is to present the main trends on the vegetable market in Romania at the level of the last 7 years, based on the statistical data available in the database of National Institute of Statistics (NIS) from Romania and International Trade Center (ITC). The results showed that the demand for vegetables increased, while the supply showed slight downward trends, the largest share of production being intended for self-consumption, thus, our country is forced to resort to imported vegetables. This situation had a negative influence on the trade balance with vegetable products. In the period 2015-2022, the trade balance for the category of horticultural products registered an increase in the deficit of 311%, from -8,335,747 thousand euro in 2015 to -34,269,689 in 2022.

Key words**:** *vegetables, demand, supply, trade, Romania*.

INTRODUCTION

Currently, the global population exceeds 8 billion people, and the trend is increasing. Estimates by the Food and Agriculture Organization (FAO) claim that the population will reach 8.5 billion by 2030, respectively 9.7 billion by 2050. Along with population growth, food needs also increase, and the pressure on the agri-food system to ensure food security is emphasized [1].

In the specialized literature, the research carried out at the level of Romania is focused on the analysis of the vegetable market and on the identification of the distribution channels of Romanian vegetables. Following the query of the keyword vegetable market in the Web of Science (WoS) database, 10,309 documents were identified, of which 149 documents were developed by authors from Romania.

The studies identified in the WoS highlighted Romania's very high production potential in terms of growing vegetables, both in the field and in protected areas, due to the favorable pedo-agroclimatic conditions. However, vegetable production is known for its seasonal nature, the population's consumption needs not being covered throughout the year.

Another particularly important feature is the perishability of the products, they must be consumed immediately after harvesting to preserve your vitamin content. In addition to these, characteristics such as: the homogeneity of the products, the variation of demand and supply, the high consumption of inputs in obtaining the products are also mentioned [10,12].

The vegetable sector represents a traditional activity at the level of Romania, having a very high economic importance.

The importance of the horticultural sector is demonstrated both by the cultivated area and by the high number of producers in the field.

From the perspective of total vegetable production, Romania cannot ensure the consumption requirements of the population, resorting to imports, which have a negative influence on the trade balance [2, 3].

In this context, the study aimed to present the main trends in Romania's vegetable market in the period 2015-2022.

MATERIALS AND METHODS

The research is based on the statistical data on the areas, productions and consumption of vegetables, available in the tempo online database of the INS [7] in Romania and the data on foreign trade in vegetables, provided by ITC [8]. The research method used in developing the study was quantitative and qualitative data analysis, as well as comparative analysis. At the same time, a study of the specialized literature at the level of Romania was carried out on the studied theme, based on the researches indexed in WoS [13]. Following the query of the keyword "vegetables market", 149 documents elaborated by Romanian authors were identified, which were reviewed, from which the most relevant works were selected, which are the subject of this research.

RESULTS AND DISCUSSIONS

In Romania, the area with vegetables showed a downward trend in the period 2015-2022, when a decrease of approx. 26%, from 239 thousand hectares in 2015 to 178 thousand hectares in 2022. The dependent variable (surface cultivated with vegetables) was expressed by the independent variable (year) in proportion to approx. 83% In this case, there was a strong relationship between time and cultivated area, as shown by the multiple value R 0.915 and R squared (√0.8373).

When there is an increase in the independent variable x by one year, there is a decrease in the dependent variable y by 7.8106 thousand hectares.

According to the trend equation y = -7.8106 x + 250.4, on average annually, the area with vegetables decreased by approx. 8 thousand hectares per year (Fig. 1).

Also, a decrease in horticultural production by approximately 34% was noted during the analyzed period, from 3,674 thousand tons in 2015 to 2,426 thousand tons in 2022. This time, the dependent variable - production of vegetables is expressed by the independent variable – year in a proportion of approx. 36%.

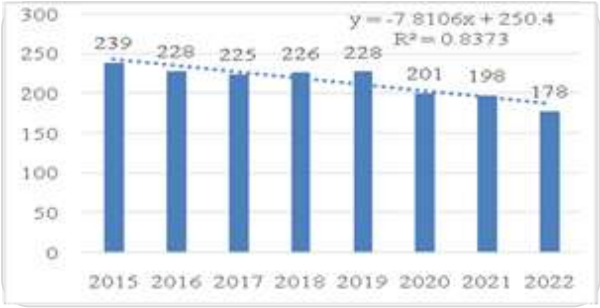

Fig. 1. Dynamics of vegetable areas in Romania, in the period 2015-2022 (thousands of hectares)
Source: Own processing based on data from NIS, Accessed on 29.11.2023 [7].

In this case, there is a direct and moderate relationship between time and vegetable production as shown by Multiple R value is 0.602 and R squared (√0.3622).

It can be appreciated that when the independent variable x increases by one year, the dependent variable y decreases by 104.55 thousand tons. According to the trend equation y = -104.55 x + 3,895.7, vegetable production decreased on average annually, by approx. 105 thousand tons per year. The most significant production was recorded in 2018, respectively 3,797 thousand tons (Fig. 2).

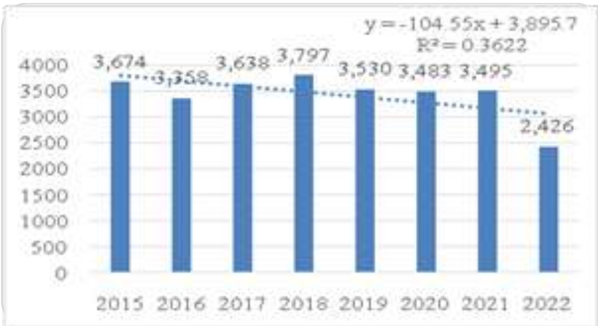

Fig. 2. Dynamics of total vegetable production in Romania, in the period 2015-2022 (thousands of tons)
Source: Own design and calculations based on NIS data, Accessed on 29.11.2023 [7].

In Romania, vegetable production is carried out at low salt, by family farms, being intended in a very large proportion for self-consumption, the surplus being sold by traditional means directly to consumers (at the farm gate) [9].

Studies have shown that farmers grow many types of vegetables in large numbers, both for diversity and to sell the vegetables throughout the year, given their seasonality and crop rotation. Also, the vast majority of farmers plan production according to the season as follows: spring: early crops and greens; in summer: tomatoes, cucumbers and peppers and in autumn root vegetables are grown [4].

From the analysis of vegetable production per inhabitant, a decrease of approx. 31%, at the level of the analyzed period. The highest production per capita was recorded in 2018 (0.194 tons/capita), and the lowest in 2022 (0.127 tons/capita). With a relatively constant population and a vegetable production with a decreasing trend, the inability of the horticultural sector to ensure the demand for products at the national level can be distinguished, thus resorting to imported products (Fig.3).

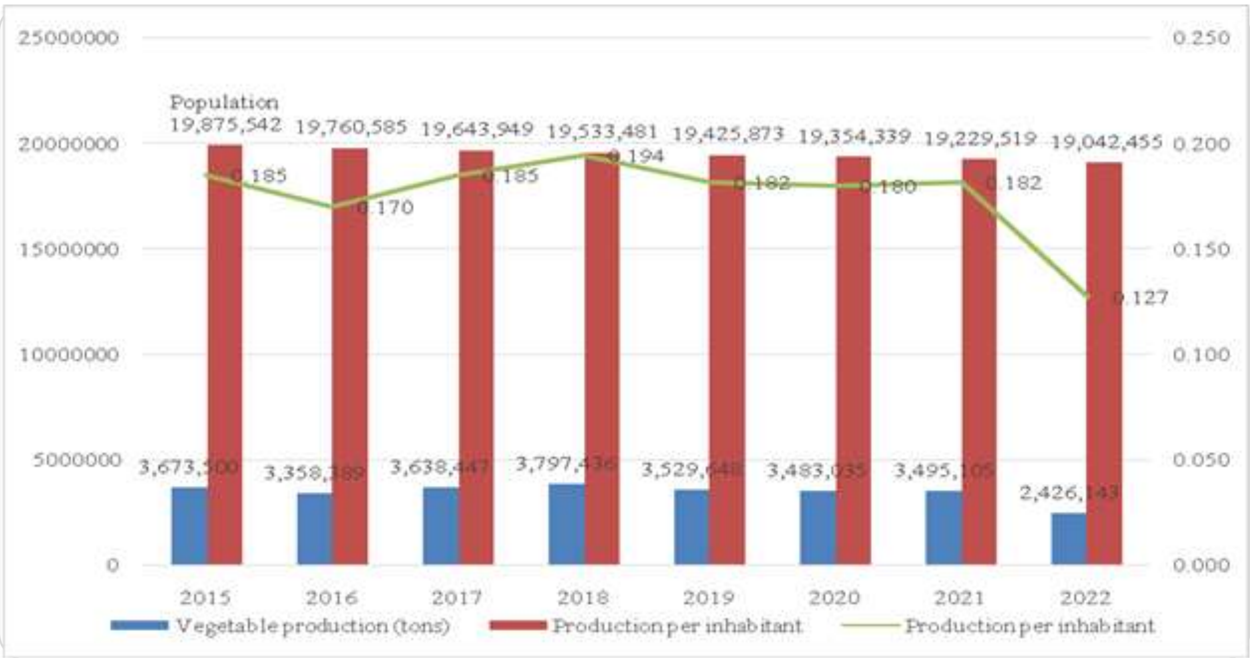

Fig. 3. Dynamics of vegetable production per inhabitant in Romania, in the period 2015-2022 (tons/inhabitant)
Source: Own design and calculations based on NIS data, Accessed on 29.11.2023 [7].

Regarding the average annual consumption of vegetables per inhabitant, an increase of 13% was observed during the analyzed period, from 159 kg in 2015 to 180 kg in 2021. The dependent variable (average annual consumption of vegetables), is expressed by the independent variable (year), in proportion to approx. 87%, the correlation coefficient being 0.9379 and R-squared (√0.8797), which signifies a direct and strong relationship between time and vegetable consumption. When there is an increase in the independent variable x by one year, there is an increase in the dependent variable y by 3.9857 kilograms. According to the trend equation y = 3.9857x +151.94, the average annual consumption of vegetables per inhabitant increased on average annually, by approx. 4 kilograms per year.

The increase in vegetable consumption among the population can be attributed to the trends towards a healthy lifestyle, as well as public information campaigns on healthy eating and its benefits (Fig. 4).

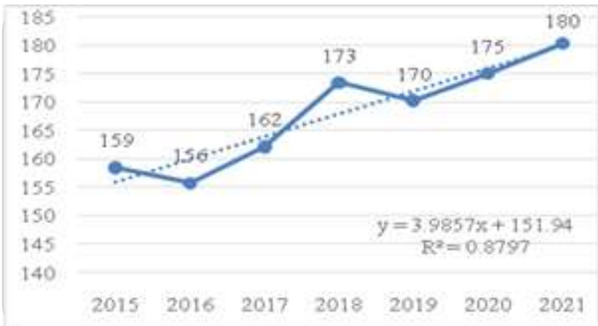

Fig. 4. Dynamics of the average annual consumption of vegetables per inhabitant in Romania, in the period 2015-2022 (kilograms)
Source: Own design and calculation based on the data from NIS, Accessed on 29.11.2023 [7].

Rădulescu et al. (2021) analyzed consumer behavior regarding fruit and vegetable consumption, conducting a survey on a sample of 268 people. The results showed that the consumption trends of the sampled population are largely influenced by the information they have available regarding the characteristics of the products consumed, such as: the country of origin, the cultivation system (conventional or organic) and the producer [11].

Although it is known that the consumption of vegetables has many benefits for the body, in Romania, it is significantly lower than the recommendations of doctors and nutritionists. The FAO and the World Health Organization (WHO) recommend the consumption of at least 400g of vegetables, excluding potatoes and starchy tubers, to prevent the occurrence of chronic diseases [6].

A study carried out by the publication Progresiv, shows that from the basic foods of the Romanian population, vegetables and fruits are frequently consumed by 81% of Romanians, being the most consumed agri-food products [5].

The exported value of vegetables in Romania showed an increase of 57% in the period 2015-2022. Among the top 5 importing countries of vegetables exported by Romania are: Italy (66,512 thousand euro in 2022), Germany (13,564 thousand euro in 2022), Poland (11,162 thousand euro in 2022), Ukraine (10,158 thousand euro in 2022) and Hungary (10,158 thousand euro in 2022). Significant increases in the value of exported products were noted in countries such as Cyprus (+2,495%), Ukraine (+112,767%) and Poland (684%) and the Netherlands (647%) (Table 1).

Table 1. List of important markets for edible vegetables and certain roots and tubers imported from Romania (Export value- thousands of euro)

Exported value (thousands of euro)									
Importers	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2022/2015**
World	90,798	86,781	143,306	96,016	95,338	95,104	106,738	142,631	57%
Italy	47,063	37,459	50,904	44,859	45,307	48,953	51,026	66,512	41%
Germany	12,483	10,943	11,265	11,375	10,641	8,387	12,143	13,564	9%
Poland	1,423	1,761	2,467	3,047	4,418	6,437	9,034	11,162	684%
Ukraine	9	16	29	5	15	832	1,043	10,158	112,767%
Hungary	3,720	3,364	3,935	4,167	4,285	5,754	6,537	7,816	110%
Spain	4,358	4,537	11,828	15,642	13,235	5,875	7,101	4,750	9%
Moldova, Republic of	1,164	926	2,886	1,837	2,582	4,296	3,690	4,526	289%
Bangladesh	0	0	0	0	0	0	62	4,196	
France	4,685	2,633	2,817	4,865	3,947	4,281	4,522	4,109	-12%
Austria	2,567	2,363	2,166	2,985	2,790	2,202	2,580	3,070	20%
Netherlands	291	243	271	613	253	209	284	2,174	647%
Switzerland	1,183	382	424	133	600	945	739	1,444	22%
Belgium	853	596	383	340	238	394	958	1,416	66%
Bulgaria	3,908	2,158	1,357	1,279	1,590	904	435	1,061	-73%
Cyprus	40	32	18	50	12	20	25	1,038	2,495%

Source: Intracen, Trade Maps, Accessed on 10.11.2023 [8].

Regarding the imported value of vegetables imported by Romania, an increase of 131% is observed in the period 2015-2022. Among the top 5 exporting countries from which Romania imports vegetables are: Turkey (134,119 thousand euro in 2022), the Netherlands (92,418 thousand euro in 2022), Germany (90,798 thousand euro in 2022), Poland (52,785 thousand euro in 2022) and Spain (40,823 thousand euro in 2022). Large increases of imported values were recorded in Turkey (+291%), Egypt (+289%) and Germany (+270%) (Table 2).

The existence of significant gaps in the production of vegetables in Romania was observed, with imports covering most of the domestic demand for vegetables. Therefore, support is needed to develop the horticultural sector in such a way as to stimulate Romanian vegetable exports.

Table 2. List of supplying markets for edible vegetables and certain roots and tubers imported by Romania

Imported value (thousands of euro)									
Exporters	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2022/2015**
World	273,492	364,921	403,333	427,704	517,882	479,775	530,486	632,188	131%
Türkiye	34,306	55,478	69,380	81,127	75,916	92,225	113,442	134,119	291%
Netherlands	35,761	46,273	47,537	46,706	73,037	67,570	71,445	92,418	158%
Germany	24,551	34,320	41,493	46,302	62,408	58,928	70,216	90,798	270%
Poland	22,904	36,551	44,366	48,476	56,258	41,626	42,563	52,785	130%
Spain	24,404	26,738	28,034	28,454	42,006	35,549	37,020	40,823	67%
Egypt	8,000	5,697	12,875	10,199	16,877	17,933	19,790	31,089	289%
Greece	15,439	25,668	26,001	22,892	28,415	25,318	29,527	30,489	97%
Hungary	24,052	32,732	30,359	31,924	29,515	27,317	26,936	29,772	24%
France	15,827	15,698	11,147	14,501	22,978	19,821	18,255	27,622	75%
Italy	21,309	29,572	27,416	29,282	30,734	20,286	26,348	27,219	28%
Belgium	11,472	10,101	10,314	12,277	17,783	19,542	21,660	25,519	122%
Bulgaria	7,905	10,542	17,900	15,628	14,790	17,338	17,949	15,209	92%
Austria	4,144	6,676	6,388	7,732	7,275	4,302	4,992	7,958	92%
Serbia	2,831	1,450	2,273	4,306	6,383	4,608	4,812	5,442	92%
Macedonia, North	1,895	3,525	2,109	3,467	5,698	4,989	4,377	5,092	169%

Source: Intracen, Trade Maps, Accessed on 10.11.2023 [8].

The trade balance recorded for the analyzed product category was a deficit throughout the analyzed period, oscillating between -8,335,747 thousand euros in 2015 and -34,269,689 in 2022. An increase in the trade balance deficit by 311% was observed (Fig. 5).

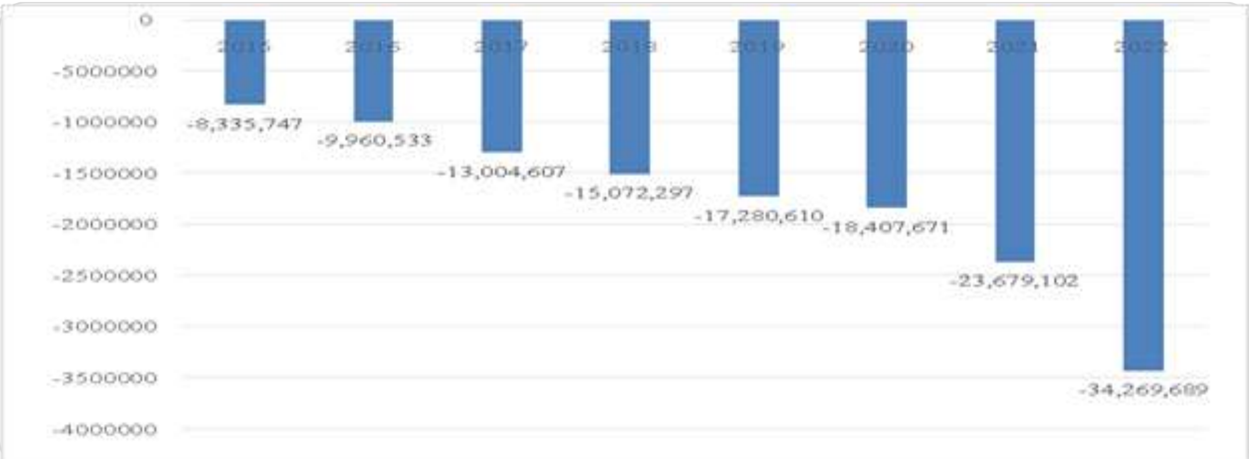

Fig. 5. The trade balance recorded in the product category – edible vegetables and certain roots and tubers, in Romania, at the level of the period 2015-2022
Source: Intracen data processing, Trade Maps, Accessed on 10.11.2023 [8].

Currently, Romania is focused to the greatest extent on the export of raw materials and massively imports finished products, which does not ensure the sustainable growth of the export of agri-food products, but on the contrary, accentuates the trade balance deficit even more. In conclusion, Romania should focus on the creation of added value of agri-food products by developing the activity of processing agricultural products, and then on the export of finished products.

CONCLUSIONS

The chernozem type soils in Romania, especially those in the Western Plain, the Romanian Plain, the Transylvanian Plain, the Moldavian Plateau and Dobrogea, are extremely favorable for growing vegetables.

However, the national production of vegetables is not sufficient to meet the consumption needs of the national population. The vast majority of horticulturalists are small farmers (family farmers), and most of the production is intended for self-consumption, with a very small share being intended for sale. On the other hand, vegetables are seasonal and perishable agri-food products, the supply of horticultural products cannot be ensured throughout the whole year, the only solution to satisfy the demand is the import, which during the last 3 years has recorded increasingly large increases , negatively influencing the trade balance, which is a deficit, at the level of 2022, it reached -34,269,689 thousand euros.

At the same time, both producers, processors and distributors face problems that negatively influence the economic-financial results. The use of non-performing technologies that contribute to the decrease in vegetable production, the difficulty of marketing products in an optimal time frame and the use of non-performing seeds, represent only some of the most important problems faced by Romanian farmers. An optimal solution for solving these problems is represented by the association of small producers within agricultural cooperatives that have all the resources, both economic and material, for a viable commercialization, ensuring an adequate and efficient distribution of vegetable production.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE BIOHARMONIZED RECONNECTION OF THE AGRICULTURAL SYSTEM IN ROMANIA'S TERRITORY IN THE PROCESS OF ADMINISTRATIVE REORGANIZATION

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Abstract

Territorial reorganization is a concern at the European level and of the component states in order to adapt to the requirements of contemporary society. Romania is an eloquent example in this sense because of the major imbalances of all kinds which have been accumulated between Romania's counties based on an outdated model of territorial organization having serious socio-economic and political implications. In this context, the paper aimed to find a performant, optimized and balanced solution through a new approach based on the principles of the concept of "societal bioharmonisation". A conceptual and methodological mechanism is described which is based on the evolution of the development in the convergence with natural resources (relief, waters, forests, land categories) with food territorial security through production and agri-food potential, based on human and financial resources, with the quality of life and (through purchasing power and life expectancy) of the local community. The research methodology included: bibliographic study, data collection and processing using different procedures like: multi-criterion analysis, pointing method, weighting method, the weighted arithmetic mean, comparisons among the extreme regions etc. A series of calculation formulas were used to quantify through the necessary objective indicators and to reorganize the territory from 41 counties with huge gaps among them at present to 11 balanced departments and the capital separately as shown in the proposed new Model of territorial administrative balanced and bio-harmonized organization. The offered solution shows that by harmonizing the factors taken into account in terms of agriculture and food (for example: weighted arithmetic mean etc) a level of bio-harmonization of the administrative-territorial structures of Romania is reached with the potential integration, efficiency and balance, thus reducing the differences in the economic development and life quality. A significant decrease of the polarization of the society development and improved life quality is assured by the new Model so that the difference among the territorial units was diminished from +/- 110 % to a much smaller difference of +/- 14 %, without taking into consideration Bucharest which operates like a metropolis. In this way, the new administrative organization induces through the proposed model an optimized utilization of the resources and a greater equity by bringing closer the opportunities offered to the population throughout the country.

Key words: *agro-food system, bio-harmonization, territorial governance, resource optimization, a new model of territorial administrative organization for Romania*

INTRODUCTION

The challenges of the present make necessary research and studies on the societal reform and administrative reorganization for adapting to the current conditions. We are referring especially to the period after the year 2020. Thus, as a result of the actual overlaping crises, mainly regarding the climate change and geo-political crises (e.g. the consequences of the war in Ukraine and in the Middle East), it becomes mandatory for Romania to adapt to the new requirements and situations of the current reality. Adaptation means a better local governance which is called to contribute to the competition under the conditions national and European integration and synergy.

In this respect, scientific research is an opportunity to illustrate the possibility of strengthening and consolidation in the centralization-decentralization relationship, showing **the place of the territorial departments in governance** through territorial reorganization.

The state and its specific areas faced with the renewed challenges imposed an increased responsibility for their solution. Thus, it becomes **mandatory** to research and set up the principles, rules and effective regional and departmental solutions for a harmonized and efficient reform regarding the **administrative-territorial reorganization of Romania.**

The relevance of the agri-food pillar is decisive for balancing food safety and security, leading to the specific contribution of all the regions (departments) and avoiding the food crisis. This undesired crisis may appear as a result of the negative synergies of todays' major problems such as: the acute lack of fertile agricultural land, uncontrolled deforestation, biodiversity degradation, drought and the lack of drinking water, demographic evolution etc. and all of these under the conditions of climate, economical, social and geo-political changes.

In this context, **the objectives of this research** are the evaluation and quantification of the actions aimed at the balanced and bio-harmonized reorganization of the territory, based on the natural and human resources for assuring food security and Romania's sustainable development.

All these through the existential "spring" of **food production** ("geo-eco-bio" with harmonization with the maximized performance of the agri-food system) and **the establishment of the principles** necessary for *the centralization-decentralization ratio* to highlight the structure and the territorial response to the ecological and demographical challenges, reducing the current imbalances among the counties of Romania through a new territorial model with more balanced regions from an economic point of view, and also regarding the population chance for a better, fair and ethical life quality throughout the country.

Current situation

In a thematic approach based on the main findings provided by the current state of the regionalization in Europe [44], the trends and perspectives lead to open questions about the future of the regions in the European landscape, and more broadly, the role of the national and sub-national authorities in shaping the continent. Hence, the concern regarding the administrative compatibility in the centralization-decentralization relationship along the axis: "national (departmental)-transnational-regional (Euro-regions) - continental (European)".

The status of regionalization and multi-level governance in the European countries represents a major concern of the EU and directly of the Assembly of the European Regions (ARE), especially in the idea of a more efficient use of the European financial funds.

In this context, as premises specific to Romania, a paradox can be noted, but also a series of disharmonies linked to the territorial administrative organization. These have serious socio-economic and political implications which require an immediate reform, because, as already stated, Romania is still organized at present according to an old model and with small adjustments for over 55 years (since 1968). It is noted, on the one hand, that, demographically, Romania has major problems (naturally decreasing population, unprecedented emigration in the last decades, the increasingly poor quality of education, especially through school dropouts etc, that require rebalancing solutions and providing opportunities. On the other hand, the problem is aggravated by the outdated territorial administrative organization with 41 counties, 103 municipalities, 2,862 communes, 216 cities (of which some are wrongly classified, some are in involution and some are even completely abandoned) [9].

It inevitably results in administrative management problems, with systemic effectiveness and economic efficiency strongly affected. In this respect we can mention the high number of "elected officials" in relationship with the population at different levels: country, regions, counties, cities, communes and also the irregularities in the administration of budget or European funds due to the lack of administrative reform, poor digitization and excessive politicization.

But, important and beneficial achievements in Romania regard a series of adjustment actions along the lines of "Rural Development and Regional Agriculture Policies". This happened in the context in which the country benefited from cohesion funds to support vulnerable agricultural areas within the sporadic territorial reorganization and rural development projects. In certain counties, such as in the region of Moldova and Muntenia, these funds were

PRINT ISSN 2284-7995, E-ISSN 2285-3952

directed to agri-food infrastructure (local markets, storage facilities, food processing centers) that would ensure a sustainable local market for small and medium producers.

But, analyzing Romania compared to the other European countries, it appears (perhaps a little exaggerated) as a poorly developed country, which requires a conceptual and methodological remedy, a situation in which the proposals to renew the territorial administrative organization become not only timely, but and of utmost urgency.

Literature review

This research on the process of territorial administrative reorganization regarding the agri-food sector is based on a large study of key publications on concerns, topics and policies from the last decades. They are approached both at the European level and also regard various regions or countries.

The main directions have been sustained by personalities and their publications, for example: „Agricultural policy, food policy, agri-food policy" [26]; „Spatial components, forms and geographical processes of identities" [8]; „Regions and Regionalism in Europe" [21]; „Feeding Humanity. Major problems of the world agriculture in the 21st century" [31]; „Food policy. Integration of health, environment and policy"[25]; „ The global food system. Concepts and methods, analyses and dynamics" [36]; „Reconnection of agriculture and food in the territories: dynamics and challenges" [24]; „How to promote healthy food within the intercommunities?" [2]; „The region: from identity to citizenship" [14]; „Local geopolitics – Territories, actors, conflicts" [39]; „Europe of the regions: what return?" [30].

For Romania, a benchmark can be France, which is relatively similar in terms of agri-food sector, a country which has also carried out territorial administrative reforms taking into account this branch of basic economic activity directly related to resources.

Thus, **the French Model** has managed to effectively support the agri-food sector through administrative-territorial organization. This demonstrates how territorial organization can assure a sustainable, equitable and adapted agri-food system to the local needs, which allow regions to promote their agricultural specificity and culture. Among the publications which analyzed the French model and with applicability for Romania could be mentioned: „Geohistory of regionalization in France" [28]; „Territoriality of the French food policy: the vision of the public actors on governance PNNS" [18]; „The politicization of the peri-urban agricultural question in France: reference points" [4]; „White Chart regarding food governance" [20]; "A new map of the French regions", geoconfluences.ens-lyon.fr, Géoconfluences [7]; „Big Bang Territorial: regional reform under debate" [5].

Among other important publications regarding the reorganization of agri-food sector at the territorial level for various zones of France there are: The agricultural program for Grenoble [1],

The referendum on the territorial collectivity [22, 29], Geopolitics of Alsace [23], agrarian territory of Stephanoise [38], When France cried Alsace-Lorraine [40], Alsace atlas [43], Innovations traditionnelles dans le système alimentaire francilien [41].

Other researchers studied the territorial reorganization in relationship with the short supply chains and the peri-urban and urban agriculture development: collective practices for direct sales [3], food for urban societies [6], spatial components, forms and geographical processes of identities [10], the figures of the emergent city [12], agrarian policy of Lyon [11], from peri-urban to urban agriculture [13], short supply chains [27], peri-urban agriculture Lyon [32], rethinking the supply dimension, closer to "plate" [33, 35], peri-urban agriculture and decentralization [37, 42].

MATERIALS AND METHODS

To attain the objectives of this research work**,** the data had to be collected from various official information sources, then the strategy of analyzing was established and also the work techniques based on statistical methods, multi-criterial analysis, pointing and weighting method.

For this study, the data have been provided by the National Institute of Statistics. Also, there

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

were used maps, legal and administrative documents.

A large range of specific indicators were used and calculated for making comparisons and the results were tabled and graphically illustrated.

The applied methodology quantifies the balance of the regions using objective indicators which express the contribution of various resources which sustain the perennial existence of the territorial organizational units foreseen, but also the life quality of the citizens in the proposed territorial structures.

Multi-criterial analysis/AMC [34], respectively the *pointing method* and *weighting method*.

The matrices of performance provide 3 stages:

(1) ***Pointing:*** a stage in which the expected consequences receive each one separately a number of points on a scale of the preference level for each option for each criterion;

(2) ***Weighing:*** the stage in which numerical weights are assigned to define, for each criterion, the relative estimates of the oscillations between the lower limit and the upper limit of the chosen scale;

(3) ***Quantification of indicators through the weighted arithmetic mean*** **(Mp)**, as follows: [45]:

$$Mp = \frac{a_1 \cdot p_1 + a_2 \cdot p_2 + \ldots + a_n \cdot p_n}{p_1 + p_2 + \ldots + p_n} \quad (1)$$

where:

$\mathbf{a_1, a_2, ..., a_n}$ represent the numbers,

$\mathbf{p_1, p_2, ..., p_n}$ represent the weights.

RESULTS AND DISCUSSIONS

The present territorial organization is based on the division of counties and comes from the reorganization in 1968, with minor changes over time, i.e. over half of century in which the Romanian society has evolved rapidly, needing a commensurate adaptation of the way of administering the country's area.

(A)Chalenges and diagnosis of the Romanian agri-food system

Romania' agri-food system has been facing various challenges during the last years being influenced by factors such as: climate changes, the global geo-political context and the EU agricultural policy and local policies. All these indicate the need of a better organization and performance in agriculture, and at the same time, the need to be directly and indirectly supported by ***reforms and a balanced territorial reorganization*** imposed by the raising of the potential for solving the mentioned challenges

Romania's agri-food system is characterized by multi-factorial causes and by a polivalent situation with considerable challenges, but also with important opportunities for medium and long term development.

This complexity shows that the solution requires a strategy based on the rethinking of the Romanian territorial organization. A short diagnosis and the challenges the agri-food system is facing indicate the solution of the problems in harmony at the central and territorial level, concerning:

- Agricultural production, in relation to the problems caused by drought and climate change, non sufficient irrigation systems, high potential for organic agriculture;

-Animal sector is required to solve meat and dairy products output, the African Swine Fever, the Plague of Small Ruminants, Avian Influenza etc.

-Agricultural policies established at the EU level and in Romania;

-The negative impact of the war in Ukraine regarding the invasion of the imports (cereals, poultry meat, eggs, honey etc) which imbalanced the domestic agri-food market and raise the prices disadvantaging the Romanian producers and consumers;

-The export corridors for Ukrainian cereals have disturbed the normal traffic on the roads and activity in the harbour of Constanza;

-The European subsidies and also the subsidies offered by the Romanian Government have been given per surface unit and not in accordance with the results and performance of the agricultural holdings, favouring only a few categories of units and marginalizing the largest number of farmers. This reflect the need of a reform of subsidies and passing to a new system based on results and performance.

-Digitization in agriculture is still at the beginning, involving first the large agricultural holdings which have financial resources;

-Food prices have exploded affecting the daily basket of the consumers and also inflation with its negative influence.

-The incapacity of agriculture to produce as much output to cover the domestic market, the self sufficiency rate being below 100% for many products, except cereals, oil seeds and honey.

-For this reason, imports of processed foods are higher and higher to cover the population needs, but affecting local producers.

-Also, the limited access to financing is another challenge.

-Export is a good alternative for improving the agri-food trade balance, but the higher and higher competition in the EU and international market oblige the Romanian exporters to supply more food products involving a larger gross value in order to get a higher price.

-Agro-tourism is an efficient alternative for increasing jobs and incomes in the rural localities and contribute to the sustainable development of local communities.

The agri-food and societal problems could be solved only by finding optimal solutions, including the bio-harmonization of the territorial organization of Romania based on the principle of *„centralization-decentralization”.*

In Romania, there have been several territorial reform initiatives and projects with an emphasis on agri-food and rural development, but many of them have NOT been implemented on a large scale, remaining in the phase of proposals and pilot projects.

(B)Ethical and sustainable territorial reorganization

The afore mentioned actually support the idea of territorial food sovereignty which is based on the definition recognized in 2018 by the United Nations Declaration as *"the right of peoples to healthy and culturally appropriate food produced with sustainable methods, as well as the right of peoples to define their own agricultural and food systems".* Since then, this notion has been used in many senses, often reclaimed and diverted. When used by governments, for example, sovereignty now justifies all environmental and social regressions for the benefit of competitiveness in deregulated global markets.

In this research work ***the paradigm of the food sovereignty*** is approached as **an item expressed at the territory level and local community level,** starting from the fact that we intend to assure a harmonious reorganization of Romania's territory.

Based on the principles of bio-harmonism, we try to reconnect agriculture to local foods *for sustaining in a balanced manner* the new territorial departments proposed.

For each department (region) there were considered **5 levers to achieve food sovereignty:**

(a)Avoiding industrial agriculture's dependence on imports;

(b)Transition to food autonomy: diversification of production for local consumption and specificity;

(c) Re-analysing or existing free trade treaties and preserving the "global peasantry";

(d)Ensuring a decent income for farmers;

(e)Accelerating the transition to agro-ecological system to ensure long-term food sovereignty.

This needs to set up a new agri-food policy, which to promote the agri-ecological transition destined to guarantee the farmers' capacity to produce more and of higher quality products to satisfy consumers' requirements. To set up this new sustainable agri-food system, the local communities, citizens and farmers have to give their contribution with concrete and efficient solutions for a decentralized territorial organization at the regional level.

The model of territorial reorganization of Romania is based on the following principles:

-The principle of multi-level and multi-criteria territorial balance;

-The principle of harmonizing the diversity of resources;

-The principle of debureaucratization and optimization of the centralization-decentralization ratio;

-The principle of minimizing disadvantages and risks.

The hypothesis for carrying out **a balanced model, sustained by a comprehensive and integrative mechanism,** described as *„mechanism of bio-harmonization*” in "Theory of Bio-harmonism" [15].

The expected results anticipates that the research will provide clear data about **bio-harmonization** of life and society, ecosystems and anthropo-systems and its role in the balance, viability, yield and societal resilience through the administrative-territorial reorganization of Romania.

Criteria to approach the research for assuring a bio-harmony from a geographical, demographical, socio-economical and ecological point of view. According to [17], two criteria: natural and human capital must be taken into consideration for reoptimizing the territorial organization as follows:

(a)Natural capital regards: land surface and quality, agricultural land structure (arable, orchards, vineyards, pastures and meadows etc) and production potential, relief, forests, climate, environment health;

(b)Human capital regards: population size, demographic indicators (age and education structure), employment, labour productivity, income, purchasing power, life expectancy.

Natural potential capital of the considered region ***was evaluated using 4 criteria***: land surface and quality, relief, forests and agricultural potential, and within these 4 criteria, there are 6 componets whose weight is differently depending on the importance in the developmnet of the region. All these aspects are described in Table 1.

Table 1. Weighted criteria of the simplified and optimized model of territorial organization

TOTAL LAND		**RELIEF**		**FORESTS**		**AGRI-FOOD POTENTIAL**	
Surface (km^2)	***Points (a)***	***Categories***	***Points (a)***	***Share in the total surface of the territorial unit***	***Points (a)***	***Category***	***Points (a)***
Up to 17,500	1	*Mountains*	1	< 10 %	1	*Total utilized agricultural area -UAA*	**2**
17,501-20,000	2	*Hills*	1	10-20 %	2	*Arable land*	**4**
20,001-22,500	3	*Highlands*	1	20-30 %	3	*Family gardens*	**1**
22,501-25,000	4	*Plain*	1	30-40 %	4	*Pastures and meadows*	**3**
25,001-27,500	5	*Wet areas*	1	40-50 %	5	*Permanent crops (ex.vineyards, orchards etc)*	**2**
27,501-30,000	6	*The Danube Delta*	1	> 50 %	6	*Forest cultures (tree nurseries)*	**x**

Source: Own calculation.

The described ones were applied, namely the established principles. The working hypotheses and the mechanisms for implementing the predetermined objectives were fixed, so that it was possible to process the primary data collected on this topic [19, 46]. Although not all initiatives are part of an extensive administrative reform, they contribute to the better integration of agriculture in territorial planning and rural development. All these can constitute benchmark elements for the directions pursued and for the quantification of some indicators.

Based on this consideration, the reference items were selected and analyzed both for the current counties and for the proposed regions (departments). In the end, **the maximum limits** regarding polarization (the gap) can be observed, finding along the research analyzes that: in the current administrative organization, the maximum gap is **very pronounced** between the counties of Cluj and Tulcea, and in the territorial reorganization that we propose it is found **much attenuated** between the departments of Transilvania Nord and Crisana.

Evaluation of the gap by grouping and establishing the elements concerning the contribution level of the proposed departments

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Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

The new model aims a territorial administrative reform which imply the creation of new territorial structures named: regions, departments, etc, which to be administrated by elected authorities with claire functions and which could also have the task to manage the European funds. This imposes a Conceptual Renewal regarding the administrative structure of Romania's territory, the new model involving ***items, principles, mechanisms of the bio-harminist ideology*** [15, 16], meaning a socio-economic and also a psichological "unlocking".

Item 1. A corect and ethical involvement of the Government in the implemantation of the EU rules in relationship with the concrete conditions of Romania.

Item 2. Imposing meritocracy by objective criteria and a high profesional level for absorbing the EU funds.

Item 3.Sustaining financial mechanisms and banks or programmes specialized in the development of territorial structures based on decentralization.

Item 4. The juridical rethinking of the public administration by coherent legislative changes.

Item 5. Digitization and education focused on organizational culture**.**

Item 6. Depolitization of administration and an increased transparence in the maangement of national and EU financial funds.

The actual territorial organization in Romania has a series of imbalances, coming from its history.

Fig.1. Romania's actual territorial-administrative organization
Source: https://www.google.com/, Accessed on October 25, 2024 [46].

On January 2nd, 1919, the Dirigent Council of Transilvania decided the administartive organization of the territories united with Romania.

Since 1968, Romania has 41 counties, plus the municipality of Bucharest, which has a special status of an administrative-territorial unit (Figure 1).

Along the time, major imbalances have appeared among the counties [46]. Just an exemple is enough to explain a major unbalance. In 2019, the GDP variation among the counties accounted for Lei 763,774, without taking into account Bucharest + Ilfov county GDP (Table 2).

Table 2 shows that the differences among the counties are very high, expressed synthetically by means of GDP. The gap among counties ranges between - 110 % and + 110 %. Taking into account these huge differences between the counties, it is normal to think that the financial flow and investments are deeply affected, and also the living standard, and all these justify the need of a new territorial reorganization.

Despite it does not fit to Romania's Constitution to approach the territorial organization based on racial, ethnic, religious, gender, sexual orientation etc, we mention that it is compulsory to be **a balanced principle regarding all these**.

Taking into account **the ethnic structure,** bio-harmonization could be discussed in the counties with a high share of national minorities like Harghita and Covasna, where the Romanian citizens of Hungarian ethnicity have a very high share compared to the Romanian citizens.

The solution of territorial-administrative reorganization given in our research indicate a balanced ethnicity by creating the Department "Carpatica" where the ethnic share decrease from 80% for minority population to almost 50% (Table 3).

Figure 2 present the imbalance among two counties with extreme gap value, Cluj and Tulcea, based on the multi-criterial analysis..

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Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 2. An example of imbalances in the actual territorial organization of Romania (County GDP in 2019)

Counties with "extreme GDP"	**GDP (Lei Million)**	**Variation around the avergage gap**	**Extreme GDP versus gdp average**
Cluj	50,421	264 %	264 - 154 = + 110 %
Tulcea	8,120	43 %	43 - 154 = - 110 %
GDP average per county (Bucharest excluded)	763,774 Thousand Lei: 40 counties = 19,094.35 (Average value as reference term of 100 %, versus which are compared GDP values registered by all the other counties	100 % **Gap average: (264 +43) / 2 = cca. 154 %**	High variation around the avergae gap, between **- 110 % and + 110 % !!**

Source: Own calculation.

Table 3. The balanced and synergic ethnic and religious componence of "Carpatica" Department (including the counties Brasov, Covasna, Harghita and Mures)

ETHNICITY	**BRAȘOV**	**COVASNA**	**HARGHITA**	**MUREȘ**	**AVERAGE BY DEPARTMENT**
Romanians	87.3	23.0	16.0	53.3	45.0
Hungarians	8.7	71.8	82.9	39.3	50.7
Germans	0.8	0	0	0	1.0
Other ethnicity (Roma included)	3.3	5.1	1.2	7.4	3.3

Source: Own calculation.

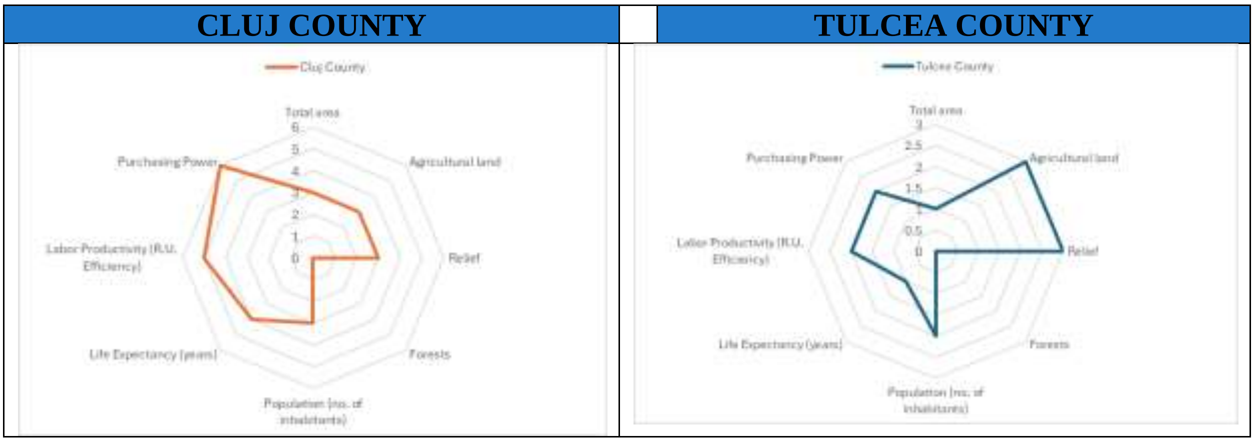

Fig. 2. The comparative image through multicriteria analysis in the case of the current administrative organization, illustrating major imbalances between extreme territorial structures
Source: Own calculations.

The variants of the resulting solutions allowed to chose the **Model of administrative reorganization with 12 territorial structures,** including: 11 Departments and the Municipality of Bucharest, as described in Fig. 3.

The arguments which sustain our model proposal are shown in Table 4, where it is made a comparison between the 11 new regions and separately, Bucharest, which had a different evolution based on the principles of a great metropolis. Within the calculation stages, a series of intermediary tables have been made. The most important is the **Table reflecting the agri-food potential.**

Cumulating the surfaces of arable land, family gardens, pastures and meadows, permanent crops (orchards, vineyards etc) for each new established region, it was possible to determine the share of the potential for feeding the population depending on the total surface of the region, and the obtained percentages have been divided by 6 groups, as presented in the cassettes from Table 4.

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PRINT ISSN 2284-7995, E-ISSN 2285-3952

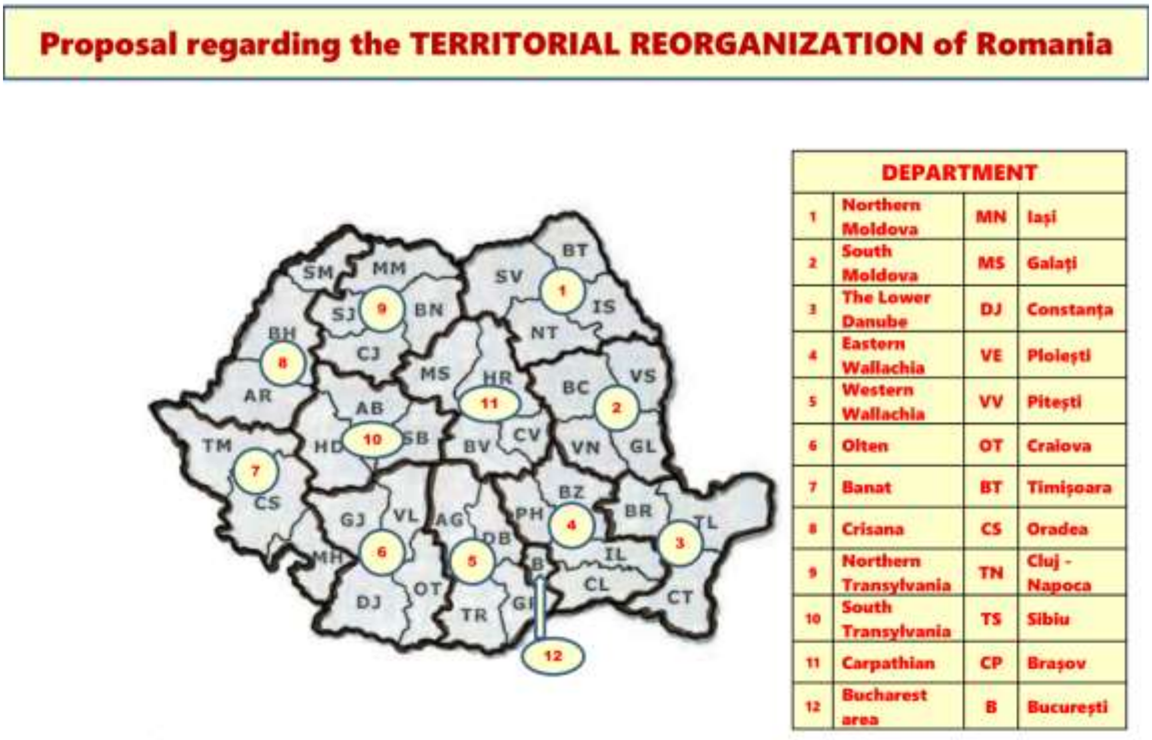

Fig. 3. Proposed Model of territorial administrative reorganization of Romania, 2024
Source: Own conception.

Table 4. Cassettes with the calculations reflecting the share in the total agricultural land of each group group

Agricultural land % of the total	Below 40	40-49	50-59	60-69	70-79	Over 80
Group:	1	2	3	4	5	6
No. regions in the proposed model	-	3	4	3	-	1

Source: Own calculations.

Human capital taken into consideration in this MODEL

For analyzing the potential of human resource capital in the 11 regions, there were taken into consideration 3 criteria: population density (number inhabitants per km^2), productivity in terms of GDP per region and inhabitant and the labour efficiency as contribution to the territory (GDP region/km^2), and for the life quality, life expectancy and purchasing power. The obtained values allowed to continue the calculations by applying the weighting method, resulting 6 levels as shown in Table 5.

Table 6 centralizes and groups the criteria depending on the "pointing" and " weighting" stages.

Applying the formula of the arithmetic weighted mean, we calculated with the aid of the numbers from "Pointing" ($a_1, a_2, ..., a_n$) and with the fixed weights ($p_1, p_2, ..., p_n$), the averages for the main groups of criteria connected to life quality: natural capital, human capital (Table 7 and 8).

Table 7 presents the quantification of natural capital of the new departments and also shows how the arithmetic weighted mean was determined.

Table 8 shows quantification of human capital of the new departments and also how the arithmetic weighted mean was calculated for which of the new administrative units in the territory.

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PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 5. The results for the Model based on the population density, GDP/inhabitant, life expectancy and purchasing power

Population (Mil. capita)	**1.00 - 1.99**	**1.20 - 1.39**	**1.40 - 1.59**	**1.60-1.79**	**1.80 - 1.99**	**Over 2.00**
Group	1	2	3	4	5	6

GDP (Mil. Lei)	**Below 60**	**60-64**	**65-69**	**70-74**	**75-79**	**Over 80**
Group:	1	2	3	4	5	6

Life expectancy for male	**69.29-70.55**	**70.56-71.38**	**71.39-72.25**	**72.26-73.60**	**73.61-75.06**
Group average	70	71	72	73	74
Life expectancy for female	**77.02-77.78**	**77.79-78.49**	**78.50-79.08**	**79.09-79.82**	**79.83-80.76**
Group average	77.5	78	78.5	79	80

Longevity (years	**74.50 -74.74**	**74.75 -74.99**	**75.00 -75.24**	**75.25 -75.49**	**75.50-75.74**	**Over 75**
Group	1	2	3	4	5	6

Index of Purchasing Power (Methods Gfk, 2018)	**sub 75**	**75 – 79**	**80 - 84**	**85 - 89**	**90 - 94**	**95 and over**
Group:	1	2	3	4	5	6

Source: Own calculations.

Table 6. „Pointing” („a”) and weighting” („p”) of the criteria of the basic resources for quantifying the weighted average

Department		NATURAL CAPITAL				HUMAN CAPITAL			
		Total surface	Agricultural land	Relief	Forests	Population (no. inhabitants)	Life expectancy (years)	Efficiency of the activity R.U.	Puchasing power
	p	Weight (p) 1	Weight (p) 2	Weight (p) 1	Weight (p) 2	Weight (p) 1	Weight (p) 2	Weight (p) 3	Weight (p) 2
		$p_1 + p_2 + p_3 + p_4 = 1+2+1+2 = 6$				$p_1 + p_2 + p_3 + p_4 = 8$			
	a	Points (a)	Points (a)	Points (a)	Points (a)	Points (a)	Points (a)	Points (a)	Points (a)
		Total surface	% agric. area of total surface	Presence number of relief forms					
Moldova North		3	3	4	3.75	6	3	3	2
Moldova South		2	3	5	3.25	5	2	2	3
Dunărea de Jos		2	4	4	1.67	2	2	3	4
Valahia East		1	6	4	2.25	5	2	5	3
Valahia West		2	4	5	2.75	4	2	3	3
Oltenia		3	3	5	3.50	5	4	2	3
Banat		2	3	4	3.67	2	3	3	5
Crişana		1	4	4	2.67	2	1	2	6
Transilvania North		2	2	3	3.75	4	4	5	6
Transilvania South		1	2	3	4.33	1	5	3	6
Carpatica		3	2	3	4.25	3	5	3	5

Source: Own calculations.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 7. Quantification of natural capital of the new departments

DEPARTMENT	Calculus of the arithmetic weighted mean	M_p
Moldova North	M_p = (3 x 1+ 3 x 2 + 4 x 1 + 3.75 x 2) / 1 + 2 + 1 + 2 = 20.50 / 6	**3.42**
Moldova South	M_p = (2 x 1+ 3 x 2E+ 5 x 1 + 3.25 x 2) / 1 + 2 + 1 + 2 = 19.50 / 6	**3.25**
Dunărea de Jos	M_p = (2 x 1+ 4 x 2 + 4 x 1 + 1.67 x 2) / 1 + 2 + 1 + 2 = 17.34 / 6	**2.89**
Valahia East	M_p = (1 x 1+ 6 x 2 + 4 x 1 + 2.25 x 2) / 1 + 2 + 1 + 2 = 21.50 / 6	**3.58**
Valahia West	M_p = (2 x 1+ 4 x 2 + 5 x 1 + 2.75 x 2) / 1 + 2 + 1 + 2 = 20.50 / 6	**3.42**
Oltenia	M_p = (3 x 1+ 3 x 2 + 5 x 1 + 3.50 x 2) / 1 + 2 + 1 + 2 = 21.00 / 6	**3.50**
Banat	M_p = (2 x 1+ 3 x 2 + 4 x 1 + 3.67 x 2) / 1 + 2 + 1 + 2 = 19.34 / 6	**3.22**
Crişana	M_p = (1 x 1+ 4 x 2 + 4 x 1 + 2.67 x 2) / 1 + 2 + 1 + 2 = 18.34 / 6	**3.06**
Transilvania North	M_p = (2 x 1+ 2 x 2 + 3 x 1 + 3.75 x 2) / 1 + 2 + 1 + 2 = 16.50 / 6	**2.75**
Transilvania South	M_p = (1 x 1+ 2 x 2 + 3 x 1 + 4.33 x 2) / 1 + 2 + 1 + 2 = 16.66 / 6	**2.78**
Carpatica	M_p = (3 x 1+ 2 x 2 + 3 x 1 + 4.25 x 2) / 1 + 2 + 1 + 2 = 18.50 / 6	**3.08**

Source: Own calculations.

Table 8. Quantification of human capital of the new departments

REGION	Calculus of the arithmetic weighted mean	M_p
Moldova North	M_p = (6 x 1+ 3 x 2 + 3 x 3 + 2 x 2) / 1 + 2 + 3 + 2 = 25 / 8	**3.13**
Moldova Soith	M_p = (5 x 1+ 2 x 2 + 2 x 3 + 3 x 2) / 1 + 2 + 3 + 2 = 21 / 8	**2.63**
Dunărea de Jos	M_p = (2 x 1+ 2 x 2 + 3 x 3 + 4 x 2) / 1 + 2 + 3 + 2 = 23 / 8	**2.88**
Valahia East	M_p = (5 x 1+ 2 x 2 + 5 x 3 + 3 x 2) / 1 + 2 + 3 + 2 = 30 / 8	**3.75**
Valahia West	M_p = (4 x 1+ 2 x 2 + 3 x 3 + 3 x 2) / 1 + 2 + 3 + 2 = 23 / 8	**2.88**
Oltenia	M_p = (5 x 1+ 4 x 2 + 2 x 3 + 3 x 2) / 1 + 2 + 3 + 2 = 25 / 8	**3.13**
Banat	M_p = (2 x 1+ 3 x 2 + 3 x 3 + 5 x 2) / 1 + 2 + 3 + 2 = 28 / 8	**3.50**
Crişana	M_p = (2 x 1+ 1 x 2 + 2 x 3 + 6 x 2) / 1 + 2 + 3 + 2 = 22 / 8	**2.75**
Transilvania North	M_p = (4 x 1+ 4 x 2 + 5 x 3 + 6 x 2) / 1 + 2 + 3 + 2 = 39 / 8	**4.88**
Transilvania South	M_p = (1 x 1+ 5 x 2 + 3 x 3 + 6 x 2) / 1 + 2 + 3 + 2 = 32 / 8	**4.00**
Carpatica	M_p = (3 x 1+ 5 x 2 + 3 x 3 + 5 x 2) / 1 + 2 + 3 + 2 = 32 / 8	**4.00**

Source: Own calculations.

Table 9. Integrator Index of bio-harmonization of the territorial unit according to the proposed Model of organization for the territorial unit

Department	**Potential polivalent of the new departments**			**Variation around the gap average**	
	Natural Capital	Human Capital	Polivalent Sum	Variation versus the average of the departments (6.59 p = 100%)	Variation versus the gap average (102 p.)
0	1	2	1+2	%	%
Moldova North	3.42	3.13	6.55	99.39	99.39 - 102 = - 2.61
Moldova South	3.25	2.63	5.88	89.23	89.23 - 102 = - 12.77
Dunărea de Jos	2.89	2.88	5.77	87.56	87.56 - 102 = - 14.44
Valahia East	3.58	3.75	7.33	111.23	111.23 - 102 = + 9.23
Valahia West	3.42	2.88	6.30	95.60	95.60 - 102 = - 6.40
Oltenia	3.50	3.13	6.63	100.61	100.61 - 102 = - 1.39
Banat	3.22	3.50	6.72	101.97	101.97 - 102 = - 0.03
Crişana	3.06	2.75	5.81	88.16	88.16 - 102 = - 13.84
Transilvania North	2.75	4.88	7.63	115.78	115.78- 102 = + 13.78
Transilvania South	2.78	4.00	6.78	102.88	102.88 - 102 = + 0.88
Carpatica	3.08	4.00	7.08	107.44	107.44 - 102 = + 5.44
Total polivalent evaluation	x	x	72.48	x	x
Average potential per department	x	x	6.59	x	x
Extreme values	2.75 to 3.58	2.63 to 4.88	5.77 to 7.63	88.16 to 115.78	x
Gap variation	-/+ 13 %	-/+ 30 %	X		-14 % ... + 14%

Source: Own calculations.

Once the basic values are quantified regarding the natural capital and human capital of the new departments, these values could be processed based on the principles of bio-harmonization in order to assess the balance of the resources among the new regions (Table 9 and 10).

Figure 4 presents the rebalance and bio-harmonization in the territorial administrative organization of Romania using the multi-criteria analysis of the extreme departments of the gap.

NORTHERN TRANSYLVANIA DEPARTMENT	CRISANA DEPARTMENT

Fig. 4. The comparative image through multicriteria analysis in the case of administrative reorganization, illustrating a substantial balancing between extreme territorial structures.
Source: Own calculations.

Making a comparison between Table 2 and 8, in other words at the beginning and at the end of the analysis, we noticed that the gap between the actual administrative structures and the new structures proposed in our MODEL is significant smaller, which reflects a correct balance between the departments proposed in this study (Table 10).

Table 10. The degree of balance and territorial bio-harmonization by reducing the differences among the departmental proposed structures

Territorial administrative organization	***-GAP VARIATION -***			
	NATURAL CAPITAL	**HUMAN CAPITAL**	**GAP OF THE MODEL**	**Reduction of polarization**
ACTUAL MODEL (Counties)	x	x	-/+ 110 %	110 : 14 = 7.86
PROPOSED MODEL (Departments)	-/+ 13 %	-/+ 30 %	-/+ 14 %	***Conclusion:*** ***In the new model, the territorial situation is balanced almost 8 times!***

Source: Own calculations.

CONCLUSIONS

The conducted research looking to establish a new territorial administrative organization based on a balanced MODEL regarding natural capital and human capital have led to the following main conclusions:

-It is necessary the reorganization of Romania's territory in order to solve the actual polarization among the counties. Some imbalances are major and regard: a double surface (8,700 km^2 versus 3,700 km^2) and 3.5 times concerning the population (772,000 inhabitants versus 211,000), and the differences in terms of GDP are even of 5 times (50,000 Million Lei versus 9,500 Million Lei). In addition, between Bucharest and the counties, the county average is 15 times smaller than the capital mean.

-The management of the internal and European funds in legal conditions could allow the proposed model of territorial organization, which provides the creation of new territorial units named: departments, lands, regions etc, the most frequently utilized term being *„administrative departments with a large basis of decentralization”,* respectively units with elected leaders and claire functions (managerial, economic, financial, traditional/cultural). In this respect we nominate: Moldova North (MN with the capital Iași), Moldova South (MS with the capital Galați), Dunărea de Jos (DJ with the capital Constanța), Valahia East (VE with the capital Ploiești), Valahia West (VV with the capital Pitești), Oltenia (OT with the capital Craiova), Banat (BT with the capital Timișoara), Crișana (CS with the capital Oradea), Transilvania North (TN with the capital Cluj-Napoca), Transilvania South (TS with the capital Sibiu), Carpatica (CP with the capital Brașov) and Zona București (B).

-The territorial structures of the proposed Model, named Departments are well balanced by polivalent harmonized criteria, as follows:

- *like surface:* between about 19,000 - 25,000 km^2 with an average of about 22,000 km^2;

-*like population:* between 1.1 - 2.3 million inhabitants per region, with an average of about 1.7 million inhabitants/region;

-*like density:* between 60 -90 inhabitants/km^2, with a national average of 82.50 inhabitants/km^2;

- *like regional GDP*: between 58 Billion - 87 Billion with an average of 72 Billion per region (except Bucharest zone with 276 Billion.

-The proposed Model for territorial organization, being based on objective criteria and bio-harmonism mechanisms (integration, efficiency, balancing, chance equity) carried out an attenuation of the imbalances between the actual territorial structures. The proposed Model reduces the number of 41 counties plus the Municipality of Bucharest to 11 departments plus Bucharest, assuring a much better balance among the new administrative department structures by a significant reduction of the polarization of the societal development and regarding life quality. The results proved that the reduction is 8 times, from a difference of +/- 110 % to a much smaller difference of +/- 14 %, without taking into account Bucharest area, which as a metropolis has its own rules and different criteria for a special development.

ACKNOWLEDGEMENTS

Many thanks to the Academy of Romanian Scientists for the opportunity offered us to give our contribution of the research Programme "Romania of Knowledge" and based on a scientific competition for financing our Project entitled: "Evaluation of the agri-food pillar regarding the systemic bio-harmony of natural resources with human performance, in the process of administrative-territorial reorganization of Romania" (acronym AGRATER) and with the subject's framing under the theme: High-performance and ecological agriculture, the proposal being initiated within Section 7- Agricultural Sciences, Forestry and Veterinary Medicine.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

TRENDS REGARDING DEVELOPMENT THE SUSTAINABLE WINE TOURISM IN THE REPUBLIC OF MOLDOVA

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Abstract

The country's winegrower entrepreneurs have discovered a new opportunity to expand their core business by serving tourists. The tourists of wine businesses have changed. Nowadays visitors to wineries are not only wine experts. This refers to consumers attracted by new activities, such as discovering new scenic spots, sporting and cultural activities. These changes bring an increase in the number of tourists to wine producing regions around the world. In this context, the purpose of the paper is to identify and analyze the current trends and developments in the wine tourism sector in Moldova, focusing on sustainable practices. We use academic articles, industry reports, and case studies to gain insights into international trends in sustainable wine tourism and compare them with Moldova's current situation. Tourists' appreciation of wine tourism is also shaped by sociological surveys. Enhanced marketing strategies in wine tourism enable wineries to strengthen their communication and increase their global visibility.

Key words**:** *wine, tourism, wineries, winemaking, Republic of Moldova*

INTRODUCTION

Wine tourism in the Republic of Moldova, while still a developing economic sector, has emerged as a competitive and vibrant industry that attracts significant interest from tourists and effectively showcases the country's rich heritage. However, its growth hinges on addressing certain limiting factors [6, 30, 7]. Currently, one in four active citizens—approximately 150,000 people—are directly or indirectly involved in the wine industry, which contributes 3% to the nation's GDP and accounts for 8% of its exports [10]. Moldova ranks 16th globally in vineyard area and stands as the largest foreign vineyard in Eastern Europe, outside the EU [6, 25, 11, 9].

Winemakers from the Republic of Moldova have created and produce over three thousand names of wine products, among the most varied, from aperitifs, national strength, vodka, liqueurs to divine, sparkling, still white, red, rosé, dry and dessert wines, ice wine, and even whiskey, gin, rum and other exotic drinks. The wines, the sparkling wines, the divine wines of local producers have obtained hundreds of the most prestigious awards at most of the international exhibitions and competitions where they have been presented, and are in great demand by more than 55 countries [4, 26, 16, 23].

Since 2002, under the initiative and patronage of the President of the Republic of Moldova, the National Wine Festival has been organized, featuring around 80 wineries and catering companies. The event attracts not only locals but also foreign tourists from various countries participate in the celebration, including: Austria, Bulgaria, Belgium, Holland, Germany, Romania, France, Italy, USA, Turkey, Czech Republic and others. The maximum number of foreign countries present at the National Wine Day was 67 countries. The festival program includes the holding of various competitions.

The Republic of Moldova is renowned for its exceptional cellars, wineries, and underground cities. Among the most celebrated Moldovan wineries that captivate tourists is Mimi Castle, established in 1893, which is widely regarded as one of the most stunning and beautiful historical buildings in Moldova, and international specialists have included it in the top 15 architectural masterpieces in the world of wine (Photo 1).

Photo 1. MIMI Castle
Source: MIMI Castle history, https://www.epcsummit2023.md/mimi-castle, Accessed on August 5, 2024 [15].

Mircești Winery, founded in 2011, but its architecture is reminiscent of manorial mansions. The winery has its own guesthouse and offers international and domestic varieties for tasting (Photo 2).

Photo 2. Mirceşti winery
Source: Crama Mircesti, https://www.google.com/search?q=Crama+Mirceti+site&oq=Crama+Mirceti+site&aqs=chrome..69i57j33i10i160l2.4285j1j15&sourceid=chrome&ie=UTF-8#lpg=ik:CAoSLEFGMVFpcFBMMW92X1ZONVR6bWpwODA4cGJOal8yN2lJeWF1OTNieW9xd2tB, Accessed on August 5, 2024 [5].

Chateau Purcari. This winery has an important role in the history of Moldovan wine, because it offered the first international award-winning local wine in 1878. Purcari is a true oasis of beauty and tranquility, offering a unique wine tourism experience (Photo 3).

Photo 3. Chateau Purcari
Source. Chateau Purcari, https://www.facebook.com/chateau.purcari/, Accessed on August 5, 2024 [29].

Cricova Winery. A real underground city, Cricova totals 180 km of galleries, and access is also done here by small trains. Many types of wines, including award-winning sparkling wines, can be tasted in underground rooms. There is even a small cinema in the winery, to the delight of tourists (Photo 4).

Photo 4. Cricova S.A. Wine Combine
Source: Europafm.ro, Republica Moldova-Cricova-unlabirint subteran al vinului, galerie foto, https://www.europafm.ro/republica-moldova-cricova-un-labirint-subteran-al-vinului-galerie-foto/, Accessed on August 5, 2024 [8].

Winery Cricova S.A has also an extensive network of underground tunnels stretching for 120 km. The tasting complex includes five large, spacious and imposing halls: European Hall, Fundul Marii, Presidential Hall, Fireplace Hall, Great House, in which elements of classical architecture are interwoven with plastic details of modern invoice, decorative elements of great sophistication, works of art and valuable furniture. These halls serve as the venue for various national and international tastings, as well as for the highest level meetings.

Milestii Mici winery has the largest collection of wines in the world, according to the Guinness Book (Photo 5).

Photo 5. CVC ÎS Mileștii Mici wine collection
Source: Wikipedia, Milestii Mici (Vinarie), https://ro.wikipedia.org/wiki/Mile%C8%99tii_Mici_(vin%C4%83rie), Accessed on August 5, 2024 [28].

The Mileștii Mici Quality Wines Complex boasts a remarkable collection of nearly 2 million bottles, housed within a sprawling 250 km of underground tunnels, of which only 120 km are currently in use. The wines stored here are 70% red wines, with only 20% white wines and 10% dessert wines.The most valuable wine bottle in the collection was produced in 1973-1974 and is worth €480 [14, 21].

Due to their quality, many of the wines produced in the Republic of Moldova enjoy a good reputation internationally. Proof of this fact are the medals won at prestigious international competitions such as: Decanter World Wine Awards, Mundus Vini, Concours Mondial du Bruxelles, International Wine Challenge, etc.

Thus, during the period 2013-2023, Moldovan wines brought home over 6,000 medals, of which 50% are gold medals. For example, in 2020, Moldovan wines won 956 medals (417 gold, 277 silver and 169 bronze awards) at 32 international competitions. 624 of these medals were won by local winemakers whose presence at the competitions was supported by ONVV. Thus, in 2020, 65 wine companies from the country participated in the international contests with samples of wines, sparkling wines and spirits and received excellent qualifications from the foreign jurors. The leader of the ranking was the winery Fautor with a record number of medals, the top being completed by the winery Purcari Winery. Cricova, Chateau Vartely and MIMI are the wineries that continue to maintain their positions in the ranking, and Novak Winery DK Intertrade and Gitana Winery are the surprise appearances in the 2020 top [13, 19].

In this context, the purpose of the paper is to analyze sustainability initiatives adopted by Moldovan wine producers and tourism operators, such as ecological production techniques, organic vineyards, resource conservation, waste reduction and promotion of local culture and heritage.

MATERIALS AND METHODS

To examine the trends related to the development of sustainable wine tourism in the Republic of Moldova we use a well-structured research methodology and materials.

Databases such as Google Scholar, JSTOR, and industry-specific reports (Global Wine Tourism Organization) provide us valuable information.

In this research we has selected 5 wineries in Moldova known for implementing sustainable practices, such as Cricova, Purcari, and we analyzed their tourism activities, sustainability measures, and marketing strategies.

Geographic Information Systems (GIS) was used to map wine regions in Moldova and their environmental impacts. Data can be collected from Moldova's National Bureau of Statistics and environmental agencies will investigate areas vulnerable to environmental degradation and regions that are actively embracing eco-friendly farming practices. This paper's methodological framework aims to provide a comprehensive understanding of the trends in sustainable wine tourism development in the Republic of Moldova. By combining quantitative and qualitative data, analyzing both stakeholder opinions and practical case studies, the research we offer insights into how the Moldovan wine industry can grow sustainably while maintaining its rich cultural heritage.

RESULTS AND DISCUSSIONS

The findings of a study following the methodology of the World Tourism Organization and commissioned by the Ministry of Culture of the Republic of Moldova with strategic support, in collaboration with the National Association of Inbound Tourism, shed light on this matter. The study features a comparative analysis of surveys assessing tourists' perceptions of Moldova as a tourist destination in 2012, 2016, 2018 and 2023 [13, 19]. Respondents were asked what they knew about Moldova before visiting it, without being given any answer options. The top 3 things respondents in 2023 knew about Moldova are: good wine is produced in Moldova (18%), Moldova has a rich history and culture (11%) and Moldova has a historical connection with Romania and is a neighbour with it (8 %). Depending on the collection point, the tourists surveyed at Beciurile Cricova are the ones who most often mentioned good wines/cellars (31%), followed by tourists from the Airport (21%), Piata Marii Adunări Naționale (PMAN) (15%) and the Romanian crossing point (10 %). Among the factors that motivate visiting Moldova in 2023 are personal recommendations from family, friends or acquaintances (41%), followed by the accessibility of travel to Moldova (27%) and the desire to taste Moldovan wine (25%). The fact that Moldova is a wine country remains a significant influence and motivator for tourists, with 49% citing it as a reason for their visit. As for the motivations behind participating in National Wine Day, 64% mentioned the tasting of Moldovan wine, followed by visiting the stands/terraces set up by the wine producers (34%), the special events/tastings organized within the festival (34%)and buying wine (33%). In the current survey, respondents expressed a high level of satisfaction with all the mentioned aspects, the top five areas being the hospitality and kindness of the locals (91%), traditional Moldovan food (90%), the quality of food in local restaurants (89%), wines (86%) and natural landscapes (85%). Respondents were able to think of a word or phrase that came to mind when they heard tourism in Moldova. Most of the surveyed tourists, namely 42%, associated tourism in Moldova with wine. About half of the respondents state that Moldova is a country of wine that influenced their decision to visit the country to a great extent or to some extent (49%). This share increased by 6 percentage points compared to 2018 (43%) and by 3 percentage points compared to 2016 (46%). Among tourists, 51% were influenced to a great extent or to some extent to visit Moldova because it is a wine country. In contrast, the Moldovan diaspora, while still appreciating Moldova's wine identity (25% very influenced, 19% to some extent), recorded a higher percentage of those who indicated that the reputation of Moldovan wine had no influence on their decision to visit it (56%). Among respondents from events in PMAN (65%) and Beciurile Cricova (68%), the reputation of Moldovan wine had a significant influence on their decision to visit the country. Conversely, respondents at the Romanian checkpoint and at the airport were not significantly influenced by this factor (39% each).

Wine tourism has a positive impact on wine businesses, on the regions where they are located, as well as on the Republic of Moldova by contributing to:

1) valorization of rural space by ensuring recreation and tourism activity;
2) increasing the gross domestic product
3) increasing state budget revenues through tax collection;
4) increasing the incomes and respectively the profits of wine enterprises and tourism agencies;
5) employment in the region;
6) improving the infrastructure and the quality of life for citizens in rural areas;
7) attracting investments in the respective tourist towns.

Based on the research into the potential for developing wine tourism in the Republic of Moldova, we can conclude that:

1. The Republic of Moldova has an area of 112 thousand ha of vines, and in the household sector approx. 44 thousand ha of vine

plantations. More than 600 thousand tons of grapes are harvested annually in Moldova, including 100 thousand tons of table varieties.220-280 thousand tons of technical varieties are processed at wine enterprises. According to the Wine Registry, the Republic of Moldova is home to 76,205 vineyards and 309 wineries. In the Republic of Moldova, 3 types of vines are grown: European, Caucasian, native.

2. The quality of Moldovan wines is well-known and appreciated at various competitions of the world's winemakers. The distinctions and medals obtained by the winemakers are a source of pride for practically every third winemaking company in Moldova. Over the past decade, Moldovan wineries have earned 600 medals at international competitions, with half of them being gold.

3. Additionally, one in every four active citizens (150,000 people) in the Republic of Moldova is involved, either directly or indirectly, in the wine industry. Winemaking contributes 3% to the national GDP and accounts for 8% of the country's exports. In 2023 [17, 22, 20].

4. Moldova produced approximately 1.8 million hectoliters of wine, placing it 18th among the world's top wine producers.

The Republic of Moldova is ranked 16th in the world and 9th in Europe in terms of wine exports. France is the leader in the value of exports, Italy - the leader in volumes. Over 80% of the wine produced in the Republic of Moldova is exported. The main export markets are: Romania, Poland, the Czech Republic, the USA and China. The largest volumes of Moldovan wine products in 2023 were delivered to European countries 58.08%, CIS countries 29.1%, America 6.49%, Asia 6.33% [18, 1, 12].

5. In the last 20 years wine companies (about 309 enterprises) produce high quality wines, wines with geographical indication, which are in demand on the EU market, which ensures a sustainable development of both the wine sector and wine tourism. According to the Wine Tourism Guide of the Republic of Moldova, about 33 wine enterprises, representing 10.68% of all wineries, engage in wine tourism. However, the sector is experiencing growth in tourism activities [20, 24, 27].

6. The development of wine tourism brings positive economic, social, cultural, and environmental benefits to both the regions where wineries are located and the country as a whole. Guide associations in Moldova identify wineries as the leading tourist attractions, followed by historical monuments and churches. Wine tourism is highly popular, with 42% of surveyed tourists associating Moldova with its wine, and 60% of visitors to the country engaging in wine-related tourism visited at least one winery, and 49% of respondents participating in the survey state that Moldova is a country of wine which influenced their decision to visit to a great extent or to some extent country. This share increased by 6 percentage points compared to 2018 (43%) and by 3 percentage points compared to 2016 (46%) [31, 3, 2].

7. The main organizations that promote wine tourism are ONVV and ANTRIM. On February 15, 2022, ANTRIM and ONVV signed a Collaboration Agreement, which aims to: - the development of common promotional materials: maps, wine tourism guides and informative leaflets – Wine Routes of Moldova; - organization of online and offline training sessions with local and international experts, trainings for wine tourism guides, info-tours for guides at existing wineries and those to be opened for tourists; - development of an action plan for the development of Wine Tourism; - organization of press tours for media representatives from the target markets;

8. Moldova's wine tourism has registered a positive upward trend in the last 10 years: - In 2018, the 3rd Global Conference of the UN World Tourism Organization (UNWTO) on wine tourism was organized in Chisinau, Republic of Moldova; - In 2021, the Moldovan winery Château Vartely was declared the winner of the category the most original practice of wine tourism at the international competition organized by ITER VITIS and Phoenician Routes, part of the European Cultural Routes of the Council of Europe meeting held at Palazzo Pannitteri in Sambuca di Sicilia, Italy; - The Winerist.com publication ranked the Republic of Moldova among the top

10 wine tourism destinations in 2020; - Cultural events such as National Wine Day and the Tree of Life cultural-tourist agenda.
the Be Our Guest promotion campaigns, Come to my home, they promoted wine tourism.
9. On October 17-19, 2024, the Republic of Moldova will become the European capital of wine tourism and will host the "ITER VITIS - Les Chemins de la vigne" General Assembly, where local producers and producers from 24 European countries will be present.

CONCLUSIONS

From the information presented, we can conclude with certainty that wine tourism has all the prerequisites to develop and expand further in the Republic of Moldova. Wineries, as a whole, present an essential motivation to visit the Republic of Moldova.
The tourism industry is more accessible to everyone, tour packages include different prices, types of travel, mode of travel and so on, which allow people who want new experiences to travel to their country or other countries, regardless of their budget. Due to the fact that the wine industry is more visible and transparent, wine products and wine tourism offers are widely publicized. This is one of the explanations why hikers are more attracted to wine tourism. Wine tourists are focused on different types of activities besides visiting wineries. Whether it is visiting tourist attractions, cycling, boating, hot air ballooning, attending Festivals around vineyards or wineries, etc. Currently, the development of social networks allows maintaining contact with people and promoting activities through free media. Everyone can share their experiences on the different social networks used by the winery. Visual means are necessary for a business to attract people, the best example is the power of Instagram. In the wine shops, the traditional national costumes of the natives are presented, which attracts tourists. This is essential for the wine and wine tourism industry to use marketing in their strategy, it took time to implement but it is going some way to revolutionizing this fascinating industry. Wine tourism allows the promotion of local products of the wine region and local heritage. In fact, producer countries have understood this and implemented labels and symbols of origin to develop wine tourism. In a wine region, you can find guesthouses and other accommodations, restaurants that suggest wine pairings or local products, and even wine tourism activities.

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ECONOMIC EFFICIENCY OF BIOLOGIZED TECHNOLOGIES OF GROWING AGRICULTURAL CROPS

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Abstract

The study was conducted in 2017–2019 at the experimental field of the Institute of Irrigated Agriculture of NAAS (now the Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine).Based on the results of the economic analysis of winter wheat field trials, it has been established that varieties, sowing dates, and plant protection applications significantly influence the indicators of economic efficiency in winter wheat cultivation. The conditional net profit under natural moisture increased to 11,000 UAH/ha with the variety Maria sown in the first term (September 20) and the application of chemical plant protection. The maximum level of profitability (157%) was achieved with the variety Kohana sown in the third term and adhering to a biological plant protection system. The highest conditional net profit (14,800 UAH/ha) and profitability level (103.3%) were obtained by cultivating winter wheat with irrigation, sown on September 15, and using chemical plant protection. The most profitable results (11,000-11,100 UAH/ha) were obtained with the Ovidiy variety using integrated and chemical plant protection methods. The highest profitability level (75.8%) was achieved with the Ovidiy variety using plant protection involving chemical products. Additionally, high profitability at 71.7% was achieved with this variety using integrated plant protection.

Key words: *economic analysis, winter wheat, variety, conditional net profit, profitability, net income, cost*

INTRODUCTION

In market conditions, ensuring guaranteed profitable harvests requires assessing the economic efficiency of various measures. Economic efficiency is a comprehensive economic category that reflects the high performance in resource utilization. The essence of economic efficiency in agriculture is expressed through its indicators, with the key indicators being the yield of cultivated crops and the quality of the products. The primary indicator characterizing agricultural production volume is the value of gross and marketable products, which serves as the basis for calculating gross and net income, as well as conditional net profit [3].

Research by agricultural economists confirms that a significant direction towards increasing production efficiency in any form of economic activity within a complex economy is the rational and efficient use of land resources and material-technical means using methodical approaches from economic science [11].

Addressing the problem of increasing the production of high-quality agricultural products while reducing costs, while maintaining the ecological state of the environment and enhancing soil fertility, remains a key task for Ukrainian agriculture. An important condition for increasing the efficiency of producing high-quality agricultural products is identifying and implementing effective agronomic practices suitable for different soil-climatic and economic conditions [8].

One of the fundamental measures to prevent and mitigate environmentally hazardous processes and negative impacts on plant productivity in agroecosystems is scientifically substantiating crop rotations, the structure of sown areas, the variety composition, and crop placement in rotations after the best predecessors, with rational soil management practices [6]. These measures enable more productive use of mineral fertilizers, maximally realizing the biological potential of crop varieties and hybrids, reducing vegetative cover, mitigating the impact of pests and diseases in crops with minimal use of chemical pesticides. All of these positively impact the environment and provide additional opportunities to increase agricultural production while reducing production costs [9].

According to many scientists, the economic efficiency of agriculture is achieving the maximum amount of production per hectare of land with minimal expenses. Therefore, it is necessary to use both natural and purely economically justified parameters in agricultural production. The natural indicators of obtaining agricultural products, considering their quality, serve as the starting point for economic efficiency. The yield indicator of agricultural crops reflects the entire system of economic measures and directly influences the magnitude of other indicators [2, 12].

Among valuable indicators, the most crucial is the cost price, which reflects the outcome of the entire agricultural operation from production to sale of agricultural products. The cost price of production is the monetary representation of expenses incurred in the production and sale of products, enabling conclusions to be drawn regarding the efficiency of crop cultivation and identifying ways to enhance profitability. Cost price serves as the starting point for determining net profit [4, 7].

When analyzing the cost structure of agricultural production, expenses are grouped into economic elements and calculation categories, thereby calculating the cost price per unit of production based on specific expenses. The total expenditure consists of three main groups: 1) material costs (the cost of seeds, feed, fertilizers, fuel, lubricants, and plant protection substances entirely used for production and fully included in the expense amount); 2) depreciation charges (wear and tear of fixed and production assets); 3) labor costs. Grouping expenses by specific categories allows for their classification based on economic content aimed at calculating the total value of net production [1].

Therefore, the economic literature presents numerous indicators of economic efficiency and methodologies for their determination, which continue to increase in number with the development of market relations. However, they are unified toward the common goal of enhancing agricultural efficiency. We will focus only on those directly related to solving the issue of increasing agricultural production based on rational land use, addressing previously unresolved parts of the overall problem. To calculate the economic efficiency of winter wheat cultivation under different soil cultivation systems in crop rotations, it is necessary to correctly determine a system of interconnected indicators that most objectively characterize its level.

Calculations were conducted using electronic technological sheets, which allowed obtaining the following economic indicators: gross production value (based on the cost of 1 ton of production at market prices [5, 10], which were compiled in the last year of research), production costs, cost price of 1 ton of grain, net profit, and profitability level.

MATERIALS AND METHODS

The study was conducted in 2017–2019 at the experimental field of the Institute of Irrigated Agriculture of NAAS (now the Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine).

The soil of the experimental field is dark chestnut medium loam with a humus content in the plow layer of 2.2%. The field capacity of the soil layer to a depth of one meter is 22.4%, and the wilting point moisture content is 9.5%. The groundwater is located deeper than 10 meters.

The area size of the primary seed plot is 500 m^2, the accounting plot is 100 m^2, and the secondary plot is 50 m^2. The plots are systematically arranged. The experiment is replicated three times.

ORAKUL® Multicomplex is a comprehensive liquid microfertilizer for foliar feeding, containing macro- and microelements in chelated and other readily accessible forms that plants perceive as part of their own structure.

Vimpel is a natural growth regulator that stimulates seed germination, promotes active root system development, and increases crop yield by 20–30%, depending on the crop. It contains polyatomic alcohols, humic acids, and naturally occurring carbonic acids.

Agat-25K contains biological active substances from the life activities of Pseudomonas aureofaciens strain N16 bacteria, with a total amino acid content of 38%. This product supports soil fertility and plant health through its biological activity.

Huapsin is a bacterial preparation containing two strains of Pseudomonas aureofaciens (B-111 and B-306) along with initial doses of macronutrients. It is used to combat plant diseases and pests effectively, even after symptoms appear.

Trichodermin is a biological fungicide used to protect plants from a wide range of fungal and bacterial diseases. It contains specially selected strains of Trichoderma fungi with enhanced synthesis of natural fungicidal and biologically active substances.

RESULTS AND DISCUSSIONS

The results of the economic analysis of the field study with winter wheat have shown that the varieties, sowing dates, and plant protection applications significantly impact the economic efficiency indicators of winter wheat cultivation (Table 1).

The gross production value per hectare across all varieties and sowing dates in the plant protection treatment options exceeded the control, attributed to a significant increase in grain yield with protection, especially chemical protection.

Production costs varied mainly due to the experimental scheme, influenced by the plant protection factor. In the control variant, this indicator amounted to 6.5 thousand UAH/ha, while in the variants with chemical and biological protection, it increased by 6.2–13.8%, corresponding to 6.9 and 7.4 thousand UAH/ha, respectively.

The cost of seed was also characterized by a certain stability. The lowest cost, at 0.98 thousand UAH/ton, was observed with the variety Maria sown on September 20 and treated with biological plant protection. The highest seed cost, at 1.07 thousand UAH/ton, was recorded for the same variety sown on October 10 with chemical plant protection.

The conditional net profit increased to 11 thousand UAH/ha with the variety Maria sown on September 20 and using chemical plant protection. The investigated economic indicator decreased by 18.3% (to 9.3 thousand UAH/ha) for the Ovidiy variety sown on September 20 without plant protection (control with water treatment only).

The maximum level of profitability (157%) was achieved with the Kohana variety sown on October 10 and using biological plant protection. The reduction of this indicator to 131% was observed with the Maria variety sown on October 10 with chemical plant protection. Therefore, considering that profitability is the most important aspect of each studied element of the technology, it can be concluded that the optimal approach is to cultivate the Maria variety of winter wheat sown on September 20 and applying chemical plant protection. This combination of agricultural practices ensures an increase in conditional net profit to 11 thousand UAH/ha and a profitability level of 148%.

The calculations of the economic efficiency of the second study on winter wheat showed that the Maria variety, grown on irrigated lands with different sowing dates and plant protection systems, exhibited more significant fluctuations in the studied indicators compared to the first study (Table 2). For instance, the gross production value was lowest at 23.0 thousand UAH/ha for wheat sown on October 15 without plant protection (control with water treatment). This value increased by 26.1–26.5% (to 29.0–29.1 thousand UAH/ha) for earlier sowings (September 15 and 25) with chemical plant protection.

Table 1. Economic efficiency of winter wheat varieties depending on sowing dates and plant protection

Variety (factor A)	Sowing Date (Factor B)	Plant Protection (Factor C)	Economic indicators				
			Gross Production Value, thousand UAH/ha	Production Costs, thousand UAH/ha	Cost of 1 ton of Grain, thousand UAH	Conditional Net Profit, thousand UAH/ha	Profitability, %
Ovidiy	First (20.09)	Control	15.8	6.5	1.02	9.3	144
		Bio-protection	17.0	6.9	1.02	10.1	145
		Chemical protection	17.7	7.4	1.05	10.4	140
	Second (01.10)	Control	16.3	6.5	0.99	9.9	152
		Bio-protection	17.3	6.9	0.99	10.4	149
		Chemical protection	17.7	7.4	1.03	10.3	139
	Third (10.10)	Control	15.9	6.5	1.00	9.4	146
		Bio-protection	17.2	6.9	1.00	10.3	148
		Chemical protection	17.4	7.4	1.06	10.0	135
Maria	First (20.09)	Control	16.1	6.5	0.99	9.6	148
		Bio-protection	17.4	6.9	0.98	10.5	151
		Chemical protection	18.4	7.4	0.99	11.0	148
	Second (01.10)	Control	16.0	6.5	1.00	9.5	147
		Bio-protection	17.1	6.9	1.00	10.1	146
		Chemical protection	17.8	7.4	1.03	10.4	140
	Third (10.10)	Control	16.0	6.5	1.00	9.5	147
		Bio-protection	16.8	6.9	1.03	9.9	142
		Chemical protection	17.1	7.4	1.07	9.7	131
Kohana	First (20.09)	Control	16.4	65	0.99	10.0	154
		Bio-protection	17.1	6.9	1.02	10.2	146
		Chemical protection	17.7	7.4	1.04	10.3	139
	Second (01.10)	Control	16.9	6.5	0.99	10.4	156
		Bio-protection	17.4	6.9	1.00	10.5	150
		Chemical protection	17.9	7.4	1.03	10.5	142
	Third (10.10)	Control	16.7	6.5	0.99	10.2	149
		Bio-protection	17.3	6.9	1.00	10.4	157
		Chemical protection	17.5	7.4	1.05	10.1	137

Source: Own calculation based on experimental data.

Production costs ranged from 13.2 to 14.3 thousand UAH/ha, resulting in a difference of 8.3% between the variants. This slight variation can be attributed to the particular study design, as there were no differences in costs based on sowing dates. The variations were only observed in variants with biological and chemical plant protection, as well as due to the additional costs associated with harvesting and transporting the additional wheat grain yield.

Table 2. Economic efficiency of cultivating different winter wheat varieties with biological properties of the Maria variety depending on the sowing period under irrigation.

Sowing Date (Factor A)	Plant Protection (Factor B)	Economic indicators				
		Gross Production Value, thousand UAH/ha	Production Costs, thousand UAH/ha	Cost of 1 ton of Grain, thousand UAH	Conditional Net Profit, thousand UAH/ha	Profitability, %
5 September	Without protection	24.3	13.3	2.45	11.1	83.4
	Bio-protection	25.7	14.1	2.46	11.6	82.7
	Chemical protection	26.7	14.3	2.41	12.4	87.0
15 September	Without protection	26.0	13.3	2.30	12.7	95.8
	Bio-protection	27.5	14.1	2.31	13.4	94.8
	Chemical protection	29.1	14.3	2.21	14.8	103.3
25 September	Without protection	25.4	13.3	2.35	12.2	91.6
	Bio-protection	27.5	14.1	2.31	13.4	94.8
	Chemical protection	29.0	14.3	2.22	14.7	104.4
5 October	Without protection	25.0	13.3	2.39	11.7	88.3
	Bio-protection	26.7	14.1	2.37	12.7	89.8
	Chemical protection	27.1	14.3	2.37	12.9	90.0
15 October	Without protection	23.0	13.2	2.59	9.8	73.9
	Bio-protection	25.2	14.1	2.51	11.1	79.0
	Chemical protection	25.5	14.3	2.52	11.2	78.7

Source: Own calculation based on experimental data.

The lowest cost of 1 ton of grain for the studied crop was 2.21 thousand UAH with wheat sown on September 15 and using chemical plant protection throughout the vegetation period. This cost increased by 17.2% (to 2.59 thousand UAH/ton) for winter wheat sown in the late period (October 15) without plant protection.

The maximum conditional net profit (14.8 thousand UAH/ha) and level of profitability (103.3%) were achieved by cultivating winter wheat with irrigation, sown on September 15th, and using chemical plant protection. These economic indicators decreased significantly by 50.0% and 38.6%, respectively (to 9.8 thousand UAH/ha and 73.9% profitability), when sowing the Maria variety in later periods without plant protection (control variant of factor B). Additionally, it is worth noting that for later sowing dates (October 5th and 15th), the effectiveness of biological plant protection increased significantly and was comparable to chemical plant protection, with a difference in conditional net profit of only 0.9–1.6% and profitability of 0.2–0.4%.

In the third winter wheat trial for the Zira and Ovidiy varieties, the effectiveness of both chemical and integrated plant protection containing a biological component on irrigated land was demonstrated. An analysis of the gross production value of cultivating winter wheat varieties by factors and variants allowed establishing their impact on agrotechnological process indicators. It was shown that this economic indicator reached its maximum value of 26.5 thousand UAH/ha in the variant with the Ovidiy variety under a chemical plant protection system (Table 3). The minimum level of gross production value (20.4 thousand UAH/ha) was obtained in the control variant of the Zira variety. Therefore, the difference between these variants was 29.9%.

Table 3. Economic indicators of cultivating winter wheat varieties depending on the impact of plant protection under irrigation

Variety (factor A)	Plant Protection (Factor B)	Economic indicators				
		Gross Production Value, thousand UAH/ha	Production Costs, thousand UAH/ha	Cost of 1 ton of Grain, thousand UAH	Conditional Net Profit, thousand UAH/ha	Profitability, %
Zira	Without protection	20.4	12.9	2.71	7.6	58.9
	Bio-protection	21.7	13.8	2.73	7.9	57.6
	Chemical protection	23.7	14.7	2.65	9.1	62.0
	Integral	25.1	15.6	2.66	9.6	61.4
Ovidyi	Without protection	22.5	13.4	2.55	9.1	68.4
	Bio-protection	23.4	14.0	2.56	9.5	67.9
	Chemical protection	25.6	14.6	2.45	11.0	75.8
	Integral	26.5	15.5	2.50	11.1	71.7

Source: Own calculation based on experimental data.

The calculations from the technological map revealed that production costs for cultivating the researched crop tended to increase in variants with plant protection, attributed to higher expenses for purchasing pesticides and increased costs for harvesting, grain transportation, drying, etc. The highest (15.5 thousand UAH/ha) and lowest (12.9 thousand UAH/ha) conditional production costs were observed in the Zira variety under control conditions (no plant protection, water treatment only) and in the variant where integrated plant protection practices were followed, respectively. Therefore, the difference between these values amounted to 21.9%.

The cost at the minimum level of 2.45 thousand UAH/ton was observed with the Ovidiy variety when implementing a chemical plant protection system. The increase in this cost to 2.73 thousand UAH/ton was evident in the Zira variety with biological plant protection.

The maximum profitability of 11.0–11.1 thousand UAH/ha was achieved with the Ovidiy variety using integrated and chemical plant protection. The worst result of 7.6 thousand UAH/ha was obtained for cultivating the Zira variety without any plant protection. Thus, the difference between these variants amounted to 46%.

The highest profitability level of 75.8% was achieved with the Ovidiy variety when applying plant protection with chemical products. Additionally, a high profitability level of 71.7% was achieved with integrated plant protection for this variety. The lowest profitability, at 57.6%, was observed with the Zira variety under biological plant protection.

CONCLUSIONS

The economic analysis has demonstrated that the gross production value per hectare in the first winter wheat field trial across all varieties and sowing dates with plant protection exceeded the control, primarily due to a significant increase in grain yield with protection, especially chemical plant protection. Production costs in the control variant amounted to 6.5 thousand UAH/ha, while in variants with chemical and biological plant protection, they increased by 6.2–13.8%. The lowest cost price of 0.98 thousand UAH/ton was achieved with the Maria variety sown on September 20th with bio-protection. The highest conditional net profit reached 11 thousand UAH/ha with the Maria variety sown on September 20th and using chemical plant protection. Notably, the highest level of profitability, 157.1%, was achieved with the Kohana variety sown in the third period and applying biological plant protection.

In the second winter wheat trial, it was determined that the gross production value was highest, ranging from 29.0 to 29.1 thousand UAH/ha for sowings on September 15th and 25th with chemical plant protection. This was 26.1-26.5% higher than the variant with sowing on October 15th without plant protection. Production costs ranged from 13.2 to 14.3 thousand UAH/ha. The minimum cost price was 2.21 thousand UAH for sowing on September 15th with chemical plant protection. Net profit also increased to 14.8 thousand UAH/ha, and profitability reached 103.3% with the same combination of factors. The efficiency of biological plant protection significantly increased for late sowings (October 5th and 15th).

The highest gross production value of 26.5 thousand UAH/ha was achieved with the Ovidiy variety under chemical plant protection. Production costs for cultivating the crop tended to increase with plant protection, with a maximum difference of 21.9%. The lowest cost price (2.45 thousand UAH/ton) was obtained for cultivating the Ovidiy variety with chemical plant protection, while some increase in this indicator was observed for the Zira variety with biological protection. Net profit reached 11.0–11.1 thousand UAH/ha with integrated and chemical protection on the Ovidiy variety. This same variety exhibited maximum profitability of 75.8% with chemical plant protection.

The gross production value for cultivating sunflower reached its highest level at 24.7 thousand UAH.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

DEVELOPMENT OF BULGARIAN AGRICULTURE PRODUCTION STRUCTURES

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Abstract

Bulgarian agriculture is traditional and very important for developing rural areas. Over the years, the agricultural sector has been transformed by processes and policies that affect its changes. The Common agricultural policy significantly facilitates the transformation of Bulgarian agriculture regarding farm development and redistribution of activities. In this regard, the article aims to track the development of the main agrarian structures in Bulgaria from 2010 to 2020. The materials provide the most recent statistical data for the analytical period, during which we examined the evolution of Bulgaria's main agricultural systems. We used regional-level indicators such as farm numbers, utilized agricultural areas, farms by economic size classes, standard output by economic size classes, and farm specialization. The study takes into account production volume discrepancies between regions and the Country. The South-Eastern region has the most significant economic contribution, producing more than EUR 250,000 Standard Output while having the fewest farms. Conversely, the South-West and South-Central areas have the lowest economic share, making less than EUR 2,000 Standard Output while having the most farms. This zoning presents a complete picture of farm economic conditions, which impacts agricultural growth in Bulgarian rural areas. Finally, regarding GDP distribution in key economic centers and mechanical movement, Sofia (the Capital), Plovdiv, Varna, Burgas, and Kardzhali show the most significant contrasts.

Key words: *rural development, agriculture, production structures, changes*

INTRODUCTION

In Bulgaria, the pandemic has impacted the regional economic development map. In some regions, the economy is expected to decrease in nominal terms in 2020. It was found that the capital city of Bulgaria, Sofia – the first driving force, has a Gross domestic product (GDP) nearly stable at slightly over BGN 51 billion, or 43% of the national economy (Figure 1) [29]. The second force is Plovdiv, whose economy forms more than half of the gross product of the South-Central Region. The third force, Varna, maintained a robust industry on the outskirts of the maritime capital despite experiencing a decline in the service sector. Stara Zagora is the next force that temporarily overtook Burgas, the area that suffered the hardest pandemic hit. Veliko Tarnovo and Ruse, which move comparatively at the same rate of development, are the next forces. The gap between Northern and Southern Bulgaria is determined mainly by the lesser size of the economic hubs in Northern Bulgaria, except Varna, and the weaker connectivity between them. A treemap chart, which provides a hierarchical view of the Regional Gross Domestic Product data, demonstrates the spread of economic centers (Figure 1).

According to Institute for Market Economics [30], sixteen significant economic centers stand out, covering 132 municipalities set map the borders of Bulgaria’s economic centers. The centers include about ¾ of the country's population, accounting for over 80% of Bulgaria's economic activity. Every economic center has a core and a peripheral (Map 1).

The municipalities with the best local economies are the economic cores, and the municipalities closest to that core's economy are the peripheries. The study [30] found that some of the sixteen centers have multiple cores due to existing links between the different cores and a shared perimeter or zone of influence.

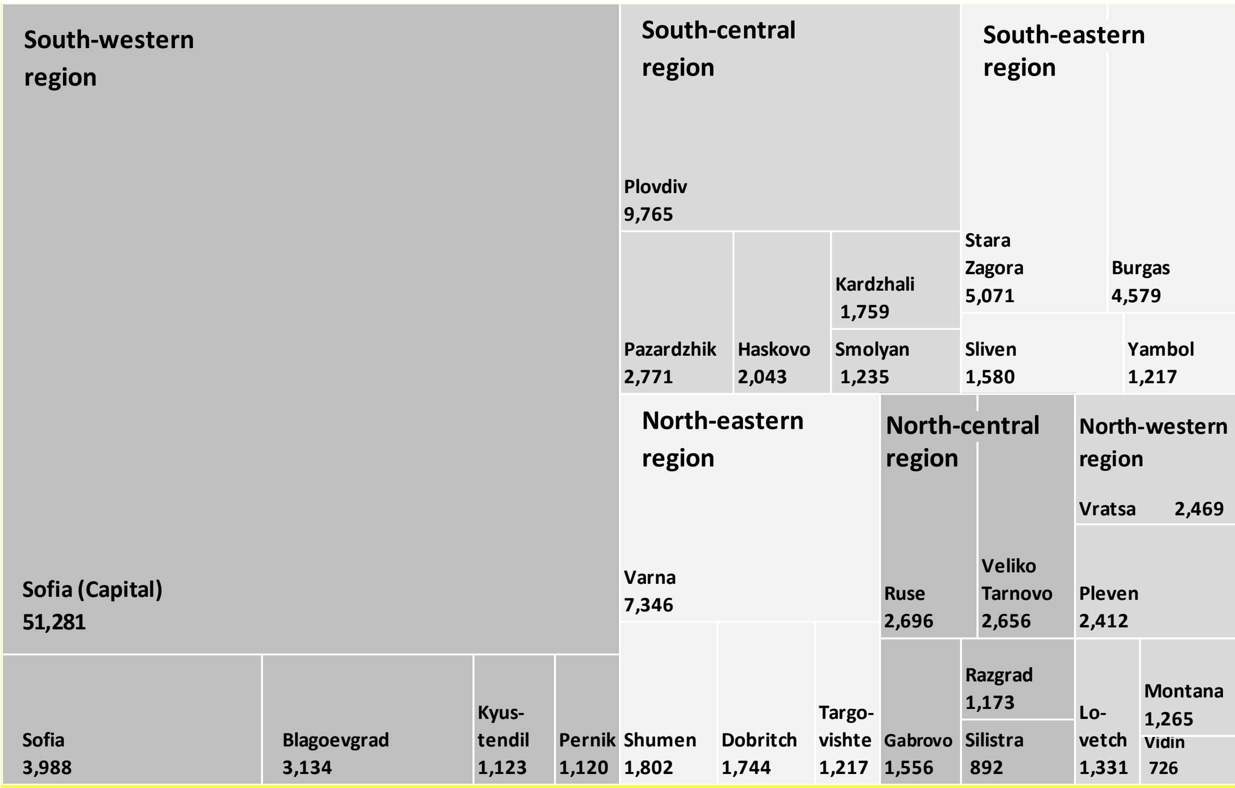
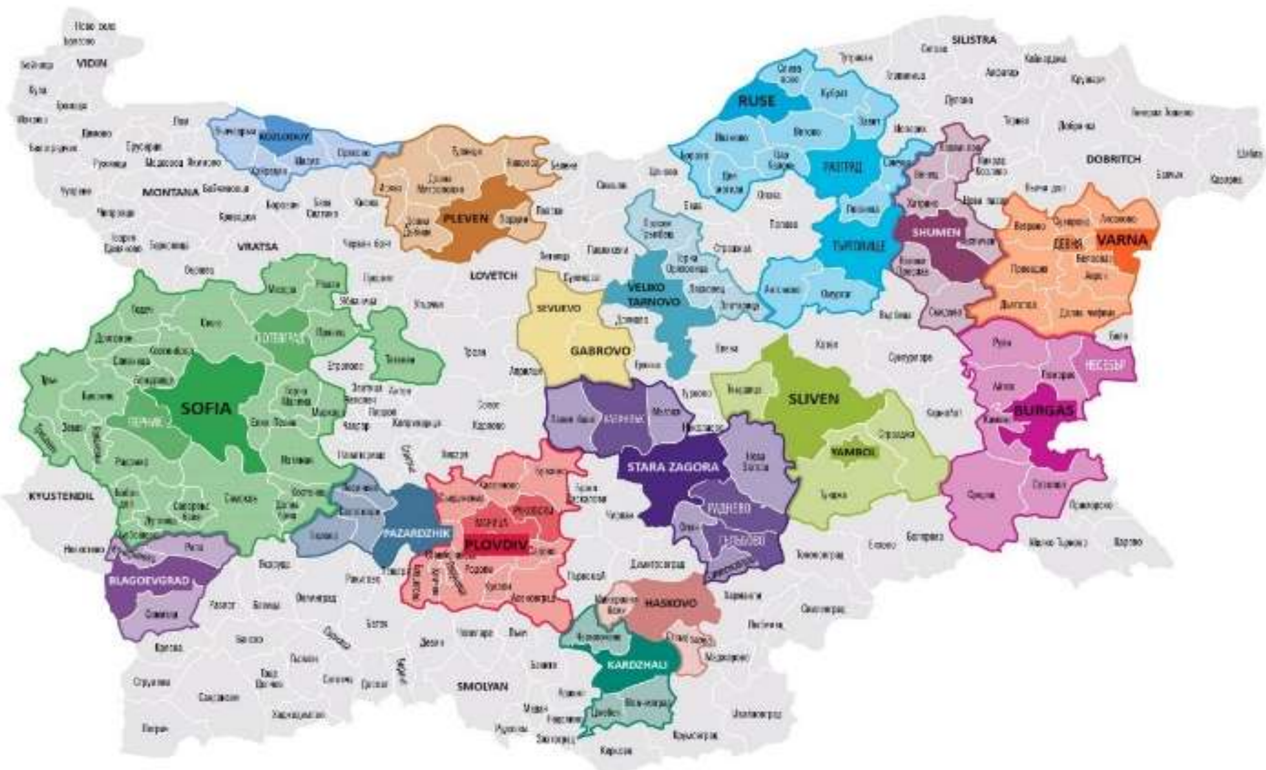


Fig.1. Regional Gross domestic product in Bulgaria – 2020 (mln. BGN)
Source: Institute for Market Economics (2022) [29].



Map 1. Main economic centers in Bulgaria – 2021
Source: Institute for Market Economics (2023) [30].

Nine economic centers stand out in the direction of agricultural development [30]. The "Pleven" economic center has the highest share of added value in the agriculture sector (12.3%). Agriculture plays a dominant role in smaller municipalities like Iskar and Nikopol.

The second position is the economic center "Sliven-Yambol" (11.5%), where agriculture plays a significant role in Yambol's peripheral municipalities, accounting for half of the added value.

It is followed by "Ruse-Targovishte-Razgrad" with 10.2% added value and "Shumen" with 7.9%. In fifth position is the economic center "VelikoTarnovo" (6.6%), where agriculture plays a more significant role in the core. The following is "Haskovo" (4.8%), where agriculture again dominates the periphery. The lowest share is found in the economic centers "Pazardzhik" (3.8%) and "Zagore" (3.3%). The leading agricultural sector in the economic center "Kozloduy" is found in the periphery municipalities, contributing significantly and generating over half of the added value.

Regarding Bulgarian agricultural development, the trend is to an annual farm decline. The farms decreased by 64%, which is approximately 230 thousand farms, for the studied period 2010-2020 (Figure 2). At the same time, the utilized agricultural area increased with 9%, which means that many farmers are cultivating much more area than before. This dual structure is a common for Bulgaria and since 1989 is not changing, even the policy get changed and trying to create a middle size farms.

Fig. 2. Utilized agricultural area and farms number in Bulgaria – 2010-2020
Source: Own calculation by data of [34].

Average utilized agricultural areas data confirm this. At national level, we observed that 11% of farmers run over 90% of average utilized agricultural area of 50 ha, while 17% of farmers run over 8% of average utilized agricultural area of 10 to 50 ha, considering that the average size of utilized agricultural areas is 36 ha (Figure 3). It was found that at the national level farms with less than 5 ha represent 64.5% of all holdings in Bulgaria, and 63.7% of all holdings in the European Union [7].

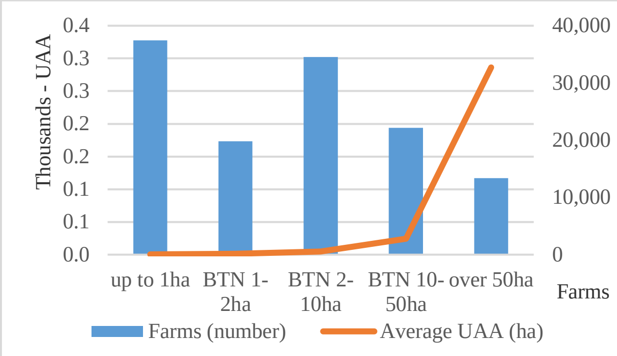


Fig. 3. Farm distribution by size of utilized agricultural area in Bulgaria – 2020
Source: Own calculation by data of [31].

It was found that the agricultural production structure has changed generally from policy, economics, social, environmental, and technology point of view in other countries [4, 14, 36]. Following this, we examine Bulgarian development of agrarian systems in terms of policy, economics, social, and ecological factors.

Regarding the policy development, in Bulgaria, many studies are dedicated to the problems related to reducing farms and increasing the share of big production structures. This problem was due to changes in farm intensification, which furthered Bulgarian agriculture problems since 2007 [48].

In some respects, the Common agricultural policy (CAP) helps farm development, rejuvenation of the agricultural sector, improvement infrastructure in rural areas [25], supporting farmers' income [23], implementation innovation [17], and others through the application of the Rural Development Programme. In other respects, the CAP creates a permanent trend of farm reduction [7]. Some authors note significant problems and factors limiting the Bulgarian development of sectors such as fruits, vegetables, and livestock [27], [38].

Regarding the economic development, agriculture's contribution to total value added has steadily dropped since joining Bulgaria to the European Union [6]. A key factor for the successful Bulgarian agriculture development is the sustainable increase in productivity and efficiency [32]. Another factor for economic development is land consolidation and territorial planning [3]. The local territorial strategies have shown a positive impact on the economic environment of the rural municipalities, which have introduced the local integrated strategies under the Common local-led development programme [1]. Other factors influencing the development are linked to infrastructure, markets and the quality of the working force [26].

Financing of the agricultural value chain is necessary to focus on integration in the chain of finance providers, structural government support to strengthen the supply chain, enhancement of risk protection information systems, and strengthening collaboration and cooperation [31]. Also, developing high-added-value products is related to high financial investment and participation in a longer value chain [22].

Regarding the social development, many factors have an impact on production structures in agriculture in Bulgaria, such as population ageing [19], negative demographic trends [33], lack of sufficient labour resources [9], and low economic activities [1]. Despite negative demographic tendency in Bulgaria, it was found that urban unemployment falls in all regions in Bulgaria, while two of rural areas have high unemployment level in rural areas and lower in the urban areas [20]. It was found that generational renewal is possible in more successful farms [11, 12].

Land fragmentation [14], [15], [48] and changing the primary livelihood of the population [47] impacted on population migrate to large economic centers in search of more profitable work [2], [13]. This leads to desertification of rural areas and consolidation of small farms [18].

Nowadays it matters competitiveness for sustainable development of economic entities in rural areas [41]. Urban farming is gaining popularity [42]. Proximity to the larger urban centers impacts organic farming, direct sales, and agricultural diversification [21].

Anticipated developments in rural areas by the end of 2027 have been predicted, and optimistic scenarios have been put up, which should lead to positive improvements in socioeconomic and demographic aspects [39]. However, barring a significant worsening in demographic indices, the author anticipates that the negative trend of depopulation in rural areas will persist, albeit slower than before.

Ensuring access to digital technologies in rural areas depends on social, economic, and political systems providing fundamental conditions and opportunities for digital transformation [8]. Regarding the ecological development, some environmental risks are linked to a negative influence on natural resources such as soil, water and air [43]. In some contexts, the CAP strategic plan introduced a new system of eco-schemes aimed at ensuring farmers' income by implementing environmentally friendly production systems such as agroecology, agroforestry, and organic farming [10].

Cluster analysis is a grouping method that assigns an object to a specific group. This method is one of the most popular procedures for analyzing data. It was first used as a term in 1939 [46]. The word "cluster" means a group of closely lying objects whose primary goal is to reveal the hidden groupings of the studied objects [24].

Clustering analysis methods are classified into two types: non-hierarchical and hierarchical. The first category of approaches involves partitioning the data space into a structure known as a Voronoi Diagram including a series of areas containing subsets of related data. The second is based on the concept of creating a binary tree of data, which is then merged into related groupings. This tree, also known as a dendrogram, is a handy overview of data that has been joined to form groups depending on their known distance [5].

A hierarchical approach generates a breakdown of the provided data items. According to how the hierarchical breakdown is generated, it may be classed as agglomerative. The divisive hierarchical clustering method, also known as the top-down technique, begins with all of the items in the same cluster. In each iteration, a cluster is divided into smaller clusters until each item is put in its own cluster or a termination condition is met [45].

In agriculture, it was researched through cluster analysis the performance of agriculture and food industry sectors [37], the internal structure of farms based on a multicriteria evaluation, main functions of agriculture [28], and others.

Some authors applied cluster analysis to factors such as land use, physical farm dimensions, socio-economic and management characteristics, and environmental indicators at level NUTS 2 [16]. Also, in some studies, cluster analysis was applied, which brought information about targeted regions at the NUTS 2 level and identified good practices for applying in Romania and Poland [40].

In Bulgaria, cluster analysis was created at the NUTS 3 level, studying revealing the place and the role of Bulgarian agriculture in rural development which defined the following clusters: "economically poor - ecologically stable", "economically developed", and "transitional - towards good economic development and ecologically unstable" [35, 44]. Also, cluster analysis was made by classifying the regions based on socio-economic criteria and indicators of employment in the country by main agricultural categories. Another study used cluster analysis to determine the attitudes of Bulgarian farmers toward the implementation of innovations [11].

The study aims to follow the change in the development of the main agrarian structures in Bulgaria in the period of 10 years.

MATERIALS AND METHODS

The article is based on the latest statistic data, which is available according to studied issues. The study includes the following parts, presented in the Figure 4.

In the article is included analytical period 2010-2020, as we analyzed the development of the main agrarian structures in Bulgaria. We assigned the following tasks to meet the study's aim: 1) Introduction of regional development of the country; 2) Theoretical concepts for reasons for changing agrarian structures (politics, economy, social and ecological development) were presented; 3) The actual change in the production structures in Bulgaria was traced at the territorial level according to the farm size and specialization;

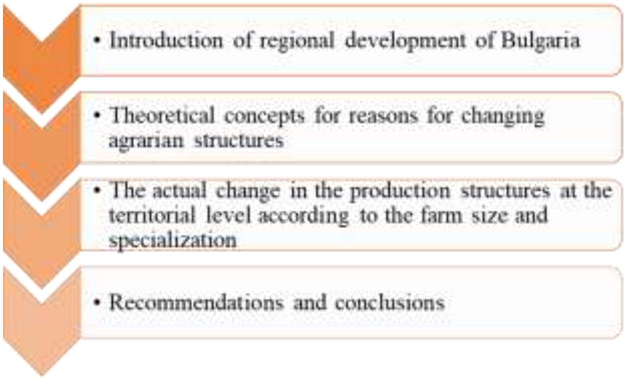


Fig. 4. Methodological framework
Source: Own elaboration.

4) A cluster analysis of some variables at the NUTS 3 level was applied; 5) Conclusions and reasons for the change in agrarian structures were made.

In the study we used following indicators by regional level in Bulgaria:

-Farms number;
-Utilized agricultural area;
-Farms by economic size classes;
-Standard Output by economic size classes;
-Farm specialization.

RESULTS AND DISCUSSIONS

We have assigned ourselves many tasks in order to achieve the research objectives.

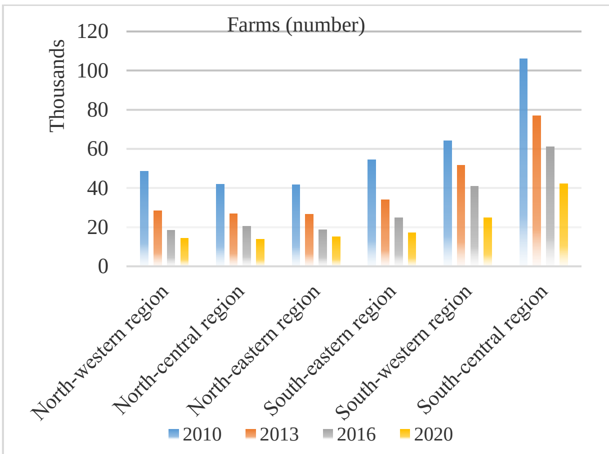


Fig. 5. Farms number by regions in Bulgaria
Source: Own calculation by data of [34].

The first is to track the actual change in production structures at the regional level in

Bulgaria. Over 10 years, the number of farms dropped at national and regional levels (Figure 5).

For the same period, we observe an increase in the used agricultural area at the regional level (Figure 6).

Second, we analysed the actual change in production structures by the growth of Bulgarian farms. The distribution of farms by economic class gives us an idea of their real economic size, expressed by Standard Output (Figure 7 and Figure 8).

According to the laws for implementing the measures under the Rural Development Program, the Standard Output reflects the monetary value of the produced agricultural products at the producer's price.

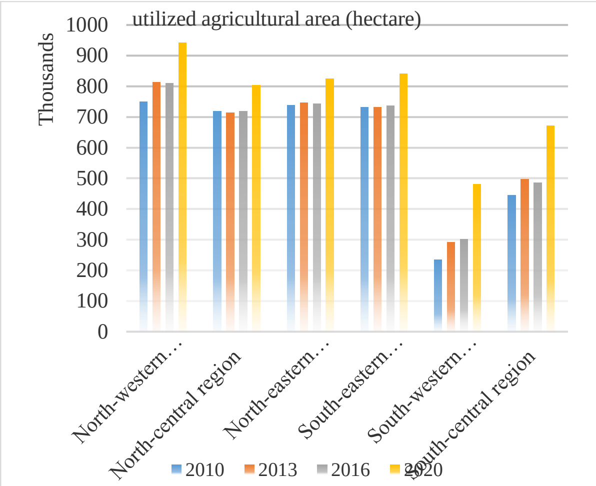


Fig. 6. Utilized agricultural area by regions in Bulgaria
Source: Own calculation by data of [34].

Fig. 7. Farms by economic size classes by regions in Bulgaria
Source: Own calculation by data of [34].

This value is calculated in EUR. It should be noted that the Standard Output excludes direct payments, value-added tax, and other taxes. It is calculated based on average prices for agricultural/livestock production.

The research considers regional and national disparities in production volumes. The northern regions, including the South-Eastern region, have the most significant economic share, producing more than EUR 250,000 Standard Output while having the lowest farm number. On the other hand, the South-West and South-Central regions have the lowest economic proportion, producing less than EUR 2,000 Standard Output while having the biggest farm number. This zoning provides a comprehensive picture of the farm economic situation, which also influences the agricultural development of Bulgarian regions.

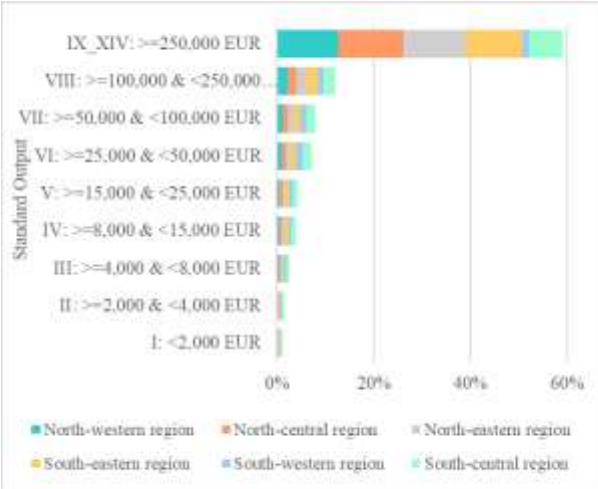


Fig. 8. Standard Output by economic size classes by regions in Bulgaria
Source: Own calculation by data of [34].

Third, we track the actual change in production structures in Bulgaria based on farm specialization. Examining the specialization of farms gives us an in-depth picture of the agricultural orientation of the regions.

The overall Standard Output in Bulgaria is 4,091,460, with specialized farms accounting for 92% and mixed farms accounting for 8%. Cereals, oilseeds, and protein crops dominated (53.5%) among specialized farms, followed by farms breeding pigs, poultry and rabbits (9.4%), and milk cattle (8.7%). On the other hand, mixed farms are dominated by arable crops and grazing livestock (3.4%). In other research it was found small share of women farmers, as dominant share has men engaged in Bulgarian agriculture [26].

According to data from the last national census of farms in Bulgaria in 2020, farms are mainly classified into crop-growing, animal-breeding, and mixed farms based on specialization. On the other hand, crop farms consist of two cluster groups, the first of which includes technical and field crops, forming 64.4% of standard output at the national level, and the second includes orchard farms, forming 3% of standard output at the national level. Regarding livestock farms, they also form two cluster groups. The first group includes farms with cattle (11,2% standard output), and the second - small cattle and small farm animals (13% standard output). The last classification group includes farms with mixed cultivation of crops growing and grazing livestock, which form 8% of standard output at the national level.

It was found that farm specialization over ten years changed standard output. The group of crop farms increased their standard output by 40.3%, and the group of livestock and mixed farms decreased their standard output by 32% and 35%, respectively. The change in agricultural production structures in Bulgaria is provoked by many factors in rural areas, such as:

-reducing farms and increasing the share of big production structures;
-farm development, rejuvenation of the agricultural sector, improvement infrastructure;
-supporting farmers' income;
-CAP creates a permanent trend of farm reduction;
-land consolidation and territorial planning;
-high-added-value products is related to high financial investment;
-negative demographic trends;
-urban unemployment falls;
-generational renewal is possible in more successful farms;
-land fragmentation;
-changing the primary livelihood of the population;
-population migrate to large economic centers;
-desertification of rural areas and consolidation of small farms;
-competitiveness for sustainable development of economic entities;
-urban farming is gaining popularity.

Considering the distribution of GDP in the major economic centers and the mechanical movement, the most significant contrast is in Sofia(Capital), Plovdiv, Varna, Burgas and Kardzhali.

Also, the study included the distribution of farms by size of the utilized agricultural area at the NUTS 3 level in Bulgaria, including 28 districts. The analysis shows that the initial set of cluster groups was four but the cluster numbers were changed due to no or little change in cluster centres. Hereby, the stopping criterion was reached at the third iteration, and the minimum distance between initial centers is 101,801.546 (Table 1).

Itera-tion	Change in Cluster Centers			
	1	2	3	4
1	16,273.533	14,286.885	2,293.859	25,137.045
2	0.000	0.000	4685.372	5530.820
3	0.000	0.000	0.000	0.000

Table 1. Iteration History by regions in Bulgaria (2020)
Source: Own calculation by SPSS Statistics

The final cluster centers (Table 2) and number of cases (Table 3) were shown. A dendrogram visually represents the data from 2020 (Figure 9).

The first cluster center defines Bulgaria's most significant territory, including Veliko Tarnovo, Plovdiv, and Haskovo districts, predominantly from the South-Central region. The second cluster center pick the next larger group including Pleven, Dobrich, Burgas, Stara Zagora and Yambol districts, predominantly from the South-Eastern region. The third cluster center defines the next group, which in the study is the most numerous, including following districts: Vidin, Vratsa, Lovech, Montana, Razgrad, Ruse, Silistra, Varna, Targovishte, Shumen, Sliven, Blagoevgrad, Sofia (district), predominantly from the North-Western, North-Central and North-Eastern regions. The fourth cluster center chose the last group with a smaller utilised agricultural area, which includes Gabrovo, Kyustendil, Pernik, Sofia (Capital), Kardzhali, Pazardzhik, and Smolyan districts, predominantly from the South-Western region.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 2. Final Cluster Centers by regions in Bulgaria (2020)

	farms.UAA	size.UAA
1	5,744.33	235,895.83
2	4,221.00	354,163.00
3	4,049.62	156,432.15
4	4,532.14	58,118.86

Source: Own calculation by SPSS Statistics.

Table 3. Number of Cases in each Cluster (2020)

Cluster	1	3
	2	5
	3	13
	4	7
Valid		28
Missing		0

Source: Own calculation by SPSS Statistics.

The cluster analysis and the Institute for Market Economics analysis have observed the withdrawal of the agricultural sector and the concentration of the service sector in the South-Western region of Bulgaria. One of the key factors influencing this shift is Sofia (Capital), which serves as a significant economic center. However, this concentration negatively affects the development of agriculture in the region, highlighting the need for a more balanced economic strategy.

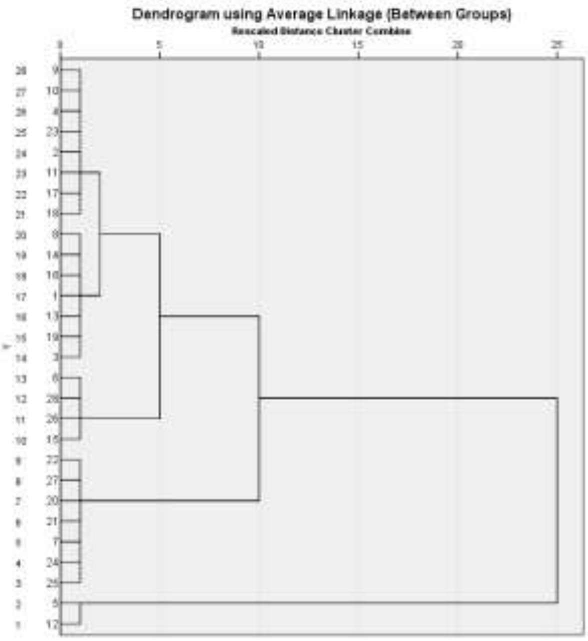


Fig. 9. Dendrogram by regions in Bulgaria (2020)
Source: Own calculation by SPSS Statistics Final

We returned to compare the same cluster with the 2010 data. In the 4 clusters formed, the stopping criterion was reached at the sixth iteration, and the minimum distance between initial centers is 85,479.918 (the change with 2020 is 16%). The final cluster centers (Table 4) and number of cases (Table 5) were shown. A dendrogram visually represents the data from 2010 (Figure 10).

Table 4. Final Cluster Centers by regions in Bulgaria (2010)

	farms.UAA	size.UAA
1	13,151.64	47,873.86
2	15,733.20	203,573.35
3	11,255.00	313,292.65
4	11,123.00	144,590.03

Source: Own calculation by SPSS Statistics.

Table 5. Number of Cases in each Cluster (2010)

Cluster	1	11
	2	5
	3	2
	4	10
Valid		28
Missing		0

Source: Own calculation by SPSS Statistics.

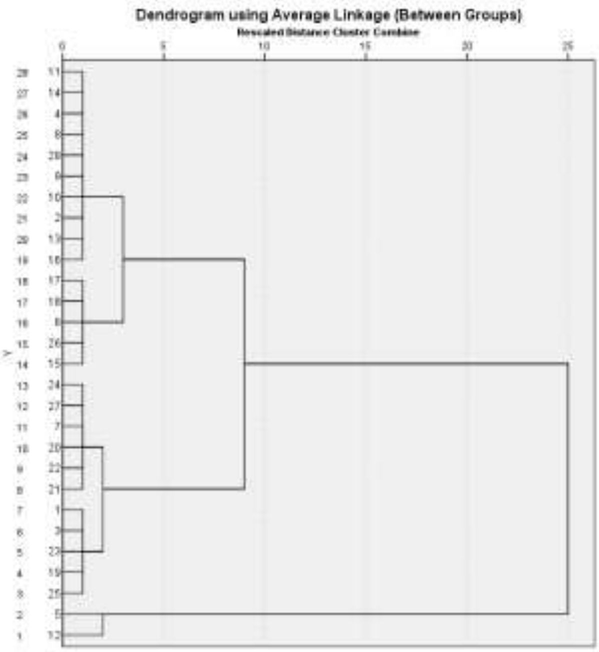


Fig. 10. Dendrogram by regions in Bulgaria (2010)
Source: Own calculation by SPSS Statistics Final.

The first cluster center include following districts: Vidin, Lovech, Gabrovo, Blagoevgrad, Kyustendil, Pernik, Sofia (Capital), Sofia (district), Kardzhali, Pazardzhik, Smolyan, predominantly from the South-Western region. The second cluster defines the next group, including following districts: Veliko Tarnovo, Stara Zagora, Yambol and Plovdiv, predominantly from the South-Eastern region. The third cluster center picks the next group including: Pleven and Dobrich district. The fourth cluster center includes districts: Vratsa, Montana, Razgrad, Ruse, Silistra, Varna, Targovishte, Shumen, Sliven and Haskovo, predominantly from the North-Central and North-Eastern regions.

CONCLUSIONS

Bulgarian agriculture is a traditional sector that is vital to rural development. The agricultural industry has evolved over time due to the processes and policies that influence its developments. The Common Agricultural Policy greatly supports Bulgarian agricultural reform in terms of farm development and activity redistribution.

In this context, we examined the growth of Bulgaria's major agrarian structures from 2010 to 2020. At the regional level in Bulgaria, we examined farm numbers, utilized agricultural land, farms and standard output by economic size class, and farm specialization. We found that the number of farms fell at both the national and regional levels, but the share of used agricultural land increased at the regional level.

Furthermore, we discovered regional and national inequalities in production volumes. This indicates that the northern region and the South-Eastern region, has the largest economic share but the smallest farm number. The South-West and South-Central regions, on the other hand, have the smallest economic proportion but the greatest number of farms. The zoning offers a thorough picture of the farm's financial status, which influences agricultural development in Bulgarian rural areas.

In terms of actual change in farm specialization, research has indicated that specialized farms have the biggest proportion, while mixed farms have the smallest. We focus on the most important farms cultivating cereals, oilseeds, and protein crops, followed by those raising pigs, poultry, rabbits, and milk cattle.

When comparing 2010 and 2020 data, the cluster groups do not change. Even the two larger cluster groups are preserved. There is only movement between areas within the clusters, but it is not large.

Finally, we recommend favorable changes in agricultural production structures in Bulgaria:

-Prioritize small and medium-sized farms in production structures;

-Improve infrastructure and farm development through changes to the CAP;

-Support farmers' income through real activity;

-Land consolidation and territorial planning - to prevent agricultural land fragmentation;

-High-added-value products - ensuring enough financial resources;

-Change for positive demographic trends - to ensure adequate actions to prevent negative consequences;

-Farm education - staff specialization;

-Rural unemployment falls - providing enough jobs and decent salaries;

-Generational renewal - in most farms;

-Preservation/return of the population in rural areas - ensure main livelihood;

-Migration to rural areas - revitalization of rural areas;

-Development of competitiveness - for sustainable development of economic entities.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

CLUSTER ANALYSIS OF DISTRICTS IN BULGARIA ACCORDING TO THE DEVELOPMENT OF THE LIVESTOCK SECTOR

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Abstract

The aim of the research is to group the districts in Bulgaria according to the development of the livestock sector. A hierarchical cluster model was developed based on the indicators for the number of cattle and buffalo, sheep, pigs and poultry by district in Bulgaria. Data on the number of farm animals were taken from the Register of Farmers for the 2020/2021 business year. A dendrogram was constructed showing the distribution of districts by clusters. Average values of the studied indicators for each cluster were calculated. The districts can be divided into 4 clusters according to the considered indicators. The first cluster includes 6 districts: Burgas, Haskovo, Kardzhali, Sliven, Blagoevgrad and Plovdiv. The second cluster includes 17 districts: Kyustendil, Pernik, Sofia-grad, Vidin, Smolyan, Montana, Lovech, Vratsa, Silistra, Gabrovo, Sofia, Yambol, Pazardzhik, Shumen, Razgrad, Targovishte and Pleven. The third cluster includes only one district - Veliko Tarnovo. The fourth cluster includes 4 districts: Stara Zagora, Dobrich, Varna and Ruse.

Key words: *hierarchical cluster model, livestock sector, districts*

INTRODUCTION

The livestock sector in Bulgaria is of key importance for supplying and feeding the population with irreplaceable and quality products. It provides employment for the population mainly from the rural areas of the country and helps to reduce unemployment among the people with a lower level of education.

In the last years (2012 - 2022), according to the statistics [6], [8], [10] the number of cattle was: 526,112 heads in 2012, and in 2022 – 559,544 heads, or their number increased by 6.4%. On the other hand, the number of buffaloes in the country has grown 2.2 times: from 9,212 heads in 2012 to 20,317 heads in 2022.

The number of sheep in the country has also undergone a change during the considered period in the direction of a decrease of 19.5%: from 1,361,545 heads in 2012 to 1,096,399 heads in 2022 [8], [10].

The number of pigs increased by 13.3%: from 530,945 in 2012 to 601,702 in 2022 [8], [10].

The number of poultry also has changed during the studied period: from 15.260 million in 2012 to 15.507 million in 2022 [7], [9]. There was a slight increase of 1.6% in 2022 compared to 2012.

In the current study, the method of cluster analysis was applied, which is widely used in analyses of the agrarian sector in the country ([1], [4], [5].

The aim of the research is to group the districts in Bulgaria according to the development of the livestock sector.

MATERIALS AND METHODS

A hierarchical cluster model was developed based on the indicators for the number of cattle and buffalo, sheep, pigs and poultry by district in Bulgaria. Data on the number of farm animals were taken from the Register of Farmers for the 2020/2021 business year [12]. The indicators refer to the business year 2020/2021 and show the distribution of the number of different types of farm animals by districts in Bulgaria. The hierarchical cluster model was developed using the statistical software *R* [11], *factoextra* package [2], [3]. The number of clusters was determined with *eclust()* function from *factoextra* package [14]. Districts were clustered based on the Euclidean distance between them [13]. A dendrogram was constructed showing the distribution of districts by clusters. The average values of the studied indicators by clusters were calculated.

RESULTS AND DISCUSSIONS

Table 1 shows the number of different types of farm animals by district for the 2020/2021 business year [12] and their percentage share of the total number of the respective type of farm animals in the country:

-The total number of studied farm animals in the country for the 2020/2021 business year is as follows: 534,119 cattle and buffalo; 987,488 sheep; 552,975 pigs; 29,716,611 poultry number.

-The largest number of cattle and buffalo are raised in the districts: Plovdiv (60,539 heads or 11.33%), Haskovo (44,507 heads or 8.33%) and Blagoevgrad (42,624 heads or 7.98%); and the smallest number – in the districts: Sofia-grad (3,430 heads or 0.64%); Vidin (4,322 heads or 0.81%) and Pernik (5,072 heads or 0.95%).

-The largest number of sheep are raised in the districts: Blagoevgrad (96,645 heads or 9.79%), Burgas (93,102 heads or 9.43%) and Plovdiv (87,606 heads or 8.87%), and the least number - in the districts: Sofia-grad (4,185 heads or 0.42%); Vidin (5,764 heads or 0.58%) and Gabrovo (7,680 heads or 0.78%).

-The largest number of pigs are raised in the districts: Dobrich (95,921 heads or 17.35%), Stara Zagora (79,553 heads or 14.39%) and Ruse (71,440 heads or 12.92%), and the smallest number - in the districts: Pernik (1 head) and Sofia-grad (4 heads). In the Smolyan district there is not a single registered pig according to the Register of farmers for the 2020/2021 business year.

-The largest number of poultry are raised in the districts: Veliko Tarnovo (6,635,452 numbers or 22.33%), Razgrad (3,111,016 numbers or 10.47%) and Targovishte (2,258,707 numbers or 7.60%), and the smallest number - in the districts: Sofia-grad (22,612 numbers or 0.08%); Pernik (23,010 numbers or 0.08%) and Blagoevgrad (46,815 numbers or 0.16%).

The favourable forage base can be noted as the reason for the largest number of animals in some of the districts - these districts are traditionally one of the largest producers of cereals in the country due to their suitable soil and climate conditions (Dobrich, Plovdiv, Ruse, Veliko Tarnovo, Varna).

Based on the analysis, 4 clusters of districts were formed (Fig. 1). The first cluster includes 6 districts: Burgas, Haskovo, Kardzhali, Sliven, Blagoevgrad and Plovdiv. The second cluster includes 17 districts: Kyustendil, Pernik, Sofia-grad, Vidin, Smolyan, Montana, Lovech, Vratsa, Silistra, Gabrovo, Sofia, Yambol, Pazardzhik, Shumen, Razgrad, Targovishte and Pleven. Only 1 district, Veliko Tarnovo, is included in the third cluster. The fourth cluster includes 4 districts: Stara Zagora, Dobrich, Varna and Ruse.

From Fig. 1 it can be seen the pairs of districts that share the most common characteristics with each other based on the investigated indicators. These are: Kardzhali and Sliven (Kardzhali district is most similar to Sliven district according to the studied indicators); Blagoevgrad and Plovdiv; Kyustendil and Pernik; Sofia-grad and Vidin; Lovech and Vratsa; Silistra and Gabrovo; Pazardzhik and Shumen; Targovishte and Pleven; Stara Zagora and Dobrich; Varna and Ruse.

Fig. 2 and Fig. 3 present the average number of the respective type of farm animals by clusters. In the first cluster, the average number of cattle and buffalo per district is the largest (41.2 thousand heads); in the third and fourth clusters, the average number of cattle and buffalo are similar in value (17.5 thousand heads for the third and 16.8 thousand heads for the fourth cluster). The value of the indicator is the lowest in the second cluster (11.9 thousand heads).

The average number of sheep in the first cluster is the largest (78.6 thousand sheep), followed by Veliko Tarnovo district (31.2 thousand sheep).

In the last place are the second and fourth clusters with a similar average number of sheep (23.1 thousand heads in the second and 23.2 thousand sheep in the fourth cluster).

In the districts from the first cluster, on average, 3.4 times more sheep are raised than in the districts in the second cluster.

Table 1. Indicators for analysis of the development of livestock sector at the district level

District	Cattle and buffalo		Sheep		Pigs		Poultry	
	total number	%	total number	%	total number	%	total number	%
Blagoevgrad	42,624	7.98	96,645	9.79	886	0.16	46,815	0.16
Kardzhali	35,260	6.60	59,503	6.03	36	0.01	262,773	0.88
Haskovo	44,507	8.33	70,004	7.09	589	0.11	1,111,936	3.74
Plovdiv	60,539	11.33	87,606	8.87	4,641	0.84	1,091,131	3.67
Burgas	31,086	5.82	93,102	9.43	46,245	8.36	96,827	0.33
Sofia	22,273	4.17	45,495	4.61	5,245	0.95	198,477	0.67
Sliven	33,265	6.23	64,464	6.53	2,697	0.49	768,847	2.59
Stara Zagora	23,517	4.40	28,277	2.86	79,553	14.39	1,446,707	4.87
Pazardzhik	14,669	2.75	31,773	3.22	31,622	5.72	652,854	2.20
Yambol	22,031	4.12	28,335	2.87	25,659	4.64	617,722	2.08
Lovech	11,726	2.20	23,930	2.42	1,895	0.34	505,850	1.70
Kyustendil	7,598	1.42	14,552	1.47	33	0.01	122,304	0.41
Smolyan	6,871	1.29	29,560	2.99		0.00	103,066	0.35
Veliko Tarnovo	17,493	3.28	31,226	3.16	19,477	3.52	6,635,452	22.33
Varna	9,354	1.75	25,001	2.53	57,576	10.41	956,664	3.22
Montana	14,581	2.73	23,235	2.35	107	0.02	961,753	3,24
Pernik	5,072	0.95	12,820	1.30	1	0,00	23010	0.08
Targovishte	14,197	2.66	40,855	4.14	10,354	1.87	2,258,707	7.60
Shumen	16,427	3.08	28,907	2.93	36,909	6.67	953,896	3.21
Pleven	16,154	3.02	33,156	3.36	2,086	0.38	1,598,433	5.38
Vratsa	12,770	2.39	23,782	2.41	37	0.01	592,403	1.99
Sofia-grad	3,430	0.64	4,185	0.42	4	0.00	22,612	0.08
Dobrich	23,947	4.48	26,299	2.66	95,921	17.35	1,494,355	5.03
Razgrad	14,199	2.66	16,995	1.72	35,503	6.42	3,111,016	10.47
Ruse	10,417	1.95	13,133	1.33	71,440	12.92	1,852,416	6.23
Silistra	9,071	1.70	21,204	2.15	18,310	3.31	959,833	3.23
Gabrovo	6,719	1.26	7,680	0.78	1,725	0.31	1,034,398	3.48
Vidin	4,322	0.81	5,764	0.58	4,424	0.80	236,354	0.80
Total	**534,119**	**100**	**987,488**	**100**	**552,975**	**100**	**29,716,611**	**100**

Source: data from the "Register of farmers for the 2020/2021 business year" [12] and own calculations.

The largest average number of pigs falls on the districts of the fourth cluster (76.1 thousand). Next is Veliko Tarnovo district (19.5 thousand).

In the first and second clusters, the average number of pigs is the lowest: 9.2 thousand heads for the first and 10.2 thousand heads for the second.

In the Veliko Tarnovo district, the highest number of poultry are raised (6,635.5 thousand), which is 11.8 times more than the average number for the first cluster (563.1 thousand poultry), in which the lowest number of poultry are raised.

In the fourth cluster, the average value of the indicator is 1,437.5 thousand, and in the second cluster – 820.7 thousand.

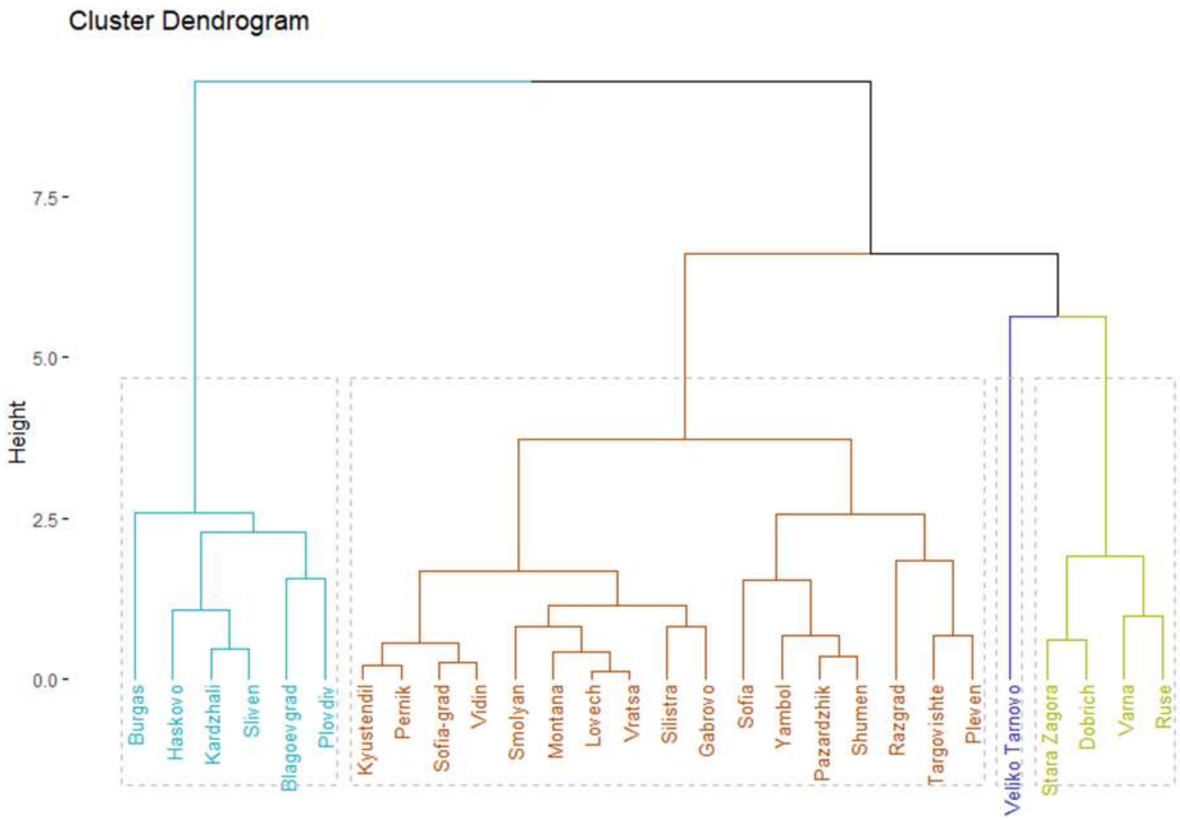

Fig 1. Cluster dendrogram of districts
Source: Generated with *R* program, *factoextra* package [3], [11]

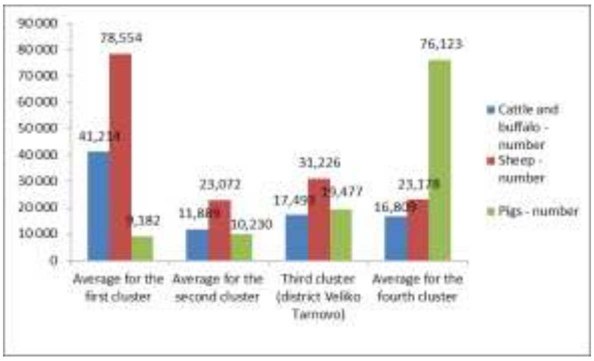

Fig. 2. Average values by clusters - cattle and buffalo; sheep and pigs
Source: Own calculations.

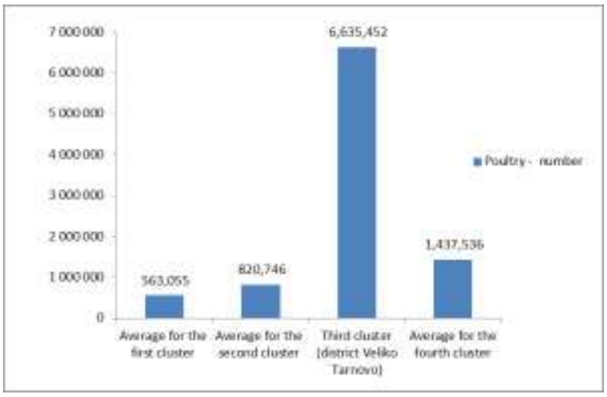

Fig. 3. Average values by clusters – poultry
Source: Own calculations and data [12].

CONCLUSIONS

The largest number of cattle and buffalo are raised in the districts: Plovdiv (11.33% of the total number), Haskovo (8.33%) and Blagoevgrad (7.98%). Sheep are most numerous in the districts: Blagoevgrad (9.79% of the sheep population), Burgas (9.43%) and Plovdiv (8.87%). Pig farming is most prevalent in the districts: Dobrich (17.35% of the pigs), Stara Zagora (14.39%) and Ruse (12.92%). It is noted that in the Smolyan district there is not a single registered pig according to the data source [12] and in the Pernik district there is 1 animal registered, in the Sofia-grad district - 4 animals. The largest number of poultry are raised in the districts: Veliko Tarnovo (22.33%), Razgrad (10.47%) and Targovishte (7.60%).

The districts can be divided into 4 clusters according to the considered indicators. The first cluster includes 6 districts: Burgas, Haskovo, Kardzhali, Sliven, Blagoevgrad and Plovdiv. The second cluster includes 17 districts: Kyustendil, Pernik, Sofia-grad, Vidin, Smolyan, Montana, Lovech, Vratsa, Silistra, Gabrovo, Sofia, Yambol, Pazardzhik, Shumen, Razgrad, Targovishte and Pleven. The third cluster includes only one district - Veliko Tarnovo. The fourth cluster includes 4 districts: Stara Zagora, Dobrich, Varna and Ruse.

The pairs of districts that share the most common characteristics with each other based on the studied indicators are: Kardzhali and Sliven (Kardzhali district is most similar to Sliven district according to the studied indicators); Blagoevgrad and Plovdiv; Kyustendil and Pernik; Sofia-grad and Vidin; Lovech and Vratsa; Silistra and Gabrovo; Pazardzhik and Shumen; Targovishte and Pleven; Stara Zagora and Dobrich; Varna and Ruse.

In the first cluster, the average number of raised cattle and buffalo and sheep is the largest when compared to the average values of the other clusters (41.2 thousand cattle and buffalo and 78.6 thousand sheep). The largest number of poultry (6,635.5 thousand) are raised in the Veliko Tarnovo district. The largest average number of pigs falls on the districts of the fourth cluster (76.1 thousand heads).

ACKNOWLEDGEMENTS

This research was financed by Project “Стохастичен анализ на перспективите и ефектите от Зелената сделка в българското земеделие – GREENBASE” (Stochastic analysis of the prospects and effects of the Green Deal in Bulgarian Agriculture), funded by the “The Bulgarian National Science Fund”, "Fundamental Scientific Research-2022”, Contract № КП-06-Н-66/3 – 13.12.2022.

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P2P-ACCOMMODATION IMPACT ON THE RURAL HOST'S WELLBEING: THE BULGARIAN BLACK SEA COAST CASE STUDY

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Abstract

Sharing economy has entered the tourism industry and significantly influenced the accommodation activity. P2P-accommodation has become an effective alternative of hospitality and is already one of the most developed sharing industries worldwide. The host is one of the main participants in P2P-accommodation and plays a key role in the P2P-accommodation system. The host's reasons for participating in sharing services are diverse, but all of them are aiming to improve the host's wellbeing in different aspects. Sharing economy is a new phenomenon on the Bulgarian market and it is remarkable that its entrance in the accommodation sector is dynamic. Even more, P2P-accommodation already plays a significant role in some rural regions in the country helping the local communities to develop tourism business and creating a livelihood for people. Therefore, the main purpose of the article is to investigate the rural host's perception of the P2P-accommodation influence on their wellbeing on the Bulgarian Black Sea coast as this is the most developed tourist region in the country. Within the current study a specific methodology in four main steps is developed based on variable scientific methods, such as: questionnaire survey, comparative analysis and correlation analysis. The main results show that the rural host's perception about P2P-accommodation impact on their wellbeing is positive in various ways, but most importantly in economic and social manner. Though, improvement in the P2P-accommodation regulation framework and supply diversity is also needed in terms of its positive development perspectives.

Key words: *rural tourism, sharing economy, P2P-accommodation, host, Bulgarian Black Sea coast*

INTRODUCTION

Sharing economy has dynamically influenced the travel industry through the last years [1]. As the most significant representative of the sharing economy in tourism, P2P-accommodation enables tourists to "get closer" to the tourist destination and its *local community* adding an authentic experience in their stay. Some of the most well-known brands in P2P-accommodation such as Airbnb, 9Flats, HomeAway, VRBO, etc. are experiencing a dramatic growth in their transaction volume connecting millions of guests and hosts in their platforms. Alone, P2P-accommodation leader Airbnb offers over 7 million accommodation offers in over 220 countries and regions worldwide and over 100,000 different cities, covering 98% of the world globe [20].

Specifically, in rural regions there is evidence that P2P-accommodation is gaining a lot of popularity. In support of this statement, one of the most highlighted trends on the Airbnb platform is rural travel, accounting for 22% of booked nights in 2021 and registering a 10% cumulative increase from 2015 [15].

On the other hand, the sharing economy in Bulgaria is still in its initial development stage, with the most developed activity in the system being P2P-accommodation. According to data on nights spent in P2P- accommodation units in Bulgaria, 2019 is a peak year in the period from 2018 to 2021, when there is a 7.2% growth in comparison to the previous year. In terms of destinations, most of P2P-accommodation nights spent are in the municipality of Sofia, Plovdiv, *Varna* and *Burgas* [6].

In terms of the size of the shared accommodation unit, bed nights are dominated by units with fewer than 10 beds, accounting for just under 96% of the country's total over the period 2018 to 2021 [6]. This evidence that P2P-accommodation is predominantly practiced in small units, which affirms the suggestion that the hosts are mostly renting their residence or villa.

Additionally, rural tourism is the fastest growing branch of tourism in Bulgaria in recent years. Rural municipalities occupy 81% of the country's territory and 42% of the population. Bulgaria's rural areas are characterized by economic, social and cultural underdevelopment and a *low standard of living*. However, there is a positive attitude towards rural regions in Bulgaria in the society [12]. Although Bulgaria's agriculture is one of the most difficult sectors of the national economy to develop, rural tourism supports a number of rural regions and provides a livelihood for the local population. There are numerous rural areas in Bulgaria that have pioneered the development of rural tourism, and those situated along the Bulgarian Black Sea coast have gained significant experience, considering the fact that this is the most developed tourist region in the country. In support, the Black Sea coast accounts for a major share of the activity of accommodation establishments in Bulgaria. In 2023 the revenue from accommodation on the Bulgarian Black Sea coast accounted for 59.8% from the total in the country [13]. Regards rural regions, the statistics in Bulgaria show that 215 municipalities can be counted as rural regions taking into consideration the regulations in the National plan for agricultural and rural development [10]. Of these 13 are situated on the Bulgarian Black Sea coast as follows: Nessebar, Pomorie, Primorsko, Sozopol and Tsarevo in **Burgas region**; Avren, Aksakovo, Dolni Chiflik and Byala in **Varna region**; Balchik, Dobrich, Kavarna and Shabla in **Dobritch region**. Therefore, in the current research paper we assume the 13 municipalities mentioned as tourism rural regions on the Bulgarian Black Sea coast for the purpose of the study.

Literature review

Overall, research and definitions of P2P-accommodation in the academic literature can be described as fragmentary as exploration of this type of accommodation is still at a beginning stage [17]. Furthermore, current research papers come mostly represented by the so-called 'grey literature', including conference papers, research reports and articles [7]. Though, in recent years P2P-accommodation has attracted increasing academic attention and the number of articles published in leading hospitality and tourism journals has sensitively grown. According to a study, the first articles on P2P-accommodation date back to 2010 and till 2015 they numbered only 5. In 2016, the publications on P2P-accommodation grew to 13 papers and in 2017 they reached 35 [5].

According to the literature review, we can assume that P2P-accommodation is a successfully developing and dynamic part of the sharing economy, representing a type of collaborative consumption. The shared resource is a *short-term accommodation,* which can vary widely – room, apartment, house, caravan, tent, etc. The sharing relationship takes place between a guest and a host, but is mediated by a third party – an online based sharing platform. The act of sharing can be both non-reciprocal and reciprocal, as the latter can be profit or non-profit in nature. The temporary stay can be in the presence or absence of the host, but there are always conditions for direct interaction between guest and host. As a conclusion, the main participants in the P2P-accommodation process are:

-The host – offers access to short-term accommodation.

-The guest – seeks a short-term other than hotel accommodation.

-The mediator – an online platform for sharing accommodation services.

The host of the P2P-accommodation is a provider that offers short-term accommodation free of charge, for monetary or non-monetary profit. Besides shaping the supply in the system, another important function of the host is to give feedback for guests who have stayed at the host`s property, helping to create real insight for other members and adding real value and trustworthiness to the P2P-accommodation service. According to research by Deale & Crawford [2], hosts are attracted by a variety of reasons to join the P2P-accommodation system. The most important of these include: *generating additional income*, *optimal use of house*, *diversifying social* *contacts*, the *desire to share the beauty of their city/neighborhood/home* and the *aspiration for community belonging*.

Regarding the term 'wellbeing' two conceptual approaches are widely accepted for defining. The *subjective well-being theories* are based on people's perception about life [18]. The measurement is composed in two aspects – the human affects, such as emotions and feelings, and people's life satisfaction in terms of family, work, friends etc. [3] On the contrary, *objective theories* explain wellbeing based on external quality of life indicators. The latter can be divided in social terms such as education, social circle etc., and material – income, employment, housing etc. [19]. As we can assume, the above mentioned reasons for host's P2P-accommodation participation are generally aiming to improve their wellbeing in both aspects – social and material.

In terms of P2P-accommodation host segmentation, the basic host types can be divided into non-professionals (individuals) and professional (commercial) accommodation providers. For the latter, the P2P-accommodation platform represents an additional distribution channel to reach more clients. They will not be considered in this research paper as they are not essentially practicing P2P-accommodation but commercializing hotel type of accommodation. It is worth noting that not all platforms allow the presence of the professional hosts, following the example of Couchsurfing. In terms of non-professional hosts, they can be segmented according to the main reason for P2P-accommodation platform participation [4]:

•*The Capitalist* – these hosts have profit goals and aim to maximize their *income*. Commonly, they have no interest in socializing with guests, and do not seek communication with other hosts.

•*The Friend* – these hosts have the desire to *socialize*. They aim to expand their social circle and create social belonging in a community as they also often seek communication with other hosts.

•*The Ethical* – hosts that strive for an ethical lifestyle. Their behavior is dictated by the principle of ensuring *sustainability through all aspects of their life*, material and social.

As we can conclude, the P2P-accommodation hosts generally aim to improve their wellbeing, but they usually prioritize one of both wellbeing aspects [16] – material resources, mostly represented by their income, and social life. Though, they can also target a balanced approach in terms of a sustainable behavior [21] through gaining improvement in both of the mentioned areas.

MATERIALS AND METHODS

After making a literature review of the topic we can conclude that P2P-accommodation is one of the fastest growing industries in the sharing economy and it has already entered the Bulgarian market. The host in the P2P-accommodation process is one of the main participants, which has different leading reasons for hosting but is generally seeking a wellbeing improvement. The research **methodology** in this paper is based on the following scientific research tasks:

-*Development of a questionnaire for investigation* of the P2P-accommodation hosts's opinion and evaluation.

-*Creation of a database* for quantitative processing of information in SPSS.

-*Analysis of results* in order to describe the respondents group and to determine their evaluation of P2P-accommodation influence on their wellbeing.

-*Discussing the results* to highlight key conclusions and provide recommendations for the future successful development of P2P-accommodation as a tool for improvement of host's wellbeing.

The subject of this study is the P2P-accommodation influence on the host's wellbeing.

The **object of the study** is the P2P-accommodation host in rural regions on the Bulgarian Black Sea coast

The **purpose of the research** is based on empirical study to investigate the host's evaluation of P2P-accommodation influence on their wellbeing.

In the current investigation paper a set of diverse **scientific methods** is used such as observation, analysis and synthesis, questionnaire survey, comparative analysis, descriptive and discriminative statistical methods and correlation analysis.

The **questionnaire survey** is conducted on the basis of an online survey among P2P-accommodation hosts. The study was conducted in the period from 01.04.2023 till 30.07.2023 using the tools of Google Forms Questionnaire.

Like any scientific publication, this paper has some **limitations** as follows:

-*Geographical limitation* – the study is collecting responses about the opinion of non-professional hosts, who are operating their units in the rural regions of the Bulgarian Black Sea coast.

-*National limitation* – this study is investigating only the opinion of Bulgarian non-professional hosts. Therefore, the sections of the survey are distributed in Bulgarian language only

-*Time limitation* – the empirical research is conducted during a certain period considering the beginning of the active tourist season in 2023.

Some of the major **research problems** in the current empirical research are the low rate of survey responses among the potential respondents; the absence of specialized P2P-accommodation host's organization and the lack of P2P-accommodation platforms in Bulgaria.

In order to collect empirical data in the first phase of the research, **questionnaires** were distributed to Bulgarian non-professional rural hosts through variable channels such as: specialized P2P-accommodation platforms (Airbnb.com), non-specialized tourism related platforms offering also P2P-accommodation (Booking.com, Pochivka.bg, Rooms.bg), not tourism related platforms offering also P2P-accommodation (Olx.bg), related groups for P2P-accommodation in social media (Facebook).

The survey is anonymous, consisting of 2 separate sections. *Section 1* is specifically designed to describe the respondents and to form their demographic profile. *Section 2* consists of 8 questions. The type of questions are a choice of given options with some of them multiple choices possible, open questions and interval scale questions with evaluation from 1 (absolutely not correct) to 5 (absolutely correct). The questions explore objective external quality of life indicators – income, employment and job position (material indicators); marital status and education (social indicators), and subjective internal quality of life indicators – satisfaction, safety and leading reason for participation in P2P-accommodation.

A sample approach to the study of aggregates was used to study the P2P-accommodation hosts evaluation towards the P2P-accommodation influence on their wellbeing. The sample model is a non-target random sampling type, which is widely used.

In processing the survey data for analysis specialized software for data processing and statistical analysis was used (SPSS standard package). In the current research we work with accuracy: *Significance level = 0,05.* In addition, a statistical approach to find association between variables was also applied in the analysis of survey responses. For this purpose, the Chi-square test (χ^2 test) is applicable, which is a statistical method used to analyse the relation between two categorical variables.

RESULTS AND DISCUSSIONS

After the survey was conducted, it was found that for the purposes of the analysis, the questionnaires of 112 respondents could be used. The demographic profile of the hosts who participated in the survey can be presented as follows:

- The majority of respondents are female – 66.1% (74 respondents) compared to 33.9% (38 respondents) male;
- A major proportion fall into Generation Y - a total of 46.5% of responding hosts (aged 25-44), with a significant proportion also of Generation X – 41.4% (aged 45-64). Baby Boomers (aged 65+) and Generation Z (aged 18-24) form respectively 8.4% and 3.7% shares.
- In terms of income, the main share has more than 1,200 BGN household monthly income per person (55.4%). Of the rest, nearly one

third (32.1%) indicates household monthly income per person in the range of 801 - 1,200 BGN. The mode and the median are presented by 1,200 BGN household monthly income per person and the asymmetry has a coefficient of -1.102, which means that the left tail is longer.

Table 1. Income distribution among survey respondents

	Frequency	Percent	Valid Percent	Cumulative Percent
600 BGN or less	2	1.8	1.8	1.8
601-800 BGN	12	10.7	10.7	12.5
801-1190 BGN	36	32.1	32.1	44.6
1200 BGN+	62	55.4	55.4	100.0
Total	112	100.0	100.0	

Source: Created by the author.

- In relation to marital status, the main share is of those who are married with children (41.1%), but a major share also consists of those who are married without children living in the household (35.7%) (Fig. 1).

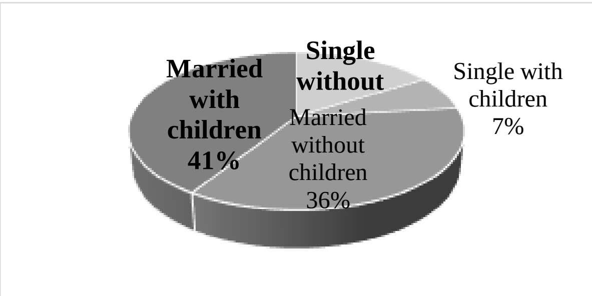

Fig. 1. Structure of survey respondents in terms of marital status.
Source: Created by the author.

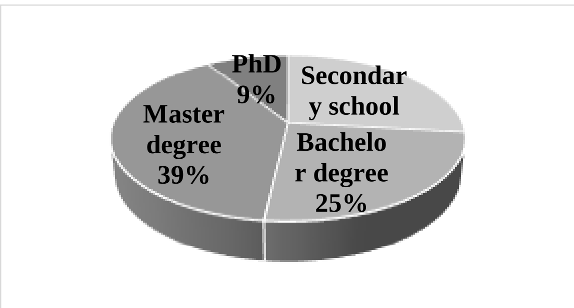

Fig. 2. Structure of survey respondents in terms of education.
Source: Created by the author.

- In terms of education, the biggest share is represented by highly educated persons (73.2% - combined PhD, master and bachelor degree) and a little over a quarter have secondary education (Fig. 2).

- Notably, a major share of the respondents are full-time workers (37.1%). The remaining groups ranged as follows: 1.8% are students; 11.8% are unemployed; 14.3% are self-employed; 15.4% are retired and 19.6% are part-time workers.

- Of those in employment, the profile of respondents is more diverse, with a predominance of operative/service staff (26.8%) and specialist/technician (28.6%). The remaining groups are: 16.1% occupy administrative positions; 16.0% have executive positions and 12.5% did not specify (no data) (Fig. 3).

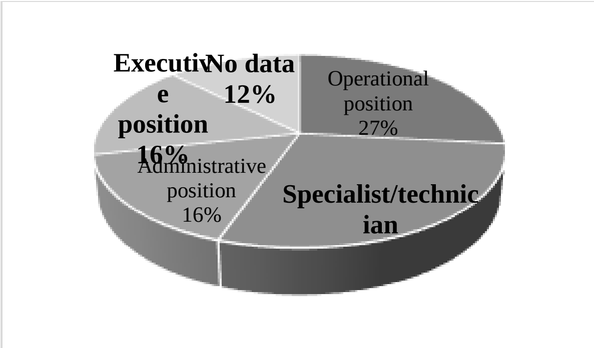

Fig. 3. Structure of employed survey respondents in terms of job position.
Source: Created by the author.

In relation to the host experience with P2P-accommodation, a major proportion of host respondents have been sharing accommodation on the platforms for more than 1 year (62.5%). Those renting within 6 months to 1 year make up 17.9% and those renting within 6 months make up 19.6%.

Most hosts share one unit of accommodation (71.8%) and those renting out 2 shared units account for 13.9%. There are few hosts renting 3 units (10.7%) and 4 or more units (3.6%).

In terms of the type of shared unit, where more than one response could be given, the clear leader is apartment type of unit (36.5%), followed by: holiday cottage (28.3%); private room (12.7%); self-serviced floor of house (9.9%), caravan (9.9%); other type (such as bungalow; 2.8%) of all responses given.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Regarding the average number of bookings made on an annual basis through a P2P-accommodation platform, the answers vary. The maximum value indicated is 80 and the minimum value indicated is 0. Accordingly, the mean is 20.47, i.e. according to the respondents, the average number of bookings they make per year through the P2P-accommodation platform is 20. The mode equals 15, which is the most common answer given by the respondents. The median equals to 15, i.e. 50% of respondents indicated a number of bookings less than or equal to 15. The standard deviation is 15.229 which is less than 50 and means that the variance is insignificant (Table 2).

Table 2. Statistics on average number of bookings in P2P-accommodation platform.

N	Valid	98
	Missing	14
Mean		20.47
Median		15.00
Mode		15
Std. Deviation		15.229
Minimum		0
Maximum		80

Source: Created by the author.

The reasons for participating in the P2P-accommodation platform are variable, but with relatively two prominent leaders:
- Efficient use of underutilized real estate (27.9%)
- Generation of additional income that increases the respondent's standard of living (23.3%)
- Expanding the host's social contacts (19.4%)
- Generating additional income that guarantees the living wage of the host (14.7%)
- Sharing pride from the beauty of the city/neighborhood/home (8.5%)
- Sense of community belonging (6.2%).

In relation to safety consideration, most respondents feel safe but have some concerns when accommodating strangers (2.00) - 41.1%. Nearly a third (28.6%) could not state whether they feel safe and pointed out that it depends on the profile and their impression of the guest (3.00).

An equal and small proportion shared they feel “completely safe” (1.00) or „relatively unsafe, but the risk is justified by the benefits” (4.00) (14.3% each). A negligible proportion respond that they feel very insecure (5.00) - 1.8%.

Table 3. Distribution structure among survey respondents in terms of reason for P2P-accommodation participation

	Responses		Percent of
	N	Percent	Cases
Additional income – guarantee of living	38	14.7%	33.9%
Additional income – increase of living standard	60	23.3%	53.6%
Efficient use of underutilized space	72	27.9%	64.3%
Expanding social contact	50	19,4%	44,6%
Sharing beauty of home	22	8,5%	19,6%
Sense of community belonging	16	6,2%	14,3%
Total	258	100,0%	230,4%

Source: Created by the author.

Giving the opportunity to assess the statement if P2P-accommodation brings satisfaction to the hosts, most of the respondents give a positive answer (81.4%). From those satisfied, the predominant share states the satisfaction based on economic reasons (69.6%). Nearly one quarter from the respondents are socially satisfied (21.4%) and about 7% from the respondents are equally socially and economically satisfied (Fig. 4).

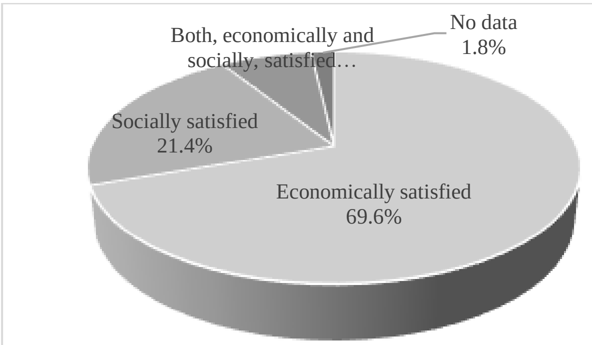

Fig. 4. Structure of responses in terms of type of satisfaction from P2P-accommodation hosting
Source: Created by the author.

Regarding the relationship between the P2P-accommodation satisfaction type (X9) and the security consideration (X10), the Chi-square test of the host’s responses would help to find out whether there is sufficient evidence to say that there is an association between the two variables (Table 4).

Table 4. Cross-tabulation between satisfaction with P2P- accommodation (X9) and security consideration (X10).

		Safety consideration					Total
		1,00	2,00	3,00	4,00	5,00	
Economically satisfied	Count	8	32	22	16	0	78
	% within X9	10.3%	41.0%	28.2%	20.5%	0.0%	100,0%
	% within X10	57.1%	69.6%	68.8%	100.0%	0.0%	70,9%
	% of Total	7.3%	29.1%	20.0%	14.5%	0.0%	70,9%
Socially satisfied	Count	6	8	10	0	0	24
	% within X9	25.0%	33.3%	41.7%	0.0%	0.0%	100.0%
	% within X10	42.9%	17.4%	31.3%	0.0%	0,0%	21.8%
	% of Total	5.5%	7.3%	9.1%	0.0%	0,0%	21.8%
Both, economically and socially satisfied	Count	0	6	0	0	2	8
	% within X9	0.0%	75.0%	0.0%	0.0%	25,0%	100.0%
	% within X10	0.0%	13.0%	0.0%	0.0%	100,0%	7,3%
	% of Total	0.0%	5.5%	0.0%	0.0%	1.8%	7.3%
Total	Count	14	46	32	16	2	110
	% within X9	12.7%	41.8%	29.1%	14.5%	1.8%	100.0%
	% within X10	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	12.7%	41.8%	29.1%	14.5%	1.8%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	42.481[a]	8	<.001
Likelihood Ratio	34.115	8	<.001
Linear-by-Linear Association	.503	1	.478
N of Valid Cases	110		

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.621	<.001
	Cramer's V	.439	<.001
N of Valid Cases		110	

Source: Created by the author.

The crosstab analysis shows that the number of respondents who indicated economic satisfaction for participating as a host in P2P-accommodation was 78 (70.9% of responses). Of these, 7.3% indicated that they felt completely safe from hosting strangers in their property; 29.1% indicated that they felt safe but had some concerns about hosting strangers; 20.0% indicated that they could not judge; 14.5% indicated that they felt unsafe but the risk was justified by the benefits and 0 people indicated that they felt very unsafe. Consequently, there is a preponderance of householders who indicated that they felt generally safe (36.4% overall).

The number of respondents who indicated social satisfaction with their participation as a host in P2P-accommodation was 21.8% of respondents. Of these: 5.5% indicated that they felt completely safe hosting strangers in their property; 7.3% indicated that they felt safe but had some concerns about hosting strangers; 9.1% indicated that they could not judge and 0 people indicated that they felt unsafe but the risk was justified by the benefits or that they felt very unsafe. Therefore, this category is dominated by householders who indicated that they felt generally safe (12.8% overall).

The number of respondents who were equally economically and socially satisfied with their participation as a host in P2P-accommodation was 7.3% of respondents. Of these: 0 people indicated that they felt completely safe hosting strangers in their property; 5.5% indicated that they felt safe but had some concerns; 0 people indicated that they could not judge or they felt unsafe but the risk was justified by the benefits; 1.8% indicated that they felt very unsafe. Therefore, this category is dominated by householders who indicated that they felt safe but had some concerns when hosting strangers (5.5%).

Additionally, in this case the significance level is <0.001 and it is less than the error α=0.05, which means that the null hypothesis that the two variables are independent of each other can be rejected. Therefore, there is a relationship between the two variables X9 and X10. Cramer's V has a value of 0.439, which means that the relationship between the two variables is *moderately strong*.

CONCLUSIONS

From the analysis of the survey data we can highlight the following important conclusions about the P2P-accommodation influence on rural host's wellbeing:

-The P2P-accommodation rural hosts on the Bulgarian Black Sea coast are mostly women. The marital status of the hosts is mainly married, with most indicating that they have children living in the household. The host participants in the survey are mainly well educated people, with only a quarter having secondary education.

-In relation to the income of rural hosts, predominantly household monthly income per person above 1200 BGN is reported in data observation. However, around a third from respondents indicated income ranged between 801 BGN and 1,200 BGN, which is the reason to believe that this host group could be practicing P2P-accommodation to improve their subsistence level, as the subsistence level for a working person in Bulgaria is 1,268 BGN for a single person and just over 800 BGN for a family member in a three-member family. [9] In addition, more than a tenth of the participants reported a household monthly income per person below 800 BGN. In these hosts' cases we can assume that P2P-accommodation provides a living wage and plays a significant role in their lives. Generally, the results show that P2P-accommodation is perceived as a material wellbeing improvement tool by rural hosts.

-It is notable that in the host structure over 5% are retired. In this regard, the fastest growing segment of hosts is those aged 60+, accounting for 13% of hosts on the U.S. P2P-accommodation market [11]. For these rural host's segment P2P-accommodation provides not only additional income, but also creates opportunity for a professional activity. This states the opportunity of P2P-accommodation to improve rural host's objective wellbeing indicators in terms of employment status.

-In terms of employment, mainly respondents work full time, but interestingly about one fifth (19.6%) are part-time employed and a further 14.3% are self-employed. In our opinion, these hosts are clearly practicing P2P-accommodation to supplement or diversify their work commitments and it is highly possible that for them P2P-accommodation is professionally motivated once again improving their wellbeing.

-The hosts are relatively experienced in P2P-accommodation as most of them have been practicing the service for more than one year (62.5%). This result highlights the positive attitude of rural hosts toward P2P-accommodation as a preferable modern type of activity. However, the remaining nearly 40% have started sharing P2P-accommodation within the last 12 months, which makes us believe that this modern accommodation activity is gaining popularity and is in a process of development and growth on the Bulgarian Black Sea coast.

-More than half of hosts share one accommodation unit and those renting 2 units account for a third of respondents. In our opinion, the latter segment will grow, as the number of people owning more than one property has been trending upwards in recent years in Bulgaria. Given that a major proportion of these people have a second property in rural regions, we believe P2P-accommodation will grow in this segment, especially as it offers an authentic experience.

-The shared units are mainly self-serviced apartments, which is an indication of the presence of a second home, and a holiday cottage, which is the typical unit in rural areas. Due to the availability of campsites on the Bulgarian Black Sea coast, around one tenth of respondents share a caravan, which could be registered as a positive prospect for the future development of niche P2P-accommodation in rural regions.

-According to the number of bookings made on an annual basis, the responses are different, but the mode and the median is 15 bookings on an annual basis, as also the indicated variance is insignificant. From our point of view, the data suggests low occupancy levels of shared units, indicating a need for change in hosts behaviour or type of offering. Although most users of P2P-accommodation are Bulgarian tourists, local customs, traditions and attractions vary according to the rural region in Bulgaria. The Black Sea coast, apart from the beach, has many other tourist resources - local cuisine, specific customs (such as Strandzha mountain area, Burgas), local attractions (such as Aladzha Monastery, Varna), etc., that can diversify and supplement the host's supply.

-The P2P-accommodation sharing reasons for rural hosts are clearly economic. Therefore, the hosts' reasons for generating additional income to raise their standard of living or guarantee a living wage are clearly expressed as leaders (48% in total). Though, expanding their social contacts accounts for a fifth from the responses, which also suggests the good opportunity of P2P-accommodation to improve the social aspects of their wellbeing as a co-influencer to the material indicators.

-In terms of security, it is clearly evident that hosts feel some insecurity to accommodate strangers on their property. The lack of guarantees in P2P-accommodation concerns the hosts, as the accommodation unit is not legally and financially fully guaranteed, unlike in the hotel industry. Here we would like to emphasize the importance of developing and integrating a specialized legal framework for P2P-accommodation regulation that would guarantee a secure sharing process [14]. Though, legal frameworks governing transparency are expected to be developed in the coming years, which will definitely affect P2P-accommodation development positively in terms of social wellbeing improvement [8].

-In terms of subjective wellbeing indicators, rural hosts are highly satisfied in terms of their P2P-accommodation activity. Most of them are economically satisfied, which gives the material wellbeing improvement a leading position. Corresponding to the findings in the part of reasons for hosting, a fifth from the respondents states social satisfaction. Fewer people point out a balanced satisfaction between economic and social aspects, which confirms our suggestion that there is mostly a leading position of material or social motivation in hosting.

-By exploring the relationship between satisfaction and security perception we would like to find out whether there is a lack of P2P-accommodation wellbeing improvement in the social aspect. Feeling and emotions are hardly to be reported as they are subjective, but the sense of safety is one of the basic and most important human needs. The findings show a moderately strong relationship between both variables, which means that their changes correspond to each other. Socially satisfied hosts more often feel safe in P2P-accommodation activity, which shows that there is no lack in social wellbeing improvement. Economically satisfied hosts feel safe but with some concerns about accommodating strangers. The latter suggests that P2P-accommodation material wellbeing improvement can cause some decline in the rural host's social wellbeing, but the benefits justify the risk as this is stated as the most common reason.

Generally, we can assume that P2P-accommodation positively affects rural host's wellbeing in both material and social aspects taking into consideration the Bulgarian Black Sea coast area. However, some improvements should be performed in terms of regulation framework and P2P-accommodation supply diversity to guarantee host's wellbeing improvement in the best manner.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

BIBLIOMETRIC INFERENCES ON UNFAIR TRADE PRACTICES IN THE AGRICULTURAL SECTOR

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Abstract

This paper presents the scientists' interest in studying the topic of unfair trade practices in agro-food chains, trying to answer the questions how important is this topic in academic writing and how it interferes with other terms? Exploring and understanding fairness-enabling practices in the agro-food chain is essential to create a sustainable and resilient agro-food system. The objectives of the research are to identify the main unfair trade practices that impacts the agents along the agro-food chain and the solutions given by scientists to solve inequity. In order to achieve these goals, a systematic literature review of papers covering the topic of unfair trade practices in agricultural sector has been conducted. The results show that there is an increased and relatively recent interest in studying unfair trade practices in the agro-food sector, with a noticeable growth in research since 2018. The main research connections of this topic include sustainability, emerging technologies to improve fairness in supply chains, the role of governance, agro-food policy and producers' organizations in mitigating unfair trade practices, the impact of different crisis on supply chains and trade practices. The results are relevant for rising awareness of how unfair trade practices impact the agents of agro-food chains and for finding solutions to avoid or reduce them.

***Key words**: unfair trade practices, equity, agriculture sector, agro-food chain, sustainable food chain, food waste*

INTRODUCTION

Unfair trade practices (UTP) manifest themselves through a variety of behaviors that exploit power and information asymmetries between supply chain actors [3]. For example, imposing unfair contract terms, delaying payments, unilaterally changing contract terms, and imposing unjustified additional costs are just some of the tactics used by some supply chain actors to maximize their profits at the expense of weaker links [1]. These practices not only undermine the economic stability and viability of primary producers, but also create dysfunctionalities throughout the supply chain, ultimately affecting consumers and the economy as a whole [21, 23].

The phenomenon of unfair trade practices is not a new one, having been associated over time with business and economics, and is emerging in technology, services and even the agricultural sector [26].

The concept of "unfair trade practices" has been identified and studied in various areas of business and economics over time. Initially, concerns about unfair practices were often associated with the field of competition and antitrust, dating back to the Sherman and Clayton Acts in the United States of America in the late 19th and early 20th centuries [23]. These laws were designed to regulate and limit forms of anti-competitive behavior, including unfair business practices [13, 24].

In the European Union, discussions on unfair trade practices started in 2009, accompanied by several communications on the subject. In 2013, there was a public consultation on the questions raised in an EU paper. In September 2016, a report was published calling on the Commission and Member States to take immediate action to prevent unfair commercial practices [6].

The European Union developed Directive (EU) 2019/633 to address the issue of unfair business-to-business trading practices in the agricultural and food supply chain. This Directive was developed to address significant inequalities in the bargaining power of suppliers and buyers of agricultural and food products, which can lead to unfair trading practices [27].

At the national level, Romania transposed the provisions of Directive (EU) 2019/633 through the Law on Unfair Commercial Practices between Enterprises in the Agricultural and Food Supply Chain. This law establishes a list of prohibited unfair trade practices in relations between buyers and suppliers within this supply chain, by regulating payment terms, the powers and duties of the competition authority, designated to ensure the national application of the provisions of the directive, such as and the sanctions applicable to the perpetrator of the violation [8].

The agri-food chain is not just a series of steps through which food products pass, but a complex ecosystem with a profound impact on society [15]. It plays a key role in ensuring food security, serving as the backbone of many countries' economies and providing jobs from agricultural production to [12,7].

In addition, the agri-food chain is fertile ground for innovation and technology with the potential to revolutionize the way food is produced and consumed, but its importance does not stop there and by adopting sustainable practices, the agri-food chain has the potential to contribute to protecting the environment and reducing greenhouse gas emissions [10]. An efficient and well-managed agri-food chain is also essential for public health, ensuring access to safe and nutritious food [9]. In a global context, it also facilitates international trade, connecting different markets and crops, and in crisis situations, be it pandemics or natural disasters, a resilient agri-food chain can mitigate the impact and help recovery [18]. Therefore, the agri-food chain is much more than a simple distribution mechanism, it is a vital element influencing the economy, health and the environment [28].

Considering the effects of unfair practices on agro-food system, this research has the objective of investigating the specialists and academics' interest in studying this issue and their main conclusions. The paper starts from the hypothesis that unfair practices not only disturb the economic activities along the food chain, but also have ethical implications. In pursuing this goal, bibliometric analysis and detailed literature review are used, as described bellow.

The paper is structured as follows: after the introduction, the methodology for studying the literature is described. The results are then presented and discussed, in the last part. Finally, conclusions are drawn, underlining the significance and the impact of unfair trade practices upon agro-food system's actors.

MATERIALS AND METHODS

In order to identify how researchers in the field have contributed to the topic of "unfair trade practices in agri-food", a systematic review of papers covering this area was conducted. Therefore, this was achievable by going through the reporting checklist of Preferred Reporting Items for Systematic Reviews and Meta-Analyses [20].

To achieve this aim, a comprehensive search was performed among 138 scientific articles in the SCOPUS and Web of Science Core Collection databases that addressed the topic of unfair trade practices in the agri-food sector, without imposing restrictions on publication date or language used. Thus, essential information such as abstract, keywords, journal name, year of publication, number of citations were exported to a spreadsheet. In order to search the articles in all fields of the two mentioned databases were: ***Unfair AND practices AND in AND the AND agri-food AND sector.***

The next step consisted in analyzing the titles and abstracts that were downloaded, verifying the eligibility of the articles in relation to the established topic, and eliminating those that did not meet the analysis criteria. For this purpose, 89 articles out of the total of 136 were eliminated in the first phase, and after the initial analysis, after a more detailed selection, 6 more

articles were eliminated, so that in the end the study aimed to address 41 scientific articles (Figure 1).
Further, the results of the bibliometric analysis carried out for the keywords “Unfair practices in the agriculture sector” are mentioned. For the bibliometric analysis, 5,300 articles published between 1928 and 2023 were analyzed. The topic of unfair trade practices has been debated since 1928, when the first scientific work on the subject appeared in the Purpose database.

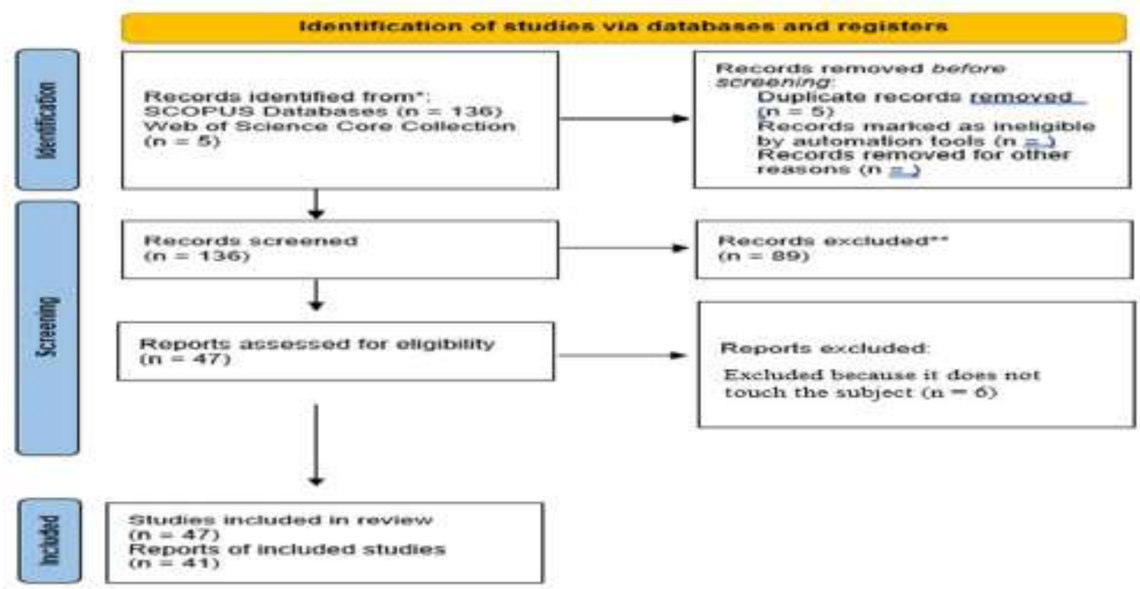

Fig. 1. PRISMA 2020 flow chart for the current agri-food UCP study
Source: PRISMA flow diagram, processing after (Moher et al., 2010) [20].

RESULTS AND DISCUSSIONS

On the analyzed topic, between 1998 and 2023, 289 scientific papers have been produced and are included in the Scopus database.

In terms of paper dynamics, the maximum number of papers drafted was in 2021 with 32 papers, decreasing in the following years to reach 19 papers in 2023 (Figure 2).

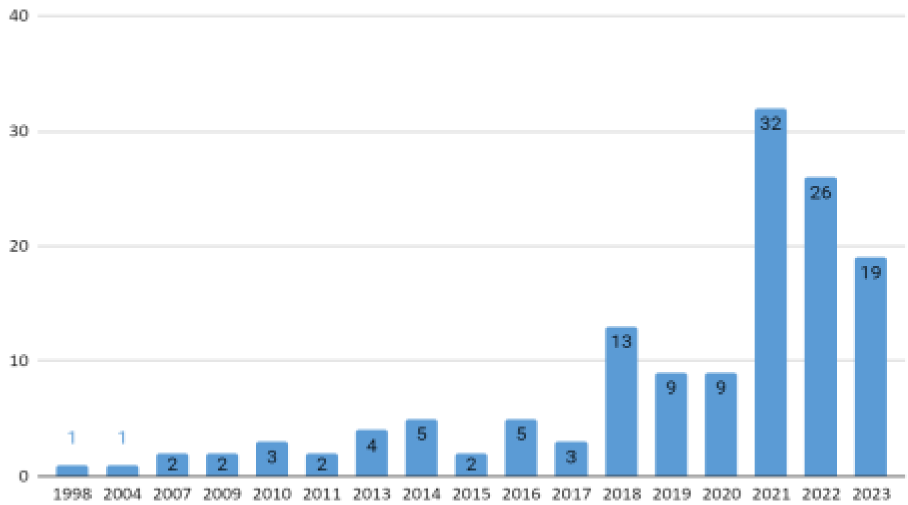

Fig. 2. Dynamics of the number of papers on the subject of "Unfair practices in the agriculture sector"
Source: Scopus data processing, Accessed on 10.09.2023 [25].

On the topic of unfair trade practices in agri-food, according to the Scopus database, articles were included in categories such as: social sciences (79 papers), economics (40 papers), business (37 papers), environmental science (35 papers), etc. (Figure 3).

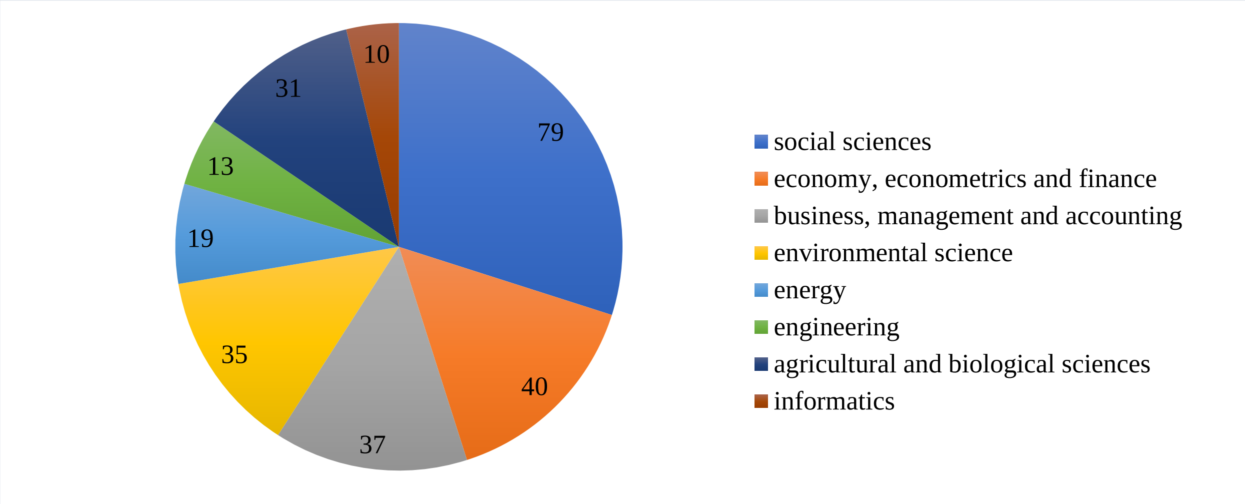

Fig. 3. Number of papers on the subject of "Unfair practices in the agriculture sector"
Source: Scopus data processing, Accessed on 10.09.2023 [25].

The keywords interconnected with the analyzed topic have been grouped into 3 clusters. The first cluster, focused on sustainability, includes keywords such as sustainability, food supply, agriculture, supply chain, sustainable development, agribusiness, showing that researchers are preoccupied by the topic of unfair trade practices in relation to sustainable development, through its social dimension, including ethics.

The second cluster, focused on equity, includes keywords such as fairness, supply chain management, dairy production, market power, literature review. It reveals the researchers' interest in fairness and equity along the food chain, emphasizing, in some papers, the unequal spread of power within agro-food system and in accessing markets.

The third cluster includes human rights and food industry and is less represented.

For the keywords used by year, from the fifth month of 2019 to the fifth month of 2020, researchers were concerned in studying human rights, agriculture, sustainable development, sustainability, up-to-date agriculture, food supply. Later on, starting from the sixth month of 2020 to the beginning of 2021, the main topics were on: supply chain management, agribusiness, supply chain, food industry, fairness. Countries such as the United States of America together with the United Kingdom, Italy and Germany are particularly interested in the topic.

The studies reported in data bases on the topic of unfair trade practices in agriculture have been ranked according to the number of citations. The results of the most cited articles are discussed below.

The majority of the studies on the topic of unfair trade practices concern about the negative effects of *power asymmetries* in agri-food supply chains [14]. Moreover, unfair trade practices have been associated with *food loss and waste*, impacts on the farm and farming communities, and negative effects on social and economic sustainability [11]. In particular, studies have highlighted that agri-food supply chains are susceptible to unfair trade practices that can damage trust and fairness among agricultural producers [2].

Some studies have highlighted the potential of emerging technologies such as *block chain* technology and digital applications in improving transparency and fair practices in supply chains [28, 17]. Thus, block chain technology can contribute to a more equitable distribution of value in supply chains by increasing transparency and more effectively tracking transactions and product provenance [26].

Some studies have examined the role of value chains in the development of *agri-food policy*

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

and in the regulation of unfair trade practices. It has also been noted that agri-food policy can play a significant role in promoting equity in supply chains by addressing challenges related to bargaining power and asymmetry in trade relations [9].

The COVID-19 pandemic has also contributed to this, exposing the fragilities and asymmetries in these chains and underlining the need to tackle unfair practices more effectively to ensure their resilience and sustainability [2]. At the same time, studies from various geographical and socio-economic contexts have highlighted how unfair commercial practices can vary according to local conditions and market characteristics [16].

Various studies have highlighted that *producers' organizations* can strengthen the bargaining power of farmers and help promote fairer practices in supply chains [4]. Producers' organizations membership reduces the likelihood of farmers reporting unfair trade practices, the estimated impact of producers' organizations membership is found to be largest for smaller farms [5].

Not least, *sustainability* is studied in connection to unfair commercial practices, many studies describing how sustainable are particular food chains, including from the ethical point of view. It was observed that the upstream levels of food chain include many unethical elements, from unfair trading practices to ethical treatment to farmers, from lack of transparency through technology and innovation to ensuring fair remuneration. The solution is to improve the position of farmers in the chain [22]. The authors have considered the following five upstream focused business applications to warrant fairness practices: blockchain, cooperatives, interbranch organizations, business applications for small-scale farmers, and Fairtrade. Moreover, for sustainable and resilient food systems, the governance is essential [19].

CONCLUSIONS

Fairness in the agro-food systems is an increasingly important issue, as shows the results of the bibliometric analysis and the literature review. The topic increased in relevance since the sustainable development goals brought into discussions equity and fairness.

There is an increased and relatively recent interest in the study of unfair trade practices in the agri-food sector, with a noticeable growth in research since 2018. The topic is approached from various academic perspectives, indicating its importance and complexity, as well as the need for interdisciplinary collaboration to fully understand the impact and implications of these trade practices.

The main research directions connected to unfair trade practices are:

-Sustainability effects of UTPs: focuses on identifying and assessing the impact of UTPs on sustainability issues, including food loss and waste, the economy of farmers and farming communities, and social and economic sustainability effects in the agro-food industry.

-Emerging technologies to improve fairness in supply chains: refers to the role of emerging technologies, such as block chain technology and digital applications, in improving transparency, fair distribution of value and preventing unfair trade practices in agro-food supply chains.

-The role of governance, agro-food policy and producers' organizations in mitigating unfair trade practices: addresses the impact of agro-food policy and the role of producers' organizations in mitigating unfair trade practices. It also underlines the importance of cooperation and collective initiatives to promote fair practices in supply chains.

-The impact of different crisis on supply chains and trade practices: the impact of the COVID-19 pandemic on agro-food supply chains, including on unfair trade practices and the need to adapt to new socio-economic contexts.

Ensuring fair and ethical practices in the agro-food chain is essential for sustainable and resilient agro-food systems. Future research may focus on finding solutions in mitigating unfair trade practices in agro-food chains.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

MANAGEMENT OF OCCUPATIONAL STRESS IN LEADERSHIP. CASE STUDY IN AGRICULTURAL ENTREPRENEURSHIP IN CĂLĂRAȘI COUNTY, ROMANIA

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Abstract

The role of leadership in managing occupational stress is particularly important because leaders have a significant influence on how their team perceives and manages stress. Managing occupational stress is a necessary skill for leaders in all fields, including agricultural entrepreneurship. In Călăraşi county, where agriculture plays a significant role in the economy, agricultural entrepreneurs face numerous challenges that can generate stress. Through this case study, we will identify the stress factors and the employees behavior, the self-assessment of their physical condition, the sources of tension at work, the moral values of employees and the strategies for managing occupational stress in the context of agricultural entrepreneurship in Călăraşi county. In this sense, we initiated a survey based on a questionnaire and unstructured interview, on a number of 200 respondents from the agricultural entrepreneurship of Călăraşi county, who work in commercial companies located in different areas of the county. The questions were structured on 2 levels, respectively, 4 filter questions and 6 sentence templates with 3 predetermined answers, in order to simplify the process of completing and analyzing the answers but also so that the respondents could choose the one that best reflects their perception regarding that item. By identifying and acknowledging the stress factors, using time effectively, open communication, and self-care, these entrepreneurs can promote a healthy work areat and maximize their business performance. As a general conclusion, occupational stress in agricultural entrepreneurship in Călăraşi county is manifested through a complex set of factors, linked both to the specificities of agricultural activities and to the socio-economic context. Faced with these challenges, agricultural entrepreneurs must adopt stress management strategies, be flexible and innovative to adapt to climate, economic, legislative, social and political changes to ensure the sustainability of their businesses in this dynamic and demanding area.

Key words: *entrepreneurship, management, leadership, stress, tension*

INTRODUCTION

In the contemporary world, the professional activity becomes an inherent aspect of human life, generating numerous stressful situations in modern society. The individual involved in the world of work is often obliged to adapt to specific organizational and occupational circumstances [4]. When organizations operate in areas characterized by risks and intense demands, stressful situations can arise that can lead to professional stress or occupational stress [2,17].

Currently, stress occupies a predominant place in the sphere of organizational behavior. It is perceived as a set of circumstances in which the individual cannot react adequately to environmental stimuli or can respond with an excessive cost to the body, manifesting itself through phenomena such as chronic fatigue, tension, anxiety, loss of self-esteem, depressive states and physical damage [1, 17].

Occupational stress is characterized as a complex and multidimensional phenomenon, reflected in the individual's psychophysiological reactions in a specific work area, manifested by the imbalance between work requirements and the individual's objective or subjective ability to manage them [18, 12].

The causes and effects of stress are varied and identification of the factors can be a difficult task. In the European Union, work stress represents the second health problem related to professional activity, after back disorders, being among the most frequent health problems encountered in the work place, affecting about 28% among EU employees [8, 11].

The framework directive 89/391 of the European Commission establishes fundamental regulations in the field of safety and health at work, clearly stating the obligation of employers to ensure safety and health at workplaces, including regarding the effects of stress. All member states of the European Union transposed this directive into their national legislation, and some of them developed additional guidelines for the prevention of stress at work [3, 1, 7].

The role of leadership in managing occupational stress is particularly important because leaders have a significant influence on how their team perceives and manages stress. An effective leader understands that occupational stress can negatively affect the performance, morale and health of employees and directly impact organizational results [5, 10]. Therefore, a responsible leader is committed to creating a work area that promotes the mental health and well-being of the employees [6].

Also, leaders can play an active role in identifying and managing stress factors within the organization. By constantly monitoring the work area and work demands, leaders can identify the main sources of stress and develop strategies to proactively address them. This may include adjusting tasks and responsibilities, providing training and resources to strengthen employees' stress management skills [1, 9].

Managing occupational stress in agricultural entrepreneurship leadership in Călărași county represents a constant challenge, especially in the current context of rapid changes and uncertainty. Through adaptability, agricultural entrepreneurs can more effectively manage stress and promote healthy and resilient work areas for themselves and their team [1, 21].

The motivation for the study of occupational stress management in agricultural entrepreneurship leadership in Călărași county is supported by many considerations which reflect the importance of this subject in the current context. First of all, agriculture represents one of the pillars of the economy in Călăraşi county, and agricultural entrepreneurs play a vital role in the development and prosperity of the region. Facing constant pressures and challenges in their business sector, these leaders are exposed to a high level of occupational stress, which can affect not only their personal well-being but also the performance of their businesses.

Secondly, agricultural entrepreneurs face new and unpredictable challenges, which can intensify stress and uncertainty. Climate change generated extreme and unpredictable weather conditions, affecting agricultural production and adding another dimension of stress for entrepreneurs.

In this context, understanding the effective ways of managing occupational stress among the leaders of agricultural entrepreneurship in Călărași county become essential for promoting resilience and success in this field. Understanding the specific stress factors that agricultural entrepreneurs face, and identifying the strategies and resources available to manage them, can help improve personal well-being and increase business performance.

MATERIALS AND METHODS

The purpose of this study is to identify the stress factors, the sources of tension at the workplace, the way they manage the stress and the satisfaction of the organization staff with regard to the work performed, correlated with the evaluation of the organizational culture in agricultural entrepreneurship in Călărași county as an essential aspect in shaping the work area and the impact on occupational stress.

Managing occupational stress is a necessary skill for leaders in all fields, including agricultural entrepreneurship. In Călăraşi county, where agriculture plays a significant role in the economy, agricultural entrepreneurs face numerous challenges that can generate stress. Through this case study, we aimed to identify stress factors and employees' behavior, self-assessment of their physical condition, sources of tension at work, employees' moral values and occupational stress management strategies in the context of agricultural entrepreneurship in Călărași county.

In this sense, we initiated a survey based on a questionnaire and unstructured interview, on a number of 200 respondents from the agricultural entrepreneurship of Călăraşi county, who work in commercial companies located in different areas of the county. Data collection was carried out physically, within commercial companies with an agricultural profile, during 4 calendar months, by four teams of data operators, under the authors coordination.

The questions were structured on 2 levels, respectively 4 filter questions and 6 templates of statements with 3 pre-set answers, to simplify the process of completing and analyzing the answers, but also so that the respondents can choose the one that best reflects their perception of the respective item.

The age groups were structured in five steps, as follows: up to 30 years, between 31-40 years, between 41-50 years, between 51-60 years, over 60 years.

With regard to the criterion regarding the level of studies, we structured it as follows: secondary, high school studies, higher studies, postgraduate studies; by gender: man and women; according to the occupational status, we structured the respondents by work departments: management staff; economic, technical and technological; administrative, other categories, as presented in Table 1.

Table 1. Sample structure and features features

Category	No. of respondents	%
Age		
Up to 30 years old	37	18.5
31-40 years old	56	28.0
41-50 years old	47	23.5
51-60 years old	39	19.5
Over 60 years old	21	10.5
Total persons depending on: age	**200**	**100**
Study level		
Secondary	16	8.0
High school	87	43.5
University	76	38.0
Postuniversity	21	10.5
Total persons depending on: studies	**200**	**100**
Residence area		
Urban	111	55.5
Rural	89	44.5
Total persons depending on: residence area	**200**	**100**
Gender		
Masculine	126	63.0
Feminine	74	37.0
Total persons, depending on gender	**200**	**100**
Field/Occupational status		
Management	31	15,5
Economic	42	21,0
Technical and technological	73	36,5
Administrative	38	19,0
Other categories	16	8,0
Total persons depending on post field	**200**	**100**

Source: Centralization of information obtained based on questionnaire [15].

From the centralized information following the application of the questionnaire, it is found that most of the persons included in the sample have university/post-graduate studies in percentage of 48.5%, followed by the category of persons with high school education, in percentage of 43.5%. By residence place, 55.5% live in the urban area, by gender, 63%

are men, by occupational status, 36.5% are from the technical and technological field, followed by those from the economic field and 19% from the administrative staff.

RESULTS AND DISCUSSIONS

The abundant natural resources of Călăraşi county are a major advantage for local agricultural entrepreneurs. The fertile soils and favorable climate allow for a remarkable diversity of crops and the raising of a wide range of animals. These favorable natural conditions are the solid base of operations for agricultural entrepreneurs in the area [14].

However, the sector faces significant challenges, among which climate change stands out as one of the most pressing. Their impact on crops and pressure on water resources can seriously affect agricultural activity. In addition, the technological upgrading required in this area requires significant investment, and access to adequate finance and infrastructure can often be limited [15,16].

Legislative and political changes represent another influencing factor on agricultural entrepreneurs in Călăraşi county. Agricultural subsidy regulations, environmental policies and international trade agreements can determine the direction and viability of businesses in the local agricultural sector.

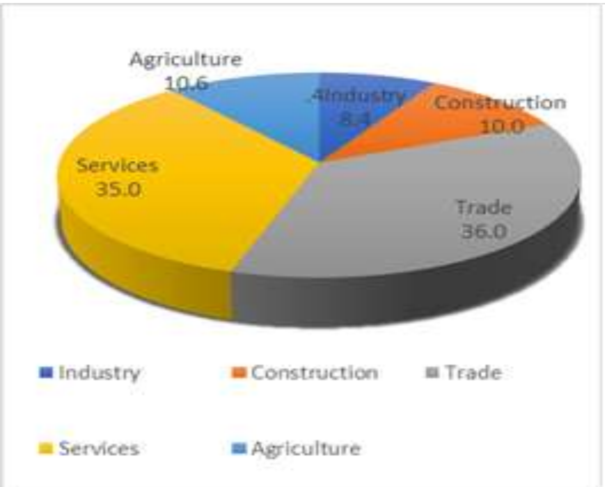

Fig. 1. Procentage structure of active enterprises depending on activities, in year 2023
Source: Statistical Yearbook, Călărași County [19].

Regarding the business sector at the level of Călărași county it is remarked a significant difference regarding the agricultural sector, that represents 10.6 % of the number of active enteprises at county level, compared to 36% in trade field and 35% in market services field, as it is shown in Figure 1. Thus in 2023 a decrease is recorded compared to year 2020 by 0.6% regarding active enterprises [20].

Regarding the turnover structure, 20% of the agricultural sector is noted, as shown in Figure 2.

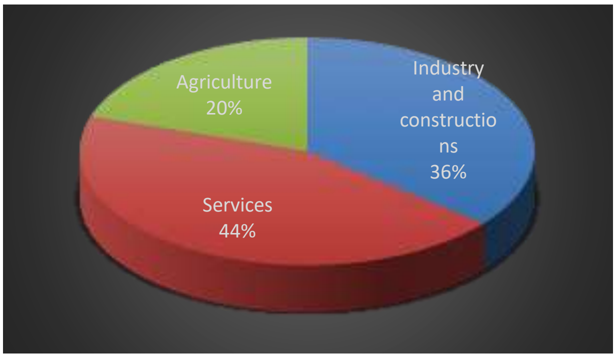

Fig. 2. Structure of business sector in Călărași from the point of view of turnover in the year 2023
Source: Statistical Yearbook, Călărași County [19].

Occupational stress in agricultural entrepreneurship in Călărași county reflects a complex and distinct reality, characterized by particularities specific to this sector. In an agricultural business sector, entrepreneurs face unique challenges, deriving from the specific characteristics of agricultural activities, environmental conditions, as well as the socio-economic context specific to the region. Analyzing these particularities, a detailed picture of the impact of occupational stress on agricultural entrepreneurs in Călărași county is outlined (Table 2).

Leaders can also shape their behavior, by adopting a balanced and resilient approach to workplace challenges and pressures, they can inspire and motivate their team to do the same. It is important for leaders to be aware of their own limits and take responsibility for managing their own stress, as their behavior can impact organizational culture. By addressing and analyzing these aspects, we can gain a deeper understanding of the context and challenges faced by agricultural entrepreneurship in Călăraşi county, and we can identify strategies and solutions for the effective management of occupational stress and for promoting the sustainable development of the sector.

Table 2. Aspects followed in the particularization of occupational stress specific to agricultural entrepreneurship in Călăraşi county

Aspects followed	Features
Agricultural entrepreneurship structure	-We analyse if agricultural entrepreneurship in Călărași county is dominated by small individual farmers or larger associative forms, such as agricultural cooperatives, producers groups, stock companies. -We analyze the distribution of farms depending on dimension, type of property (individual, associative) and production profile.
Turnover and financial performance	We evaluate the impact of turnover level and financial performance on occupational stress level and agricultural entrepreneurs in the region.
Concrete conditions of area nad work	We analyze how weather conditions, soil charactristics and other environment variables influence the occupational stress of agricultural entrepreneurs.
Demographic tendencies and labor force	We evaluate the impact of demographic tendencies on availability and qualifications of labor force in the agricultural secotr, as well as the migration degree and active population ageing.
Infrastructure and access to technology	We analyze the level of rural infrastructure, access to technology and internet, that can influence efficiency and competitiveness of agricultural entrepreneurs.
Efects of climate changes	We investigate the impact ofclimate changes on agricultural production, related risks (such as drought, floods) and adaptation strategies adopted by entrepreneurs.
Institutional support and agricultureal policies	We evaluate the way in which the national and local agricultural policy, including support and financing programs influence the agricultural business sector and entrepreneurs stress level.
Conditions of market and competitiveness	We analyze the dynamic of agricultural market, including prices of agricultural products, competition with important products and export opportunities, that can affect the entrepreneurs stress level.
Resilience and innovation	We investigate the capacity of agricultural entrepreneurs to adapt to changes and innovate in production, management and trade processes, in order to face challenges and to maximize success potential.

Source: carried out by authors.

In addition, leaders can promote an organizational culture that recognizes and values the importance of mental health and work-life balance.

By creating a work area that encourages openness, mutual support and collaboration, leaders can help reduce the stigma associated with discussing mental health and promote a climate where employees feel comfortable asking for help when they need it.

The organizational culture in agricultural entrepreneurship in Călăraşi county represents an essential aspect in modeling the work area and its impact on occupational stress. This organizational culture is defined by the values, norms, behaviors and relationships between the members of the organization, and in the context of agricultural entrepreneurship, it can substantially influence the levels of stress felt within the business, as presented in Table 3.

Organizational culture can also influence the degree of team support and collaboration. An area where employees feel part of a community, encouraged to share knowledge and collaborate in solving problems, can reduce isolation and pressure on individuals.

Professional development and recognition of efforts are also key aspects in defining organizational culture.

When there is a concern for skill development and recognition of contributions, agricultural entrepreneurship can become more attractive and motivating for employees.

However, certain characteristics of organizational culture can also contribute to increased occupational stress.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

A culture that promotes excessive competition or does not encourage work-life balance can increase the pressures on employees. Also, work conditions and workplace safety are essential components of organizational culture, and their lack can contribute to increased levels of stress.

Table 3. Correlation of organizational culture elements with occupational stress

Elements of organizational culture	**Stress factors**
Leader communication	-Lack of communication or inefficient communication of expectations or directions can generate confusion and incertainity among employees, that can lead to stress. -Inconsistent communication or lack of transparency from leader can nourish rumors and speculations among the team, that can affect trust and moral.
Leader values	-Differences between values and invididual principles of leader and employees can create conflicts in the team, generating stress. -Lack of coherence between values expressed by leader and his real behavior can undermine trust and respect of employees, contributing to feeling of frustration and stress.
Leader behavior	-Authoritative or inappropriate behavior from the leader can create a tense and unpleasant work area, contributing to employee stress. -Lack of support from leader in difficult situations can amplify feeling of uncertainty and frustration, increasing the stress level.
Work conditions	-Lack of some safe and healthy work conditions, such as adequate protection equipment or ergonomic work conditions, can expose employees to risks and can generate sress related to health and security. -An innapropriate work area, such as overcrowd, excessive noise or lack of intimacy can affect psychological well-being of employees and can contribute to general stress.
Personal development	-Lack of development opportunities and professional perspective can generate frustration and dissatisfaction among employees, that can lead to stress and demotivation. -Pressure to improve or stay undated to technological and industrial changes can generate anxiety and stress among employees, especially in a evolving sector chs as agricultural sector.

Source: carried out by authors.

I. Organizational background

Job satisfaction is an important aspect in organizations, influencing not only the well-being and motivation of employees, but also the efficiency and productivity of the organization as a whole.

Table 4. Organizational background

	Items	**Dissatisfaction**	**Relative satisfaction**	**Satisfaction**
1	Communication and way in which information circulate between departments/employees.	30%	20%	50%
2	Work you currently perform.	15%	10%	75%
3	Style of management used by superiors.	10%	10%	80%
4	Way in which changes and suggestions are put into application.	5%	15%	80%
5	The extent to which you feel you can develop or fulfil yourself within this organisation	0%	30%	70%
6	The way in which conflicts within organization are solved	0%	20%	80%
7	The degree to which your job requires the professional training and experience you believe you possess.	5%	5%	90%
8	The psychological atmosphere or climate existing in the organization	0%	30%	70%

Source: Centralization of information obtained based on questionnaire [13].

In this context, identifying the factors that contribute to job satisfaction or dissatisfaction is essential for improving the work area and organizational performance.

The first category of questions addressed in this study aims precisely at this dimension of satisfaction within the organization.

Subjects were asked to rate their perception of the work carried out, communication within the organization, the leadership style practiced by superiors, as well as the general atmosphere within the organization, with a value scale with levels: ***satisfaction, relative satisfaction, dissatisfaction.***

Analyzing the percentage distribution of these answers, it results that most of interviewees appreciated items on organizational background generating complete satisfaction, as it is shown in Table 4.

II. Employees perception regarding tension they feel on the work place

The feelings and behavior of employees at work are topics of major interest in organizational psychology studies, as these aspects can significantly influence the performance and well-being of employees, but also the success of the organization as a whole. One of the factors that can deeply affect the emotional and behavioral state of employees is the tension felt at work. Stress can be caused by various reasons, such as overloading with tasks, lack of clarity about role and responsibilities, or strained organizational background.

In this context, it is important to understand how employees' feelings and behaviors manifest in relation to workplace stress, and the subjects were asked to rate their perception of the stress they feel at work, based on four items, evaluated with a scale of values with 3 levels: ***high extent, relative extent, small extent***, according to the information in Table 5. Most of the interviewees appreciated that they feel the items regarding the tension at work in a relative extent.

Table 5. Employees perception on tension they feel at workplace

	Items	High extent	Relative extent	Small extent
1	During an usual working day you feel disturbed, although the reasons of this state are not always clear, obvious	17%	53%	30%
2	You notice somethimes a decrease of trust you have in your own strength	19%	41%	40%
3	You live long period of sadness or melancholy for reasons you cannot simply explain	12%	28%	60%
4	It happens at work that the things you have to do become too much and you feel overworked (overwhelmed)	30%	55%	15%

Source: Centralization of information obtained based on questionnaire [13].

III. Self-evaluation of physical health

For the self-assessment of the physical health of the respondents, we proposed the analysis of specific signs and symptoms that may indicate a state of well-being or stress for the individual, based on five items, evaluated with a 3-level value scale: ***never, sometimes, frequently,*** according to information from Table 6.

Table 6. Self-evaluation of physical health of interviewees interviewees

	Items	Never	Sometimes	Frequent
1	Unexplained fatigue or exhaustion.	2%	62%	36%
2	Tendency to eat, drink or smoke more than usual.	4%	56%	40%
3	Feeling of suffocation or dizziness.	4%	70%	26%
4	Tingling or stabling in some parts of the body	8%	72%	20%
5	You struggle to go out of bed in the morning	8%	72%	20%

Source: Centralization of information obtained based n questionnaire [13].

In a range between 56-72% of the respondents, they mentioned that they ***sometimes*** feel the stated symptoms, and in a range of 20-40% they mentioned that they feel them ***frequently***.

IV. Sources of tension at the workplace

The sources of workplace stress are diverse and can significantly affect employee well-being and performance. These can range from excessive tasks and responsibilities to lack of recognition and poor working conditions.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Following the analysis of a number of 13 items, which capture aspects such as the level of guidance and support from superiors, discrimination or favoritism, the impact of changes in work requirements on employees, etc., evaluated with a 3-level value scale: ***it is not source of tension, it is sometimes, it is frequent,*** according to the information in Table 7. Most of the interviewees appreciated the mentioned items as ***frequently*** or ***sometimes*** sources of tension at the workplace.

Table 7. Sources of tension at workplace

	Items	It is not a source of tension	Sometimes, it is a source of tension	It is frequently a source of tension
1	To manage or supervise others work.	20%	30%	50%
2	To have work also at home.	0%	30%	70%
3	To work at inferior level of your capacities.	30%	20%	50%
4	Guidance and insufficient support from superiors.	10%	20%	70%
5	Lack of consulting and communication.	20%	30%	50%
6	To keep up with technique, innovations, ideas and new technologies.	10%	10%	80%
7	To participate in meetings	50%	40%	10%
8	To work late	10%	30%	60%
9	Discrimination and favoritism	10%	70%	20%
10	To be underestimated	0%	10%	90%
11	To be obliged to take risks	10%	20%	70%
12	The requirements how to do your work	40%	40%	20%
13	Bad work conditions (heat, ventilation, light, noise etc.)	30%	40%	30%

Source: Centralization of information obtained based on questionnaire [13].

V. Ways for stress management

Based on the data presented in Table 8, we remark that the employees go through various modalities to manage stress and tension at the workplace.

Table 8. Modalities of stress management

	Items	Never	Sometimes	Frequent
1	I refer to hobbies and fun.	10%	38%	52%
2	I try to look at the situation objectively, I do not let myself influenced by my emotional states.	10%	20%	70%
3	I smoke, drink coffee, energy drinks	8%	32%	60%
4	I talk to friends, family	20%	40%	40%
5	I broaden interests and activites outside work.	10%	40%	50%
6	I solve problems in order of importance and emergencies.	0%	30%	70%
7	I refer to specialized assistance	99%	1%	0%

Source: Centralization of information obtained based on questionnaire [13].

Among these modalities they go though hobbies and fun, discussions with friends and family, prioritizing solving problems depending on importance and emergency, trying to look at situations objectively, that are evaluated with a scale of value ***sometimes*** or ***frequent*** related to the 8 items mentioned as modalities to reduce stress, by which employees maintain a balance between professional and personal life and face professional challenges.

VI. Values valued by the respondents.

Based on the data presented in Table 9, it is obvious that the respondents value certain values that they want to have at their workplace. Among them it is the possibility of a salary according to the work performed, suitable working conditions, positive relations with chiefs and colleagues, job security, promotion of opportunities and incentives leading to their personal development, which they rate as ***very important*** on value scale.

Table 9. Values valued by respondents related to workplace workplace

	Items	Very important	Relatively important	Not at all important
1	Salary corresponding to wokr performed	90%	10%	0%
2	Good work conditions.	80%	20%	0%
3	Good work relatins with colleagues and chiefs.	80%	20%	0%
4	Job safety.	100%	0%	0%
5	Compliance with work schedule	60%	20%	20%
6	Possibility to be promoted.	100%	0%	0%
7	Existence of some incentives that lead to personal development	100%	0%	0%

Source: Centralization of information btained based on questionnaire [13].

VII. Factors generating stress, outside organization.

Based on the data presented in Table 10., it is obvious that the factors specific to the conditions in which entrepreneurship in the agricultural field carries out its activity, leave their mark on the stress level of those who are part of this economic-social process, all the stated items being appreciated as ***frequently*** generators of stress, with percentages between 70-100% on the value scale.

Table 10. Evaluation of stress generating factors, outside organization

	Items	**Never**	**Sometimes**	**Frequent**
1	Seasonality of the agricultural works	0%	22%	78%
2	Climate incertitude	0%	0%	100%
3	Financial resource management/Access to financing	0%	20%	80%
4	Availability of qualified work force	0%	30%	70%
5	Integration of modern technologies in agricultural practice	0%	30%	70%
6	Legal aspects and specific regulations in the feild of agriculture	0%	10%	90%

Source: Centralization of information obtained based on questionnaire [13].

Regarding the organizational climate, the results indicate a significant level of satisfaction in terms of internal communication, the work currently carried out and the leadership style of superiors. Also, the psychological atmosphere and the way conflicts are resolved were perceived as very satisfactory by the majority of respondents. However, there is a significant percentage of dissatisfaction with how changes and suggestions are implemented, which may indicate the need for improvements in the process of implementing organizational changes.

It is obvious that an environment where information flows efficiently and employees feel encouraged and motivated to carry out their activities contributes to greater satisfaction. However, there is a need to improve the processes for implementing changes and suggestions to ensure proper adaptation to organizational changes.

Self-assessment of physical health shows that unexplained fatigue or exhaustion sometimes occurs, as does the tendency to eat, drink, or smoke excessively. However, feeling suffocated or dizzy is less common, indicating that the physical aspects of stress can vary by individual.

Promoting a healthy lifestyle and providing resources to deal with fatigue and daily pressures can help improve employee health.

The sources of stress in the workplace are diverse, and the results indicate multiple tasks, changes in work demands, overtime, and their recognition is essential for the implementation of corrective measures. Issues such as leadership, overwork, lack of support and working conditions must be addressed through proper human resource management and the adoption of policies and practices that support employee balance and well-being.

The stress management strategies adopted by employees reflect the diversity of personal approaches. Regarding stress management, respondents adopt different ways, such as go to hobbies and fun, trying to look at the situation objectively, and talking to friends and family. However, smoking, drinking coffee and energy drinks seem to be quite common, suggesting that some stress management behaviors may be less healthy.

Values, such as the balance between professional and personal life, through the possibility of promotion and personal development supported by employers, salary corresponding to the volume and complexity of the work performed, good working conditions, service safety and positive relations with the direct chief are important for employees. Understanding these values can guide organizational strategies for creating a work area that meets the needs and aspirations of employees.

The evaluation of the information obtained through the questionnaire and free discussions with the respondents offers a comprehensive perspective on the complexity of the working area in agricultural entrepreneurship in Călărași county, highlighting important aspect related to satisfaction in the work job, emotional state and perceived stress. This information provides an useful background for developing some efficient strategies of improving working condition and promoting employees welfare.

This analysis provides a general image of employees perceptions and experiences among the agricultural entrepreneurship in Călărași county, thus providing the base for identification and implementation of efficient strategies for stress management an improve organizational climate.

CONCLUSIONS

In the current context, the management of occupational stress in agricultural entrepreneurial leadership in Călăraşi county becomes urgent, considering the rapid and unpredictable changes in the economic sector in general.

One of the defining factors of stress in agricultural entrepreneurship is the seasonal nature of agricultural activities. Production cycles and agricultural work are often dictated by weather conditions and natural phenomena, imposing intense pressures at certain times of the year. This seasonality can generate a significant workload in a limited amount of time, increasing stress levels for contractors and workers

Climate uncertainty is also a significant source of stress in agricultural entrepreneurship. Unforeseen changes in the weather, such as droughts or floods, can affect harvests and create difficulties in the efficient management of resources. Agricultural entrepreneurs face permanent risks related to climate variability, which can generate considerable stress and financial pressure.

The stress related to the management of financial resources represents another particularity in agricultural entrepreneurship in Călărași. Production cycles and market fluctuations can create uncertainties regarding revenues and costs. Access to finance and effective management of agricultural budgets are significant challenges, contributing to increased levels of stress for entrepreneurs.

Labor-related aspects are also an important component in generating occupational stress. The availability of skilled labour, managing teams during busy periods and dealing with human resource issues can bring significant pressures on agricultural entrepreneurs in the region.

Another distinctive aspect of stress in agricultural entrepreneurship is related to technological aspects. Integrating modern technologies into farming practices, while it can bring efficiency and innovation, can also be a source of stress. Learning and adapting to new technologies, as well as initial investments in advanced equipment, can create additional pressures for entrepreneurs.

Also, legislation and regulations specific to the agricultural field add complexity and stress to business management. Changes in agricultural policies, compliance requirements, and bureaucracy can demand additional resources from agricultural entrepreneurs and contribute to increased levels of stress and uncertainty.

Occupational stress in agricultural entrepreneurship in Călăraşi county is manifested by a complex set of factors, linked both to the specificities of agricultural activities and to the socio-economic context. Faced with these challenges, agricultural entrepreneurs must adopt stress management strategies, be flexible and innovative to adapt to changes and ensure the sustainability of their businesses in this dynamic and demanding area.

In conclusion, a well-defined organizational culture that promotes open communication, work-life balance, professional development and workplace safety can create a healthier and more sustainable work area for entrepreneurs and employees in agricultural entrepreneurship. In contrast, a culture that emphasizes excessive competition, isolation or ignoring welfare issues can contribute to increased levels of stress and pressure in this sector.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

EFFECTIVENESS AND SIGNIFICANCE OF CROP YIELD FORECAST MONITORING CONSTITUTED ON VEGETATION INDICES

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Abstract

The article presents the post-hoc analysis on the crop yield forecasting on three crops across EU carried out by JRS-Mars: wheat, maize, sunflower. These crops, to less extent sunflower are one of the most widespread and grown crops across EU-27. The area occupied with those crops tallies up to 23 per cent of the utilized agricultural land and over 39 per cent of the arable land throughout EU, where in some members, including Bulgaria, their share exceeds 75 per cent of arable land. The main goal of the research is to investigate and through statistical analysis to reveal the statistical significance, effectiveness and accuracy of the crop yield forecast monitoring done by JRC-Mars, which is developed on remote sense monitoring and models set up in the of vegetation indices. The forecast results on March-April for wheat and June-July for grain maize and sunflower are juxtaposed by the actual data baseline yields. The goal of the paper is also complemented to analyze the differences in the forecast outcomes related to country's specifics, crop sensitivity and forecast time coherences. The results demonstrate that such statistical analysis are quite relevant and convincing tools to illustrate and substantiate the level of reliability of yield forecasting and that vegetation indices are appropriate element for building up yield forecasting models.

Key words: *yields, accuracy, vegetation indices, effectiveness, statistical significance*

INTRODUCTION

The grain and oilseed industries are of a great importance for the EU agriculture. Thus, the tasks for forecasting and projecting the yield and production from those staple crops in EU is considered crucial not only from the scientific point of view but also as a practical issue related to food security, coping with farmer's risk management, policymakers and commodity traders [1, 3, 16].

The EU system for information on crop growing conditions and yield forecasting was set in 1992 and is an object of a widespread interest in the academic community [20]. The yields are affected by complex and various factors - the applied production technology, farmer`s management skills and performance, climate and soil characteristics [17].

To evaluate the forecasting relevance, the following key elements are assumed – accuracy, statistical significance and effectiveness [15].

The general understanding of interpretability is to create models that are easy understandable. Such models might be linear regressions and hierarchical based models (trees) [19, 18]. A Gradient-boosted decision tree (GBDC), such as the Joint Research Center -MARS, is a standard machine learning model which demands expert interpretation to evaluate the results correctly [17].

In this paper we use basic statistical procedures based on the error – accuracy, effectiveness and significance to analyze through the statistical tool the main forecasting performance characteristics and based on it to deliberate on the robustness of vegetation indices, which are widely used as a factor for remote sense yield forecasting models.

The most interesting feature of MARS CropYield Forecasting System is to predict the "end-of-season" vegetation levels of crop production [20] when it is at completely matured quality. The most of EU-27 member states experienced their highest wheat production harvesting in 2021, while in 2018 is estimated the lowest yield of the selected period [11]. The difference between these annual wheat yields on EU level were accounted up by12.4%while the planted area in 2021 was only 1.36% more than 2018 [5].

Average yields of maize and sunflower also had a significant volatility more than two times within the covered period. The variation in production of these two crops also had a significant scale, more than twice in difference – Romania had the poorest maize production (5.5 t/ha on 6-year average). On the other side, the highest was in Spain (11.6 t/ha), but at a cost of the lowest yield of sunflower (1.2 t/ha) in which field Croatia was the top producer with 3 tons per hectare.

The EU total (UAA) had reduced by 0.55% during the period under this study. This had a stronger impact on the crop rotation of the agricultural area. The arable land usage decreased by 2.38% [6].

The most important field crop producers are France processed arable land more than17 million hectares and Spain cultivated 11.7 in 2022 [6]. Furthermore, the rates of their land usage declines were also the most valuable – respectively 8% and 5% less than 2017. Germany (1% reduction)and Poland (2% increase) also had more than 11 million hectares. Romania had 8.2 which is 4% less than 2017 while Italy also raised the crop rotation area to more than 7 million hectares or by 2%.

MATERIALS AND METHODS

The yield forecasting in the agriculture is a complex multi-disciplinary exercise and widely explored research goal [7]. Regarding the most widespread approaches to crop yield forecasting are different statistical models, usually based on the regression and none linear modeling, and elaboration of crop-specific mechanistic models that examined in detail plant physiology and its interaction with the air and soil environments - process-based models [7]. Since 1993, the European Commission by one of its research hubs – Joint Research Center begun crop monitoring, yields and production forecasting. It has established Mars Crop Yield Forecasting System (MCYFS). The main role of the MCYFS is to provide yield statistics of the major crops at EU and national level, as accurate and timely as possible, while ensuring independence from all external sources of estimates, including the national statistical systems [8]. The JRC-MARS unit has managed to set up a comprehensive and multi-parametric system for forecasting based on meteorological analysis, agro-meteorological simulated crop growth indicators, low-resolution satellite data and statistical analysis thus it does not rely on one or limited number of factors and data sources.

The Crop Growth Monitoring System (CGMS) is under a constant upgrading and is composed of the following data factor pillars: weather indicators, crop indicators, remote sense based vegetation indices, national yield statistics, additional sources [9].

The vegetation indices are essential modules of the CGMS and those indexes are collected by remote satellite sensing. The Normalized Difference Vegetation Indices (NDVI) are most frequently applied remote sense indices, which are incorporated in the crop yield forecasting. These indices could be applied as qualitative indicators for biomass development and consequently crop yield [14].

The NDVI is thought as one of the most widely used indicator describing the level of vigour, the metabolic activity of crop, the consumption of $CO_2$by photosynthesis, of water and nutrients [2].

In the literature is revealed that the use of solely vegetation indices, regardless of what type is connected to not sufficient yield forecasting accuracy, which is due to various reasons where the leading one is that vegetation biomass factor might not be the absolute yield benchmark. It is unequivocally found that similarity in vegetation biomass crop growth recorded by vegetation indices might result in different regions and years with different harvesting yields, which reveal the inadequacy of vegetation indices as a sufficient tool for yield measuring.

The methodology of this paper is dedicated to illustrate the statistical approaches for analyzing the prognostic robustness carried out in wide range of agricultural economic studies.

The particular object of this analysis is the yield forecasting delivered by MARS bulletins on EU main crops. The purpose is not to evaluate and scrutinize the MARS methodology and forecast outcome reliability rather it is designated to demonstrate the statistical approaches in general to conduct such analyses and concretely to emphasize on the accuracy, statistical significance and effectiveness in work with vegetation indices for crop forecasting.

Velde and Nisini (2018) provide a quality assessment of MCYFS forecasts made from 1993 to 2015 focusing on accuracy, in-season, and year-to-year improvements. It is noted that accuracy of the forecasts can be investigated by calculating the mean absolute error (MAE), the mean absolute percentage error (MAPE), the root mean square error (RMSE), etc. The forecast accuracy can be analyzed in terms of forecast timing and can be defined as accuracy of early yield forecasting during the season, as well as the late forecasts a month before harvest (the pre-harvest forecast) [21].

The accuracy in this analysis is a derivation of the mean absolute error rate, which is calculated as follows:

$$MAER = \left|\frac{(FY_M - AY_M)}{AY_M}\right| \qquad (1)$$

$$ACR = 1 - MAER \qquad (2)$$

where:

FY_M - yield forecast by months;

AY_M - actual yield by month;

ACR – accuracy of yield forecast.

The analysis of yield forecast based on the JRC-MARS model cover up three main and vastly grown crops in the EU – wheat, maize and sunflower. The selected forecast months are March-April for wheat and June-July for spring crops – maize and sunflower. The selected forecast months are positioned 2-3 months before harvesting of these crops, which represents about 2/3 of the vegetation period concerning wheat and more than half of the whole vegetation duration for maize and sunflower. It anticipates that the vegetation of the crops is in advanced phases and vegetation indices and meteorological data are soundly evolved and probabilistically appropriate. It is also alleged that generally the JRC-MARS system characterized with higher forecast errors at the beginning of the season and lower at the end according to a cumulative effect of the climate impact on the crop behavior [9].

The forecast error and accuracy are related statistically to plausibility and significance. The statistical significance is important criteria to accept or reject the obtained results, which in common is represented by probability (p-value). Although, the Fisherian and Neyman-Pearson schools [12] do not affirm that p-values of less than 0,05 is regarded as statistically significant whereas p-value of over 0,1indicates for not statistically significant difference [4], it is commonly accepted to infer in this direction. The determination of p-value can be done from t-statistics, using the classical formula:

$$t = \frac{\bar{X} - \mu}{\sigma/\sqrt{n}} \qquad (3)$$

In this analysis coefficient of significance is estimated by the following formula suggested by [10]:

$$CS = \frac{\bar{X} - \sigma}{\frac{\bar{X} + (N-1)*\sigma}{N}} \qquad (4)$$

where:

$\bar{X}$ - average estimated between the yield forecast and actual yield;

σ - standard deviation between forecast and actual yield results.

The interpretation of the coefficient of significance (CS) is whenever it is higher than 1, the forecast results and actual yield results are not found different and practically they have same meaning, which complies with confirming the null hypothesis in F and Pearson statistics. This way of estimating the statistical significance of the forecasts brings simplification through obtaining certain coefficient demonstrating without needs to refer to t-statistics to conclude the likeness of results. The coefficient of significance of 1 complies with a confidence level of 67%, which is considered at critical point to accept the deviations.

The analysis of yield forecast is supplemented by an overview of effectiveness of the approach MARS model. The effectiveness is thought to show how much and to what extent the intended results are attained and how the effectiveness changes through the member states and crops. The maximum effectiveness means achieved result meets or surpass the targeted intended value. In terms of this study, maximum effectiveness is reached when the forecast and actual yield results are same and no error is calculated. The equation used for effectiveness (EFVE) is:

$$EFFE = 0.5 + \left(0.5 - \frac{MAER}{(1+MAER)}\right)............(5)$$

Thus the effectiveness can vary in the range of 0 to 1 and it takes into account the mean absolute error rate, which differently from the accuracy demonstrates the rationality and usefulness of forecast model and indirectly reveals the plausibility of vegetation indices incorporation in yield forecasting.

The observation years of the research, where the data is collected by JRC-MARS bulletins are from 2017-2022. The actual yields for selected crops are checked year later than the forecast months, i.e. the forecast yields for wheat in March-April, 2022 is validated by the MARS bulletin March-April, 2023. For the needs of result interpretation, the result ranges are assumed. The accuracy coefficients are divided into four tiers: over 0.95 – very good accuracy, 0.90 – 0.94 – good, 0.80-0.89 – moderate and less than 0.79 – generally insufficient composed of lowering grades, which are not interested for analytical purposes.

Regarding the effectiveness of the forecast tool to achieve the outcomes, the four tiers are defined as: over 0.91 – very good, 0.81-0.90 – good, 0.71-0.80 – moderate, less than 0.70 – insufficient.

RESULTS AND DISCUSSIONS

The results from analysis and statistical procession are illustrated by crops and harvesting years.

It is found that the most precise and accurate yield forecasts are achieved to soft wheat, which is characterized as the most important and widespread crop in the EU-27. The average measured forecast accuracy is estimated at 0.90 over the whole period 2017-2022.

The lowest accuracy is recorded for the crop harvest of 2018 with a moderate accuracy score at 0.84 while 2022 was with the highest accuracy outcome marked as good at 0.93.

The Netherlands and France received only good and very good statistical results which is also applicable to the common EU forecast. Most of the member states(85% of them) received good forecast accuracy, which is ranged between 0.90-0.94.

It is interesting that the JRC-MARS forecast model is working quite successfully in terms of predicting EU average yield, where the accuracy is defined as a very good level of 0.97.

By geographic cross-sectional analysis is viewed that the accuracy achieved for the North situated member states is quite more often seen compared to the same coefficient calculated for Southern member states.

Under the edge of 0.80 (but not less than 0.70) are identified a bunch of predominantly new member states: Bulgaria, Estonia, Hungary, Latvia, Lithuania.

Those states are seen with a yield forecast, which deviates in the frequent cases over the certain tolerance of forecast errors.

In that group are found the results for Romania and Estonia, where in three out of the six monitored years, the accuracy is less than 0.79 (Table 1).

Along with it, in 15% of the cases or 4 out of 26 MS is noted that in some years the yield forecasts dropped to insufficient margins.

The forecast accuracy is very unsatisfactory (0.54 – 0.59) in Spain (2017) and Finland (2018) of the explored time period. Below these levels of accuracy, worse results are measured only in other two MS – Romania (2020) and Sweden – respectively 0.41 and 0.50 (2018).

As regards the yield forecast of grain maize, the results for the accuracy are depicted as of the lowest compared to other two crops. It is estimated to 0.86, as the best predictions are achieved on forecasts for Spain and Italy up to 0.96, whereas Romania forecasts are computed up to 0.61. Altogether, three MS have good or very good accuracy results (17%) in the analyzed years – Portugal, Spain and Austria (Table 2).

Table 1. Yield forecasts accuracy of soft wheat (coeff.)

MS/ Years	2017	2018	2019	2020	2021	2022
EU	0.99	0.90	1.00	0.97	0.97	0.97
AT	0.92	*0.82*	*0.89*	*0.87*	0.97	1.00
BE	0.98	0.96	*0.89*	0.97	*0.86*	0.94
BG	0.90	*0.87*	*0.88*	**0.76**	*0.80*	0.97
CZ	0.93	*0.86*	0.96	0.96	0.97	0.97
DE	0.96	*0.80*	0.95	0.98	0.92	0.98
DK	0.91	*0.81*	0.93	0.94	0.99	0.94
EE	0.91	**0.71**	**0.73**	**0.78**	*0.88*	0.98
ES	**0.54**	*0.81*	0.94	**0.73**	*0.86*	**0.79**
FI	0.94	**0.59**	*0.85*	*0.82*	**0.77**	0.98
FR	0.99	0.92	0.92	0.91	0.99	1.00
GR	0.97	*0.80*	0.98	0.96	0.97	0.95
HR	*0.85*	0.96	0.97	0.93	*0.86*	0.99
HU	0.90	0.91	*0.87*	0.93	*0.88*	**0.71**
IE	0.96	*0.87*	0.99	*0.82*	0.93	0.93
IT	0.97	0.93	0.94	0.99	*0.84*	0.96
LT	0.96	**0.77**	*0.88*	*0.89*	*0.89*	0.95
LU	*0.88*	0.99	0.98	0.98	0.98	0.97
LV	*0.85*	**0.76**	0.92	*0.86*	0.93	0.97
NL	0.97	0.97	0.93	0.95	0.90	0.90
PL	0.94	*0.83*	0.92	0.96	0.95	0.95
PT	0.98	*0.89*	1.00	*0.86*	**0.77**	**0.79**
RO	**0.79**	1.00	0.92	**0.41**	**0.78**	*0.86*
SE	0.95	**0.50**	0.90	0.96	0.91	0.97
SL	0.97	*0.87*	0.90	0.98	*0.88*	*0.87*
SK	0.96	*0.81*	0.94	0.91	*0.89*	0.91

Source: Own calculation on the basis of data from JRC MARS 2017-2022 [11].

Germany, Greece and Poland are other three countries that have relatively high accuracy with only two years with forecasts defined by moderate meaning and in other years with good or very good qualification. Romania, Slovakia and Hungary are seen as member states, where the forecast accuracy is under the verge of reliability in most of the observed years.

The worst accuracy in yield forecasting were received by Romania (4 out of 6 were very bad), Slovenia had only one forecast where the mean absolute error rate exceeds 0.20, while Bulgaria, Hungary and Belgium have up to 2 years with relatively low accuracy over 0.80 coefficient. It should be also underlined that the maize is one of the most vulnerable in terms of yield variation crop. The yield in new member states generally is over a constant increase through the years and is positioned lower than the average yield in western member states. That is seen as one of the reason, the forecast accuracy in new MS is scored under the average outcome.

Table 2.Yield forecasts accuracy of grain maize (coeff.)

MS	2017	2018	2019	2020	2021	2022
EU	*0.89*	0.90	0.98	*0.87*	0.99	**0.72**
AT	0.96	0.98	0.96	0.91	0.93	0.90
BE	0.90	**0.65**	0.98	**0.58**	*0.85*	*0.82*
BG	0.98	*0.84*	0.95	**0.51**	*0.89*	**0.60**
CZ	0.91	**0.79**	0.90	*0.81*	*0.85*	0.93
DE	0.94	*0.80*	0.94	0.96	0.95	*0.88*
ES	0.98	0.95	0.92	0.99	0.96	0.94
FR	*0.87*	0.96	0.96	*0.88*	0.91	*0.80*
GR	0.93	0.91	0.98	*0.87*	*0.89*	0.93
HR	0.91	*0.81*	0.91	0.95	0.93	**0.64**
HU	*0.89*	*0.89*	0.95	0.91	**0.69**	**0.06**
IT	0.97	0.98	0.97	0.94	0.98	*0.89*
NL	*0.87*	**0.59**	0.95	0.92	*0.83*	1.00
PL	0.91	0.93	*0.83*	0.93	*0.84*	0.98
PT	0.90	0.95	0.95	0.95	0.93	0.97
RO	**0.67**	**0.63**	0.94	**0.37**	0.95	**0.10**
SL	*0.81*	*0.87*	*0.89*	*0.84*	0.98	**0.60**
SK	*0.89*	**0.79**	0.95	*0.89*	0.96	**0.26**

Source: Own calculation on the basis of data from JRC MARS 2017-2022 [11].

As for the sunflower forecast accuracy, it is placed at the level of 0.89, which is ranged at mid between that of wheat and maize. Within the sunflower yield forecast there is any MS that receives a top-up result. The closest to it were Italy, Slovakia and the Czech Republic. This is similar to Bulgaria, Greece where there was another one.

Croatia and Hungary have only one year with accuracy less than 0.79 but for the first country, it is estimated for 2017 while for Hungary is in 2022 harvesting year. The scope of states for the sunflower is the smallest and it set are included only 12 MS, most of them situated in eastern part of EU. The EU average yield forecast is estimated with good and very good accuracy in four of the monitored years, as in the years 2020 and 2022 the results are under the accepted reliable level of at least 0.80.

Table 3. Yield forecasts accuracy of sunflower (coeff.)

MS	2017	2018	2019	2020	2021	2022
EU	0.86	0.96	0.96	**0.77**	0.95	**0.78**
AT	*0.85*	0.94	*0.88*	*0.85*	0.90	*0.83*
BG	0.91	0.95	*0.88*	*0.80*	0.93	0.97
CZ	0.91	0.96	0.99	0.94	*0.82*	0.93
DE	0.92	*0.87*	1.00	0.95	*0.85*	*0.88*
ES	*0.83*	0.91	0.96	*0.89*	0.98	**0.72**
FR	*0.83*	0.92	0.92	**0.79**	*0.88*	0.91
GR	*0.86*	*0.84*	0.97	0.93	0.91	0.98
HR	**0.79**	0.96	0.98	0.92	0.97	0.99
HU	0.93	0.95	0.97	0.90	0.94	**0.51**
IT	0.94	0.96	0.94	0.99	0.98	*0.84*
RO	**0.68**	0.91	0.96	**0.39**	*0.89*	**0.68**
SK	0.94	0.93	0.96	0.91	0.98	*0.86*

Source: Own calculation on the basis of data from JRC MARS 2017-2022 [11].

Regarding the old member states, where generally the forecast accuracy is scored at the taller levels - Spain and France and similar to Germany and Austria, the accuracy outcomes are scored for the whole period within the range defined as very good, good or moderate without any year with insufficient coefficient. Romania had the worst results where only in two years the accuracy can be characterized as good and very good, while in other three years, the scores are deviated as insufficient.

Another part of the study is dedicated to JRC-MARS forecast effectiveness. The effectiveness testifies for the potential to reach the top-up result of accuracy and to eliminate the error. The results confirm that the forecast model works with lowest effectiveness for maize and the highest for wheat (Fig. 1).

As for the forecast period, it is revealed that as closer to the harvest is forecast so better is supposed to be the effectiveness. Through the member states, again Romania is described with the lowest effectiveness of forecasting (moderate according to the class tiers) concerning sunflower and maize (under 0.80), while concerning soft wheat, Spain has the lowest forecast effectiveness. Bulgaria, Hungary, Estonia and Finland are ranked with moderate effectiveness, while all the other MS got very good coefficients.

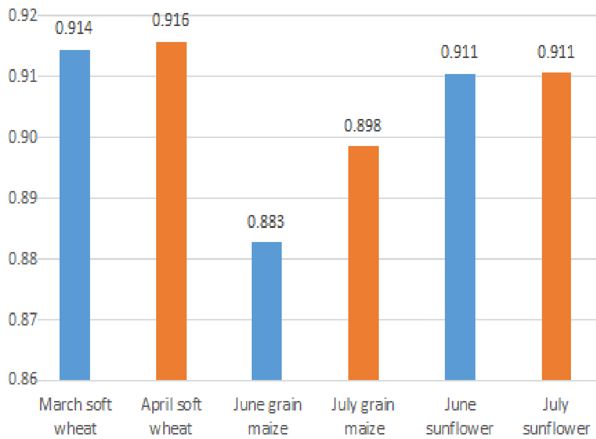

Fig. 1. Average effectiveness of yield forecasts
Source: Own calculation on the basis of data from JRC MARS 2017-2022 [11].

By statistical point of view, it is evaluated the significance of the pre-harvesting forecasts compared to actual reported yields. In almost complete set of the monitored period and member states, the results are statistically significant. It means that there is almost no difference between each one of the selected pre-harvesting months and the actual reported yield. All of the results concerning soft wheat and sunflower are in the entire observed set statistically significant. There were very few exceptions only for the maize forecasts calculated for Romania (2020 and 2022), while in 2022 forecast results are not significant to Hungary and Slovakia. The calculation of statistical significance is important study to reveal the reliability of forecast results despite of some deviations and drops in the accuracy. The statistical significance for the whole set in April-July forecast estimation is calculated at the confidence level of 94% for wheat and sunflower and 93% for maize.

CONCLUSIONS

The analysis of JRC-MARS crop forecasting covering some of the main crops for EU agriculture – wheat, maize and sunflower demonstrates the effectiveness of the forecasting model and robustness of the vegetation indices incorporated in the model. It is found out the mean absolute error rates used for estimating accuracy of yield forecasting and effectiveness are at the relatively low level between 10%-15% for March and June forecast and 10%-13% for the April-July results. Those calculations are carried out without weighting the importance and scale of the selected crop productions in different EU member states. The weighted analysis covering the first 5 biggest producers in EU (France, Germany, Poland Romania and Italy), which accounts for 64% of wheat volumes and 67% of corn quantities reaped in 2022 show the mean absolute error of yield forecasting of wheat (April) is 7,1%, whereas for maize (July) is 14,3% over the period 2017-2022 years. The weighted forecast results are scored better for the wheat compared to not weighted for all EU countries and a bit lower than the not weighted figures to all EU counties for maize. It is explained to some extent to significant level of mean absolute error for maize yield for Romania, which is ranked third biggest producer of maize in EU.

Through the ANOVA and Scheffe' tests are substantiated that principally there is not statistical difference between the forecasts carried out in March (wheat) and June (maize and sunflower) compared to a month later (April-July). The accuracy and effectiveness results of MARS forecasting are slightly better in April-July time compared to a month earlier fulfillment, which is explained by receiving and handling newer and additional data.

The yield forecasting is quite important and needed topic not only from the practical point of view but as well as from a scientific perspective. Forecasting, models, projections are not just topics and tools for analysis and research but also basis for decision-making in public and private organizations. It is assumed for the relationship between the forecast and other yield or production news appearance and the market prices or governmental policies. The robustness of forecast results is a key issue not only for the user of those results but for the implementation organizations itself. The corrections and improvements of the forecasting tools and methods is usually done after analysis of the forecast errors and accuracy. This analysis also demonstrates to a great extent that yield forecasting, which adopts in the methodology of the vegetation indices, which data is generated by remote sensing are relevant factor for such estimations improving the reliability of yield forecasting models.

ACKNOWLEDGEMENTS

This article is elaborated on the project funded by the Bulgarian National Science Fund under the Grant KP-06-N36/5 – 13.12.2019 and authors extend their acknowledgement for the support.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ECONOMIC ANALYSIS OF DRIED PLUM FRUITS

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Abstract

Fruits are beneficial to humans in many ways. They are an essential part of a varied, healthful diet as well as a crucial one. As we know, fruits are seasonal food, and to guarantee longer-term storage and consumption throughout the year, they should be treated differently. The study evaluates economic indicators of three plum cultivars: Stanley, Top Taste, and Top 2000. They were dried using four different methods: in sun, in shade, in dehydrator, in lyophilizer. The study's methodological framework includes: a theoretical overview of plum drying methods, and an analysis of the economic indicators of prune fruits, such as gross production, net income, and profitability rate. The results show that freeze-dried plums have better indicators than the other three drying methods. However, if the freeze-drying method is excluded because the production price is ten times higher than that of sun-dried, shade-dried, and dried-in dehydrator plums, then in that case, the dehydration method shows better economic indicators than the remaining three drying methods at the three cultivars.

Key words**:** *drying plum methods, prune, gross output, rate of return, net income*

INTRODUCTION

In Bulgaria, the Common Agricultural Policy aids farm growth, revitalises the agricultural sector and enhances rural infrastructure [7]. Also, other research indicates high expectations for income stabilization and support in bigger farms, while some variations and negative trends were found in smaller holdings [1].
According to some research, traditional foods represent a particular category of products with an inherent worth in preserving and advancing local and national traditions [15]. Producers, especially small farmers, need help increasing the production of this food category. For this reason, the authors have chosen a case study to identify the leading economic operators of Romania's fruit-growing areas, which research unique food and processing qualities.
In other point, fruits are a healthy element of varied nutrition. Due to the high moisture content in fruits, the growth of bacteria, and the occurrence of enzymatic reactions that cause a deterioration in their quality, fresh fruits might present specific storage difficult. While, dried fruits have preserved carbohydrates, vitamins, and salts. Also, identifying their organoleptic properties is one of the primary advantages of drying fruits [9].
Dried fruits have long shelf lives and concentrated nutrient content. Other research shows that fruits can become infected with different toxic fungal species at different points in their life cycle, such as during cultivation, harvesting, processing, drying, and storage. As a result, there's a chance that these goods have elevated mycotoxin levels [6]. According to the authors, several variables, such as fruit variety, geographic location, climate, harvesting techniques, and storage management procedures, influence the development of mycotoxin.
Plums (*Prunus domestica*) have a complex biological makeup [12]. Other research has found that indicators like air, light, temperature, and moisture cause the development of microorganisms in fruits, which leads to the deterioration of their taste, smell, colour, and vitamins [2]. As a result, many techniques for drying plums have been explored in order to increase their shelf life. Plum fruit quality can be determined in part by

measuring the dry matter content of the fruit [13].

One of drying method is in sun, which is the most popular. In some research, an alternative energy source like the author's model solar dryer is utilized. In the method drying temperature is adjusted based on the daily temperatures [4].

Second drying method is dehydration by heat pump. Additionally, a comparison was conducted between the alternative energy source and heat pump drying the fruit at 45°C [3]. It was found that sun-drying has advantages. Since the fruits are dried in shade without direct solar heating, sun-drying is a cost-effective method that guarantees the preservation of biologically active chemicals [5].

Next drying method is lyophilization. The physicochemical, biochemical, and structural-mechanical characteristics of dried fruits influence the length of drying when using lyophilization. The lyophilization includes the subsequent technological phases [11]: 1) primary drying, which under high vacuum, ice crystals in fruits created during freezing sublimate when subjected to pressure that is first intense and then moderate; 2) secondary drying, which is defined as the desorption of remaining moisture at higher vacuum and positive temperature circumstances; 3) process ends, when the product reaches a specified level of residual moisture, and the sublimation chamber's vacuum is broken with dry, inert gas, then the product is left for storage.

The conditions at which the fruits are frozen before drying have a significant impact on their quality when dried [11]. In the study was found that freeze-dried fruits exhibit low moisture content (2-5%), a high concentration of carbohydrates, vitamins, and mineral salts. Also, the authors conclude that freeze-dried fruits have a maximally conserved enzyme system, and superior organoleptic indicators.

In other research, it was applied four different drying methods: hot-air-drying, vacuum-drying, ultra sound-assisted vacuum-drying, and freeze-drying, which were used to obtain dried plums [16]. Also, it was shown morphology of fresh plum, including the four drying methods, 2,000x magnification on the outer surface, and 1,500x cross-section of the dried samples.

MATERIALS AND METHODS

The aim of the study is to analyse economic indicators of three plum cultivars dried by four methods, tested under the conditions of the Kyustendil region.

The study's methodological framework includes:

1) a theoretical overview of plum drying methods;

2) an analysis of the economic indicators of plum-dried fruits, such as gross production, net income, and profitability rate.

The study evaluates economic indicators of three plum cultivars, which are grown in the experimental plantations at the Institute of agriculture – Kyustendil:

1) Stanley;
2) Top Taste;
3) Top 2000.

In 2023, plum fruits were dried using four different ways: in sun, in shade, in fruit dehydrator, in lyophilizer. The first three methods were applied in pilot plantations at the Institute of Agriculture – Kyustendil. The fourth method was applied at the Institute of Cryobiology and Food Technologies – Sofia (Photo 1 and Photo 2).

Photo 1. Drying methods – in sun and shade
Source: Own elaboration.

In processes before drying the plums were washed, cleaned, weighed, and cut in half and cleaned of stones. Plum pieces are not treated with acid before drying. Plums were dried on nets from the first to second drying method, which were raised at 30 cm. The day and night temperatures throughout the studied period determine the drying temperature in sun and shade.

Photo 2. Drying methods – in dehydrator and lyophilizer
Source: Own elaboration.

Third method was provided on a "Klarstein Master Jerky 16" fruit dehydrator with a heat output of 1,500 W and even heat distribution. Temperature on drying was 70°C, and the drying time varies depending on each cultivar.
Fourth method was provided on a "Hochvakuum-TG - 16.50" lyophilizer. Freeze-drying includes three phases:
1) first phase – freezing on plums at -25 ℃;
2) second phase – sublimation, removal water of fruits at -25 ℃/-35 ℃ under deep vacuum;
3) third phase – desorption, by heating under deep vacuum, at +25 ℃/+35 ℃.
The economic evaluation includes the analysis on gross output (BGN/da), production costs (BGN/da), net income (BGN/da) and rate of return (%).
Studies on agriculture's economic efficiency have focused on: effectiveness of dairy cattle farms [8], evaluation of economic aspects of urban agriculture [14], dried apple pomace [10], optimized orchard systems [17] and others.

RESULTS AND DISCUSSIONS

After processing plum production data, an economic analysis of some indicators was made. The first indicator is gross output (BGN/da), which is calculated as the average yield per decare of plums at the price per unit production (Figure 1).
Freeze-dried plums stand out from the other three drying methods. In this variant, cultivar Top Taste has results that are less than those of Stanley and Top 2000, and the reason is minimal harvest per tree. Also, in general, freeze-dried fruits have a significant increase in price than others. Based on market research, it was established that the price for drying in sun and shade is 16 BGN/kg, and in dehydrator is 20 BGN/kg. The lyophilized plum price stands out by a difference between 8 and 10 times higher than other prices. At this point, the cost price for freeze-dried plums is ten times higher than that of other fruit-dried methods. In summary, the cultivar Stanley performs better than Top 2000 and Top Taste in all drying methods for this indicator.

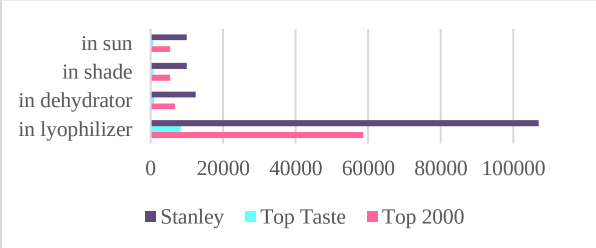

Fig. 1. Gross output (BGN, da) by four drying methods
Source: Own elaboration.

The second indicator, production costs (BGN/da), was calculated and displayed the labour and material costs associated with the production (Figure 2). The average plum production significantly influences this indicator. There is no difference between the two drying techniques, sun and shade, for cultivar Top Taste, and no extra electrical expenses were charged in these two cases.

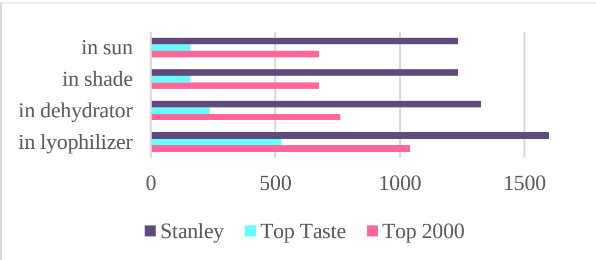

Fig. 2. Production costs (BGN, da) by four drying methods
Source: Own elaboration.

The third indicator, net income (BGN/da), was calculated as the difference between income and costs to produce prunes (Figure 3). The freeze-dried fruit price affected this indicator, 173 BGN/kg. Stanley is again the leading cultivar, followed by Top 2000 in all drying methods.

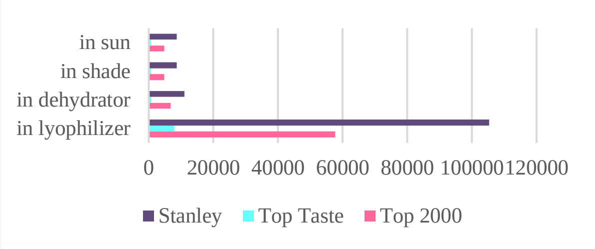

Fig. 3. Net income (BGN,d a) by four drying methods
Source: Own elaboration.

The fourth indicator, rate of return (%), reflected the percentage ratio between net income and production costs (Figure 4). This is where the pattern is repeated.

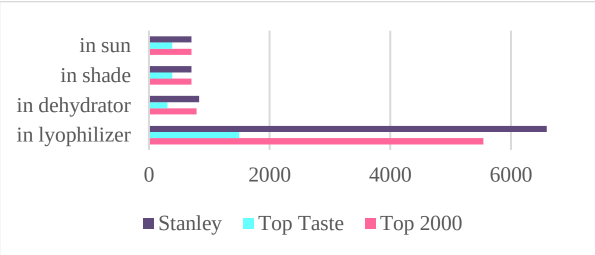

Fig. 4. Rate of return (BGN, da) by four drying methods
Source: Own elaboration.

Suppose we exclude the last drying method, which is the most expensive. We need to find out to what extent consumers are willing to pay the price in other study. In that case, it can be concluded that the dehydration method gives better economic indicators of sun-dried and shade-dried methods in the three cultivars.

CONCLUSIONS

The leading cultivar in the research is Stanley, followed by Top 2000, and in the end, Top Taste with minimal yield.

The study also showed the results of the economic analysis of gross output, production cost, net income, and rate of return indicators.

It was found that freeze-dried plums stand out from the other three drying methods with better indicators. The price for that production stands out by a difference between 8 and 10 times higher than prices in sun-dried, shade-dried, and dried-in dehydrator plums. This concludes that the cost price for freeze-dried plums is ten times higher than other fruit-dried methods.

The production costs were influenced by the average plum yield. The net income was influenced by the higher price for lyophilization fruit production, which is ten times higher than others. The ratio of net income to production costs was shown in the rate return, which repeats the findings of the preceding economic indicators.

Also, it was found that if the freeze-drying method is excluded, the dehydration method gives better economic indicators than sun-dried and shade-dried methods in the three cultivars.

ACKNOWLEDGEMENTS

The article is written as a part of the research project "Study of quality parameters and economic efficiency of fruits and vegetables depending on drying methods", funded by the National Science Fund of Bulgaria (BNSF), according to contract КП-06-М-66/4 - 15.12.2022.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

POTENTIAL OF IBAN CULTURAL HERITAGE FOR COMMUNITY-BASED TOURISM AND RURAL DEVELOPMENT: A CASE OF SONG DISTRICT SARAWAK, MALAYSIA

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Abstract

The captivating allure of Sarawak lies in its ethnic diversity, rich cultural heritage, and abundant natural resources, which serve as key assets for the development of sustainable community-based tourism (CBT) ventures in rural communities. However, realising this potential requires strong and continuous support from local stakeholders. Hence, this study explores the potential for sustainable CBT in Sarawak's Song district, focusing on the Iban community. A total of 68 respondents participated in a questionnaire survey conducted between April and July 2022. From the descriptive data analysis, the study found a strong connection between the Iban people and their traditions. This connection, along with the community's possession of traditional knowledge, has resulted in active participation in cultural events and activities at the village level. This study concluded with recommendations for enhancing the conservation of traditional culture and natural resources, and active participation in the planning and management of successful and sustainable CBT for rural development.

Key words: *community-based tourism, rural resource management, participatory, Iban community, sustainable rural development*

INTRODUCTION

Among the states in Malaysia, Sarawak stands out for its exceptional and welcoming socio-cultural fabric, owing to its status as home to the largest number of ethnicities in the country. According to Nelson [15], there are 38 sub-ethnic groups of native people with a total population of about 1,809,856 in Sarawak, boasting the Borneo state as a rich tapestry of cultural expressions. This incredible diversity of cultural and environmental resources positions Sarawak as a prime destination for tourism development, offering tremendous potential for captivating experiences and encounters. The presence of ethnic diversity not only enriches the cultural varieties but also presents challenges in preserving cultural heritage, particularly in the face of influences from social media, the internet, and modern entertainment from outside. In this light, protecting the multi-ethnic culture of Sarawak requires a united effort from all stakeholders.

As the largest ethnic group in Sarawak, the Iban community faces a significant challenge in preserving their rich cultural heritage, particularly among the younger generation and those who have migrated away from their original settlements. Most of the young people have migrated to the city to pursue their careers, resulting in a lack of time and interest in learning and perpetuating their ancestral traditions [5][10]. The influence of foreign cultures has further contributed to the dilution of authentic Iban cultural practices. Such dissipation necessitates an urgent need to harness and promote the remaining practices of the Iban culture as a valuable asset that can stimulate socio-cultural tourism. This article explores the significant socio-cultural elements that serve as invaluable assets within the Iban community, focusing on community leadership and participation.

Literature review

Sustainable Cultural Tourism

Sustainable tourism development serves as a means to safeguard and protect the culture and environment of ethnic communities residing in specific regions. According to Kamarudin [9], the notion of sustainable tourism is a pillar of the effort to promote sustainable tourism. Sustainable tourism is also an ongoing process that necessitates continual monitoring, proactive measures, and collective action when needed. It plays a pivotal role in maintaining tourist satisfaction levels and ensuring meaningful experiences that raise awareness about sustainability issues and promote sustainable tourism practices [1][2]. Sustainable tourism practices contribute to the long-term well-being of local communities by promoting responsible tourism development that respects the integrity of the environment and nurtures social and economic benefits [7][17].

Supported by natural resources and agriculture-related activities (Fig. 1), cultural and heritage tourism serves as a significant attraction to visitors. The allure lies in the opportunity to delve deeper into local cultures and heritage, either through observation or first-hand experiences [5][19][23]. Sarawak is unquestionably one of the Malaysian states blessed with an abundance of cultural assets that are still flourishing and capturing the interest of both local and foreign visitors. Sustainable tourism practices are vital in preserving and showcasing the cultural and heritage assets of the Iban community of Sarawak. By integrating sustainability principles into tourism activities, the region can ensure the conservation and appreciation of its diverse cultural products. This approach not only enriches the visitor experience but also fosters a greater understanding and respect for local traditions and customs.

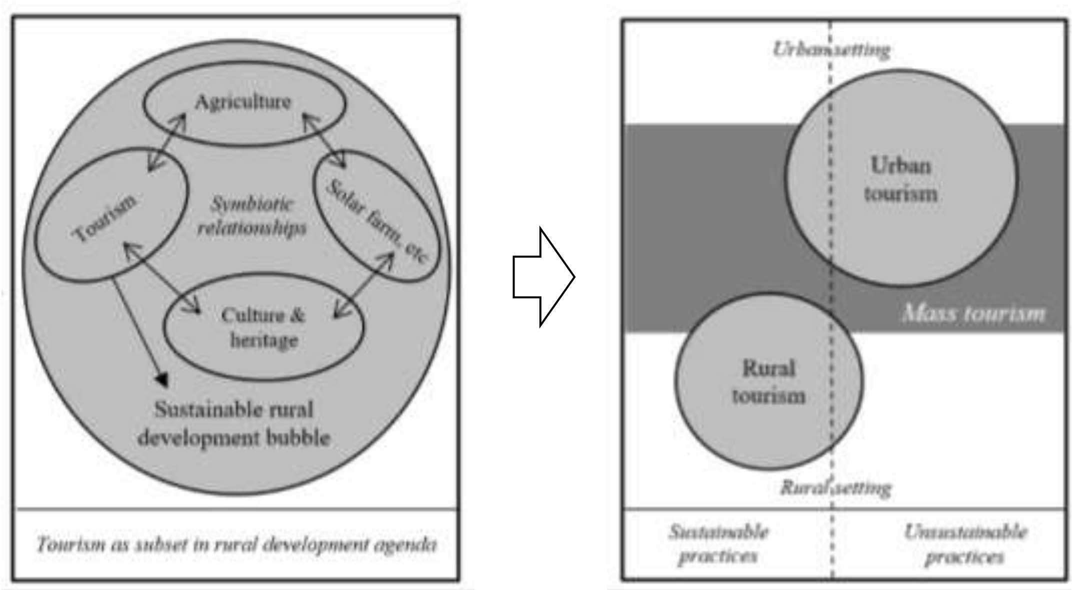

Fig. 1. Rural and cultural tourism paradigm shifting from an individual bubble into a more integrative and inclusive component of sustainable rural development bubble.
Source: [9, 18].

The Iban Heritage and Culture

Socio-cultural significance holds immense importance for all ethnic groups in Sarawak, particularly the Iban people. According to the founder of the Iban Customs Club (KAID) Mr. Nimpai, unity and understanding are a prerequisite for the Iban community to thrive alongside other ethnicities in Sarawak [20]. Renowned for their distinct culture and customs, the Iban community's daily lives are deeply intertwined with practices inherited from their ancestors since time immemorial. These enduring cultural traditions have been passed down through generations, guided by the teachings entrusted by their forebears [3]. The Iban language, as the literature indicates, remains popular with almost two-thirds of Sarawak's population (approximately 800,000 individuals in 2013) relying on the Iban language for daily communication [13]. Other than language, the Iban culture also signifies the traditional attire that people mostly wear on special days such as *Gawai* Day and wedding ceremonies [20, 21].

The *Gawai* celebration, one of the official festival days in Sarawak, is a day to celebrate the new year marked by the end of the rice harvesting season and the beginning of the new rice planting season [6]. It is a festive season of traditional and social festivals. The Iban people are also proud of their traditional dance popularly known as "Ngajat" [22]. The dance is the identity of the Iban community and previously being performed to welcome Iban warriors who returned from war. They are celebrated with a *Gawai* celebration called *Gawai Kenyalang*. In terms of the dance and those who perform the dance, it depends on the purpose of the dance. The types of *Ngajat* dance include *Ngajat Berbunoh, Ngajat Lesong, Ngajat Induk, Ngajat Ngalu Temuai, Ngajat Kuta,* and *Ngajat Pua Kumbu*.

The traditional foods and cuisine of the Iban community also reflect their identity. Among the popular traditional Iban foods loved by the people of Sarawak are *Ayam Pansuh, Pekasam Ensabi*, and *Umai* [13]. These popular cuisines are inherited from generation to generation, served daily and customarily with the *Tuak* drink (alcohol) during festivals such as the *Gawai* celebration [6]. Before embracing Christianity, many Iban people practised traditional beliefs and held various rituals and religious ceremonies. This belief originates from Raja Durong [18] so it gave birth to belief in their *petera* (God), supernatural powers, spirits of the living and the dead, and natural phenomena, among others. All the beliefs, taboos, and customs and the relationship with nature as well as respect for the spirits of those who have died have maintained the relevance of the practice of tilting in the life of the Iban community as in conservation work.

Leadership and Participation in Local Development

According to Kamarudin [9], the presence of community leadership within social institutions holds immense significance in shaping and influencing the level of participation in local development. This principle is equally applicable to the Iban community, who reside in longhouses and possess their distinctive leadership system [11][12]. Leadership within the Iban community serves to foster unity and ensure the success of transformative initiatives [4]. At the traditional level of leadership, the *Tuai Rumah* holds the highest position within the organisational structure of an Iban longhouse in Sarawak. The term *tuai* signifies wisdom and experience, highlighting the social status, personality, and knowledge of an individual. The responsibility of the *Tuai Rumah* encompasses leading, protecting, controlling, and nurturing the well-being and harmony of the residents and the longhouse as a whole [8]. To encourage wider support and participation of community members in local development projects (or cultural tourism projects in this case), the institution of *Tuai Rumah* leadership needs to be supported by a workable organisation [9]. Together with their committee, the process of shaping community development can be carried out more effectively by identifying the socio-cultural potential within the community, particularly in terms of tourism prospects. Recognising and leveraging these potentials can significantly contribute to the holistic development of the community [12][14]. In summary, the literature confirms the vital role of socio-cultural components within the Iban community, shedding light on elements such as leadership and active participation that contribute to the preservation and promotion of their rich heritage for tourism activities.

MATERIALS AND METHODS

Study Area, Sampling Method and Analysis of Data

Based on the 2010 census, the population of Kapit Division is 112,762, with Song district accounting for 20,595 residents (Map 1) [13]. In Song, the majority (80%) of the population is of Iban ethnicity while the remaining are the Orang Ulu, Chinese, Malay, Melanau, and Bidayuh. The selection of Song as the study area is attributed to its significant Iban population, particularly in the interior regions where traditional customs and practices are still observed in many of the long houses. The Iban community in Song, Sarawak, was selected as the study sample using purposive sampling. Purposive sampling was employed due to the specific knowledge and experience possessed by the chosen respondents pertaining to the scope of the research [16].

Map 1. Location of Song District in Sarawak, Malaysia.
Source: [13].

Methodology

In the context of this study, purposive sampling refers to the selection of a subgroup of the population who possesses certain characteristics that align with the research objectives. The cooperation and support received from all relevant parties in providing the necessary information for the study had been commendable and has facilitated the research process and enhanced the quality of the data obtained. This study employed descriptive statistical analysis using Microsoft Excel to analyse the data and obtain percentage values, mean, median, and related statistics.

Table 1. The list of components for assessment of Iban CBT potential in Song District

Components of assessment	Range of mean score
1. Socio-cultural practices	1-2.0 = Not practice 2.1-3.0 = Only sometimes 3.1-4.0 = Practised most of the time 4.1-5.0 = Practised all the time
2. Iban socio-cultural potential for community-based tourism (CBT)	1-2.0 = No potential 2.1-3.0 = Minimal potential 3.1-4.0 = Good potential 4.1-5.0 = Highly potential
3. Iban community participation in socio-cultural activities	1-2.0 = Not involved 2.1-3.0 = Minimal involvement 3.1-4.0 = Involved most of the time 4.1-5.0 = Involved all the time
4. Future development of CBT requires strategies and participation	1-2.0 = Highly disagree 2.1-3.0 = Disagree 3.1-4.0 = Agree 4.1-5.0 = Total agreement

Source: [13].

The mean or average was calculated by summing the scores in the score distribution and dividing it by the total number of scores. Descriptive statistical analysis methods, including mean scores, were used to measure the socio-cultural practices, assess the socio-cultural potential in cultural tourism, and evaluate the level of involvement of the Iban community in Song in promoting socio-cultural activities.
Table 1 enlists the components of the assessment and the range of mean score values.

RESULTS AND DISCUSSIONS

Profile of Respondents

The findings and analysis of the data regarding the background of the Iban community in Song are presented in Table 2. In terms of gender, the majority of respondents who participated in the questionnaire were women. The age group that showed the highest participation in answering the questionnaire was between 24 and 33 years old.

Table 2. Profile of respondents (n=68)

Question	Answers	Frequency	Percentage
Gender	Male	27	40.0
	Female	41	60.0
	Total	68	100.0
Age category	13-23 years old	10	15.0
	24-33	26	38.0
	34-43	16	24.0
	44-53	3	4.0
	>53	13	19.0
	Total	68	100.0
Year of business operation	1-5 years	3	4.0
	6-10	1	2.0
	>10	64	94.0
	Total	68	100.0

Source: [13].

Regarding the length of residence, the majority of Iban Song residents who completed the questionnaire stated that they have been living in Song for more than 10 years.

Level of Socio-cultural Practices

Table 3 presents the findings of the survey conducted among the residents of Song regarding the socio-cultural practices that are still observed in the community. The findings indicate that the Iban Song community believes that the practice of the Iban language (91.2%), traditional Iban food and drink (61.8%), *Gawai* Day Festival (88.2%), Iban *Ngajat* dance (63.2%), and *Miring* ceremony (66.2%) are still widely practised. In comparison, it is thought that traditional Iban attire (52.9%), Iban handicrafts (58.8%), and farming and hunting (61.8%) are practiced to a lower level. However, when considering the overall mean score value, it can be concluded that the socio-cultural practices in Song, as a whole, receive a rating of 4.1–5.0, indicating a high level of adherence among the Iban Song population. The majority of the Iban community in the study area continue these practices as they are deeply rooted customs that have been passed down for several decades.

Table 3. Socio-cultural practices among respondents in relation to CBT (n=68)

Elements	Percentage (%)					Mean Score*	Rank
	Very Low Practice	Low Practice	Moderate Practice	High Practice	Very High Practice		
Iban socio-cultural practices							
1. Speaking in the Iban language	0.0	0.0	0.0	8.8	91.2	4.91	1
2. Traditional attire	0.0	0.0	0.0	52.9	47.1	4.47	5
3. Traditional food/cuisine	0.0	0.0	0.0	38.2	61.8	4.62	4
4. *Gawai* festival	0.0	0.0	0.0	11.8	88.2	4.88	2
5. *Ngajat* dance	0.0	0.0	0.0	36.8	63.2	4.63	3
6. *Miring* ritual/ceremony	0.0	0.0	1.5	66.2	32.4	4.31	8
7. Traditional craft	0.0	0.0	2.9	58.8	38.2	4.35	6
8. Hunting and farming	0.0	0.0	2.9	61.8	35.3	4.32	7
Socio-cultural potential for CBT							
9. Iban language	1.5	10.3	29.4	38.2	20.6	3.66	8
10. Traditional attire	0.0	0.0	0.0	29.4	70.6	4.71	3
11. Traditional food/cuisine	0.0	0.0	1.5	26.5	72.1	4.71	4
12. *Gawai* festival	0.0	0.0	0.0	10.3	89.7	4.90	1
13. *Ngajat* dance	0.0	1.5	0.0	22.1	76.5	4.74	2
14. *Miring* ritual/ceremony	0.0	1.5	17.6	38.2	42.6	4.22	6
15. Traditional craft	0.0	0.0	2.9	36.8	63.2	4.63	5
16. Hunting and farming	0.0	4.4	7.4	66.2	22.1	4.06	7
Socio-cultural activities engagement							
17. Speaking in the Iban language	0.0	0.0	1.5	19.1	79.4	4.78	1
18. Traditional attire	2.9	4.4	29.4	48.5	14.7	3.68	4
19. Traditional food/cuisine	1.5	1.5	26.5	42.6	27.9	3.94	3
20. *Gawai* festival	0.0	0.0	8.8	29.4	61.8	4.53	2
21. *Ngajat* dance	4.4	16.2	20.6	35.3	23.5	3.57	5
22. *Miring* ritual/ceremony	14.7	16.2	13.2	25.0	30.9	3.41	7
23. Traditional craft	10.3	10.3	35.3	30.9	13.2	3.26	8
24. Hunting and farming	10.3	7.4	25.0	36.8	20.6	3.50	6

Note: Mean score range of 1.0-2.0 denoted for not practice; 2.1-3.0 denoted for only sometimes; 3.1-4.0 (practiced most of the time); and 4.1-5.0 (practised all the time)
Source: [13].

Results of mean score value analysis of the socio-cultural potential of the Iban community for future tourism development (Table 3) indicate that the practices that exhibit the highest percentage at the "highly potential" level are traditional Iban clothing (70.6%), followed by traditional Iban food and drink (72.1%), *Gawai* festival (89.7%), the *Ngajat* dance (76.5%), *Miring* ceremony (42.6%), handicrafts (63.2%), and hunting and farming activities (66.2%). Furthermore, the Iban language practice has the largest percentage at the "good potential" level (38.2%). With aside of the Iban language practice, which is rated at the "good potential" level with an average of 3.66, almost all socio-cultural practices of the Iban community have great potential in the development of cultural tourism, according to the overall mean score value achievement. This is due to the majority of residents perceiving the language to be unsuitable as a stand-alone product and might need to be supported by other practices for future cultural tourism development in Song.

The Iban Song community actively participates in the practice of the Iban language (79.4%), *Gawai* festival (61.8%), and *Miring* ceremony (30.9%), as indicated by the highest percentage of respondents engaging in these practices. On the other hand, practices such as traditional Iban attire (48.5%), traditional food and cuisine (42.6%), *Ngajat* dance (35.3%), and hunting and farming activities (36.8%) have the highest percentage of respondents at the "involved most of the time" level. The practice of Iban handicrafts (35.3%) received a moderate level of response.

A mean score of 4.1 and higher indicates that most respondents are very engaged in *Gawai* Day celebrations and Iban language practice.

This is because the Iban language is the primary language used in their daily lives, and *Gawai* Day is an annual celebration cherished by the Dayak community.

On top of that, practices such as traditional attire, traditional food, *Ngajat* dance, *Miring* ritual, handicrafts, and hunting and farming activities recorded a mean score ranging from 3.1 to 4.0, indicating that the respondents are moderately involved in these practices.

These activities can be carried out at any time, and the level of involvement may vary among individuals based on personal preferences and circumstances.

Based on the comprehensive assessment of the three main components of this study, namely socio-cultural practices, the potential of socio-cultural practices for future tourism, and community participation in socio-cultural activities, the authors have reached the following conclusion:

-The findings indicate that in Song, Sarawak, the Iban community actively participates in various sociocultural customs. These customs are widely accepted and profoundly embedded in the community.

-The Iban community's seven out of eight sociocultural traditions have a lot of potential for Song, Sarawak's cultural tourism industry to grow.

These practices, including traditional attire, traditional Iban food and cuisine, *Gawai* festival, *Ngajat* dance, *Miring* ceremony, Iban handicrafts, and hunting and farming activities, hold significant prospects for attracting cultural tourists.

-Among the socio-cultural practices, the Iban language practice and the *Gawai* festival exhibit the highest levels of involvement and participation among the Iban community in Song, Sarawak.

These practices are deeply rooted in the community's daily lives and are considered integral to their cultural identity.

Strategies for Iban Cultural Heritage Tourism

From the data analysis, a few strategies for promoting Iban CBT were identified (Table 4).

A significant portion of the respondents (57.4%) advocated for the creation of collaborative artistic and cultural endeavours within the Iban community.

Table 4. Proposed preliminary strategies for Iban cultural heritage tourism (n=68)

Preliminary Strategies	Percentage (%)					Mean Score*	Rank
	1	2	3	4	5		
1. Create a locally-led organization to organize, develop, and oversee CBT.	0.0	1.5	16.2	58.8	23.5	4.04	4
2. Boost public and governmental participation in the preservation of Iban culture and heritage.	0.0	0.0	4.4	54.4	41.2	4.37	3
3. Launch cooperative initiatives to foster Iban art, culture, and heritage.	0.0	0.0	4.4	38.2	57.4	4.53	1
4. Encourage community involvement in CBT (youth icon etc)	0.0	0.0	2.9	51.5	45.6	4.43	2

Note: *Mean score range: 1-2.0 = Highly disagree; 2.1-3.0 = Disagree; 3.1-4.0 = Agree; 4.1-5.0 = Total agreement
Source: [13].

However, there was only moderate to general agreement on the following: the necessity of increasing local support and participation (51.5%), the establishment of locally-led institutions at the local and district levels (58.8%), and the role of the government and society in promoting sustainability and art and heritage (54.4%).

Overall, the respondents strongly support these measures as a means to promote their existing socio-cultural practices to the wider community and enhance their potential as valuable assets in cultural tourism.

CONCLUSIONS

The study highlights the significance and potential of the socio-cultural practices of the Iban community in Song, Sarawak, and identifies the community’s active involvement and support for cultural tourism development. The community shows strong support for the implementation of appropriate measures to promote and develop cultural tourism in the area. Their positive stance reflects a willingness to enhance cultural tourism initiatives and contribute to the preservation and promotion of their cultural heritage. Additionally, the article outlined a few preliminary suggestions meant to support the socio-cultural potential of the Song district's Iban population. These recommendations emphasize the value of protecting and presenting the Iban community's cultural assets and act as a guide for potential tourism development projects.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support by the Ministry of Higher Education and Universiti Teknologi Malaysia under the Fundamental Research Grant Scheme (FRGS/1/2022/SSI02/UTM/02/2) and (R.J130000.7852.5F540).

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE ROLE OF WOMEN'S COOPERATIVES IN RURAL AREAS: THE CASE OF IZMIR PROVINCE, TURKIYE

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Abstract

This study aimed to determine the relationship of women who are members of agricultural development cooperatives with their cooperatives, as well as to examine their life satisfaction and assessments of the cooperatives' work. A total of 83 female members, who were actively involved in the three cooperatives, were interviewed. The study employed binary logistic regression to ascertain the characteristics that influence the life satisfaction of women members following their membership in a cooperative. Based on the research findings, it was observed that women who possessed lower levels of education, were in their middle age, lacked prior work experience outside of the home and family business, and resided in rural areas adhering to traditional social norms exhibited higher levels of life satisfaction and cooperative involvement compared to their younger counterparts. Considering the impact and importance of cooperatives for the socio-economic development of rural women, the improvement of the basic characteristics of rural society and the reduction of gender inequalities, these cooperatives should continue to exist and continue their activities.

Key words: *rural women, rural development, agricultural development cooperative, life satisfaction*

INTRODUCTION

Cooperatives are highly adaptable, inclusive, and community-oriented organizations that bring together producers and consumers to foster mutual growth. They serve as an ideal framework for economic progress, embodying values such as voluntary collaboration, accountability, self-reliance, democracy, fairness, equality, and unity. On the other hand, women's cooperatives are seen as an opportunity for women in the informal economy, particularly those in rural regions, to generate income, gain employment opportunities, access training and services, and enhance their social connections [12]. Women's cooperatives play a crucial role in empowering women and fostering economic, social, and cultural development. They also contribute to promoting gender equality and building a conscious and organized society [1]. In Turkey, the establishment of women's cooperatives dates back to 1999. However, it wasn't until 2012 that they were officially recognized and included in the Law on Cooperatives. While women's cooperatives share similarities with other cooperatives in terms of their formation, legal status, and characteristics, they hold a greater importance in terms of empowering women in society. They play a crucial role in enhancing women's social, cultural, and economic standing, as well as contributing to the national economy and socio-cultural structure [6].

Women-owned agricultural development cooperatives have a significant impact on the development of the region and country where they operate. They contribute to the achievement of United Nations sustainable development goals, including the protection and balanced use of natural resources in rural areas, reducing inequalities between regions, empowering women and reducing gender inequality in rural areas, eliminating hunger and poverty, ensuring food security, and creating sustainable living spaces.

The study sought to investigate the link between women who are part of agricultural development cooperatives and their cooperatives. It also aimed to assess their opinions on the cooperatives' initiatives, identify any challenges faced, and measure their overall life satisfaction.

MATERIALS AND METHODS

In the selection of the development cooperatives included in the study, agricultural development cooperatives where women are active were identified through interviews with subject matter experts at the Izmir Provincial Directorate of the Ministry of Agriculture and Forestry, and three cooperatives that agreed to participate in the study were interviewed. It was planned to conduct a complete census by interviewing all women who were members of the cooperatives, but due to time and financial constraints, 83 active women members who agreed to participate in the survey were interviewed. Accordingly, 40 women members of Bayındır Natural Products Agricultural Development Cooperative, 32 women members of Balıklıova Village Agricultural Development Cooperative and 11 women members of Foça Fokoop Natural Products Agricultural Development Cooperative were interviewed (Table 1).

Table 1. Data on the cooperatives surveyed

Cooperative Name	Number of Partners	Number of Female Partners	Number of Women Partners Interviewed
S.S. Bayındır Natural Products Agricultural Development Cooperative	127	126	40
S.S. Balıklıova Village Agricultural Development Cooperative	86	51	32
S.S. Foça Fokoop Natural Products Agricultural Development Cooperative	39	21	11
Total	252	198	83

Source: İzmir Provincial Directorate of Agriculture and Forestry, 2023 [5].

While the ratio of female members of the three cooperatives included in the scope was 78.6%, the ratio of female members who participated in the survey from the three cooperatives was calculated as 41.9%. Averages and percentages were used to analyze the data.

The suitability of the variables for normal distribution was determined by Kolmogorov-Smirnov test, Mann-Whitney U test was used to determine whether there was a difference between two groups for continuous variables that did not show normal distribution, and Kruskal-Wallis test was used to determine whether there was a difference between three or more groups. Factor analysis was used to determine the factors influencing women to become cooperative members.

The Life Satisfaction Scale [2] was used to determine the life satisfaction of women members. Binary logistic regression was used to determine the factors affecting life satisfaction after cooperative membership. In the analysis, the dependent variable was whether life satisfaction increased after cooperative membership, and the independent variables were age, having a high school education or higher, average life satisfaction, and rating the cooperative's work as successful. In binary logistic regression, the dependent variable is categorical and the independent variables can be continuous or categorical [7].

RESULTS AND DISCUSSIONS

The survey included 83 women, spanning from 32 to 79 years old, with an average age of 49.12. On average, women receive an education for 9.28 years. The average family size is 3.99 people.

They have been involved in farming for an average of 20.36 years. The typical amount of land they work with is 18.49 decares.

Out of the female partners, a significant majority of 78 (93.98%) engage in cultivating their own land.

Table 2. General Information About Members

	Minimum	Maximum	Average	Standard Deviation
Age	32	79	49.12	10.173
Duration of Education (Year)	4	19	9.28	3.657
Number of Individuals in the Family	2	7	3.99	1.076
Agricultural Experience (Years)	3	50	20.36	13.604
Total cultivated area (da)	1	86	18.49	13.230

Source: Own calculation.

However, it is worth noting that there are only 5 women who do not possess any land, as indicated in Table 2.

Women play a significant role in crop production. Out of the partners surveyed, 61 focus solely on crop production, 23 are involved in both crop and animal production, and one is involved in all three branches of production. 28.9% of the women surveyed earn income from sources other than agriculture. Furthermore, a significant portion of individuals express contentment with their earnings, with 34.9% reporting satisfaction. It is evident that women play a significant role in making decisions regarding agricultural activities within the family. Among women, a majority of 55.4% participate in joint decision-making with their husbands regarding agricultural matters. On the other hand, 22.9% follow the decisions made by their husbands or family elders, while 21.6% make independent decisions.

Cooperative Organization Status of Women Members

Female members have participated in cooperative activities for an average of 3.94 years. The woman who has been a cooperative member for the longest period has been with the Bayındır Natural Products Agricultural Development Cooperative for 12 years. The recent establishment of the cooperatives in the districts of Balıklıova and Foça is the main factor contributing to the lack of longevity. Almost all of the women members (96.4%) received strong support from their families throughout their cooperative membership process.

Among female members, 56.6% are affiliated with the Chamber of Agriculture. Furthermore, a significant portion of the members, 50.6%, are also affiliated with various other cooperatives such as the Agricultural Credit Cooperative, Irrigation Cooperative, Tariş, Cattle Breeders' Union, and more.

The overwhelming majority of the members expressed that being part of a cooperative where women play a prominent role had a highly beneficial effect on them and served as a source of motivation.

Over two-thirds of members have participated in cooperative education. The articles of association of a cooperative are a crucial document that encompasses decisions regarding economic and managerial matters [3, 11]. Approximately 53.0% of the interviewed members had familiarized themselves with the articles of association of the cooperative (Table 3). A study conducted in Izmir province in 2018 focused on agricultural development cooperatives that process and collect milk. The findings revealed that only 42.3% of the members actually read the articles of association [11].

Women who played a role in the formation of cooperatives made up 24.1% of the women surveyed. This percentage indicates that the survey was carried out among active members, and the high percentage can be attributed to the recent establishment of the cooperatives (Table 3).

Table 3. Key Indicators Related to Cooperatives

Indicators	Yes		No.	
	Number	Ratio	Number	Ratio
Cooperative education	57	68,7	26	31.3
Reading the articles of association	44	53,0	39	47.0
Taking part in the establishment phase of the cooperative	20	24,1	63	75.9

Source: Own calculation.

The regular annual meeting of the cooperative is held at least once a year [7]. Out of the women interviewed, a small percentage of 10.8% had never participated in voting during the general assembly of the cooperative, while the majority of 89.2% had exercised their voting rights. Women play a significant role in the cooperative's operations. In a study conducted in Izmir, 60.0% of members from the Agricultural Development Cooperative participated in general assembly meetings, as reported by Yercan and Kınıklı in 2018 [11]. Similarly, Everest [3] found that 50% of members from the Agricultural Credit Cooperative attended general assembly meetings in another study. Out of the women interviewed, 9.6% occupied a role in cooperative management.

Factors Influencing the Success of a Cooperative

A succeeding cooperative should benefit its members in the production and marketing process, while also promoting the growth of

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

the community [4]. Women members emphasize that strong management skills and a sense of solidarity among members are crucial for the success of cooperatives.

These were followed by understanding of laws, utilization of government assistance, and collaboration between cooperatives (Table 4).

Table 4. Factors Affecting the Success of the Cooperatives

Factors Affecting Success	Average	Standard Deviation
Skill/honesty of the manager	4.87	0.453
Solidarity between partners	4.79	0.553
To have a good command of the legislation related to cooperatives	4.44	0.872
State support	4.41	0.843
Cooperation between cooperatives	4.22	0.920

Source: Own calculation.

Effective Factors in Becoming a Cooperative Partner

To analyze the factors that influence women's decision to become a cooperative partner, a factor analysis was conducted using 17 statements that could potentially impact their decision. After conducting the analysis, we were able to identify three distinct factor groups: economic, social, and cultural statements. These groups were comprised of ten statements that collectively accounted for 67.219% of the variability, as shown in Table 5.

Table 5. Factor groups influencing women to become cooperative members (Factor Analysis)

Groups	Variables	Factor Weights
Economic	I wanted easier access to the tools and machinery used in production	0.815
	I asked for technical support during the production phase	0.810
	I wanted to make high profits	0.762
	I wanted to contribute to household income	0.743
	I wanted to benefit from support more easily	0.735
Social	Farmers around me guided me	0.861
	I became a member through the work of cooperative members / management	0.845
	Chamber of Agriculture. District Directorates of Agriculture. etc. institutions directed to partnership	0.780
Cultural	I continue the family habit of partnership	0.732
	I believe in organizing and acting together	0.702
Explained Variability: 67.219		
Kaiser-Meyer-Olkin: 0.716 Sig: 0.000		
Bartlett's Test of Sphericity: 334.522		

Cronbach's Alpha: 0.780

Source: Own calculation.

The presence of female members in the cooperative had a significant impact on women's decision to join (4.54). Several factors played a significant role in facilitating the process.

These included the willingness to act in a coordinated and efficient manner, a strong sense of trust and closeness to the managers, prioritizing activities that benefited the members, ensuring fair and democratic management practices, and implementing a robust audit and control mechanism.

Surprisingly, contrary to expectations, having prior cooperative experience did not have a positive impact on the process of becoming a cooperative member (2.67) (Table 6).

Table 6. Factors Affecting Women in Becoming a Member

Factors Affecting Women	Average	Standard Deviation
Having women partners	4.54	0.754
Willingness to act in an organized manner	4.46	0.611
Managers are familiar and trustworthy	4.35	0.903
The cooperative operates in the interests of its members	4.29	0.891
Fair and democratic governance	4.10	1.043
Well-functioning audit and control mechanism	4.05	1.092
Past experiences with cooperatives	2.67	1.407

Source: Own calculation.

Table 7. Evaluation on Cooperative Activities

Cooperative Work Evaluations	Average	Standard Deviation
In general, I find the cooperative's work successful	4.53	0.591
I will continue my partnership in the future	4.49	0.632
I recommend partnership to my circle	4.49	0.651
Managers are open-minded, consistent and honest	4.27	0.828
I participate in cooperative meetings and decisions taken	4.22	0.827
Cooperative work meets my expectations	4.12	0.722
I may consider joining the management in the future	2.98	1.370

Source: Own calculation.

Members expressed strong satisfaction with the cooperative's activities, indicating their intention to remain members in the future and recommending cooperative membership to others. Members generally have a positive perception of the managers, considering them to be open-minded, consistent, and honest (4.27). They appreciate the managers' active participation in the cooperative's meetings and decision-making processes (4.22) and feel that the cooperative's activities consistently meet their expectations (4.12). However, there seems to be a lack of enthusiasm among members when it comes to pursuing management positions in the future (2.98) (Table 7).

Problems in Cooperatives

The partners are facing significant challenges such as insufficient promotion and marketing, inadequate tools, equipment, and machinery, and ineffective financial management. However, it is worth mentioning that these issues have a moderate level of involvement. Among the other challenges faced by the partners, there are issues such as lack of interest and insufficient training activities, as well as a lack of information on legislation and technical matters.

Table 8. Main Problems Experienced in the Cooperative

Key Challenges	Average	Standard Deviation
Lack of promotion and marketing	3.64	1.111
Lack of tools, equipment and machinery	3.60	1.081
Inadequate financial management	3.14	1.049
Lack of interest of partners	3.05	1.125
Inadequacy of training activities	2.94	0.992
Lack of knowledge and implementation of legislation	2.63	0.972
Management is not sufficiently technically knowledgeable	2.48	1.052
Lack of competition	2.46	1.004
Lack of technical knowledge	2.42	1.001
Management apathy	2.39	1.080
Disagreement between partners	2.36	1.031
Disagreements at the management level	2.34	1.015

Source: Own calculation.

Additionally, there is a lack of competition and interest from the management, along with disagreements between the management and the partners, which result in lower participation (Table 8).

Women living in rural areas often encounter challenges such as limited financial resources, limited market access, and the added responsibilities of domestic life. Some women believe they face certain disadvantages in agricultural activities when compared to men. As a result, women may be more cautious when it comes to taking risks, possibly due to concerns about the adequacy of their education and experience. Furthermore, it was noted that rural life presents an additional challenge due to its strong cultural structure within a patriarchal order (Table 9).

Table 9. Problems Faced by Women Members

Key Challenges	Average	Standard Deviation
Lack of capital	4.42	0.964
Difficulty reaching the market	4.30	0.972
Responsibilities assumed in home life	3.89	1.158
Being disadvantaged compared to men in production/sales/marketing	3.86	1.299
Women's risk-taking anxiety	3.83	1.351
Women's lack of education and experience	3.82	1.117
Rural life functioning in a more patriarchal order	3.57	1.416
A more closed and resilient culture	3.35	1.329

Source: Own calculation.

Women Partners' Satisfaction with Their Lives

Life satisfaction is used in the sense of an individual's evaluation of his/her life as a whole [9, 10, 2]. According to the results of the Life Satisfaction Survey conducted by TurkStat, while the proportion of women who stated that they were happy was 61.0% in 2003, twenty years later, the happiness level of women decreased by 8.3% to 52.7% [10].

Life satisfaction refers to how individuals assess their overall life experience [9, 10, 2]. Based on the findings of the Life Satisfaction Survey carried out by TurkStat, it was observed that the percentage of women expressing happiness was 61.0% in 2003. However, over the course of two decades, there has been a decline in the happiness level of women, with a decrease of 8.3% to 52.7% [10].

Table 10. Life Satisfaction of Interviewed Women

Statements	Average	Standard Deviation
I am satisfied with my life	3.45	1.281
So far, I have got the important things I wanted from life	3.23	1.193
If I were born again, I would change almost nothing in my life	3.13	1.207
I have a life close to my ideals	3.08	1.181
My living conditions are excellent	2.67	1.127
Satisfaction Average	**3.11**	**1.029**

Source: Own calculation.

The study utilized the Life Satisfaction Scale developed by Diener et al. [2], which is widely recognized and employed. Based on the scale, women expressed a moderate level of agreement with various statements regarding their satisfaction with life (3.45), the importance of their life goals (3.23), their contentment with their current lives (3.13), and their alignment with their personal ideals (3.08). However, they believe that their living conditions are less than ideal (2.67). Overall, women's satisfaction with their lives is moderately rated at 3.11, as shown in Table 10. When considering educational attainment, individuals with a high school education or higher expressed greater satisfaction with their lives compared to those with lower levels of education. Furthermore, the life satisfaction of women in management surpasses that of other female partners (Table 11).

The study revealed that being part of a cooperative and engaging in its activities had a significant positive effect on the overall life satisfaction of women. Women expressed a heightened sense of usefulness (4.36) and empowerment (4.34) following their involvement in cooperative membership. They experienced a greater sense of fulfillment in their lives, a heightened sense of worth, and increased financial autonomy. They also mentioned an improvement in their knowledge and skills, an increase in the value placed on their opinions, and a decrease in the challenges they encountered in their business endeavors. In general, it can be concluded that their overall life satisfaction has increased since joining the cooperative (Table 12).

Table 11. Life satisfaction according to education and participation in cooperative management

	Groups	No.	Rank Mean	Row Total	Mann-Whitney U	Z Value	P Value
Education status	Up to 8 years	65	37.85	2,460.50	315.500	-2.988	0.003***
	9 years and above	18	56.97	1,025.50			
Taking part in management	No mission	75	39.97	2,997.50	147.500	-2.361	0.018***
	Mission	8	61.06	488.50			

*Significance value: *** α <0,05*
Source: Own calculation.

The surveyed group of 83 women had an average age of 49.12 years, as shown in Table 1. Out of the total number of members, 45 were below the age of 49 while 38 were 49 years of age or above. A comparison of the satisfaction levels between younger and older members revealed that the older members expressed higher levels of contentment with their lives following their cooperative membership, as indicated in Table 13.

Table 12. Women's Satisfaction with Their Lives After Cooperative Membership

Statements	Average	Standard Deviation
I feel more useful through cooperative work	4.36	0.655
Being a cooperative member made me feel individually strong	4.34	0.737
My life satisfaction increased after joining a women's cooperative	4.27	0.813
I felt more valuable after cooperative membership	4.22	0.925
I felt more economically independent after cooperative membership	4.22	0.842
My knowledge and skills increased after cooperative partnership	4.17	0.867
After the cooperative partnership, my ideas started to be given more importance in my social circle	4.11	0.911
Cooperative work has reduced the difficulties I face in business life	4.05	0.764
Satisfaction with Life After Partnership	**4.21**	**0.681**

Source: Own calculation.

Table 13. Satisfaction with the Cooperative by Age Groups

Age Range	Number	Rank Mean	Row Total	Mann-Whitney U	Z Value	P Value
Up to 49	45	35.23	1,585.50	550.500	-2.815	0.005***
49 and above	38	50.01	1,900.50			

*Significance value: *** α <0,05*
Source: Own calculation.

An analysis using binary logistic regression was conducted to identify the factors that influence the life satisfaction of women who have joined cooperatives. As age, perception of the cooperative's work as successful, and life satisfaction increased, women experienced a boost in their overall satisfaction after joining the cooperative (Table 14).

Table 14. Factors affecting life satisfaction following cooperative membership (Binary Logistic Regression)

	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I.for EXP(B)	
							Lower	Upper
Fixed	-10.660	2.806	14.431	1	0.000	0.000		
Age (years)	0.096	0.030	10.202	1	0.001	1.100	1.038	1.167
Finding the cooperative's work successful (5-point Likert)	0.997	0.448	4.945	1	0.026	2.709	1.126	6.520
Life satisfaction (Scale mean)	0.514	0.274	3.509	1	0.061	1.672	0.977	2.862

Source: Own calculation.

CONCLUSIONS

In rural areas, women play a crucial role in managing domestic responsibilities to support their families, while also making significant contributions to labor-intensive agricultural production. Just like in any other field, women play a crucial role as unpaid family laborers in the agricultural sector. Their empowerment through cooperatives is vital for enhancing their quality of life and fostering regional development.

Cooperatives that focus on agricultural development and include women members play a crucial role in boosting economic growth and stabilizing the income of individual women involved in agriculture. These cooperatives also help prevent unemployment, foster personal growth, and promote socialization among women.

Based on interviews conducted with women members of agricultural development cooperatives in Izmir province, it was found that older women, particularly those aged 49 and above, who have limited education, no prior work experience outside the home or family business, reduced domestic responsibilities, and who adhere to traditional social norms in rural areas, express higher levels of satisfaction with their lives and cooperatives compared to younger members.

Upon analyzing the reasons behind this situation, it was discovered that the elderly members enjoyed a steady income due to their involvement in cooperative activities. This not only contributed to their household income, but also garnered them a sense of respect within their community. Furthermore, their participation in cooperatives made them feel stronger and provided opportunities for socialization outside of their homes.

On the other hand, the younger members of the cooperative have a different perspective compared to the older members. They are more educated and tend to be more critical of the cooperative's activities. Their satisfaction with the cooperative is lower because they feel that the facilities and services provided by the cooperative are inadequate. Additionally, they face various challenges and disruptions due to living in rural areas, which ultimately affect the cooperative's operations. Nevertheless, the younger generation's discerning perspective on the cooperative could serve as a catalyst for future advancements and enhancements in cooperative activities.

Considering the significant role that cooperatives play in promoting the socio-economic development of rural women, enhancing the fundamental aspects of rural society, and addressing gender disparities, it is crucial to ensure the continuity and ongoing operations of these cooperatives.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

SOCIO-ENVIRONMENTAL ASPECTS OF DIGITALISATION IN SERBIAN AGRICULTURE: FARMERS' PERCEPTIONS

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Abstract

The authors examine the opinions of agricultural producers in Serbia about the impact of digitalisation in agriculture on the socio-environmental dimension of agricultural sustainability and the overall development of the country. Empirical data were collected through a semi-structured questionnaire and an interview with 53 producers who apply some of digital solutions on their farms. The research was conducted during a six-month period in 2023 (April – October). Responses to most questions regarding the social dimension of sustainability indicate some polarisation of opinions, as well as certain doubt about the contribution of digitalisation to this sustainability dimension. A unique and positive attitude is noticeable only in the assessment of the contribution of digitalisation to the reduction of the engaged labour force in agriculture and to the possibilities for greater diversification of farmers' activities into various non-agricultural sectors. On the other hand, the respondents' answers clearly show their positive perception of the contribution of digitalisation in production to the ecological aspects of agriculture and to the overall improvement of the environment. The largest percentage of the surveyed farmers' recommendations for greater implementation of digitalisation in agricultural practices refer to directing more funds to subsidies and other forms of financial support, as well as to educating producers about digitalisation.

Key words: *agricultural digitalisation, Serbia, socio-environmental sustainability, perception, recommendations*

INTRODUCTION

The global population is growing rapidly and it is estimated to reach about 10 billion by 2050 [33, 1]. According to [2], the agricultural production has to be increased by 70% compared to the current situation in order to feed the global population. However, estimates show that the current tendency of the food production increase is much below the projected requirements of the growing world population [5, 22].

Concerns about food security and food provision at a global level have led to a series of new solutions aimed at maximising productivity in agriculture. Among these, the solutions within Agriculture 4.0 or in the field of digitalisation of production and business processes are becoming increasingly relevant. Digitalisation represents a set of diverse digital tools and applications, i.e. mutually connected digital technologies which participate in the agricultural production process. These technologies are based on business automation, use of electronics, robotics, computers, telecommunications, genetic engineering, artificial intelligence and communication technologies, as well as various applications used for processing large quantities of data, in addition to other existing technologies such as smartphones, satellites, the Internet of Things and alike [17, 7, 29, 23, 14].

The implementation of digitalisation in agriculture brings greater productivity and profitability of production, lowers costs and losses, while simultaneously helping to preserve the environment and achieve environmental and social sustainability [15, 18, 4, 12, 29, 14, 28, 20]. Digital technologies enable the automation of production processes, monitoring of the quantitative characteristics of soil and crops, crop rotation management, i.e. supervising the complete production cycle of a crop from planting to harvest. In this manner, it is possible to accurately determine when it is necessary to intervene in agricultural processes (ploughing, irrigation, fertilisation, pesticide treatments) in accordance with the condition of the soil, the current phenophase of the plants and values of climatic parameters

[21, 35, 30, 24]. The main benefits of the digital transformation of agriculture are the increasing sustainability, knowledge and production efficiency [31].

Although Serbia has considerable potential resources for diverse agricultural production, there are numerous limiting factors for greater productivity and efficiency. They mainly refer to the fragmentation of land holdings, low economic power of agricultural farms, unfavourable age and educational structure of farmers, as well as low and inconsistent support from agricultural policies [26, 10, 25, 34]. These factors also lead to an insufficient use of the potentials of the application of digital technologies in Serbia, despite the fact that these technologies offer a wide range of creative solutions and benefits to business. Digital solutions are rarely implemented primarily because they are financially inaccessible for average farmers, who also lack information about the advantages of applying these solutions [19, 15, 13, 20]. More advanced and larger-scale farmers mainly choose partial solutions related to remote irrigation systems. Installing digital meteorological stations and sensors is mainly experimental. The following technologies of precision agriculture are most commonly used in Serbia: (a) recording/inspection/control of plot conditions using drones; (b) using satellite recordings and monitoring crop conditions; (c) using different software for estimating and assessing the state of land and crops before and after planting, fertilisation, chemical protection, inter-row cultivation; (d) using automatic systems for regulating and adjusting passageways of tractors and towed vehicles; (e) applying sensor networks and software for the real-time monitoring of changes in soil, crops, climate and similar factors [27].

The subject of the authors' research is examination of the opinions of agricultural producers in Serbia about the socio-environmental component of the sustainability of investments in the digitalisation of production and business processes in agriculture. In addition, the authors studied and analysed farmers' recommendations on how to expand the digitalisation process in Serbian agriculture and make digital solutions more accessible to average, small-scale farmers. The research aims are directed towards acquiring empirical knowledge and better understanding of the analysed topic, which is still insufficiently represented in the scientific and professional literature. The obtained findings will significantly enrich the scientific literature in this field and will have practical importance for agricultural extension services, agricultural producers, as well as agricultural policy makers in Serbia.

MATERIALS AND METHODS

In order to obtain the perceptions of farmers on the socio-environmental dimension of investments in digital solutions (abbr. DSs) in agriculture, the authors conducted a qualitative study using the methods of an interview and semi-structured questionnaire [16].

The sample included 53 farmers who apply some types of DSs in their production and business processes. A certain number of the respondents were interviewed over the telephone, with conversations lasting from 45 to 60 minutes. Responses of the other part of the respondents were collected directly through fieldwork and face-to-face conversations with producers. The research was conducted in the territory of the Republic of Serbia from April to October 2023, which made the sample territorially representative.

The questionnaire included the following questions relevant to investigating social aspects of the sustainability of investments in digitalisation in agriculture:

(1)Will a greater application of digitalisation in agriculture lead to a reduction in the engagement of labour force in agriculture and its redirection to other non-agricultural activities? Response options: yes; no; partially;

(2)Will a greater application of digitalisation in agriculture led to stopping the departure of young people from rural areas? Response options: yes; no; partially;

(3)Does the local community ensure effective transfer of knowledge and information about DSs to farmers? Response options: yes; no; partially;

(4)How satisfied are you with the cooperation of key stakeholders in this area (the government, economic sector, universities and institutes, banks, agricultural extension services, farmers and others)? Response options: 1 (not satisfied); 2 (slightly satisfied); 3 (satisfied); 4 (highly satisfied); 5 (extremely satisfied).

The questionnaire also involved the following questions relevant to investigating the environmental aspects of the sustainability of investments in digitalisation on farms:

(i)Does the application of DSs in agriculture lead to the reduced consumption of energy and chemicals in agricultural production? Response options: yes; no; partially;

(ii)How does the implementation of DSs in agriculture affect the environment, society's fight with climate change and global pollution? Response options: positively; negatively; neutral.

In order to obtain a comprehensive view of the respondents' opinions about the research subject, the questionnaire also included the question regarding farmers' recommendations to the government and producers of machinery, equipment and software in digital agriculture related to making the implementation of DSs more accessible to average, small-scale farmers.

All responses were objectively analysed and presented using descriptive and synthesis methods.

RESULTS AND DISCUSSIONS

The results of the research are presented through the description of the sample structure, followed by the respondents' opinions about the socio-environmental sustainability of investments in different DSs in agriculture.

Sample description

The sample included 53 respondents, i.e. 53 holders of registered agricultural holdings in the territory of Serbia. Within the sample, 44 respondents were holders of family farms, 7 were managers of agricultural companies, while one respondent was registered as an entrepreneur and one as a manager of an agricultural cooperative. The respondents were distributed across 19 areas throughout the territory of the Republic of Serbia.

The largest percentage of the respondents cultivates the land area ranging from 5 to 20 ha (20 respondents or 37.7%). These are followed by 18 respondents (34%) cultivating small holdings (up to 5 ha), then 9 respondents (17%) cultivating the area ranging from 20 ha to 100 ha and only 6 farmers (11.3%) cultivating more than 100 ha of land. On the largest number of farms (64.2%) up to two individuals are involved in the production, while on a smaller number of farms (30.2%) three to five people are involved in the agricultural production process. The majority of the respondents engage in mixed agricultural production on their farms (34%). The respondents specialising in crop growing constitute 32.1% those specialising in fruit growing and/or viticulture account for 18.9%, while the respondents specialising in animal husbandry constitute 15.1%.

The interviewed agricultural producers apply various forms of digitalisation in the process of agricultural production and business. Out of the total number of the respondents, the largest percentage (55%) use the Internet in their production as a digital solution for collecting information and news about agriculture, market, incentive measures, etc. A significantly smaller number of the interviewed farmers state that they use some of more advanced solutions in the digitalisation of business and production processes (automatic systems for regulating and adjusting passageways of tractors and towed vehicles; satellite recordings and commercial drones for monitoring crop conditions; probes and sensors for soil sampling and irrigation control).

The production processes have been replaced with DSs to different degrees on the farms of the interviewed agricultural producers. The largest number of them (60.4%) has replaced production and business processes with DSs by up to 10%, while the fewest number of the respondents (7.6%) have replaced their production and business processes with DSs by more than 50%.

The surveyed agricultural producers apply some forms of DSs on their farms in the following business and production processes:

(a) soil tillage including planting, fertilisation, irrigation and phytosanitary protection; (b) greenhouse heating and related automatic processes in greenhouses; (c) measuring and supervising the production; (d) selling products; (e) obtaining information about the market and about subsidies and incentive measures.

The respondents mentioned numerous benefits of digitalisation, the most significant being: (a) savings related to engaged labour force and time; (b) higher work productivity; (c) rational use of resources (water in the irrigation process, fertilisers, and seeds) and lower production costs; (d) higher yield of agricultural crops. At the same time, the respondents underlined numerous limitations in the process of DS implementation on their farms, among which the most significant were high costs of acquiring/implementing/installing and/or maintaining digital systems, equipment and devices.

Social aspects of the sustainability of investments in digitalisation in agriculture: views of the surveyed farmers

Social aspects of the sustainability of investments in different DSs on the farms were analysed using the four questions from the Questionnaire mentioned in the Materials and Methods section. The processing of the results obtained in the research is presented in the following text.

Question 1. Graph 1 shows that as many as 29 respondents, or 55%, think that digitalisation leads to a reduction in the number of workers and number of working hours in agriculture. This creates possibilities for redirecting the labour force to other non-agricultural activities (diversification of activities towards processing, rural tourism or other forms of engagement in the local community, due to time savings and reduced involvement in agricultural activities during and outside the vegetation period). At the same time, 17 respondents (32%) answered “partially“, while only 7 respondents (13%) do not believe that greater digitalisation on the farm will reduce the engagement of labour force in agriculture and enable its redirection to other non-agricultural activities (Figure 1).

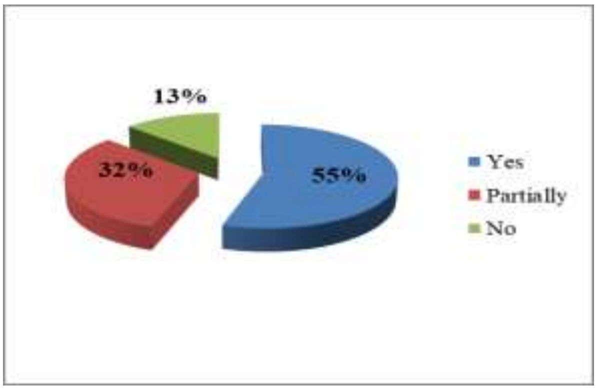

Fig. 1. Will a greater application of digitalisation in agriculture lead to a reduction in the engagement of labour force in agriculture and its redirection to other non-agricultural activities? (%)
Source: Producers' responses.

Question 2. The issues of insufficient labour force in agriculture and depopulation in rural settlements (caused mainly by migrations to urban centres due to higher earnings and better employment possibilities) are becoming increasingly concerning in Serbia and other countries in the region [11].

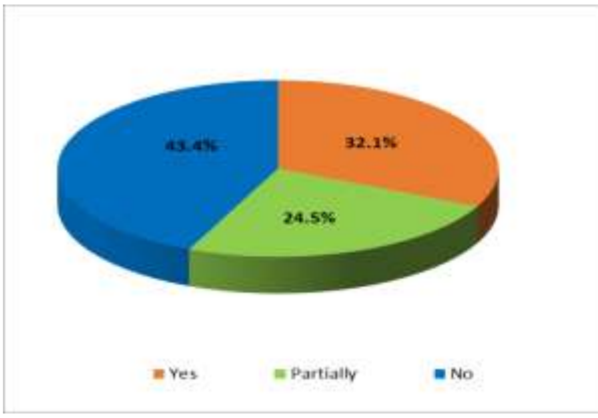

Fig. 2. Will a greater application of digitalisation in agriculture leads to stopping the departure of young people from rural areas? (%)
Source: Producers' responses.

Figure 2 shows that the respondents do not have a unanimous response to the question whether digitalisation in agriculture contributes to stopping the departure of young people from rural areas. However, the opinion of farmers about this aspect of digitalisation cannot be estimated as overly optimistic, since 23 respondents, or 43%, believe that a greater application of DSs on farms will not stop the departure of young people from rural areas. Approximately one third of the respondents (17 respondents, or

32%) have an opposite attitude – they believe that greater digitalisation in agriculture will contribute to stopping the departure of the young from rural areas. Thirteen farmers (or 25%) could not decisively express their opinion on this question (Figure 2).

Question 3. In response to the question whether they are satisfied with the manner in which the local community ensures the transfer of knowledge and information about DSs to farmers, 26.4% of the respondents stated that they were satisfied, while 43.4% of them provided a negative answer (Fig. 3).

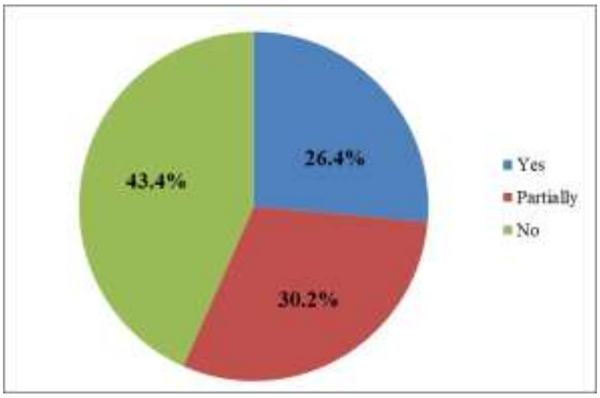

Fig. 3. Does the local community ensure effective transfer of knowledge and information about DSs to farmers? (%)
Source: Producers' responses.

It is obvious that the respondents do not have a unified stance regarding this question. However, it is evident that a significant percentage of the interviewed farmers are not satisfied (43.4%) or are only partially satisfied (30.2%) with the measures and activities undertaken by the key local stakeholders (agricultural extension officers, representatives of local authorities, local media, companies producing digital solutions and other stakeholders) with the aim of making knowledge and information about digital agriculture accessible to average agricultural producers (Fig. 3). The research shows that farmers in Serbia are aware of the fact that the implementation of digitalisation in production and business can have numerous benefits. Still, in most cases they do not completely understand the way of introducing and managing digitalisation.

There are numerous tools which can be useful on a farm and are available to everyone and can be obtained at affordable prices. These are primarily mobile applications which are most commonly free, and which can be used for crop monitoring and alerting in case of nutrient deficit or diseases. In addition, there are free GIS platforms for PCs where geospatial data from various sensors can be used. Sensor detection is becoming increasingly accessible. Both close-range and remote detection enable timely detection of problems on the plot. However, due to the low level of digital literacy in rural areas, low education level of farmers and their small economic power, Serbia lags behind the EU countries in the process of agricultural digitalisation [15, 13, 20]. These circumstances require the urgent creation of suitable advisory and educational programmes through which IT professionals, agricultural extension officers and other stakeholders might support farmers. This will consequently result in certain progress in this area [15, 20, 36].

Numerous authors highlight the significance of education and efficient transfer of digital knowledge and skills to farmers, stating that only in this manner can the digital divide between the inhabitants of rural and urban areas be overcome. In this way, various digital solutions will be represented even on agricultural holdings of medium and small-scale farmers [29, 3].

Question 4. When asked if they are satisfied with the cooperation between the key stakeholders (the government, private sector, universities and institutes, banks, agricultural extension services, farmers and others) in the sector of development, application and dissemination of knowledge from DSs to farmers, as many as 31 farmers (58.5%) stated that they were dissatisfied or slightly satisfied with the cooperation. On the other hand, 22 respondents, or 41.5%, were satisfied, highly satisfied or extremely satisfied (Fig. 4.).

Despite the benefits that digitalisation offers to agricultural producers, it also creates the so-called digital divide between agricultural producers and other market participants that have an access to the most modern technologies in this production process and those who do not [29, 6]. In order to decrease this divide and enable an equal access to digitalisation for everyone, private efforts of companies in the digitalisation sectors and intelligent and constructive public policies should be combined [6]. This cooperation between the private sector and governmental authorities should result in an "agricultural revolution". It would bring benefits to all farmers, agricultural workers, and consumers, as well as the environment worldwide, while efficiently managing the threats of market concentration [6].

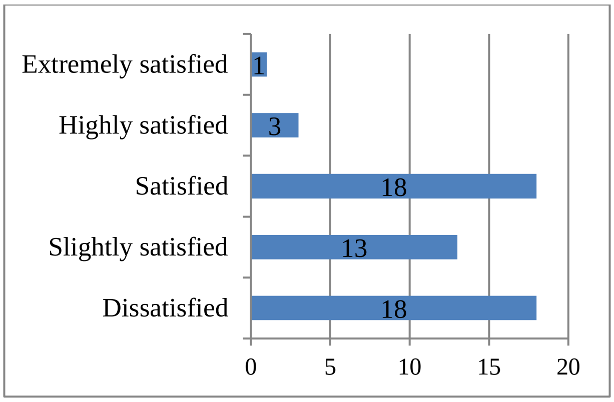

Fig. 4. How satisfied are you with the cooperation of key stakeholders in this area (the government, economic sector, universities and institutes, banks, agricultural extension services, farmers and others) in the segment of development, application and dissemination of knowledge from DSs to farmers? Number of responses.
Source: Producers' responses.

It is important for the government, private sector, faculties and institutes, banks and other stakeholders in Serbia to cooperate on providing educational and financial support to all agricultural producers in the field of digitalisation, regardless of their physical or economic size or power. Only in this manner can the agricultural sector completely benefit from the new digitalisation era, by improving the sustainability and profitability of agricultural activities, while simultaneously solving current issues related to climate change and food security.

Environmental aspects of the sustainability of investments in digitalisation in agriculture: views of the surveyed farmers

Question 1. When asked whether the implementation of DSs in agriculture leads to the reduced consumption of energy and chemicals in agricultural production, as many as 71% of the respondents provided an affirmative response (Fig. 5). Having in mind that 17% of the respondents believe that digitalisation partially contributes to these savings, it can be concluded that a vast majority of the respondents showed a positive stance on this question.

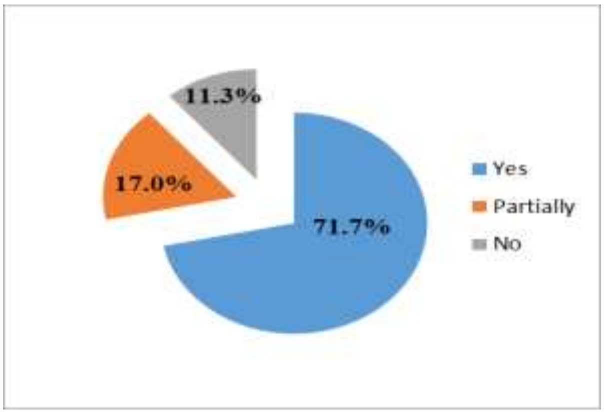

Fig. 5. Does the application of DSs in agriculture lead to the reduced consumption of energy and chemicals in agricultural production? Response structure, %
Source: Producers' responses.

Question 2. The examination of the attitudes about the contribution of digitalisation in agriculture to the improvement of the environment shows that as many as 60.4% of the respondents think that digitalisation can help society fight climate change, global pollution and global warming, and that it has a positive impact on the improvement of the environment (Fig. 6.). At the same time, around 40% of the respondents do not associate digitalisation with the improvement of the environment. Still, none of the respondents has a negative opinion on this issue (Fig. 6).

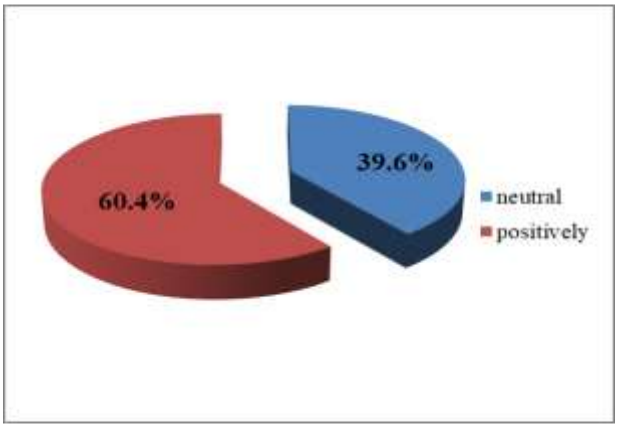

Fig. 6. The contribution of digitalisation in agriculture to the improvement of the environment. Response structure, %.
Source: Producers' responses.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

A study by a group of authors [7] also indicates that digitalisation in agriculture has a positive impact on the reduction of water or pesticide consumption in production, as well as on the more efficient efforts of society made against climate change.

Recommendations of farmers to the government and producers of machinery, equipment and software in the field of digitalisation related to making the implementation of DSs more accessible to average, small-scale farmers in the future.

Farmers' recommendations are predominantly directed towards the following types of support:

-Greater governmental subsidies for the acquisition of machinery, equipment, digital devices, various applications and digital platforms that support the transformation of agriculture towards precision agriculture. The greatest number of the respondents believe that it is of utmost importance for the government to provide some form of financial support for innovative tools from the field of digitalisation;

-Education, training, practical lectures on digital technologies and digital literacy (training seminars at the local community level; more direct communication with farmers in order to introduce them to digital solutions and the advantages of digital agriculture; accompanying video content for each purchased software and alike). Approximately 15% of the respondents believe that education is a necessary condition for the digitalisation of agriculture since these technologies are complex, require comprehensive knowledge from various fields, while the implementation effects are not clear;

-Reducing the prices of the equipment and devices in the field of digital technologies;

-Adapting software to the needs and intended uses of the users (farmers);

-More favourable bank loans for purchasing digital hardware and software.

The document ITU & FAO [13] contains similar recommendations, and highlights that, due to the poor development of digital infrastructure and high costs of acquiring digital equipment, the governmental support in the form of subsidies is of utmost importance for the adoption of new technologies in rural areas of Serbia.

Another group of authors [6] also underlines the significance of public efforts made for greater digitalisation of agriculture. They state that in developing countries public efforts should help transform numerous positive effects of digital agriculture from the private sector into sustainable practices and extend their benefits to a larger number of farmers and consumers. As these authors state, "*interventions that have promise include policies for an enabling business environment, developing knowledge and skills, providing communication infrastructure and financing applied research in support of digital technologies*" [6, p. 1281]. In addition, public policies are not only required for using the possibilities and advantages provided by digital agriculture, but also for dealing with its potential threats, such as increasing the digital divide between farmers, increasing concentration in the agricultural input industry or expanding the market power of large agribusiness companies [6]. Finally, the FAO document from 2022 [9] highlights that the creation of a favourable environment for the transition of agricultural systems towards greater automation and digitalisation involves multiple coherent actions, including legislation and adoption of appropriate regulations, development of comprehensive infrastructure and institutional arrangements, education and training, and research and development.

Although the responses obtained by the interview method reached a high degree of validity and relevance, the greatest limitation of the conducted research in this paper is the subjective opinion of the interviewed farmers. Nevertheless, subjectivity is difficult to avoid and remains present in most social studies [32]. Studying the social and environmental dimension of sustainability of agricultural digitalisation can be a solid base for more comprehensive future research by authors in the mentioned field. Further research might also be directed towards analysing available training and education programmes for farmers in the field of digitalisation, as well as towards the empirical analysis of specific effects of digitalisation on agricultural holdings (best practice examples) while applying the case study method.

CONCLUSIONS

Digital technology is having an increasingly strong impact on the socio-economic development and environmental sustainability of the Republic of Serbia. Thus, it has become the area of growing interest of the academic community and social community. Digitalisation of agriculture is one of the most important tasks which are to be implemented in the future with the aim of creating a more profitable, cost-effective and environmentally and socially sustainable agricultural production. However, due to the slow progress of Serbia in the digitalisation of business and production processes in agriculture, it is obvious that the set aims of modernisation and technological and digital transformation of agriculture cannot be quickly realised [15].

Considering that the academic community has a unique stance regarding the positive contribution of agricultural digitalisation to sustainable development, the authors of the paper examined the perceptions of farmers in Serbia about the impact of digitalisation in agriculture on socio-environmental dimensions of sustainability. Using the interview method, the authors collected the perceptions of 53 producers who apply some digital solutions in their business.

When it comes to the social dimension of the sustainability of investments in digital solutions on agricultural households, the results show the following: (a) a large majority of the interviewed farmers (87%) believe that investments in digitalisation lead (completely or partially) to a reduction in the number of engaged agricultural workers, which enables the redirection of labour force to other non-agricultural activities; (b) the respondents do not have a unanimous opinion about the contribution of digitalisation in agriculture to stopping the departure of young people from rural areas, but the general farmers' attitude on this issue is not overly optimistic (43.3% of the respondents think that a greater application of digitalisation on agricultural holdings will not stop the departure of the young from rural areas); (c)) the respondents are also not overly optimistic regarding the question asking whether the local community ensures an effective transfer of knowledge and information about digital solutions to agricultural producers (as many as 73.6% of the respondents are dissatisfied or partially satisfied with the measures and activities undertaken by the key local stakeholders in order to make knowledge and information about digital agriculture closer to average agricultural producers); (d) when asked how satisfied they are with the cooperation between the key stakeholders in the segment of development, application and dissemination of knowledge, the respondents provided polarised responses (58.5% respondents were dissatisfied or slightly satisfied with this cooperation, compared to 42.5% who were satisfied with this cooperation).

When it comes to the respondents' opinions about the environmental dimension of the sustainability of digitalisation on the farm, the results unequivocally show that a vast majority of the respondents think that digitalisation leads to the reduced consumption of energy and chemicals, and that it can help society combat climate change, global pollution and global warming.

The farmers' recommendations to the government authorities and producers of machinery, equipment and software in the field of digitalisation refer mainly to the necessity of greater subsidies from the government and the development of education, training and practical lectures about digital technologies and digital literacy, all in order to make digital solutions accessible to average, small-scale farmers.

ACKNOWLEDGEMENTS

Paper is part of research financed by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, agreed in decision no. 451-03-66/2024-03/200009 from 5.2.2024.

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ECONOMIC ASSESSMENT OF AGRICULTURAL ENTERPRISES IN IVANO-FRANKIVSK REGION, UKRAINE - IDENTIFICATION OF FACTORS THAT INFLUENCE PERFORMANCE

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Abstract

As part of the study, the methodological toolkit for the functioning of land relations is substantiated. Using the software product STELLA, a system analysis was conducted to forecast trends in the development of indicators of agricultural enterprises. The gross output of agricultural enterprises was selected as an effective indicator, and the size of land plots was one of the influencing factors. It has been proven that forecasting is an important direction in the development of land relations in agricultural enterprises in modern competitive conditions. On the basis of the system analysis, modeling was carried out using the STELLA software product. The forecast of the production of gross agricultural products by enterprises of the Ivano-Frankivsk region until 2030 was carried out. The study shows, that among the main factors affecting the dynamic of the production of the gross products by agricultural enterprises according to its volume, the amount of mineral fertilizers applied per 1 hectare of land, the number of employees in enterprises and the number of animals in conditional expression are singled out.

Key words: *modeling, land relations, agricultural enterprises, gross production*

INTRODUCTION

The volume of production of gross products in its value expression is currently the basis for the formation and identification of the effectiveness of the functioning of agricultural enterprises, as well as increasing their competitiveness. Information support reinforces these processes and helps to model and forecast the future development of agriculture through the use of special software products. One of the main components of the development of agricultural enterprises is the production of agricultural products through the effective use of land. In order to determine the development trends of a certain process for the future, it is necessary to apply the methods of scientific forecasting.

D. Medovz [17], a researcher of the art of thinking systematically, believes that a system is a set of things that are connected to each other in such a way that they produce their own pattern of behavior as an interconnected, coherently ordered set of elements that achieves a specific goal. In her understanding, the system largely determines its own behavior. I. Kozak and V. Parpan [14] also consider system dynamics in their work, where they separate the concept of a system and prove that it actually acts through the interrelationships of its elements and functions in time and space, and the concept of a model, which is a simplified representation of this real system to understand its behavior as a concrete system. L. Cornwell, R. Costanza, [10] justify market mechanisms for environmental management under different degrees of uncertainty and use the STELLA diagram. H. Balali and D. Viaggi [2] studied STELLA models and their impact on the system and what its results are. The system dynamics approach using the STELLA model was proposed to analyze and forecast the activities of agricultural enterprises [3], [5], [16], private enterprises [19], farms [9], agricultural cooperatives [20].

The main tools for assessing the ratio of global and local indices as performance indicators that can be used for analysis are proposed in works [7], [8]. Other researchers gave recommendations related to the preservation of land in ownership, which contribute to sustainable development in rural areas [18], [24] [25].

With the help of STELLA and Statistica software, we conducted an analysis of the purpose of the work to provide a deeper understanding of the current state of justifications and the protection of justifications in the specific context of our country.

Based on the results of the research, we have collected data that should serve as a resource for researchers and managers of agricultural enterprises, in particular all those stakeholders of the agricultural system who are interested in new organizational and managerial approaches to increasing the efficiency of entrepreneurial activity and ensuring optimal development of the agricultural sector of Ukraine.

The purpose of the article is to conduct an economic assessment and forecast the activity of agricultural enterprises in the region. This is achieved through the identification, with the help of the STELLA software, of the factors that affect the efficiency of the business.

The hypothesis of the study is to confirm the assumption that the main objective factors that affect the efficiency of agricultural enterprises are such indicators as the area of agricultural land, the amount of applied mineral fertilizers, the number of employees and the number of animals.

MATERIALS AND METHODS

With the help of the regression analysis method, it is best to implement the research ability of establishing the nature of the joint and separate influence of various factors on the characteristics ENTERPRISES, FERTILIZATION, EMPLOYEES and LIVESTOCK

Using the software product Statistica, the influence of factors on the magnitude of the effects of economic transactions in the sector of land relations of agricultural enterprises was determined.

The application of the system analysis method is a defined methodology, the order of sequential actions that ensure the establishment of structural inter-element or inter-variable relationships in the system of institutionalization of land relations. Based on the tools of the STELLA software product, a system analysis was carried out to forecast promising trends in the performance indicators of the implementation of land relations in enterprises.

The proposed model for forecast estimates of the volume of production of gross products by enterprises is built on the basis of the STELLA software product toolkit. Such factors as: the area of agricultural land used by enterprises for the production of products, the number of business entities (enterprises), the amount of mineral fertilizers applied per 1 ha of agricultural land, the number of workers employed in production and the conditional number of animals. It is a priority to use the data of this model for planning the volume of production in agricultural enterprises, according to the methodology of determining and taking into account the nature of the relationship between the dependent and independent variables.

Forecasting the production of gross agricultural products by enterprises of the Ivano-Frankivsk region was carried out using the special software product STELLA. STELLA modeling software was developed by the American company High Performance Systems (HPS) [21, p. 13]. It is a simulation software that helps organizations create simulations, publish models, design presentations, analyze results based on variables, and more on a single platform. The STELLA program functions on two levels: graphical and mathematical. This software product allows you to use built-in mathematical, logical and statistical operations to create interactive models and simulations [11, p. 3].

The application of the modeling method in the STELLA software proved the practicality, transparency and accessibility of using this program when building models and creating forecasts. The conducted modeling makes it possible to assess the significance of the use of various computer programs and technologies. With the help of special support, it becomes possible to evaluate the relationships between variables, discard factors that do not affect the performance indicator, form a prognostic equation and determine directions for increasing the effective development of agricultural activity in the Ivano-Frankivsk region.

It should be noted that the use of the polynomial regression method is effective in many cases. After all, the relationship between independent and dependent variables is not always linear. The use of polynomial regression has the advantages of modeling non-linear relationships between variables, as well as the availability of a large number of functions that are useful for the study of economic phenomena and processes, and the freedom to choose data sets and situations. With the help of visualization, it is possible to evaluate the relationships between the variables of the performed analysis.

RESULTS AND DISCUSSIONS

To carry out predictive analysis, it is necessary, first of all, to single out the effective indicator and correctly determine the factors that have the greatest influence on its development. The next requirement will be the collection of real statistical data of selected indicators for past periods and determination of the need for forecasting. The use of informative forecast data enables agricultural enterprises to determine the future trajectory of their activity. The main four elements, with the help of which the forecast is carried out, are shown in the upper left corner (Fig. 1). The rectangle mark represents the stock (Stock), the circle mark (Converter) denotes the factors affecting the stock, the valve with two arrows in different directions denotes the movement of the flow (Flow), which can be both input and output, the arrow (Action Connector) denotes relationships between model elements. When building a predictive model, the above elements (rectangle, arrows, circle, flow) are used in the order necessary to effectively express the performance indicator, factors affecting it, connections, input and output flows.

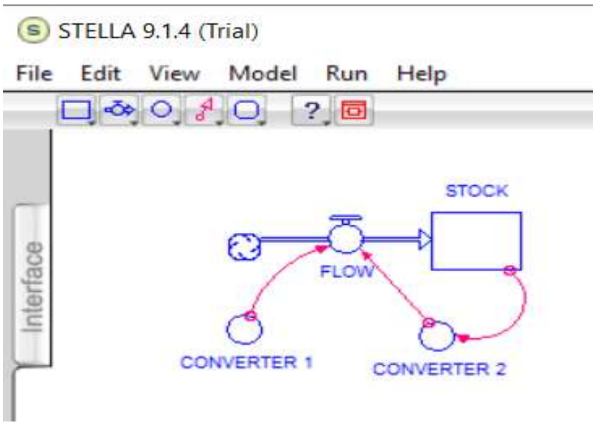


Fig. 1. Sample structure of the model in STELLA
Source: Author's computations.

Fig. 2. Function selection window in the STELLA program
Source: Author's computations.

When using the method of system dynamics in the program and building a forecast for the specified indicators, you can change the format of the model parameters with the help of built-in Bultins functions (Fig. 2).

These include mathematical, tribometric, statistical, logical, financial, time, massive, discrete and special functions. For example, to use the change of data over time, the TIME function is used, to express the MIN and MAX functions in their minimum and maximum values, to generate a system of random numbers with the minimum and maximum values, the RANDOM function is used, to calculate the arithmetic mean, the MEAN function is selected, to determine the natural expression of the LOGN logarithm, the calculation of simple extrapolation trends is performed by the FORCST function, the HISTORY function and others are used to determine the values of variables in the past using simulation.

The user, building a model with the STELLA software application, creates only the model designer, and the prediction algorithm is formed independently using the DT step. First of all, in order to start working with the STELLA software and build a forecast using it, data from the Ivano-Frankivsk region for the period 1990-2020 were selected.

The selected indicators were first processed using the statistical analysis program Statistica, where special procedures and visualization were performed data. Next, the correlational influence between dependent and random variables was considered, in particular, the influence of random factors on the change in the gross output of agricultural enterprises in the Ivano-Frankivsk region (PRODUCT) has been studied. A regression analysis was conducted, which took into account 6 variables, including the area of agricultural land of enterprises (AREA), the number of agricultural enterprises (ENTERPRISES), the amount of applied mineral fertilizers per 1 ha of land (FERTILIZATION), the number of employees of agricultural enterprises (EMPLOYEERS), conditional livestock animals of enterprises of the Ivano-Frankivsk region (LIVESTOCK) and gross products (PRODUCT). Thus, the initial stage is entering data into the cells of the statistical program (cases) or importing them from other files (Fig. 3).

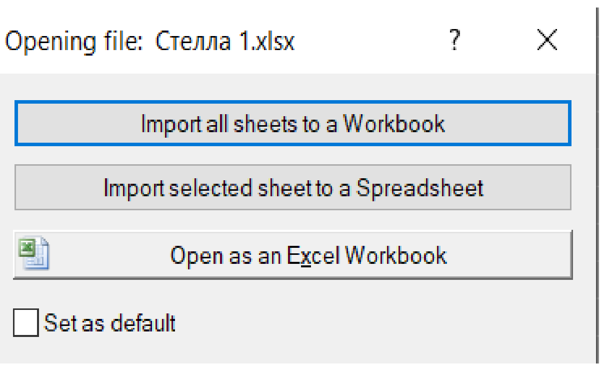


Fig. 3. Scheme of entering data into the cells of the statistical program (cases)
Source: Author's computations.

After completing the formation of the table with informative data, it is necessary to choose the correspondence of the modeled object Advanced Linear / Nonlinear Models, namely General Regression Model (Fig. 4).

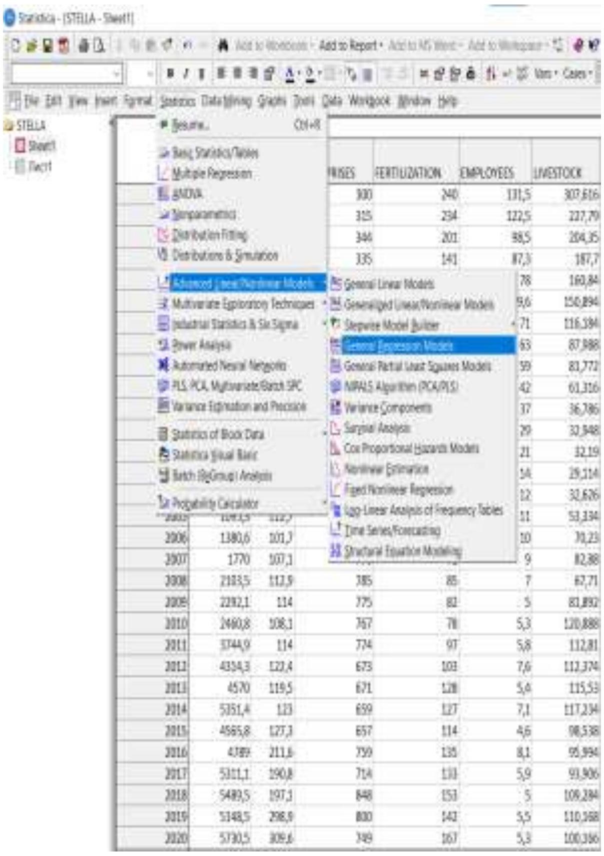


Fig. 4. Selecting an option in the Statistica software menu
Source: Author's computations.

The next step is to choose the type of regression analysis, namely Polynomial regression and variable variables (Fig. 5).

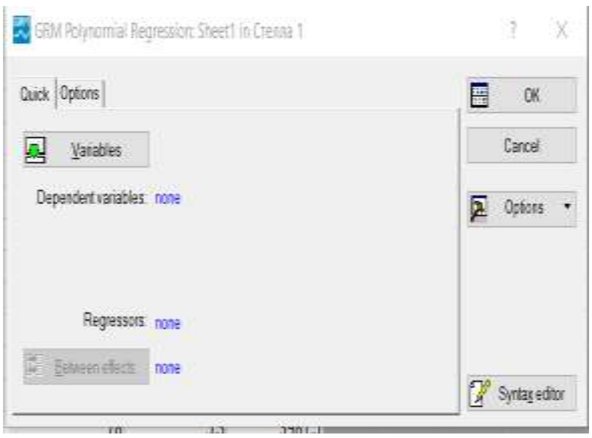


Fig. 5. Statistica software variable selection window
Source: Author's computations.

Polynomial regression contains nonlinear relationships, but it can be formulated as a statistical estimate of nonlinear parameters [20, p. 505]. This makes it possible to apply the method of multivariate linear regression in order to find coefficients in the presence of non-linear variables.

In place of the dependent variable, the gross output of agricultural enterprises of the Ivano-Frankivsk region (PRODUCT) is indicated. AREA, ENTERPRISES, FERTILIZATION, EMPLOYEES and LIVESTOCK indicators are defined as independent variables (Fig. 6).

Fig. 6. “All effects” option
Source: Author’s computations.

The obtained results of polynomial regression are displayed using the "All effects" option (Fig. 6).

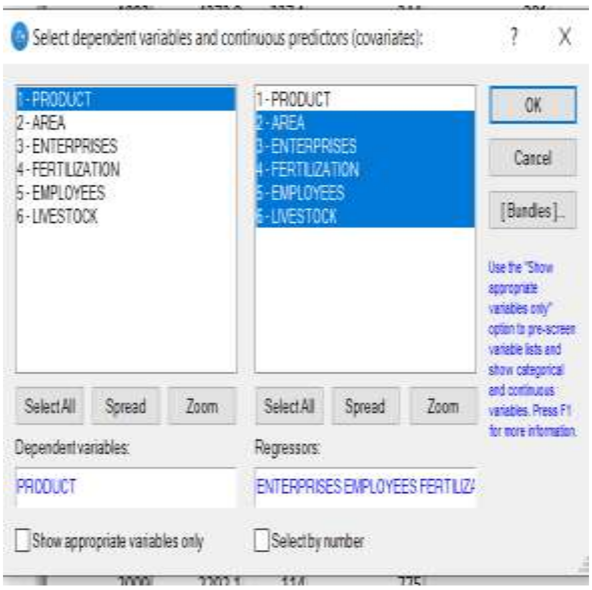


Fig. 7. Window for selecting an independent variable and dependent variables in the Statistica program
Source: Author’s computations.

With the application of the function of this tab, as a result, a regression analysis has been performed on the dependent variable PRODUCT (Fig. 7).

As a result: the multiple correlation coefficient (R), ENTERPRISES, FERTILIZATION, EMPLOYEES and LIVESTOCK is characterized by a tight linear relationship between the dependent variable PRODUCT and the independent variable AREA; the dependence of the data in the obtained regression shows the coefficient of determination (R^2), because it is close to 1. Also, with an increase in the number of variable data, the value of the coefficient of determination changes, which does not always mean an improvement in the quality of forecasting. For this purpose, the adjusted coefficient of determination (adjusted R^2) is used in the regression model [12, p. 57].

All 5 isolated factors were tested for statistical significance $p \leq 0.05$. Fisher's F-coefficient is 46.31017, and its degree of significance (p-level) is almost zero in the results of the regression analysis of the dependent variable PRODUCT.

The indicator of multiple correlation between the dependent variable PRODUCT and the five independent variables is statistically significant, and the model itself is adequate and can be meaningfully displayed.

Standardized βeta coefficients can be compared with each other, which will make it possible to rank regressors by the strength of their influence on the regressor [23, p. 354]. That is, the standardized βeta indicator describes the weight of the influence of each independent variable on the dependent variable.

During the regression analysis, the βeta coefficient shows that the variable AREA – the area of agricultural land – has the greatest influence on the increase in the output of gross agricultural products of enterprises. In second place is the variable FERTILIZATION (amount of applied mineral fertilizers per 1 ha of land), in third place – EMPLOYEES (number of employees of agricultural enterprises), in fourth place – ENTERPRISES (number of agricultural enterprises) and in fifth place – LIVESTOCK (conditional livestock

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

enterprises) (Fig. 8).

Fig. 8. Results of using the Statistica software for regression analysis of the dependent variable PRODUCT*
Source: Author's computations.

In order to evaluate the standardized deviations, the Residuals 1 tab was selected and the "Caseno&res" option was chosen (Fig. 9).

Analysis of the standardized residuals for the dependent variable PRODUCT established a shortage of values higher than ±3 sigma, which demonstrates the absence of significant deviations (Fig. 10).

Fig. 9. Residuals 1 tab with "Caseno & res" option
Source: Author's computations.

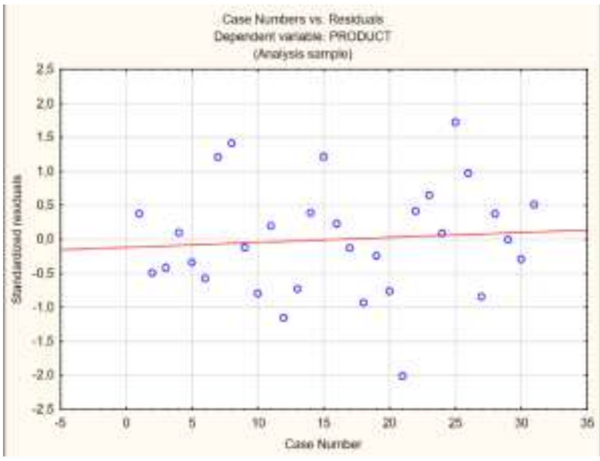


Fig. 10. Display for the dependent variable PRODUCT of standardized deviations
Source: Author's computations.

In the figure, the red regression line reflects the linear relationship between the variables: if the points are located close to this line, it can be assumed that there is a linear relationship between the variables [3, p. 33].

The use of visual methods during the systematic modeling of phenomena and management processes will provide an opportunity to illustrate the processes of agricultural enterprises.

In particular, with the help of the Pareto diagram, cause-and-effect relationships between the dependent and independent variables were established (Fig. 11). This method serves for a visual display (in the form of bar charts) of factors that have an impact on the object of research. The Pareto diagram is a graphic representation of the degree of importance of the influence of factors on the results of economic activity [15, p. 125]. It was established that the selected influencing factors on the change in PRODUCT are appropriate and can ultimately be used to form a regression equation.

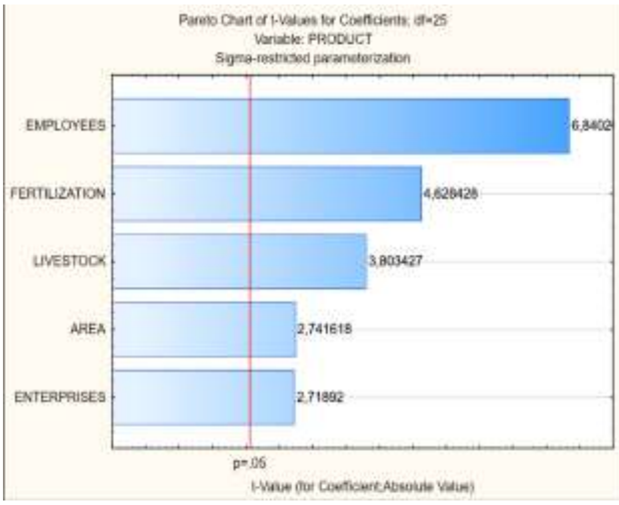


Fig. 11. Cause and effect relationships between dependent and independent variables of the Pareto diagram
Source: Author's computations.

In order to create a prognostic equation of the regression analysis, it is necessary to select the option shown in Fig. 12.

Carrying out a set of actions with the help of the Statistica software product makes it possible to carry out further analysis and research of the selected object. The formed

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

prognostic equation in the software product looks like this (Fig. 13).

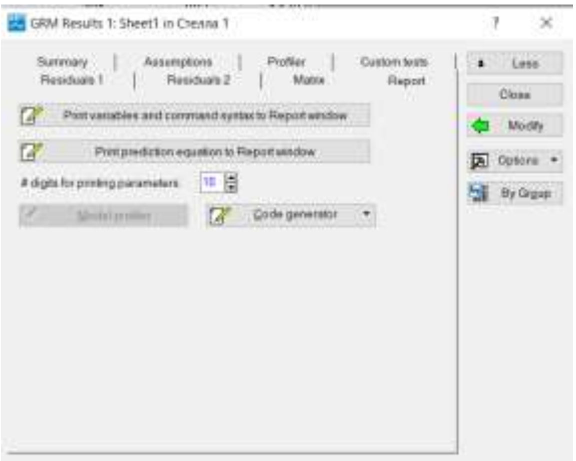


Fig. 12. Predictive equation of regression analysis
Source: Author's computations.

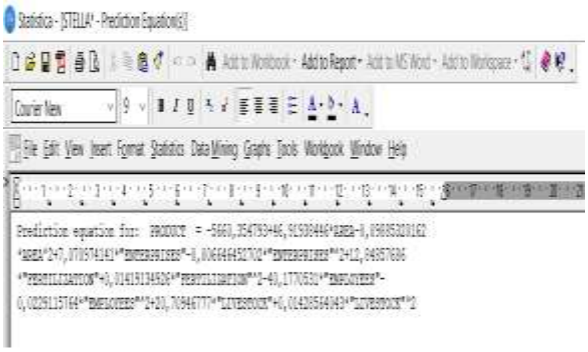


Fig. 13. Predictive regression equation created in Statistica
Source: Author's computations

In order for this equation to be used in further analysis, it must be transformed, namely: replace the comma symbol with a dot and remove the quotation marks next to the name of each variable. After these changes, the following formula was obtained:

Prediction equation for: PRODUCT = -5660.354793+46.91938446*AREA-0.09885320162*AREA^2+7.070974141 *ENTERPRISES-0.006646452702*ENTERPRISES^2+12.84857686 *FERTILIZATION+0.01419134926*FERTILIZATION^2-40.1770531* EMPLOYEES-0.0229115764*EMPLOYEES^2+20.70946777 *LIVESTOCK +0.01428564043*LIVESTOCK^2 (1)

Next, the transformed regression prognostic equation was placed in the value of the flow indicator FLOW PRODUCT (Fig. 14).

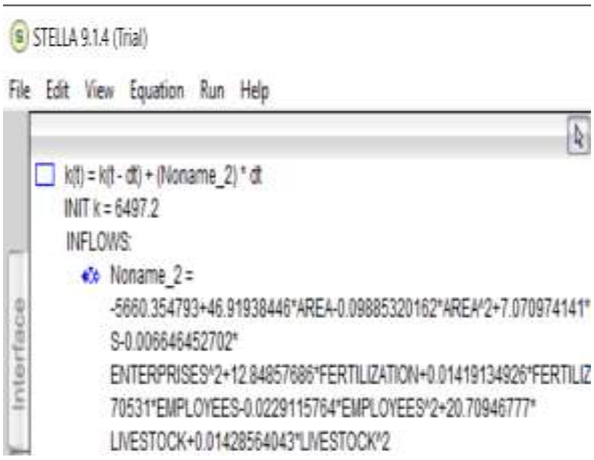


Fig. 14. Fragment of the prognostic equation in STELLA for the variable PRODUCT with the input flow FLOWPRODUCT and under the influence of factors
Source: authors' own calculations from STELLA program.

That is, the further forecast in the STELLA software will be based on the formula that was previously obtained in the Statistica program using the above-described method.

In the STELLA program, the model provides for the creation of a PRODUCT rectangle (Stock), which will display data on the production of agricultural products in million UAH. The specified stock is replenished due to the operation of the FLOWPRODUCT flow and the converter with the reverse arrow of the PRODUCTRATE. According to the formed model, 6 converters influence the PRODUCT stock through the FLOWPRODUCT flow, namely: AREA, ENTERPRISES, FERTILIZATION, EMPLOYEES, LIVESTOCK and PRODUCTRATE. The block diagram of the model can be seen in Fig. 15.

In the STELLA software, relationships between variables are expressed in the form of arrows. The possibility of building component elements of the model and graphic display is a feature of the application of this software. Also, the convenience is that all connections, formed stocks, input and output flows and converters can be changed at any time during the simulation of economic phenomena directly with the help of the user's working mouse cursor. Also, on the right of the figure, the signs of the graph (Graph 1) and table (Table 1) are visually displayed, which allow you to illustrate the obtained forecasting results in the form of graphs and tables.

The model includes information about agricultural enterprises of the Ivano-Frankivsk region in the period 1990-2019. Data from 2020 was used only to verify the veracity of the constructed model. Thus, the model was tested for reliability (forecast results as of 2020 were simulated and compared with real statistical data for this period).

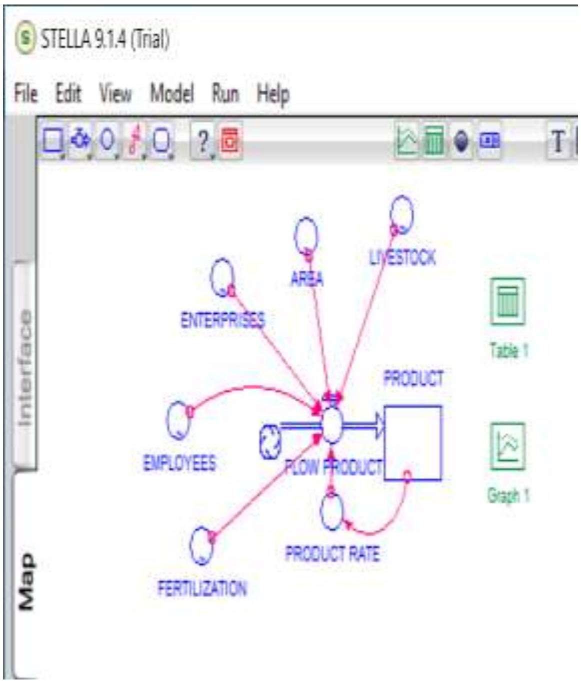


Fig. 15. Block diagram of the model created using the STELLA software product
Source: authors' own calculations from STELLA program.

After verification of the received data, a forecast of probable transformational changes of the selected indicators was made until 2030. In the process of forecasting, the STELLA program used a special TIME function, which makes it possible to simulate data changes over a certain period and determine the simulation step.

In order to simulate at the mathematical level using a system of finite difference formulas, it is necessary to use a certain algorithm and an integration scheme using the Run Specs option (Fig. 16). This tab of the program allows you to create a time step, specify the integration method (Euler or Rungu-Krut), determine the time limits of the forecast and set the initial information. The Euler`s Method option used is one of the methods of system dynamics and is implemented using cause-and-effect relationships diagrams that determine the relationship between the selected variables.

Fig. 16. Fragment of the STELLA program with setting of simulation parameters according to the Euler method
Source: authors' own calculations from STELLA program.

Thus, during the verification of the predictive model, it was found that the results it displays are 90-99 % consistent with real data as of 2020. According to real statistical data, in 2021 the data for the independent variable PRODUCT amounted to UAH 6,231.7 million, for AREA – 309.6 thousand hectares, for FERTILIZATION – 167 kg per 1 ha, for ENTERPRISES – 749 units, for EMPLOYEES – 3.18 thousand persons, for LIVESTOCK – 99.9 thousand heads.

According to the model obtained in STELLA, the value of the dependent variable PRODUCT in 2020 was UAH 7,598.89 million. The values for independent variables were determined as follows: for AREA (area of agricultural land) – 308.13 thousand ha, for FERTILIZATION (amount of applied mineral fertilizers per 1 ha of land) – 166.2 kg per 1 ha of land, for ENTERPRISES (number of agricultural enterprises) – 778.95 units, for EMPLOYEES (the number of employees of agricultural enterprises) – 5.64 thousand persons, for LIVESTOCK (conditional livestock of enterprises) – 97.8 thousand heads. The specified data for the productive indicator PRODUCT are shown in Fig. 17, and the factors affecting it are shown in Fig. 18, where the results of projected changes as of 2020 are underlined with a vertical line, if necessary, other data can be underlined using additional lines and other parameters.

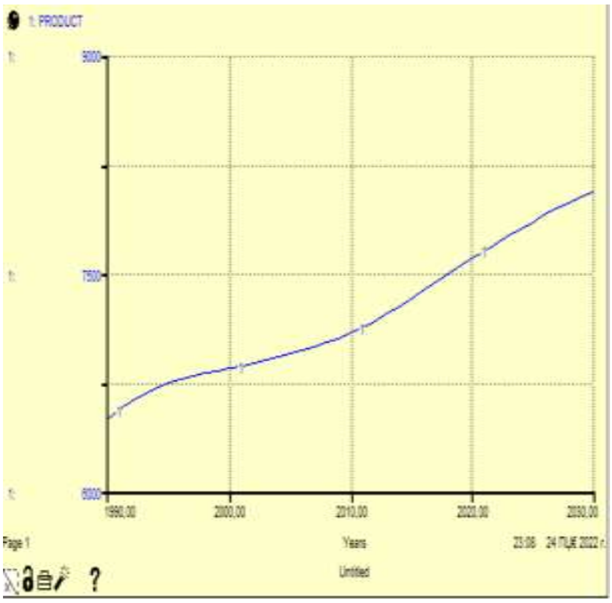


Fig. 17. Visualization of the predicted results for the PRODUCT variable using the STELLA
Source: authors' own calculations from STELLA program.

The use of graphical display of data provides an opportunity to assess the accuracy of the constructed verified model. The lines on the graphs are numbered accordingly, for example, if a single element is plotted on the graph, as shown in Fig. 18, then it is automatically assigned an ordinal value of 1. In the case that several components of the forecast are presented on the graph, they are automatically numbered according to the following format: 1. area of agricultural land (AREA); 2. number of agricultural enterprises (ENTERPRISES); 3. amount of applied mineral fertilizers per 1 ha of land (FERTILIZATION); 4. conditional livestock of agricultural enterprises (LIVESTOCK); 5. number of employees of agricultural enterprises EMPLOYEES. It should be noted that no more than five factors and no less than one can be displayed graphically on one graph at the same time.

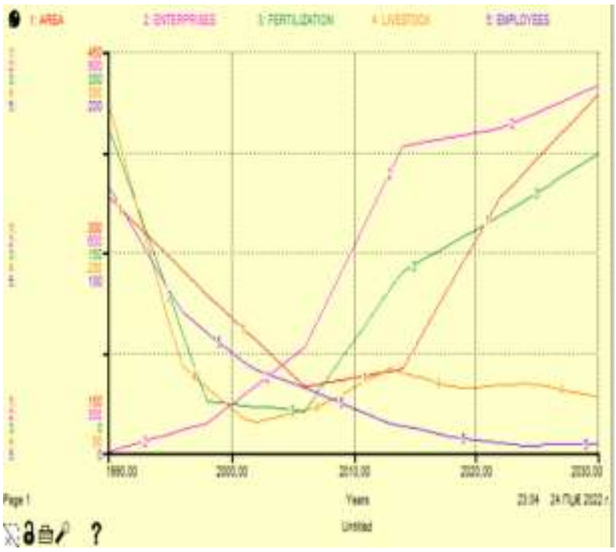
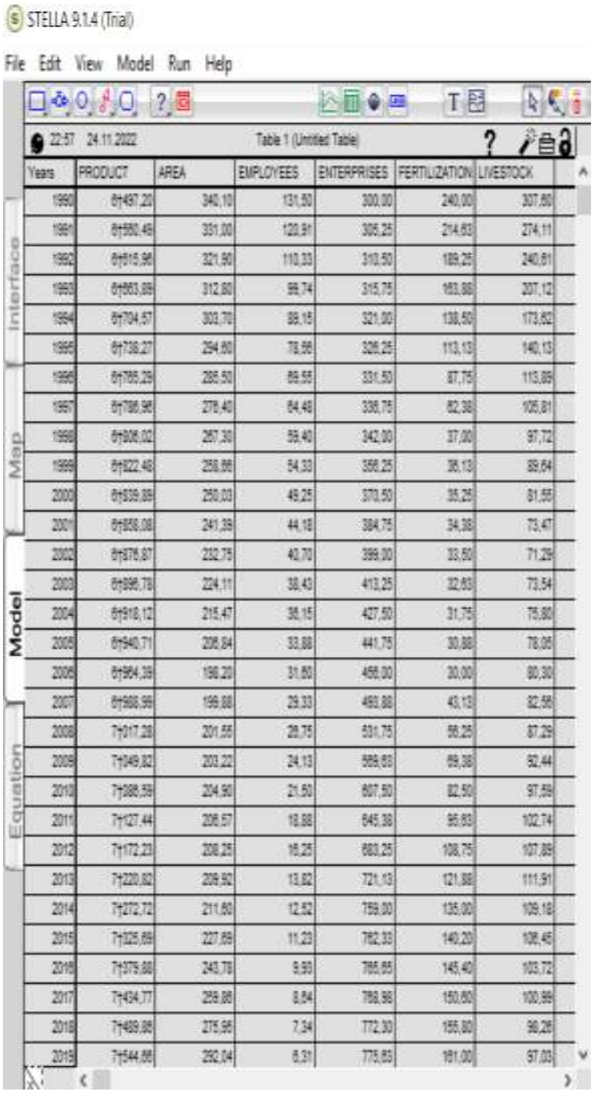


Fig. 18. Visual display of predicted results for the variables AREA, ENTERPRISES, FERTILIZATION, LIVESTOCK, EMPLOYEES using the STELLA*
1. Agricultural land area AREA
2. Number of agricultural enterprises ENTERPRISES
3. Amount of applied mineral fertilizers per 1 ha of FERTILIZATION land
4. Conditional stock of agricultural enterprises LIVESTOCK
5. The number of employees of agricultural enterprises EMPLOYEES
Source: authors' own calculations from STELLA program.

Fig. 18 shows the measurement scale for each evaluated indicator. Thus, the value can vary for the indicators: PRODUCT from 6,000 to 9,000 million UAH, AREA – from 150 to 450 thousand ha, ENTERPRISES – from 0 to 900 enterprises, FERTILIZATION – from 0 to 300 kg of mineral fertilizers per 1 ha of land, LIVESTOCK – from 50 to 350 thousand heads, EMPLOYEES – from 0 to 200 thousand people [16].

Also, the STELLA software allows you to evaluate the forecast results by displaying the obtained results in tabular form.

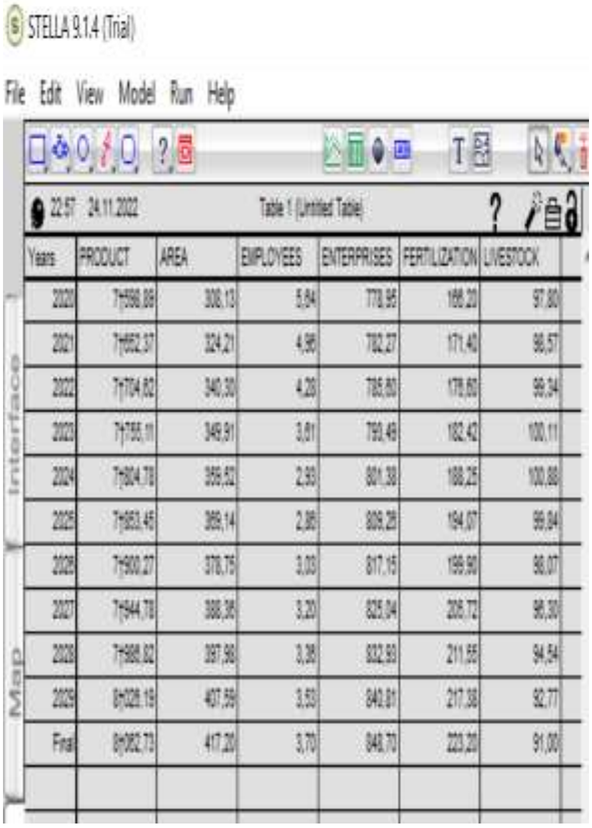
In Fig. 19 presents the results of the probable growth of the gross output of agricultural enterprises (PRODUCT) taking into account the change in factors over time that affect it, such as: AREA, ENTERPRISES, FERTILIZATION, LIVESTOCK and EMPLOYEES.



Years	PRODUCT	AREA	EMPLOYEES	ENTERPRISES	FERTILIZATION	LIVESTOCK
1990	6 497,20	340,10	131,50	300,00	240,00	307,60
1991	6 580,46	331,00	120,91	305,25	214,63	274,11
1992	6 615,96	321,90	110,33	310,50	189,25	240,61
1993	6 663,89	312,80	99,74	315,75	163,88	207,12
1994	6 704,57	303,70	89,15	321,00	138,50	173,62
1995	6 736,27	294,60	78,56	326,25	113,13	140,13
1996	6 765,29	285,50	69,55	331,50	87,75	113,89
1997	6 786,96	276,40	64,48	336,75	62,38	105,81
1998	6 806,02	267,30	59,40	342,00	37,00	97,72
1999	6 822,46	258,66	54,33	356,25	36,13	89,64
2000	6 839,89	250,03	49,25	370,50	35,25	81,55
2001	6 858,08	241,39	44,18	384,75	34,38	73,47
2002	6 876,87	232,75	40,70	399,00	33,50	71,29
2003	6 896,76	224,11	38,43	413,25	32,63	73,54
2004	6 918,12	215,47	36,15	427,50	31,75	75,80
2005	6 940,71	206,84	33,88	441,75	30,88	78,05
2006	6 964,39	198,20	31,60	456,00	30,00	80,30
2007	6 988,99	199,88	29,33	493,88	43,13	82,56
2008	7 017,28	201,55	26,75	531,75	56,25	87,29
2009	7 049,82	203,22	24,13	569,63	69,38	92,44
2010	7 086,59	204,90	21,50	607,50	82,50	97,59
2011	7 127,44	206,57	18,88	645,38	95,63	102,74
2012	7 172,23	208,25	16,25	683,25	108,75	107,89
2013	7 220,82	209,92	13,62	721,13	121,88	111,91
2014	7 272,72	211,60	12,52	759,00	135,00	109,18
2015	7 325,69	227,69	11,23	762,33	140,20	106,45
2016	7 379,88	243,78	9,93	765,65	145,40	103,72
2017	7 434,77	259,88	8,64	768,98	150,60	100,99
2018	7 489,88	275,96	7,34	772,30	155,80	98,26
2019	7 544,66	292,04	6,31	775,63	161,00	97,03

Fig. 19. Visualization in the STELLA program of essential data until 2019
Source: authors' own calculations from STELLA program.

The forecast of the analysis of informative data from 2020 to 2030 is shown in fig. 20. It is obvious that the predicted indicators in the STELLA program indicate an increase in the gross output of agricultural enterprises of the Ivano-Frankivsk region to UAH 8,062.3 million in 2030. Nevertheless, positive changes can be achieved by adjusting the area of AREA agricultural land at the level of 417.2 thousand hectares, the number of agricultural enterprises at the level of 848.7 units, the amount of applied mineral fertilizers per 1 ha of land up to 223.2 kg, the presence of conditional livestock. of agricultural enterprises up to 91,000 heads and the number of enterprise employees in the amount of 3,700 persons.



Years	PRODUCT	AREA	EMPLOYEES	ENTERPRISES	FERTILIZATION	LIVESTOCK
2020	7 598,89	308,13	5,64	778,95	166,20	97,80
2021	7 652,37	324,21	4,96	782,27	171,40	98,57
2022	7 704,82	340,30	4,28	785,60	176,60	99,34
2023	7 755,11	349,91	3,61	793,49	182,42	100,11
2024	7 804,78	359,52	2,93	801,38	188,25	100,88
2025	7 853,45	369,14	2,86	809,28	194,07	99,84
2026	7 900,27	378,75	3,03	817,16	199,90	98,07
2027	7 944,78	388,36	3,20	825,04	205,72	96,30
2028	7 986,82	397,98	3,36	832,93	211,55	94,54
2029	8 028,19	407,59	3,53	840,81	217,38	92,77
Final	8 062,73	417,20	3,70	848,70	223,20	91,00

Fig. 20. Results of forecasting 2020-2030 in STELLA software
Source: authors' own calculations from STELLA program.

The volume of production of gross agricultural products of enterprises changes under the influence of such factors as the area of agricultural land, the number of agricultural enterprises, the amount of applied mineral fertilizers per one hectare of land, the conditional number of animals and the number of employees of agricultural enterprises [16]. However, the results of the study confirmed that the main factor affecting the production of agricultural products is the area of agricultural land. Both of these indicators, according to the forecast, tend to increase.

Both variables tend to increase according to the obtained forecast. In order to achieve the predicted values of the model in 2030, the activities of agricultural producers should be oriented towards the following:

– preservation of fertility and other characteristics of soils;

– compliance with norms and technologies of soil fertilization;

– effective use of material, technical, financial and other types of resources [1];

– increasing the labor productivity of agricultural workers;
– the use of means and results of information support in economic activity and the development of the Ukrainian economy [13], cross-border relations [6];
– carrying out a scientific analysis of the sales market;
– involvement of modern technologies and methods of production [19].

The built model in the STELLA software shows a forecast of indicators for the future, which affect the output of gross products by enterprises. The obtained results of forecasting the effective indicator and the factors affecting it can be applied in practice during the development of future production plans by agricultural enterprises of the Ivano-Frankivsk region.

CONCLUSIONS

When carrying out a forecast of the production of gross agricultural products, enterprises need to build models of the main performance indicators with the help of special programs. Accordingly, the possible trend of their development is determined, which in turn should be geared to the informational data of the forecast.

In the course of the research, it has been established that the forecasting of the production of gross agricultural products of enterprises in the Ivano-Frankivsk region was carried out using the specialized software STELLA and the statistical package Statistica. During the analysis, the dependent variable was determined – the gross output of agricultural enterprises of the Ivano-Frankivsk region (PRODUCT) and independent variables: the area of agricultural land of enterprises (AREA), the number of agricultural enterprises (ENTERPRISES), the amount of applied mineral fertilizers per 1 hectare of land (FERTILIZATION), the number of employees of agricultural enterprises (EMPLOYEES), conditional livestock of enterprises of Ivano-Frankivsk region (LIVESTOCK).

The predictive values of the model suggest that by 2030, it will be advisable for agricultural enterprises to build trajectories of their activities geared in the direction of achieving effects related to: the improvement of soil fertility, technological parameters of land fertilization, rational and economically efficient use of material as well as technical, financial, human and other types of resources. They also should focus on increasing the labor productivity of agricultural workers, the use of means and results of information support in economic activity, the implementation of scientific analysis of the sales market, involvement of modern technologies and methods of production.

During the forecasting of the volumes of gross agricultural products, it was found that one of the main influencing factors is the agricultural land of enterprises. The prognostic model created with the help of the STELLA program proved that the volume of gross output by agricultural enterprises of the Ivano-Frankivsk region in 2030 will increase to UAH 8,062.3 million when the amount of AREA agricultural land is adjusted to 417.2 thousand hectares, the number of agricultural enterprises by 848.7 units, the amount of applied mineral fertilizers per 1 ha of land up to 223.2 kg, the availability of conditional livestock of agricultural enterprises up to 91 thousand head and the presence of enterprise employees in the amount of 3.7 thousand persons.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDYING THE INFLUENCE OF THE PROTEIN COMPOSITION OF RAW MILK FROM COWS WITH DIFFERENT KAPPA-CASEIN GENOTYPES ON THE HARD CHEESE YIELD AND NUTRIENT CONTENT

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Abstract

Milk that was obtained from cows with different genotypes for the kappa-casein gene in accordance with the requirements of normative documents corresponds to typical cow's milk in terms of physical and chemical parameters. According to the results of the conducted research, it was established that the sensory characteristics of the cheese are influenced by the genotype of the kappa-casein gene of the animals from whose milk it is made. In terms of the content of the main chemical components, cheeses made from BB milk had a higher content of solids and protein. Cheese made from the milk of cows with the AB genotype was characterized by a higher total content of amino acids (it was 16.6 mg/g). A higher yield of cheese was obtained from the milk of animals with the BB genotype (13.1%) compared to milk from animals with the AA and AB genotypes. The obtained results are of practical importance, since it is possible to take into account how changes in the kappa-casein genotype in raw milk can affect the yield of cheese, and therefore the profitability of its production.

Key words: *milk, cheese, protein, kappa-casein, genotype, BB, amino acids, physicochemical characteristics*

INTRODUCTION

Over the past decade, the processes of milk coagulation in cheese making have been widely studied. Scientists have concluded that milk protein fractions are the main factors in milk coagulation [13]. This explains their interest in studying the impact of animal genotype on the quantitative and qualitative characteristics of cows' milk productivity. Particular attention is paid to the study of polymorphism of milk protein genes, which can be markers of milk quality and technological indicators [5]. The researchers came to the conclusion that selection by the genotype of milk proteins can lead to the appearance of cows from which milk is obtained that is more suitable for the production of cheese [6]. A special role in this process is played by casein, which is a numerous protein of four fractions (α S1, α S2, β and κ). Between the animals of different cattle breeds there is a significant difference in the allelic variants of the genes encoding these proteins [2, 3]. The frequency of allele A in Ukrainian Black-and-White cattle is about 0.80, and allele B is 0.20 [8].

The kappa-casein fraction accounts for approximately 80% of the total milk protein and is involved in certain physiological processes [14]. This protein is a phosphoprotein containing 169 amino acids. It is encoded by the CSN3 gene. The most common variants of this gene are CSN3*A and CSN3*B, while the CSN3*E variant is rare. Scientists believe that the best variant of kappa-casein for the production of hard cheeses is the CSN3*B variant [1, 12].

Scientists have found that milk from animals of BB genotype was more suitable for cheese making both in terms of milk composition and its technological properties. It significantly

($p<0.05$) exceeded milk from animals with other kappa-casein genotypes in terms of protein, casein and solids content [4, 17]. Similar results were obtained by other scientists [5, 7].

It has been proven that the E allele is undesirable, which is associated with the deterioration of milk syrupability [11]. According to the results of genotyping of animals for the kappa-casein gene, breeders manage to improve breeding programs for breeding dairy cattle [9, 18]. The result of this work may be a decrease in the proportion of AA genotypes [16]. In turn, increasing the share of the desired BB genotype in local breeds will contribute to their preservation [15]. At the same time, other scientists state that the kappa-casein genotype did not affect the quantitative and qualitative characteristics of cow's milk [3].

In this context the purpose of the paper was to study of the influence of the protein composition of raw milk on the yield of hard cheese and the content of nutrients in it.

MATERIALS AND METHODS

A commercial herd of Ukrainian Black-and-White dairy breed in Sumy region was chosen for the study. In this study, 10 kg of milk was collected during morning milking from each of nine cows with different kappa-casein genotypes (AA, AB and BB). The tested samples of Gouda hard cheese were produced from whole milk using traditional technology in accordance with the requirements of DSTU 6003:2008 "Hard cheeses. General technical conditions". Simultaneously, nine samples of cheese were prepared from cow's milk of different genotypes. 10 kg of raw milk was used to make cheese. Pasteurisation, fermentation, curdling and subsequent curd formation were carried out in a laboratory cheese dairy.

The process of making samples of Gouda hard cheese in the laboratory includes the following stages: purified from mechanical impurities milk is pasteurised at a temperature of (72-75) °C for 20 s. Dried starter culture is added to the milk cooled to a temperature of (36±1) °C in the amount recommended by the manufacturer. The starter consists of mixed cultures of microorganisms – *Lactococcus lactis subsp. lactis, Lactococcus lactis subsp. cremoris, Lactococcus lactis subsp. lactis var. Diacetylactis* (Dalton, Italy). Next, a solution of calcium chloride (at the rate of 20-40 g per 100 kg of mixture) and rennet Albamax 600 (100 % chymosin) (Caglificio Clerici, Italy) is added. The mixture is fermented at a temperature of (36±1) °C until a dense curd is formed. Next, the curd is cut and processed (kneading, second heating at (39±1) °C, and drying). The formed curds are pressed and then salted in brine (salt concentration of 18-20%, temperature 10-14°C). The cheese is dried at a temperature of (10-12)°C for 4 hours. The dried cheese heads are coated with Polisved protective coating and sent for ripening at (12±2) °C for 30 days. The ripened cheese is stored in a refrigerator at (6±2) °C.

The quality of milk and cheese samples was evaluated according to generally accepted methods. Raw milk was analysed for quality parameters in accordance with DSTU 3662:2018, and cheese samples were analysed in accordance with DSTU 6003:2008.

To determine the density of milk samples, the aerothermic method was used (SSU 6082:2009). Determination of acidity (pH) of selected samples of milk and obtained cheese was carried out using the potentiometric method (SSU 8550:2015).

The mass fraction of solids in milk and cheese samples was determined by the method of drying to a constant indicator in accordance with DSTU 8552:2015. The mass fraction of protein was determined by the Kjeldahl method in accordance with DSTU ISO 8968-1:2005, DSTU 5038:2008. The mass fraction of fat was determined by the acid method (the Gerber method) in accordance with DSTU ISO 2446:2019.

Organoleptic characteristics of cheese samples were determined according to DSTU 6003:2008, with the recommendations described in the international standard ISO 22935-2:2023.

The analysis of amino acids in cheese samples was carried out by ion-exchange liquid column chromatography using an automatic amino acid analyser "T 339" (Czech Republic, Prague). The procedure is as follows: a weighed sample (with a protein content of about 2 mg) is placed in the bottom of a test tube, 0.5 ml of distilled water and 0.5 ml of concentrated hydrochloric acid are added. The tube is cooled in a mixture of dry ice and acetone or liquid nitrogen. After the content of the tube is frozen, the air is removed from the tube using a vacuum pump to prevent oxidation of the amino acids due to hydrolysis. The tube is then sealed and placed in a constant temperature thermostat (106±1) °C for 24 hours. After hydrolysis has been completed, the tube is opened and cooled to room temperature. The content is quantitatively transferred to a glass weighing bottle and placed in a vacuum desiccator over granular caustic soda. The air is then removed from the desiccator using a water pump. After the sample is dried, 3-4 ml of deionised water is added to the weighing bottle and the drying procedure is repeated. The sample prepared in this way is dissolved in 0.3 n lithium citrate buffer (pH 2.2) and applied to the ion-exchange column of the amino acid analyser.

The research was conducted in triplicate. The obtained experimental data are presented in units of the international SI system.

The yield of hard cheese from the studied milk samples was calculated by the formula:

$$B = \frac{m_{cheese}}{m_{milk}} \cdot 100\%, \qquad \dots\dots\dots\dots\dots\dots \qquad (1)$$

where B – cheese yield, %;

m_{cheese} – mass of cheese (30 days after production), kg;

m_{milk} – mass of milk, kg.

Mathematical and statistical processing of the obtained results was carried out on a computer using MS Excel 2016 software.

RESULTS AND DISCUSSIONS

The conducted analyzes proved that milk obtained from animals with different genotypes for the kappa-casein gene meets the requirements of the State Standard for fresh milk. Intergenotypic differentiation in terms of dry matter content, protein and fat content was established in favor of milk from animals with the BB genotype. A higher ratio of protein and fat is characteristic of milk from animals with the AB genotype (Table 1).

The photo shows the appearance of the experimental samples of hard cheese made from milk obtained from cows that differed in the kappa-casein gene genotype (Fig. 1).

Table 1. Physicochemical characteristics of raw milk samples with different kappa-casein genotypes (3 samples of each genotype)

Genotype	Acidity, units pH	Density, kg/м^3	Mass fraction of solids, %	Mass fraction of protein, %	Mass fraction of fat, %
AA	6.4±0.01	1,027±1.0	11.8±0.02 ^{a**}	2.89±0.01^{a*}	3.65±0.01^{a**}
AB	6.4±0.01	1,026±1.0	11.2±0.02	2.83±0.01	3.07±0.01
BB	6.2±0.01	1,027±1.0	12.5±0.02 a**;b*	2.93±0.01a*	4.34±0.01a**;b*

Note: a - in relation to the AB genotype; b - to the AA genotype; *P<0,05; *P<0,01
Source: Own research.

Fig. 1. Characteristics of the appearance of the obtained cheese samples (1 – made from the milk of animals with the AA genotype; 2 – made from the milk of animals with the AB genotype; 3 – made from the milk of animals with the BB genotype).

Milk from animals with the homozygous BB genotype was characterized by a higher yield of cheese (Fig. 2).

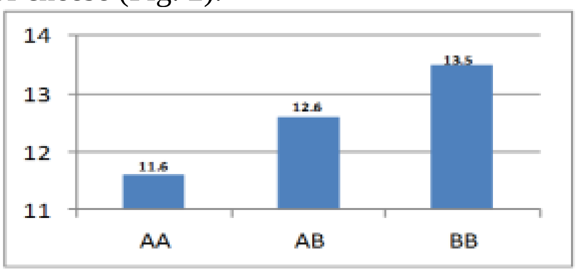

Fig. 2. Average yield of hard cheese from milk of cows with different kappa-casein genotypes, %
Source: Own research.

Based on the average results of the sensory analysis of the general characteristics of hard cheese conducted by the expert group, the specific features of such characteristics as appearance, taste, smell, consistency, colour, pattern, and head shape were identified.

The samples of hard cheese made from the milk of AA cows have an average score of 4.3 points for appearance, 4.3 points for taste and smell, 3.7 points for consistency, 4.3 points for colour, 3.3 points for the pattern on the cut, and 5 points for the shape of the cheese heads. The cheeses are characterised as satisfactory in appearance; with good taste but weak flavour; with satisfactory texture and uniform colour; with uneven slit-like arrangement of eyes on the cut.

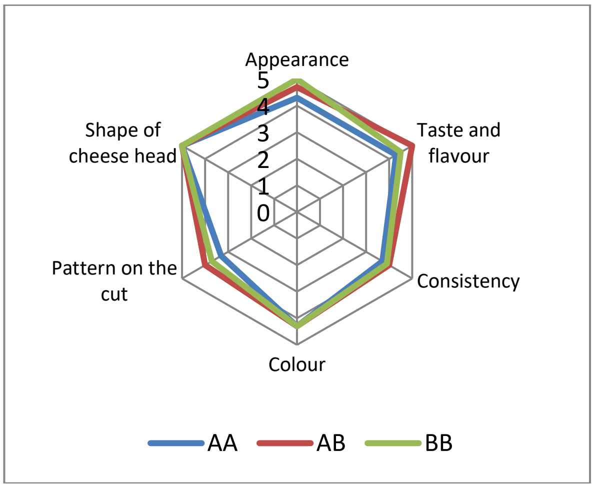

Fig. 3. Sensory profile of hard cheese samples
Source: Own research.

The samples of hard cheese from the milk of AB cows were rated on average at 4.7 points for appearance, 5.0 points for taste and smell, 4.0 points for consistency, 4.3 points for colour, 4.0 points for the pattern on the cut, and 5.0 points for the shape of the cheese heads. The cheese samples have a good appearance; excellent taste and flavour; good consistency; uniform colour and arrangement of the eyes on the cut (Fig. 3).

According to the obtained profiles of sensory analysis, the samples of hard cheeses made from the milk of BB genotype cows have an average score of 5.0 points for appearance, 4.5 points for taste and flavour, 3.9 points for consistency, 4.3 points for colour, 3.7 points for the pattern on the cut, and 5.0 points for the shape of the cheese heads.

In terms of appearance, the cheeses are characterised by experts as cheeses with a good oval; with a good taste but a weakly expressed flavour; with a satisfactory consistency and uniform colour; with an uneven arrangement of eyes on the cut.

Table 2 shows the results of the study of physicochemical characteristics of hard cheese from milk obtained from cows of different kappa-casein genotypes.

The composition of cheese differed to some extent, depending on the kappa-casein genotype.

Intergenotypic differentiation according to the chemical composition of cheese was established. The cheese obtained from milk from cows with the AB genotype prevailed in terms of dry matter content, AB - in terms of protein content, and BB - in terms of fat content.

The amino acid profile of the hard cheese samples was analysed using a chromatograph. Figure 4 shows the average results.

It was found that samples of cheese made from milk from AA genotype cows were characterised by the lowest content of essential amino acids: leucine (1.21 mg/g), lysine (0.93 mg/g), phenylalanine (0.69 mg/g), threonine (0.50 mg/g), histidine (0.33 mg/g), valine (0.39 mg/g).

Table 2. Physicochemical characteristics of cheese samples from milk of cows with different kappa-casein genotypes (3 samples each)

Kappa-casein genotype	Acidity, units pH	Mass fraction of solids, %	Mass fraction of protein, %	Mass fraction of fats, %
AA	5.44±0.01	51.6±0.20	13.5±0.10^{b**}	36.1±0.10
AB	5.16±0.01	64.5±0.20^{a**}	17.2±0.10	35.6±0.10
BB	5.33±0.01	63.6±0.20^{a**}	13.0±0.10^{b**}	38.1±0.10^{b**}

Note: a - in relation to the AA genotype; b - to the AB genotype; *P<0.05; *P<0.01
Source: The authors' own research.

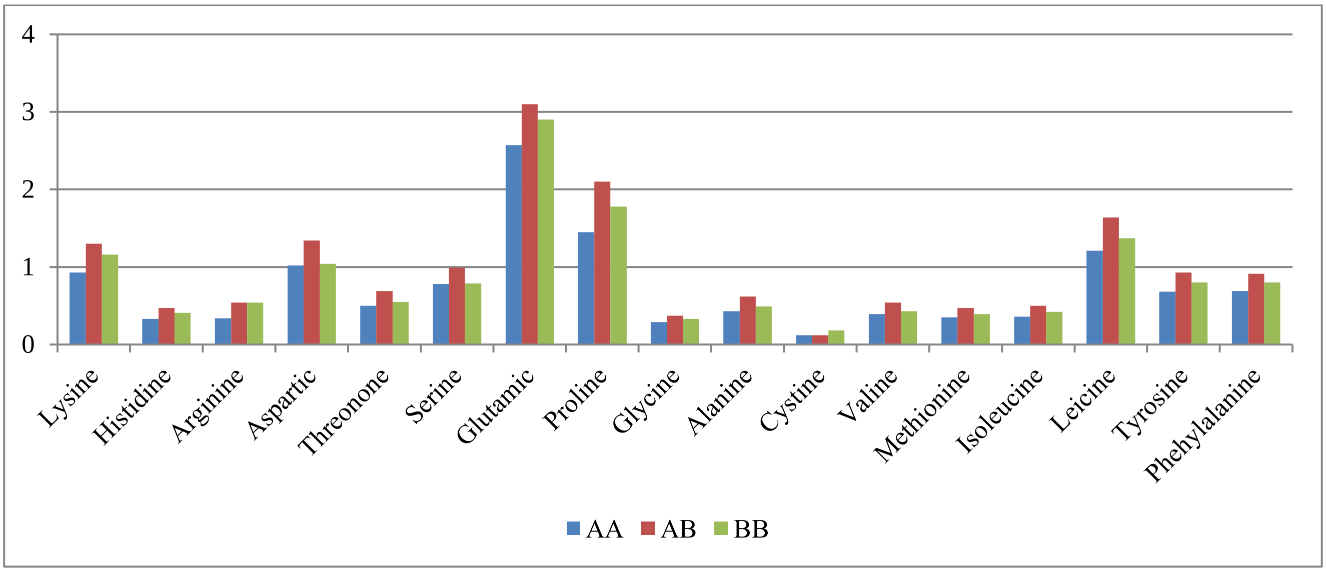

Fig. 4. Average amino acid profile of hard cheese samples made from milk of cows of different genotypes, mg/g
Source: The authors' own research.

The samples also contain the following nonessential amino acids: glutamic acid (2.57 mg/g), aspartic acid (1.02 mg/g), proline (1.45 mg/g), serine (0.78 mg/g), tyrosine (0.68 mg/g).

The samples of cheese made from milk of AB genotype cows had the highest content of essential amino acids among the studied ones: leucine (1.63 mg/g), lysine (1.30 mg/g), phenylalanine (0.91 mg/g), threonine (0.69 mg/g), histidine (0.47 mg/g), valine (0.54 mg/g). The samples contained the following nonessential amino acids: glutamic acid (3.10 mg/g), aspartic acid (1.34 mg/g), proline (2.09 mg/g), serine (0.99 mg/g), tyrosine (0.93 mg/g). The cheese samples from milk of BB genotype cows differed in the average content of essential amino acids among the studied ones: leucine (1.37 mg/g), lysine (1.16 mg/g), phenylalanine (0.80 mg/g), threonine (0.55 mg/g), histidine (0.40 mg/g), valine (0.43 mg/g).

The samples contained the following nonessential amino acids: glutamic acid (2.90 mg/g), aspartic acid (1.04 mg/g), proline (1.78 mg/g), serine (0.80 mg/g), tyrosine (0.80 mg/g).

Cheese samples obtained from milk from cows with AB and BB genotypes are characterized by both higher product yield and better quality characteristics. In order to breed animals with such genotypes, we recommend using stud bulls with BB genotype for reproduction (Fig. 5).

Our previous studies [10] identified stud bulls of domestic breeds, including the Ukrainian Black-and-White dairy breed, with the desired genotype.

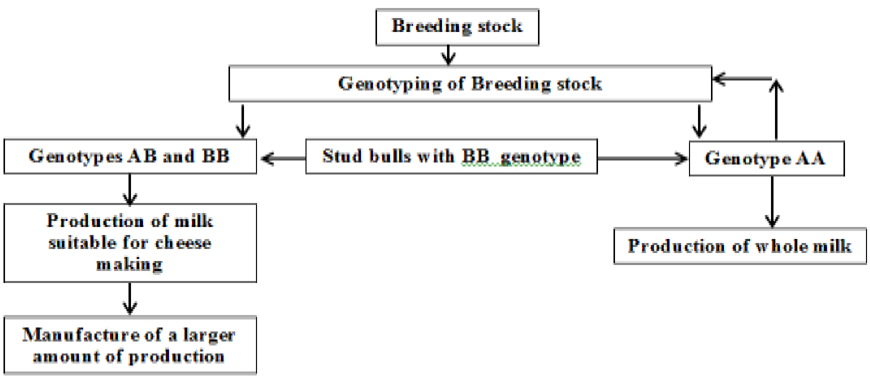

Fig. 5. Scheme of producing milk suitable for cheese making
Source: The authors' own research.

CONCLUSIONS

The studies have established that the physicochemical characteristics of raw milk from cows with different kappa-casein genotypes (AA, AB, BB) are common for fresh cow's milk production and meet the requirements of regulatory documents.

Milk from cows with different genotypes for the kappa-casein gene has certain differences in chemical composition. Milk from animals with the BB genotype prevails in terms of dry matter, fat and protein content. The effect of the genotype of the cows from which the milk was obtained on the sensory characteristics of the cheese was also determined. However, in terms of the content of the main chemical constituents, cheeses made from BB milk had a higher content of solids and protein.

The intergenotypic differentiation by the amino acid profile of cheese was established. Samples from animals with the AB genotype had a higher total amino acid content. Genotype for the kappa-casein gene had an effect on cheese yield. Thus, the output from the milk of animals with the BB genotype was greater and amounted to 13.1%.

These results are interrelated with the chemical composition of milk and the optimal protein: fat ratio in the initial milk samples.

A scheme for producing raw milk suitable for cheese making has been developed and implemented at the experimental farm.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

EFFICIENCY OF CREATING HERDS OF THE UKRAINIAN RED-AND-WHITE DAIRY BREED CATTLE WITH THE DESIRED BETA- AND KAPPA-CASEIN GENOTYPE

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Abstract

Qualitative characteristics of milk depend on the genotype of cows for beta- and kappa-casein genes. An animal's genotype for the beta-casein gene also has an impact on milk digestibility and human health. The rate of cheese yield depends on the genotype of the animal according to the kappa-casein gene. Genotyping of 349 animals of the Ukrainian Red-and-White dairy breed was carried out in order to establish the features of genotype formation by beta- and kappa- casein. The population of the studied breed (36% of homozygote A2A2 and 46% of heterozygote A1A2) can provide an increase in homozygosity by beta-casein (A2A2), that enables to increase the frequency of desired alleles under the conditions of compliance with the developed recommendations. The term of creation of a herd with genotype A2a2 is 10 years. For this, it is necessary to use breeders with the desired homozygous genotype and to cull cows and heifers with other genotypes. Breeding stock of the same breed (16% of BB homozygotes and 36% of AB heterozygotes) can also provide an increase in kappa-casein (BB) homozygosity in the next generation. Creating a herd with the desired genotype for the kappa-casein gene also requires the use of homozygous breeders. Obtaining animals with genotypes A2A2 for the beta-casein gene and BB for the kappa-casein gene will ensure boosting the economy of dairy farming.

Key words*: *breed, allele, genotype

INTRODUCTION

Milk and its various products make up the bulk of food for people around the world. The competitiveness of milk production depends on its quality characteristics [6]. One of the most produced milk products is cheese. It is considered one of the best sources of nutrients for humans, such as proteins, lipids, minerals and vitamins. One of the requirements for producing high-quality cheese is dairy raw materials not only with a high protein content, but also with the appropriate quality [12].
Scientists have noted that for the selection of milk for cheese production, it is essential to pay attention to the genotype of animals for the kappa-casein gene. The B allele is viewed as a more desirable one in cheese production. Milk from animals with the BB genotype has better technological properties in the production of cheese, and the product itself is featured by better physical and chemical qualities [16, 17]. It has been proven that when a person consumes milk from cows with the A2A2 genotype, no negative consequences are observed. Otherwise, milk from cows with the A1A1 genotype can harm human health [7, 21].
The importance of evaluating stud bulls by beta- and kappa-casein genotypes is indicated by the increased interest of livestock breeders in using stud bulls with BB and A2A2 genotypes, respectively. Over the past 2 years there has been an increase in the share of stud bulls in WWS Company with the A2A2 beta-casein genotype and the BB kappa-casein

genotype [17, 22, 25]. Thus, the frequency of such stud bulls in the 2019 Stud Bull Catalogue was 0.51 and 0.29, respectively; and in the 2021 Stud Bull Catalogue, was amounted to 0.68 and 0.31, respectively. Genotyped stud bulls, a significant part of which are imported from abroad, differ in the predominance of the A2 allele of beta-casein (the frequency was 0.63). However, the allele of the B kappa-casein was found in the group of stud bulls owned by Ukrainian enterprises only with the frequency of 0.34, which was 1.6 times lower than among American stud bulls.

Breeders are gradually turning their attention to the genotype of animals for certain caseins. The information about gene evaluation by the proteins becomes more and more common in the catalogs of breeders' semen [15]. The genotype of Holstein animals for the beta-casein gene varies depending on the country of origin. Depending on the country of origin, the A2A2 genotype varied significantly and ranged from 42 to 77%. The frequency of the A2 allele also varied and was 0.6-0.8 [3, 8, 9, 20].

The authors have established the frequency of beta- and kappa-casein genotypes of Ayrshire cattle. In different groups of cattle, the frequency of A2A2 beta-genotype ranges from 0.23 to 0.37 and BB kappa-genotype - from 0.03 to 0.06. The A2A2 and BB genotypes have no negative effect on lactation performance. The authors believe that for Ukrainian breeding enterprises that sell semen products of Ayrshire bulls, it is advisable to increase the share of stud bulls with the A2A2 (beta-casein locus), AB and BB (kappa-casein locus) genotypes. It was found that in different groups of cattle, the frequency of beta-casein loci of the A2A2 genotype ranges from 0.50 to 0.80 and kappa-casein of the BB genotype ranges from 0.66 to 0.88. The A2A2 and BB (beta- and kappa- loci) genotypes do not negatively affect the lactation performance of their carriers [2, 26].

A large sample of Holstein cows (n=8706) showed a low (8.46%) proportion of animals homozygous by the BB kappa-casein gene allele with a high proportion of heterozygotes (44.66%) and homozygotes (46.88%) of AA genotype. Genotyping of stud bulls (n=84) revealed that 7.1% of cattle were homozygous by the desired kappa-casein alleles, and 22.6% by beta-casein. The shortage of domestic Holstein bulls with the desired genotypes today can be compensated by the import of bull semen from countries where breeding is carried out not only by beta- and kappa-casein, but also in general by cheese making. A high proportion (38.87%) of homozygous cows with the A2 allele subject to a significant number of livestock makes it possible to form a specialized herd for the production of "hypoallergenic" milk.

Breeders, used in breeding herds, significantly differ in terms of both beta- and kappa-casein genotypes [1, 19].

The purpose of the article is to assess the polymorphism of beta- and kappa-casein genes in the population of the Ukrainian Red-and-White dairy breed and establish the possibility of creating dairy herds with the desired genotype.

MATERIALS AND METHODS

Genotyping of cattle of the Ukrainian Red-and-White dairy breed was carried out according to the genome of beta-casein (n=235) kept in Ichnianske LLC in Chernihiv Region and kappa-casein (n=114) kept in Khliborob LLC in Kyiv Region.

Blood samples were taken under sterile conditions into 2.7 mL manovettes containing EDTA potassium salt as an anticoagulant ("Sarstedt", Germany) with the following freezing of samples and their storage at -20ºC. DNA for genotyping was extracted from the samples using Monarch® Genomic DNA Purification Kit New England BioLab kits (USA) according to manufacturer's protocol.

The determination of the genotype of the Ukrainian Red-and-White dairy cattle breed by the kappa-casein (k-Cn) gene was carried out in the genetics laboratory of M. V. Zubets Institute of Animal Breeding and Genetics of the National Academy of Sciences of Ukraine. The amplification of gene fragment was carried out with the use of the following primers:

5'-GAAATCCCTACCATCAATACC-3 '; 5'-CCATCTACGCTAGTTTAGATG-3 ' (Pinder et al., 1991).

The length of the amplified fragment is 273 bp. The amplification product of the k-Cn gene with the use of the above primers includes the region of the 4th exon and 4th intron of the gene. The two allelic variants A and B of the k-Cn gene are detected after restriction of this Hinf1 fragment. The variant B is characterized by point mutations (amino acid replacement of Tyr with Iso in position 136; Ala with Asp in position 148).

The composition of the reaction mixture (10 µL): 4.3 µL of H2O; 2.0 µL of 5-x PCR buffer (15 m Mg-1.0 ML); 0.8 µL of 10-x dNTP mixture (2 mm each); 0.8 µL of two primers (70 ng each); 0.1 µL of Taq polymerase (1 ML /1000 U); 2.0 µL of 50-100 ng DNA. The PCR amplification of kappa-casein gene was carried out under the following temperature regime: initial denaturation –at 94°C for 3 min; 35 cycles: denaturation – at 94°C for 30 s; firing primers –at 61°C for 30 s; synthesis – at 72°C for 30 s; terminal elongation – at 72°C for 5 min.

The Hinf1 restriction was used to restrict the k-Cn gene [11] fragments with a length of 113, 91, 49 bp (cattle of the AA genotype); 224, 113, 91, 49 bp (cattle of the AB genotype); 224 and 49 bp (cattle of the BB genotype) were found after the above restriction [10, 23].

The molecular weight marker Fermentas# SM0373, GeneRuler 50-bp DNA Ladder was used during the research.

The electrophoretic separation of DNA restriction fragments was performed according to the methodological recommendations [5] in 2 %, agarose gel in tris borate electrophoresis buffer (TBE: 0.0879 m Tris, 0.089 m boric acid, 0.002 m EDTA pH 8.0) for 1-3 hours (voltage 2 v/cm of gel). The buffer composition for sample application: 0.25% bromphenol blue, 0.25% xylene cyanol, 30% glycerin. The gel staining was performed for 10 minutes subject to the use of ethidium bromide (0.5 mcg/ml) followed by washing with distilled water. Visualization was performed in UV light (ʎ = 380 nm) after staining the gel with ethidium bromide.

The TaqMan@Genotyping real-time PCR system was used to perform allelic discrimination. Two primers were designed to amplify the 101 bp product involving SNP rs43703011 (genomic DNA: X14711 (http://www.ncbi.nih.gov); forward primer, 5´-CCCAGACACAGTCTCTAGTCTATCC-3´; reverse primer, 5´-GGTTTGAGTAAGAGGAGGGATGTTT -3´). Two fluorogenic TaqMan probes were designed with different fluorescent dye reporters to allow single-tube genotyping. The first probe was targeted to the wild type allele A (5´- VIC-CCCATCCATAACAGCC-3´) and the second one to the mutated allele B (5´-FAM- CCATCCCTAACAGCC -FAM-3´) of the CSN2 gene. The powerful NFQ quencher was linked to the 3´ end of both probes. Primers and probes were designed using Primer Express software, version 3.0 (Applied Biosystems, CA, USA) and were obtained from Applied Biosystems. The accuracy of the used sequence source was verified by comparison with sequences from the GenBank database using BLAST (http://www.ncbi.nlm.nih. gov/BLAST/). Real-time PCR was performed in 20 µl reactions with 10 µl of TaqMan universal PCR master mix containing AmpliTaq Gold DNA Polymerase (Applied Biosystems, CA, USA), 200 nM concentration of forward and reverse primer, 100 nM of each probe and 2 µl (50–100 ng) of sample DNA. The PCR reaction was realized using the FAST 7500 Real Time PCR System (Applied Biosystems). The time and temperature profile of the PCR reaction consisted of the following steps: 2 min at 50°C for UNG activation, 10 min at 95°C for starting AmpliTaq Gold activity, 40 cycles of 95°C for 15 s and 60°C for 1 min. As a negative control, we used a sample without template. An allelic discrimination experiment consisted of three steps: a pre-read run, an amplification run and a post-read run. Each sample was visually verified by analyzing the generated PCR curves. Analyses of amplification products were performed using SDS software, version 4.2.

Statistical analysis was performed in the R (www.R-project.org, V.4.0)

RESULTS AND DISCUSSIONS

To improve the economic efficiency of milk production, a promising task is to take measures to form a dairy herd with programmable productivity. In two farms for breeding the Ukrainian Red-and-White dairy breed, the task was to create a herd with a certain genotype by different casein loci. In the first farm of Khrystynivske State-Owned Farm it is planned to create a herd for obtaining milk suitable for the production of hard cheeses. For this purpose, the dairy herd was assessed according to the kappa-casein gene. It was established that the desired BB genotype had an insignificant share of 16% (Table 1).

Table 1. Distribution of allelic and genotypic frequencies of the kappa-casein gene and the results of Hardy-Weinberg equilibrium statistical test

Distribution	Genotypes, %			Allele, pcs.		$\chi 2$
	AA	AB	BB	A	B	
Actual	48	36	16	0.662	0.338	4.379
Theoretical	44	45	11			

Source: The authors' own research.

The majority of animals had a different homozygous AA genotype (almost 50%). Allele B had a low frequency (0.338). It should be noted that the actual genotype frequencies and theoretically calculated ones do not coincide and there is a statistically significant difference between them. We also mention a lack of heterozygous genotypes.

In another farm (Ichnianske LLC), it is planned to obtain dairy raw materials for the production of “gentle” milk (from animals with the A2A2 genotype). According to the results of our genetic research, it was established that the A1A2 genotype had the largest share. The share of homozygous A1A1 and A2A2 genotypes differed twofold in favor of the latter genotype. The frequency of the desired A2 allele is 0.589, which is quite high, given the widespread use of Holstein stud bulls in the breeding stock of the herd (Table 2).

Table 2. Distribution of allelic and genotypic frequencies of the beta-casein gene and the results of the Hardy-Weinberg equilibrium statistical test

Distribution	Genotypes, %			Allele, pcs.		$\chi 2$
	A1A1	A1A2	A2A2	A1	A2	
Actual	18	46	36	0.411	0.589	0.409
Theoretical	17	48	35			

Source: The authors' own research.

There was no difference between the actual frequency of genotypes and the theoretically calculated one.

Research results have indicated the superiority of theoretical heterozygosity over actual heterozygosity (Table 3). More significant difference was found in the kappa-casein gene.

Table 3. Values of the main volatility indicators

Gene	Ho	He	Fis
CSN2	0.464	0.484	0.042
CSN3	0.360	0.447	0.195

Ho – actual heterozygosity, He – expected heterozygosity, Fis – fixation index
Source: The authors' own research.

Using genetic and statistical methods of analysis, by determining the digital values of such genetic constants as the degree of homozygosity (Ca), the level of polymorphism (Na), we tried to assess the prospects and investigate the effectiveness of creating herds with the desired genotype (Table 4).

It was established that the CA indicator for the studied genes varied from 51.6 to 55.3. The Na indicator prevailed over the beta-casein gene.

The heterozygosity test (HT), which indicates the level of genetic diversity of the population, is negative in the studied herds, indicating a lower proportion of actual heterozygotes compared to the proportion of theoretical heterozygotes by the corresponding casein genes. As for the excess coefficient (D), which characterizes the ratio of actual heterozygosity to theoretical heterozygosity, we note a deviation of actual heterozygosity from the expected one with left-sided excess, which also indicates a deficiency of heterozygotes. This is especially true for the kappa-casein gene. In general, it can be stated that the data of genetic and statistical analysis indicate a slight excess in the beta-casein locus of homozygous A1A1 and A2A2 variants, and a lack of heterozygous A1A2 and a significant excess of homozygous AA and BB and a lack of heterozygous AB.

Table 4. Frequency Genetic structure of herds by CSN2 and CSN3

Indicators	Genes			
	CSN2		CSN3	
	actual	theoretical	actual	theoretical
Heterozygotes	109	114	41	51
Homozygotes	126	121	73	63
Coefficient hetero/homozygotes	0.87	0.94	0.56	0.81
Heterozygosity test	-0.073	-	-0.248	-
Degree of homozygosity, Ca, %	51.6	-	55.3	-
Polymorphism level, Na	1.93	-	1.81	-
Excess coefficient D	-0.042	-	-0.196	-
Proportion of homozygotes, %	53.60	-	64.04	-

Source: The authors' own research.

According to the analysis of the Dairy and Dairy-Meat Breed Bull Catalogue showing stud bulls allowed to be reproduced in Ukraine, it was found that among the Holsteins allowed to be used and evaluated by the quality of offspring and genomically, 47% of animals had a score based on the kappa-casein genotype (Fig. 1).

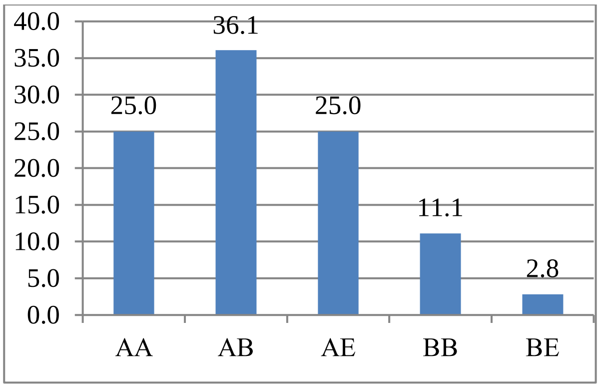

Fig. 1. Evaluation of breeders according to the frequency of the kappa-casein gene, %
Source: The authors' own research.

The frequency of the desired homozygous BB genotype among them was equal to 11%.

Solely 33% of the breeders, evaluated for the beta-casein gene, had the homozygous A2A2 genotype (Fig. 2).

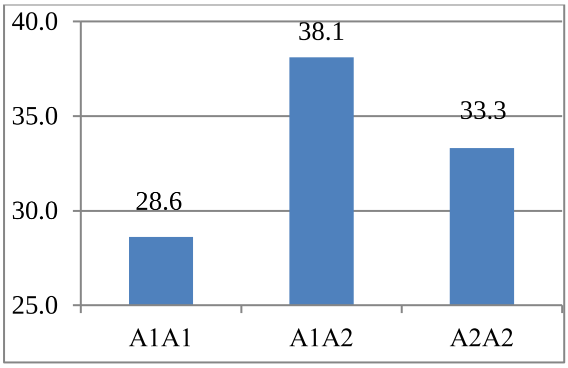

Fig. 2. Evaluation of breeders according to the frequency of the beta-casein gene, %
Source: The authors' own research.

The availability of breeders with the desired genotypes for the studied genes suggests the possibility of creating herds with the recommended genotypes.

According to the scheme of creating a herd (Table 5) only stud bulls that are homozygous by the desired genotypes (A2A2 – by beta-casein and BB – by kappa-casein) should be used [13, 14, 24].

Table 5. Possible combinations when crossing cattle of different genotypes by beta-or kappa-casein

<table>
<tr><td rowspan="5">Parent 2</td><td colspan="3">Parent 1</td><td rowspan="5">Parent 2</td><td colspan="3">Parent 1</td><td rowspan="5">Parent 2</td><td colspan="3">Parent 1</td><td rowspan="5">Parent 2</td><td colspan="3">Parent 1</td><td rowspan="5">Parent 2</td><td colspan="3">Parent 1</td></tr>
<tr><td></td><td>A1 or A</td><td>A2 or B</td><td></td><td>A1 or A</td><td>A2 or B</td><td></td><td>A1or A</td><td>A2 or B</td><td></td><td>A2 or B</td><td>A2 or B</td><td></td><td>A2 or B</td><td>A2 or B</td></tr>
<tr><td>A1 or A</td><td>A1A1 or AA</td><td>A1A2 or AB</td><td>A2 or B</td><td>A1A2 or AB</td><td>A2A2 or BB</td><td>A1 or A</td><td>A1A1 or AA</td><td>A1A2 or AB</td><td>A1 or A</td><td>A1A2 or AB</td><td>A1A2 or AB</td><td>A2 or B</td><td>A2A2 or BB</td><td>A2A2 or BB</td></tr>
<tr><td>A1 or A</td><td>A1A1 or AA</td><td>A1A2 or AB</td><td>A2 or B</td><td>A1A2 or AB</td><td>A2A2 or BB</td><td>A2 or B</td><td>A1A2 or AB</td><td>A2A2 or BB</td><td>A1 or A</td><td>A1A2 or AB</td><td>A1A2 or AB</td><td>A2 or B</td><td>A2A2 or BB</td><td>A2A2 or BB</td></tr>
<tr><td colspan="3">50% A1A1 or AA
50% A1A2 or AB</td><td colspan="3">50% A1A2 or AB
50% A2A2 or BB</td><td colspan="3">25% A1A1 or AA
50% A1A2 or AB
25% A2A2 or BB</td><td colspan="3">100% A1A2 or AB</td><td colspan="3">100% A2A2 or BB</td></tr>
</table>

Source: (Ladyka V., Pavlenko Y., 2021; Ladyka, V. et al., 2019; Sklyarenko, Y. et al., 2018) [13, 14, 24].

Taking into account the initial frequency of genotypes and alleles of the investigated casein fractions in both farms, we recommend to utilize the selection model [18]. According to it, creating a herd of animals with the A2A2 genotype will take less time than herds with the BB genotype (Table 6). At the same time, during a 10-year period, such a herd can be created using genetic testing of heifers. In the case of genetic testing of cows and heifers, such a herd can be created in nine years.

Table 6. Duration of selection work

Varants for carrying out the work	Proportion of genotype after 10 years in animals of the main herd		required time, years	
	CSN2	CSN3	for creating a herd of cows with a genotype	
	A2A2	BB	CSN2 (A2A2)	CSN3 (BB)
Lack of testing of cows and calves	0.78	0.54	>15 years	>15 years
Genetic testing of cows	0.85	0.57	>15 years	>15 years
Genetic testing of calves	1.00	0.93	10 years	14 years
Genetic testing of cows and calves	1.00	0.95	9 years	11 years
Genetic testing of cows and calves and the use of sexed semen (A2A2) or (BB)	1.00	1.00	9 years	10 years

Source: The authors' own research.

One can also significantly speed up the process of creating a herd by using the following measures:
- transplantation of female embryos with the desired homozygous genotype;
- increase in the proportion of culling of cows with genotypes (A1A1 and A1A2 by beta-casein or AA and AB by CAPA-casein) with the introduction of first-born cows with the desired homozygous genotypes (A2A2 or BB) into the herd;
- purchase of cattle with the desired genotype.

CONCLUSIONS

Cows of the Ukrainian Red-and-White dairy breed (36% of homozygote A2A2 and 46% of heterozygote A1A2) can provide an increase in homozygosity by beta-casein (A2A2) in the next generation subject to the use of homozygous (A2A2) stud bulls. The genetic structure of Holstein Red-and-White breed (33.3% of homozygotes A2A2) which may be reproduced in Ukraine enables to form populations homozygous for this trait in subsequent generations. To increase the frequency of the desired A2A2 genotype, it is necessary to cull animals with the A1A1 and A1A2 genotypes, using breeders' semen with the A2A2 genotype. Such work will take about 10 years. Using the genetic testing of cows and calves or genetic testing of cows and calves using sexed semen (A2A2) speeds up this process by a year.

Breeding stock of the same breed (16% of BB homozygotes and 36% of AB heterozygotes) can also provide an increase in kappa-casein (BB) homozygosity in the next generation. As with beta-casein, the condition is the use of homozygous (BB) stud bulls. Their genetic structure (11.1% of BB homozygotes) also enables to form populations homozygous by this trait in subsequent generations. To create herds with the desired genotype for the kappa-casein gene, it is necessary to carry out a similar work.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE SEASONALITY AND ECONOMIC EFFICIENCY OF SHEEP MILK PRODUCTION - A CASE STUDY IN KARAKUL BREED, ROMANIA

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Abstract

The present study aimed to analyze sheep milk production and its economic efficiency in terms of average production, total production, production costs, revenues, and financial outcomes during the 2022-2023 production year. The experiments were conducted on a flock of 35 sheep of the Karakul breed, white variety, raised at the Popauți Research Development and Innovation Station, Botoșani County, Romania. The evaluation of results and calculation of indicators were performed at the University of Agronomic Sciences and Veterinary Medicine Bucharest. These research endeavors are original and pursued two objectives: firstly, the analysis of production performance as aforementioned, and secondly, the improvement of this breed aiming to increase milk production, although the breed is known for its specialization in skin production, the marketing of which has become problematic both in Romania and in traditionally sheep-rearing countries. The method used to determine milk production was the "Bi-monthly coefficient control method, which allows for the determination of milk production both during the suckling period for ewes with lambs and after weaning the lambs". Applying this method to the studied animal population recorded a total production of 1954.12 liters of milk per year, an average monthly milk production of 79.38 liters, an average milk production per sheep of 56.00 liters, and an overall lactation average production of 0.266 liters of milk per sheep per day. Analyzing the productive performances, it can be concluded that this color variety within the Karakul breed can be improved towards increasing milk production without affecting the quality of the skins.

Key words: *milk yield, milk production, seasonality, economic efficiency, Karakul breed, Romania*

INTRODUCTION

The Karakul sheep breed, originating from the Bukhara region, Uzbekistan, was introduced to Romania for the improvement of local breeds, with a focus on fur production. Although initially milk production was not a priority, interest in this breed has gradually increased. Improving milk production, especially in ewes whose lambs are sacrificed for fur, has become important for increasing the profitability of farms and diversifying the sheep economy in Romania.

Given the morpho-productive characteristics of the Karakul breed, research conducted by various authors has demonstrated that the body conformation of this breed can easily transition from a breed specialized in fur production to a mixed-purpose breed, suitable for both fur and meat production, as well as fur and milk production [8][9].

In 2023, Ion Buzu highlighted that the Karakul sheep breed, with its morpho-productive traits related to body mass growth, body length, and constitution, can produce lambs with an average body mass ranging between 4.7 and 5.0 kg, sometimes even exceeding 5 kg. He emphasized that lamb body mass correlates phenotypically with various characteristics such as ewe age at lambing, body length, skin thickness, fiber length, skin surface area, and loop size, while constitution is inversely proportional to ewe prolificacy and fur quality [2].

In a study conducted by Frujina C. et al. [5] in 2009, the process of improving the indigenous Turcana breed through crossbreeding with the French Vendeen and White of Central Massif breeds was investigated. The results of the study highlighted significant improvements in growth performance, weight, and average daily gain of young sheep.

During the same period, Raducuta [12] compared milk production in the local (Turcana) breed from north-western Romania, F1 crossbred females in their second lactation, and the milk production of Awassi sheep. The conclusions indicated that F1 females recorded a higher total production than local breeds but lower than those specialized in milk production, such as Awassi.

In 2014, Mihail Groza [6] investigated the influence of color genes in Karakul sheep on milk production and observed that there were no significant differences between color varieties, except for the brown and gray varieties.

In 2006, Malos I.G. [7] presented the idea that improving milk production can be achieved through selection. He highlighted the variability coefficients calculated for average daily and total milk production, as well as for the average lactation period. It was observed that the Karakul breed, especially the black variety, exhibits wide limits in these aspects.

In light of these findings, the main purpose of the study is to demonstrate the economic efficiency of the Karakul breed, white variety, by optimizing its lactogenic potential without compromising the quality of newborn lambs' fur.

MATERIALS AND METHODS

The study was conducted between 2022 and 2023 at the University of Agronomic Sciences and Veterinary Medicine Bucharest, Faculty of Animal Production Engineering and Management, based on data collected from records completed at the S.C.P.C.O.- Popauţi unit, on the Karakul sheep population of Botoșani, white color variety.

The biological material studied consisted of 35 lactating ewes.

Quantitative milk production was determined using the bi-monthly coefficient control method (Nica T., Dermengi B, and Ștefănescu C. in 1965) [10], which allows for the determination of milk production both during the suckling period for ewes with lambs and after weaning the lambs.

The following indicators were determined: total average production per lactation, lactation duration, and average daily production to estimate lactogenic potential and lactation secretion persistence. The structure of the ewe population was then established based on total milk production per lactation and lactation duration to highlight the proportion of superior variants and determine the chances of success in potential milk production-based selection.

Lactation curves were developed using graphical methods.

The economic study consisted of calculating operating expenses, including:

- feed costs;
- costs of electricity and fuel used;
- labor costs.

The results obtained were synthesized in tables and utilized to create graphs for more suggestive interpretation compared to existing bibliographic data.

RESULTS AND DISCUSSIONS

Lactation curve

From the graphical representation of the lactation curve of the sheep nucleus over the months, it can be observed that the highest average production was recorded in March, with 10.95 liters, during the first part of the month, decreasing to 7.30 liters in the second part of the month.

Starting from April, the average production experienced an increase with a peak in May's first half, reaching 8.38 liters, followed by a slight decrease. Subsequently, there was a gradual decline until reaching a threshold of 1.23 liters (Fig. 1).

Milk yield and total production

The dynamics of milk yield and total production are illustrated in Fig. 2, where it is observed that: lactation lasted for an average duration of 7 months, with the average production per lactating sheep being 79.38 liters, the average production per ewe was 56.00 liters, and the average milk yield per ewe over the entire lactation period was 0.266 liters; the lactation curve begins in March, with a production of 18.26 liters/month, followed by a decline and plateau, maintaining around 15.00 liters until June, then gradually decreasing until September, reaching a threshold of 3.30 liters (Fig. 2).

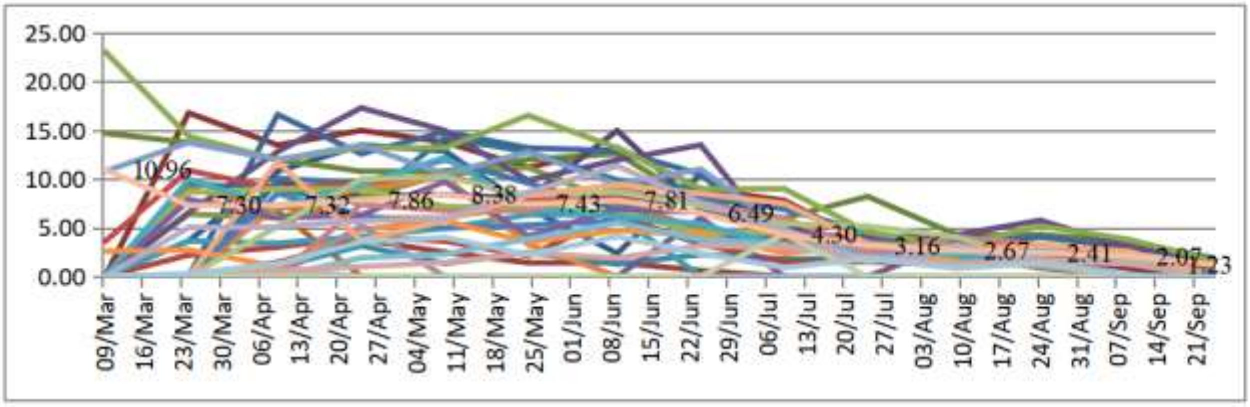

Fig.1. Lactation Curve of the Sheep Nucleus Over Months (liters/sheep)
Source: Own design based on collected farm data.

Total average milk production per month/year (liters)

The average milk production per ewe exhibited considerable variation throughout the year. During the spring and summer months (March-September), production was higher, reaching a peak in May with 15.81 liters, while during the summer months (July-August), production significantly decreased, reaching 3.30 liters in September.

In total, the average milk production per ewe for the entire year was 79.38 liters. It is observed that the highest average productions were recorded in March and April, with 18.26 and 15.18 liters respectively, while the lowest were in September, with 3.30 liters.

Seasonal variability in milk production can be attributed to factors such as the stage of lactation of the ewes, availability of food resources, and environmental conditions. The warmer and drier months of summer can negatively affect milk production, while periods with rich grazing and optimal environmental conditions can stimulate production.

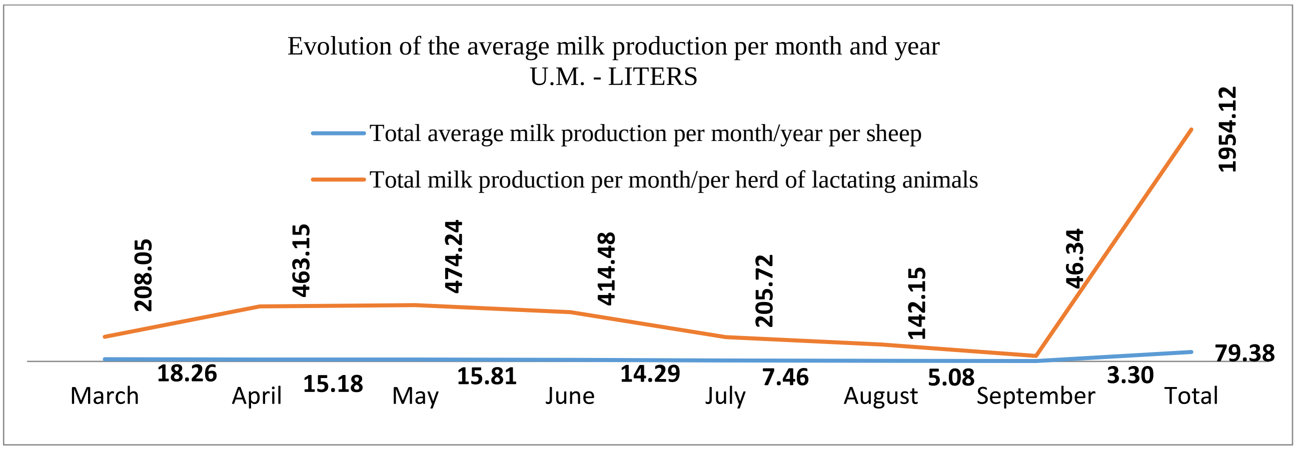

Fig. 2. Dynamics of milk yield and total production by month and lactation year (Liters)
Source: Own design based on the collected data in the farm.

In conclusion, the data indicate significant variation in milk production throughout the year, with clear trends of increase and decrease depending on the season and other environmental and management factors. It is essential for sheep producers to consider these fluctuations in planning and managing nutrition and environmental conditions to optimize sheep production performance.

Total milk production per month/lactation year (liters)

The evolution of milk production showed a significant trend during the monitoring period. Starting from March, milk production recorded an initial value of 208.05 liters, progressively increasing in the following months. This increase reached a notable peak in May, when production reached 474.24 liters, representing the peak of the lactation period. However, after this peak, milk production experienced a gradual decrease starting from July.

Regarding monthly quantitative variation, the data highlight a significant difference between the maximum and minimum milk production recorded during the study period. In May, production reached its zenith with 474.24 liters, while in September, it recorded the minimum value of 46.34 liters. This variation can be explained by the influence of various physiological and environmental factors that interact during the lactation period.

Regarding influences on milk production, it appears that the presence of the lamb and feeding with green forage played an important role in stimulating milk production, especially in the first 5 months of lactation. This finding emphasizes the importance of adequate nutrition and efficient animal management in optimizing sheep production performance throughout the lactation period.

Table 1. Milk yield by month/year and total production by month/year (Liters)

	March	April	May	June	July	August	September	Total
Total average yield by month/year	18.26	15.18	15.81	14.29	7.46	5.08	3.30	79.38
Total milk production by month/lactation year	208.05	463.15	474.24	414.48	205.72	142.15	46.34	1,954.12

Source: own determination based on the data collected from the registers completed within the S.C.P.C.O.- Popauţi unit.

Classification of milk production and milking sheep distribution by class

The milking sheep were classified by production intervals as presented in Table 2.

Table 2. Total Milk Production Classes/Head/Lactation

Nuclee	Classes of total milk production /head/lactation (%)						
	Below 20lt	20.1 – 40lt	40.1 – 60lt	60.1 – 80lt.	80.1 – 100lt.	100.1 – 120 lt	Over 120lt.
White Karakul	22.86	20	11.43	22.86	8.57	8.57	5.71

Source: own determination based on the data collected from the registers completed within the S.C.P.C.O.- Popauţi unit.

In terms of the percentage distribution of ewes, based on total production classes per lactation, it was observed that the highest proportion, 28.86%, is held by ewes from production classes below 20 and 60.1 - 80 liters, while the lowest, 5.71%, are those from classes above 120 liters (Table 2, Fig. 3).

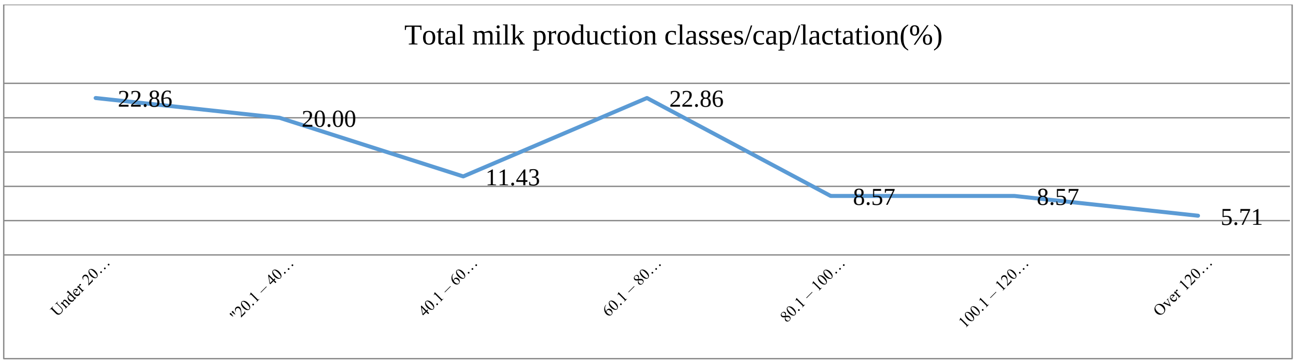

Fig. 3. The distribution of milking sheep by production classes (%)
Source: Own design based on the collected data in the farm.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

So, out of the total population of white Karakul sheep, those achieving a production below 20 liters represent 22.86%, while those producing between 20.1 - 40 liters represent 20.00%. Ewes with a production of 60.1 - 80 liters represent 22.86%, those with a production of 80.1 - 100 liters, and those with a production of 100.1 - 120 liters account for 17.14% each, while ewes with a production exceeding 120 liters of milk have a proportion of 5.71%.

Table 3. Lactation Persistence Classes (%)

	Lactation persistence classes (%)								
	Below 60 days	61 – 80 days	81 – 100 days	101 – 120 days	121 – 140 days	141 – 160 days	161 – 180 days	181 – 200 days	Over 200 days
White Karakul	14.28	2.86	5.71	0	2.86	14.28	22.86	25.72	11.43

Source: own determination based on the data collected from the registers completed within the S.C.P.C.O.- Popauţi unit.

Lactation persistence provides us with information regarding total milk production, allowing us to selectively breed only the superior ewes to obtain a flock with high yields. On the other hand, it ensures a substantial income through efficient milk utilization.

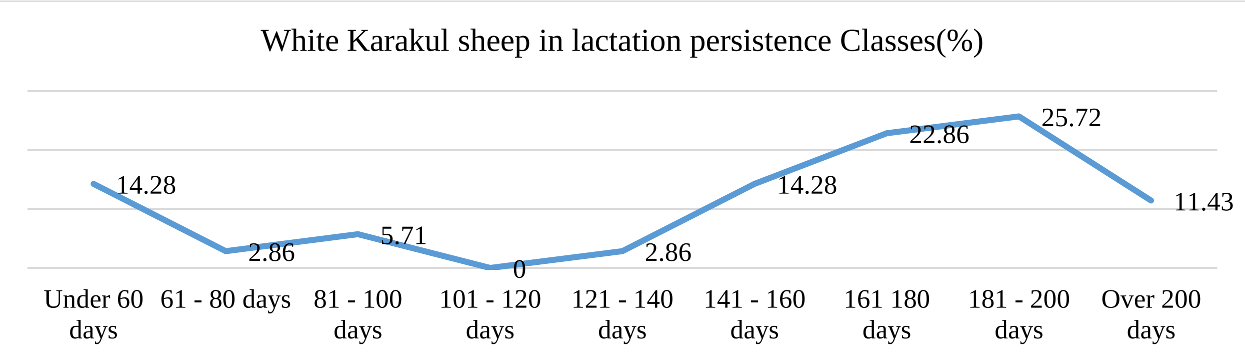

Fig. 4. Distribution of White Karakul Ewes in Lactation Persistence Classes
Source: Own design based on collected farm data.

The distribution of White Karakul ewes in relation to lactation persistence classes highlights that 25.72% of the total population are represented by ewes with a lactation persistence between 181 and 200 days, while only 2.86% fall into lactation persistence classes of 61 – 80 days and 121 – 140 days.

The graph reveals that 77.15% of the total population of White Karakul sheep exhibit a lactation persistence greater than 121 days. In this distribution, the majority of ewes fall into lactation persistence classes between 161 and 200 days, with the highest proportion (25.72%) for 181 – 200 days, followed by 22.86% for 161 – 180 days.

The combined analysis of the percentage distribution of the White Karakul population in production and lactation persistence classes emphasizes the ability to identify and select females with milk yields greater than 60.1 liters within a lactation period of 120-140 days. These findings suggest the possibility of establishing future breeding nuclei based on individuals with superior lactogenic potential.

Figure 5 reveals that the majority of individuals are positioned above average in terms of milk production. This suggests that there is a significant number of animals with yields equal to or greater than the average production, which can be leveraged in their selection for the breeding nucleus.

By identifying and retaining individuals with milk yields above average, it is possible to increase selection efficiency and improve lactation performance. Choosing these specimens for breeding can contribute to enhancing the quality and yield of the livestock intended for milk production.

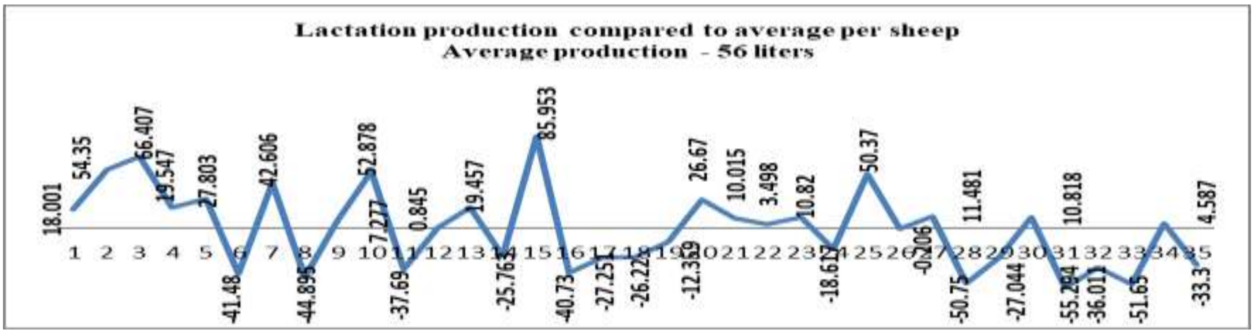

Fig.5. Deviations of Lactation Production from Average/Sheep
Source: Own design based on collected farm data.

In Figure 6, the data highlights that the number of sheep with total productions higher than the average production is significantly larger compared to the number of sheep with productions below average. This suggests that there is a considerable proportion of animals with yields above the average level of the flock.

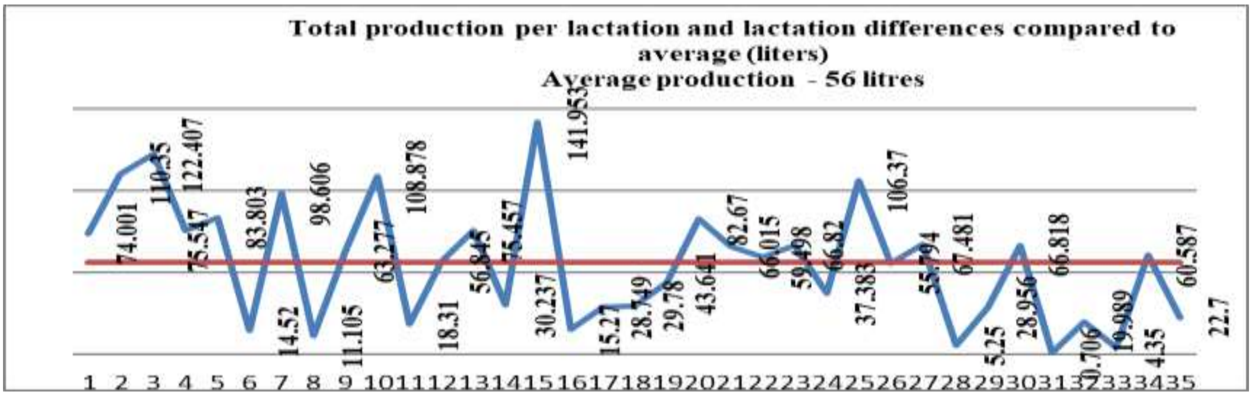

Fig. 6. Evolution of Total Lactation Production and Deviations from Average
Source: Own design based on collected farm data.

The results presented in the graphical representation underline a positive trend regarding the total production of the flock. Identifying these trends and the distribution of total production relative to the mean can guide the selection and management of the sheep flock.

Through the interpretation of graphs and associated data, it is possible to identify and select sheep with total productions higher than the average, thus contributing to improving performance and production efficiency within the farm or livestock unit.

Economic analysis regarding the profitability of production

A. Operating expenses for sheep(a) Expenses for feed are presented in Table 4.

Table 4. Feed Expenses

	Forage	Quantity kg	Price Lei/kg	Cost
1	Alfalafa green mass	17,784.06	0.08	1,422.72
2	Fodder beet - green mass	17,811.25	0.08	1,424.92
3	Cereals	4,680.55	1.0	4,680.55
4	Hay	9,746.45	0.75	7,309.83
5	Suculents–corn silage	1,4854	0.07	1,039.78
6	Straw	5,020.05	0.05	251.00
7	Milk and lamb replacers	624.4	0.5	312.2
	TOTAL			**16,214.8**

Source: "Nutrition and Feeding of Livestock", 2017, accessed on November 10, 2023[11]; Nutrition and Animal Feeding, Practical Workbook, p. 55-56[**4**]; Decision approving the average prices of agricultural products for the year 2022, Accessed on November 10, 2023 [3].

(b) Expenses for electricity and fuels

b1. Energy expenses are presented in Table 5.

Table 5. Energy Consumption and Expenditures

Average livestock			35 heads
Exchange rate Lei/Euro			4.97
Indicators	Daily consumption per farm (kw)	Annual consumption per farm (kw)	Tariff Lei/kw
Energy consumption for watering	0.3	109.5	0.45
Total value (Lei/year)		49.28	
Total value (euro)		9.91	
Revine pe animal (Lei)	Per animal (Lei)	1.40	
Revine pe animal (Euro)	Per animal (Euro)	0.28	
Energy consumption for grinding mill	0.5	182.5	0.45
Total value (Lei/year)		82.13	
Total value (Euro)		16.52	
Per animal (Lei)		2.35	
Per animal (Euro)		0.47	
Energy consumption for lighting	0.1	36.5	0.45
Total value (Lei/year)		16.43	
Total value (Euro)		3.3	
Per animal (Lei)		0.47	
Per animal (Euro)		0.1	
Total energy consumption per sheep farm	0.9	328.5	0.45
Total value (Lei/year)		147.83	
Total value (Euro)		29.74	
Per animal (Lei)		4.22	
Per animal (Euro)		0,85	

Source: Own calculation based on technical norms.

B. Income

Assessment of Productions

With a total of 35 sheepskins, valued at 500 lei per animal[1], the total value of the obtained skins is 17,500.00 lei. This aspect indicates the importance of raising and exploiting skins for generating additional income within the unit.

Table 6. Assessment of Gross Product

Specifications	**Indicators**	**Lei/ sheepskin**	**Total**
Sheepskin	35 heads	500	17,500.00
Total milk production	1,954 liters	3 Lei/liter	5,862.00
Subsidies	35 heads	84.49	2, 957.15
			26,319.15

Source: Own design based on the collected data in the farm; data retrieved from publication on January 8, 2019, 15:17, Accessed on December 8, 2023[1].

With a total of 1,954 liters of milk produced, valued at 3 lei per liter, the income generated from milk sales is 5,862.00 lei. This highlights the significant contribution of milk production to the total unit income and emphasizes the importance of optimizing this activity.

For the 35 sheepskins, the obtained subsidies amount to 84.49 lei per animal, generating a total of 2,957.15 lei. These subsidies represent significant financial support for animal raising activities and can contribute to improving the financial performance of the unit.

The total amount of income obtained by the respective unit amounts to 26,319.15 lei, considering the revenues from sheepskin valorization, milk sales, and received subsidies. This sum represents a significant part of the total revenues and demonstrates the diversity of activities and income sources of the unit.

C. The financial result (FR) is calculated according to the formula:

$$FR = I - C,$$

where:

I = income and C = costs

The financial result is presented in Table 7.

Table 7. Financial Result (Lei)

Total income	Total costs	Gross Profit
26,319.15	20,145.59	6,173.56

Source: Own design based on the collected data in the farm.

The financial result (FR) is calculated as the difference between total income and total expenses. From the data presented in Table 7, it can be observed that the total income amounted to 26,319.15 lei, while the total expenses were 20,145.59 lei. By calculating the difference between income and expenses, we obtain a financial result (FR) of 6,173.56 lei. This positive financial result (FR) indicates that the economic activity or entity has recorded a gross profit, with its value being 6,173.56 lei. The net profit is presented in Table 8. This positive financial result (FR) indicates that the economic activity or entity has recorded a net profit, with its value being 5,185.79 lei.

Table 8. Net Profit (Lei)

Gross profit	Profit tax	Net profit
6,173.56	987.77	5,185.79

Source: Own design based on the collected data in the farm.

CONCLUSIONS

Sheep, through their products: milk and meat, must significantly contribute to meeting the consumption needs, implicitly covering the deficit of animal protein.

This study focused on analyzing milk production in the Karakul breed, specifically the total average production per lactation, lactation duration, and average daily production to estimate lactogenic potential, lactation persistence, and the economic efficiency of raising and exploiting the breed without compromising the quality of the newborn lamb skins.

The study conducted on the sheep flock under investigation highlights a significant variation in the average milk production per ewe throughout the year, with a noticeable increase in spring and summer months, reaching a peak in May at 15.81 liters, and a steep decline in summer months, especially in September, with 3.30 liters. Overall, the annual average production was 79.38 liters. Seasonal variability was influenced by the lactation stage of the ewes and the availability of food resources and environmental conditions. The presence of lambs and feeding with green forage played a significant role in supporting lactogenic production, emphasizing the need for efficient management to optimize the lactogenic performance of the sheep, with the potential to maximize the economic yield of production.

The distribution of Karakul ewes according to production classes and lactation persistence reveals that a significant proportion, 28.86%, of the population presents productions below 20 and between 60.1 - 80 liters, while only 5.71% of total sheep fall into the classes of over 120 liters. This underscores the importance of identifying and selecting specimens with superior lactogenic potential to consolidate the economic performance of the sheep population.

The combined analysis of the percentage distribution of Karakul ewes according to production and lactation persistence highlights the possibility of identifying and selecting females with significant lactate productions, over 60.1 liters, in a period of 120-140 days of lactation. This strategy could contribute to forming future breeding nuclei based on specimens with superior lactogenic potential, thus strengthening the economic efficiency of livestock exploitation.

Most individuals in the sheep population are above average in terms of milk production. This finding indicates the presence of a significant number of animals with productions higher or equal to the average, emphasizing the importance of their utilization in the selection process for the breeding nucleus. Retaining and identifying individuals with above-average lactate productions can lead to more efficient selection and improvement of performances in milk production. Choosing these specimens for reproduction has the potential to improve the quality and yield of the entire herd intended for milk production. The data clearly show that the number of sheep with total productions higher than the average is considerably higher than the number with productions below the average, highlighting the presence of a significant proportion of animals with productions above the average level of the population.

Essentially, increasing the lactogenic potential of Karakul sheep, especially those forming the breeding nucleus at any given time, is important for at least three major reasons:

By slaughtering lambs within the first 24 - 48 hours of birth for obtaining skins, an additional significant quantity of marketable milk can be obtained by milking during that period.

The existence of superior quantitative and qualitative milk secretion in ewes during the nursing period of lambs is essential (mostly in the first two months of the lambs' life) for their good development, contributing to reducing losses through mortality, increasing organic resistance, and subsequently reaching their productive potential, regardless of the direction of exploitation (skins, wool, milk, meat).

The fact that sheep's milk is in high demand by processors for transformation into various assortments and types of cheeses, highly appreciated by consumers. It should be noted here that the most valuable milk for the processing industry is obtained during the summer-autumn period, which is characterized by a much higher content of dry matter, proteins, and fat.

The economic study clearly indicates that increasing milk production alongside quality skins leads to increased profitability of milk production.

The analysis of expenses in the production unit emphasizes the importance of economic efficiency in managing financial resources. Significant expenses, such as those for fodder and energy, require careful management to optimize costs and maximize the return on investments. Efficient labor management is also essential to ensure a balance between wage costs and operational efficiency. Constant control of these expenses is crucial for the long-term sustainability and competitiveness of the enterprise.

In conclusion, the financial result analysis indicates a positive financial situation, as revenues exceeded expenses, generating a net benefit of 6,173.56 lei. It is important to emphasize that achieving a positive financial result is an indicator of the efficiency and financial sustainability of the economic activity or entity.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY ON ESTIMATING THE RISK OF MANIPULATION OF FINANCIAL INFORMATION BY ECONOMIC ENTITIES

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Abstract

In this work, we proposed to analyze, starting from the existing accounting information in the financial statements, the way in which we can estimate the risk of manipulation of the financial information, by which companies. The research involved the study of specialized literature with the aim of identifying the opinions of specialists regarding the existence of this risk and the method of its identification. Starting from different models that use both financial information and non-financial information on the basis of which a score function is calculated, we carried out a case study in which, using the Beneish model, we assessed the risk of manipulation of accounting information in three listed companies on the stock market (which for reasons of confidentiality I marked with A, B and C, using the results published in the financial statements for the years 2022 and 2023. Based on the 8 indices of the Beneish model: the receivables turnover rate index at the figure of business, the gross commercial margin index, the asset liquidity rate index, the turnover growth index, the degree of depreciation of assets, the share of administration and marketing expenses in the turnover, accruals related to the exploitation activity and the financial leverage we calculated M-score, which allowed us to assess the degree of manipulation of the accounting information in the published financial statements. We thus found that by referring to the reference indices and the reference score proposed by Beneish (-1.78), a score updated compared to 1999, the year in which the value of the score function was determined for the first time, we found that for none of the analyzed entities we can states with certainty that they manipulated the reported information. However, in the case of companies B and C there are such indications, which requires additional analysis when the control bodies follow the reporting method.

Key words: *financial statements, risk, manipulation, Beneish model, accounting reporting*

INTRODUCTION

At the global level, there have been numerous financial scandals that brought into discussion the need to identify some solutions through which the risk of manipulation of the reported accounting information can be determined. These risks can be identified through financial auditing, but other solutions are also being sought that can be used equally by shareholders, associates, management, but especially creditors and investors, but also control factors, with the aim of detecting some management elements of earnings or financial fraud [4], given that the tools, methods and procedures for embellishing financial statements or applying financial fraud schemes have become more and more diverse and complicated [11, 17, 20].

The need to identify the risk of fraud or manipulation of the results reported by companies, stems from the threat they represent for the proper functioning of the economy [13, 20, 21], the recent economic crises being a conclusive example. Even if the use of accounting information manipulation tools does not automatically mean bankruptcy, they can contribute to the decrease of credibility or to the increase of costs for the following periods, costs that increase as a result of the decrease of trust of third parties [25].

Detecting the tools for manipulating the reported accounting information is sometimes difficult, this is due to the fact that the current business environment is a volatile one (globalization contributes to the rapid change of market conditions, the way of development and use of technology, etc.), which makes it difficult for managers when it comes to making objective and reliable decisions [18].

Regarding the method of risk determination, we find that traditionally, the indicators used started from the information presented in the balance sheet and the profit and loss account [12, 16, 32], but it was found that the traditional indicators that reflect performance economic indicators must be replaced by other alternative indicators, such as financial indicators of the creation of added economic value or financial ratios [22]. These indicators adjust the accounting result with various other elements that are influenced by the depreciation policy applied by the economic entity, by its financing or investment policy [3]. They are mainly used by credit institutions to determine the performance of the loans granted, with the aim of limiting the decision-making power of the credit entity, which can thus be conditioned by credit rating indicators regarding the financing structure, profitability, etc. [9, 31].

In the specialized literature, there are other models for predicting the behavior of handling financial reporting, these being based on the analysis of some financial ratios used in the calculation of a score function.

Thus, Beneish proposed in 1999 a model consisting of a set of indices for detecting accounting manipulations, indices that through a discriminant analysis allow the determination of a score function, which is then compared with the values included in the classification and evaluation intervals of the risk of fraud or manipulation of accounting information [5, 6, 14].

In turn, Dechow et al. used a similar approach, identifying a score function (F) which is however much more complex. The method is a statistical one and proposes 3 models in which both financial rates and non-financial elements are integrated and which are similar to those that estimate the possibility of bankruptcy of economic entities. Based on the result of the score function, the probability of leveling earnings or using creative accounting tools can be determined. As far as the non-financial elements are concerned, they are as important in handling as the accounting information, especially when they relate to the capital markets.

Model 1, makes strict reference to the financial statements, using different rates and indicators (variation of working capital, change in the turnover indices of receivables, stocks and accounting gains, percentage change in cash receipts) [10, 23]. Model 2 takes into account the abnormal variation in the number of employees, but also the operational leasing contracts. Model 3 uses adjusted stock returns as market-based variables [15, 19].

For his part, Montier developed a model that is based on 6 criteria that can provide information regarding the manipulation of financial statements and reported results.

These criteria measure: the difference between net income and cash flow, increasing sales (DSO and DSI), increasing other current assets to revenues, decreasing the value of depreciation, increasing total assets [7, 24].

Pustylnick created two linear functions, P-score and R-score, starting from Altman's model, in which he changed some variants. Thus the P-score model reflects the value of a company starting from the way it is perceived on the market, and the R-score is a model that modifies the P-score function and is related to the real liquidity of a company [26, 27, 28].

The models proposed by various economists have the advantage that they have been tested, that the proportion in which the results obtained were relevant was significant, which confirms the efficiency of their use for different fields of activity, for companies classified by size criteria and operating in different categories of savings.

At the level of Romania, there are Romanian economists who have adjusted the Beneish score or the Dechow score to the conditions of the national economy. Thus in 2013, Robu et al. tested the Beneish method for companies from different fields of activity, finding that the risk of tax fraud can be estimated through the detection indices of accounting manipulation [29]. Also, Burca and Lile created another model for determining the risk of manipulation starting from the Dechow model, which they adjusted to the conditions of the Romanian market economy [8].

MATERIALS AND METHODS

The Beneish model uses the financial information reported by companies in order to determine some variables that are the basis for calculating an M-score function, depending on which the probability of distortion or manipulation of accounting reports is determined. Thus, the probability of manipulation is correlated with 8 indicators:

1. Days' Sales in Receivables signifies the relationship between the effectiveness of collecting accounts receivable and the overall sales revenue generated, comparing one financial year to another. Beneish theorized that a significant rise in net receivables suggests a boost in sales, potentially due to a shift in trade credit policy. In turn, this increases the likelihood that those revenues have been overstated
2. The Gross Margin Index is calculated as a ratio between the gross margin rate from the previous year of the manipulation report and the gross margin rate recorded from the current financial year, the one in which the report is made. The decrease in the gross commercial margin indicates its negative effect on operational continuity, there is the possibility of distorting the financial reporting, with the aim of obtaining sufficient earnings to remunerate the investors who financed various investments
3. Asset Quality Index is the indicator that assesses the degree of depreciation not only for fixed assets, but also for current assets that can significantly influence financial performance. The metric is calculated by comparing the aggregated proportions of the asset composition over two successive financial years.
4. The Sales Growth Index serves as a measure that signals potential concerns about a company's operations, advising prudence when evaluating its business activities. This index is derived from the ratio between the turnover recorded in two consecutive reporting years.
5. Depreciation Index is an indicator that, if it has a significant variation, may indicate a manipulation of the accounting information, resulting from the value of the economic benefits that the company obtains from their use. This metric is determined by comparing the proportions of depreciation costs for fixed assets across two successive financial years.
6. The SGA Index, which analyzes general administrative and sales expenses, tracks their variation from one period to another. A high rate of their growth compared to the value of sales indicates a transfer of resources in the form of services to third parties, which, however, takes place under disadvantageous conditions. This index is calculated as a ratio between general administrative expenses and turnover
7. Leverage Index is an indicator whose change indicates the risk of manipulation resulting from the high pressure on cash flows. The index is calculated as the ratio between total liabilities and liabilities.
8. Accruals to Assets Index is an indicator that reflects the variation between a company's deferred income and its total assets, indicating a way of manipulating earnings. It is calculated as a ratio between uncollected receivables and the level of total assets.

These variables are the basis for determining a score function whose values can indicate the existence or non-existence of the manipulation of accounting information, especially those related to the company's profit. Values lower than the recommended threshold indicate the absence of accounting manipulation, and a higher value the application of accounting manipulation.

The score function has the following form:

$M = \beta 0 + \beta 1X1 + \beta 2X2 + ... + \beta iXi + ... + \beta nXn$ [2]..(1)

where:
M is the score of the function
Xi – the independent variables
βi – coefficients of the model, where (i = 1,...,n).

From the application of this function, Beneish has stability M-score which can be calculated either starting from 8 variables, resulting in the following equation:

M - Score = -4.84 + 0.92 x *DSRI* + 0.528 x *GMI* + 0.404 x *AQI* + 0.892 x *SGI* + 0.115 x *DEPI* – 0.172 x *SGAI* + 4.679 x *TATA* – 0.327 x *LVGI* ....(2)

The score can be calculated based on only 5 variables, like this:

M - Score = -6.065+ 0.823 DSR + 0.906 GM + 0.593 AQ + 0.717 SG + 0.107 D

in which:
DSRI – receivables turnover ratio index
GMI – gross commercial margin index
AQI – asset liquidity ratio index
SGI – turnover growth index
DEPI – degree of depreciation of assets
SGAI – share of administrative and marketing expenses in turnover
TATA – accruals related to the exploitation activity
LVGI – financial leverage
In relation to the values obtained, it can be established whether or not a company presents a risk of manipulation of accounting information. The reference value is -1.78 in the case of the score calculated in relation to the 8 factors. Initially, the score was fixed at -2.22, and then at -1.98. In 2012, the last reference value was established.

RESULTS AND DISCUSSIONS

Based on the information provided by the foundation for calculating the M-Score, derived from financial statements and managerial accounting, was established. This analysis encompassed three taxpayer companies listed on the stock exchange. It revealed that none raised definitive concerns regarding result manipulation based on their M-Score figures, which fell below the threshold of -1.78 (Figure 1).

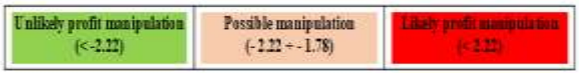

Fig. 1. Beneish M-Score
Source: own processing after [1].

However, two of the companies, company B and C, are in the range of possible manipulation, as a result of the scores of -2.08 (company B) and -2.07 (company C).
In the following, we analyzed the values of the 8 factors, for each of the 3 companies, so that we can identify the risks that contributed to the emergence of suspicions of manipulation of the published accounting information.

Table 1. Beneish score indices (variant with 8 factors)

Factors	Symbol	Society A	Society B	Society C
Sales Index	DSRI	0.804	0.427	1.632
Gross Margin Index	GMI	1.774	1.135	1.049
Asset Quality Index	AQI	0.508	2.617	0.987
Sales Growth Index	SGI	0.845	0.845	0.967
Depreciation Index	DEPI	0.832	1.070	1.504
Sales and General Administration Expenses Index	SGAI	1.108	0.840	0.711
Total Accrual	TATA	0.038	0.033	-0.060
Leverage Index	LVGI	0.978	0.839	0.962
M-Score		**-2.44**	**-2.18**	**-2.07**

Source: own processing.

The value recommended by Beneish for DSRI is 1.031. We state that companies A and B registered values below this limit, while company C has a higher value. A lower degree of collection of receivables may be due to the management policy of the receivables-debt ratio, without necessarily indicating a situation of manipulation of the reported results from a financial point of view.
The recommended value for GMI is 1.014. For the current study, all three companies recorded values above the benchmark, indicating that they have either elevated their sales levels or enhanced the proportion of their commercial markup.

The recommended value for AQI is 1.039. In the case of the analyzed companies, we note that a supra-unit value was registered by company B, the other two companies having sub-unit values, which may be due to the revaluation of fixed assets and the creation of revaluation reserves.

Beneish's recommended value for SGI is 1.134. We find that the values are sub-unit for the companies in the case study, with deviations of 0.167, respectively 0.289, indicating a decrease in turnover, which implies a reduction in the activity carried out. In the conditions of an increase in inflation, this may raise suspicions related to the manipulation of processed accounting information.

The value recommended by Beneish for DEPI is 1.077. The values obtained by two of the economic entities in the case study are below this threshold, which indicates a reduction in the weight of the depreciation of fixed assets, with an impact on the results obtained. The increased value in the case of the third company indicates an increase in depreciation expenses. These increases are influenced by the depreciation method applied, which in turn has an impact on the financial results and the profit tax owed by the entity.

The threshold proposed by Beneish for SGAI is 1.041. In the case of entity A, the value obtained is higher than this threshold, and this may be due to the granting of performance bonuses. The sub-unit values may raise suspicions related to the way of recognition and reporting of these categories of expenses.

From the analysis of the TATA factor, it appears that there are no indications regarding the use of accounting policies susceptible to the manipulation of information in financial reporting. The tax is calculated based on the total commitments of the economic entity and its total assets. An increase in commitments indicates the existence of manipulation. Beneish draws attention to the accumulations that could be used by economic entities in favor of earnings manipulation, having a favorable impact on reported profits [6].

The negative value in the case of company C indicates the inadequate recognition of some revenues, which have the effect of an increase in receivables but not accompanied by an increase in receipts.

Regarding the LVGI, the sub-unit value indicates that the analyzed companies have a low ratio between debts and assets, being able to pay off these debts, but also being able to increase their own capital through capital instruments.

We find that even When employing the model that incorporates five variables, the outcomes suggest similar findings: potential concerns for companies B and C, while indicating an absence of risk for company A.

Table 2. Beneish score indices (variant with 5 factors)

Factors	Symbol	Society A	Society B	Society C
Sales Index	DSRI	0.804	0.427	1.632
Gross Margin Index	GMI	1.774	1.135	1.049
Asset Quality Index	AQI	0.508	2.617	0.987
Sales Growth Index	SGI	0.845	0.845	0.967
Depreciation Index	DEPI	0.832	1.070	1.504
M-Score		**-2.80**	**-2.41**	**-2.33**

Source: own processing.

From the analysis of the factors that participate in the calculation of the M-Score for the entities that were the subject of the case study, it can be found that the low risk of manipulation of the reported accounting information is correlated with the existing increase in turnover which can also support the increase in some administrative expenses, marketing, etc. (Company A, Figure 2).

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

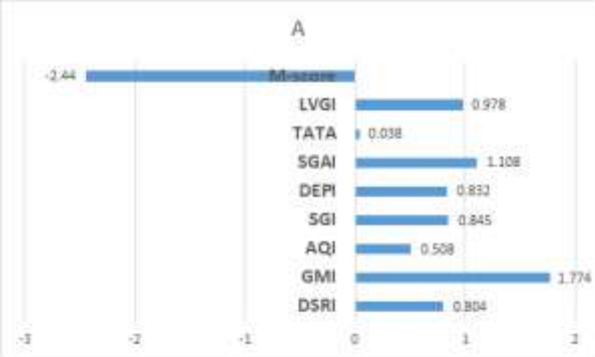

Fig. 2. M-score factors (company A)
Source: own processing.

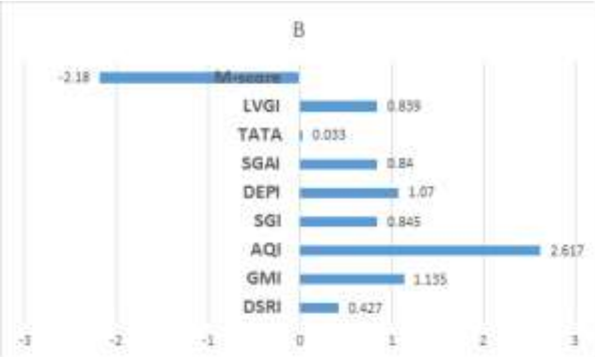

Fig. 3. M-score factors (company B)
Source: own processing.

On the other hand, we find that only an increase in the value of immobilized assets that is not due to the realization of investments, cannot support the development objectives of a company in the long term (Company B, Figure 3).

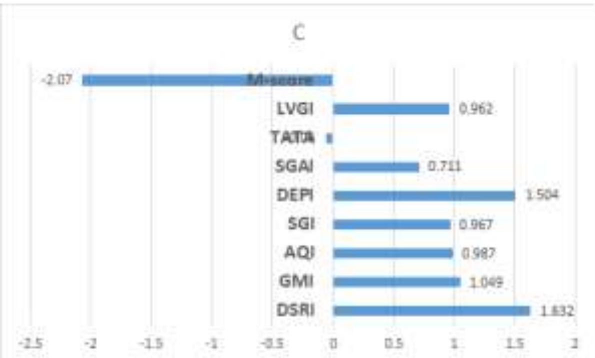

Fig. 4. M-score factors (company C)
Source: own processing.

A DEPI or DSRI supra-unit index cannot support the company's economic growth, especially when the asset growth is due to receivables whose payment term is overdue (Company C. Figure 4).

CONCLUSIONS

The use of information regarding the degree of manipulation of accounting information is useful both for risk management specialists within a company, which could lead to the economy of resources, but also for investors, creditors, control factors.

The mathematical model proposed by Beneish aims to identify the entities that manipulate the accounting information with the aim of distorting the reported earnings. In substantiating the model, the economist started from the premise that the risk of manipulation of accounting information increases when there is either an unusual increase in receivables and sales, or a decrease in gross operating margin.

The current study has shown us the fact that although we cannot state with certainty that none of the analyzed companies applied techniques to manipulate the accounting information reported through the financial statements, there are still indications that raise questions about these practices.

The use of these verification techniques, although it is not usual in the activity of an economic entity, could constitute a way of information not only for the control factors or for the creditworthiness analyzes carried out on the occasion of financing, but also for the managers of the economic entities who could thus be much more informed and more prudent in making decisions.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY ON MEASURING THE PERCEPTION OF ROMANIAN ENTREPRENEURS REGARDING THE ROLE OF ACCOUNTING INFORMATION IN DECISION MAKING

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Abstract

Accounting information plays a critical role in decision making in an organization by providing a solid data base on its financial performance. At the same time, information provided by accounting is vital for managers and entrepreneurs, who base their strategic and operational decisions on them. The use of detailed financial reports allows them to evaluate operational efficiency, manage resources and growth potential, but also monitor compliance with legal and fiscal standards, reducing the risks associated with non-compliance with regulations. In addition, this data helps to anticipate financial problems and implement timely corrective measures, which makes accounting an indispensable tool for entrepreneurs in planning and designing the future of their businesses. The aim of this study is to examine the perceptions of Romanian entrepreneurs about the significance of accounting information in decision-making processes. The research involved analyzing specialized literature on the application of accounting and its accessibility to various user categories, as well as conducting a case study using a questionnaire designed to measure entrepreneurs' perceptions of the importance of utilizing accounting data in business management. Accounting information is crucial in organizational decision-making, offering a robust foundation of data on financial performance. At the same time, the information provided by accounting is vital for managers and entrepreneurs, who set their strategic and operational decisions on it. The use of detailed financial reports allows them to assess operational efficiency, manage resources and growth potential, but also monitor compliance with legal and tax standards, reducing the risks associated with non-compliance with regulations. In addition, this data helps to anticipate financial problems and implement timely corrective measures, which makes accounting an indispensable tool for entrepreneurs in planning and designing the future of their businesses.

Key words: *accounting, decision, perceptions, entrepreneurs*

INTRODUCTION

Running a business requires knowing all the processes that take place within an economic entity, starting with supply, production, marketing, logistics activities, marketing, etc. Making decisions related to business modeling is based on economic aspects, which are influenced by the existence of restrictive factors, both material and financial, which is why accounting information is essential for an entrepreneur. Creating budgets, calculating costs, setting prices, calculating fees and taxes, etc. they are also influenced by the information recorded in the accounting of a company. The transformation of the way of management and the organization of a business, of the way in which entrepreneurs respond to the challenges of the modern world in a continuous transformation, mean that, in turn, accounting must be adapted to the major changes brought by globalization [10], digitalization [14], of the paradigm changes [22], of its continued adaptation to the needs of information and reporting [7, 20].

Many specialists are of the opinion that accounting information is the most important source of existing data at the level of a company, because it is the one that provides information both to external users and to the management of the company [1, 15, 21]. The condition that the accounting information must fulfill in order to be correctly used in decision-making is that it be updated, be real, have a high level of accuracy, allow the realization of predictive analyses, allow the identification of future trends and can provide the most valuable financial information [2, 17]. This improvement was facilitated by the swift advancement of information technology and its integration into decision-making systems, thereby enhancing the efficiency of accounting record systems. This integration has also helped to boost business efficiency and accelerate decision-making processes that significantly affect outcomes, especially in an environment of intensifying competition [3, 6, 9].

Moreover, the emergence of various information processing tools, the integration of artificial intelligence in the management of large volumes of data or in the taking over of repetitive tasks performed in classic accounting by accountants, were reasons that contributed to the modernization of accounting and the development of some directions of its improvement [13, 16]. On the other hand, the impact of accounting is not only one that is limited to its operational efficiency, but also involves making strategic decisions, informed decisions that allow both a better allocation of the resources that a company benefits from, as well as application of a strategic management so useful to entrepreneurs [11].

The manner in which entrepreneurs comprehend and utilize accounting information is another factor that impacts decision-making and the effectiveness of their business operations [5, 19]. Therefore, the manner and extent in which they adapt to legislative changes, the way in which they understand and adapt them to their own needs, represent important elements for the competitiveness of the businesses they run [12]. The versatility of these businesses, competitiveness, adaptation to global changes, to the emergence of new record systems ultimately depends on the correct understanding of this accounting information.

Another aspect or another perspective could be represented by the transition from the use of accounting as a means of justifying the decisions taken by entrepreneurs, in another direction, namely, that of supporting decisions based on information, choosing some solutions optimal ones based on concrete calculations and data, and not intuitive, which could thus have much better results and which could respond much more to the specific needs of each business.

Precisely for this reason, we consider it important to understand and measure the perception that entrepreneurs have regarding the role that accounting has in the running of their businesses, an aspect that is the subject of this work.

MATERIALS AND METHODS

This research focuses on evaluating Romanian entrepreneurs' views on the importance of accounting information for decision-making. The study includes an analysis of specialized texts concerning the application of accounting and its availability to different user groups, along with a case study involving a specifically designed questionnaire. This questionnaire assesses entrepreneurs' opinions on the critical role of accounting data in managing businesses. Accounting information is essential in organizational decision-making, providing a solid base of financial performance data. To achieve this goal, we used a questionnaire composed of 15 questions, made with the help of the Google Forms platform and distributed among professional groups, a questionnaire to which 137 entrepreneurs answered.

The questionnaire was applied between January 15 and April 15, 2024. The questions allowed us to obtain both demographic information regarding the profile of the respondents, as well as information regarding the importance of accounting information for entrepreneurs.

The questions were as follows, and the respondents were asked to provide an answer starting from a scale of 1 to 5:

(6) How crucial do you consider accounting information for managing your business?

(7) To what extent do you rely on accounting information for making strategic and planning decisions?

(8) How much do you believe accounting information assists in identifying your business's strengths and weaknesses?

(9) To what extent do you trust the accuracy and relevance of the accounting information from your accountants or finance department?
(10) How frequently do you review financial reports and analyses to assess your business performance?
(11) To what extent do you believe that using accounting information enhances your business's profitability?
(12) How significantly do you think accounting information aids in making informed decisions regarding your business's future investments and expenditures?
(13) To what extent do you feel that accounting information helps in identifying opportunities for your business's growth and expansion?
(14) How would you assess the effectiveness of the accounting information in your business?
(15) To what extent do you think that accounting information assists you in identifying financial risks and formulating effective management strategies?

The use of the 5-point Likert scale allowed us to measure the attitude of entrepreneurs vis-à-vis the use of accounting in modeling their own decisions [8, 18]. Although it has certain limits, I chose this method of assessment due to its ability to capture fine nuances regarding respondents' perceptions, an aspect that would not have been possible in the case of formulating "yes" or "no" type questions [4]. In this way we managed to obtain a much more detailed picture of the attitudes and opinions of Romanian entrepreneurs regarding the analyzed subject.

The limits of the research were represented by:
• the fact that the information that was collected through the questionnaire was at the level of respondents' perceptions;
• we faced certain difficulties related to how the respondents attributed the effects
• the existence of certain weak points in data analysis, due to the use of descriptive statistical methods, which train, sometimes, supplemented by other methods
• in the study we did not use a control group

The group of respondents

To the questionnaire applied to Romanian entrepreneurs, although a number of 137 respondents answered, only 122 valid answers could be obtained.

To obtain the results and process the data, we used statistical methods. The analysis and interpretation of the results, as well as the formulation of the conclusions, was carried out starting from the centralized data through the tables and graphs resulting from the own processing, with the help of Excel.

RESULTS AND DISCUSSIONS

Out of the total of 15 questions in the questionnaire, the first 5 had a demographic character, the results being presented in Table 1.

Table 1. Socio-demographic characteristics of the respondents

	Frequency	Percentage
Gender		
Female	59	48.36
Man	63	51.63
Age		
20-29	34	27.86
30-44	62	50.81
45-65	22	18.03
over 65	4	3.30
Education level		
Gymnasium	2	1.65
High school	38	31.14
University	59	48.36
Master	23	18.85
Residence environment		
Urban	96	78.68
Rural	26	21.32
Form of organization of the owned entity		
SRL Ltd Company	68	55.73
PFA-Authorized Physical Person	13	10.65
II-Individual Enterprise	15	12.29
Other	26	21.33

Source: Own calculation.

As seen from Table 1, 48% of the respondents are female and 52% male. Out of the total of 122 respondents, 79% live in urban areas and 21% in rural areas. Regarding their distribution by age category, we found that 28% of respondents were between 20-29 years old, 51% were between 30-44 years old, 18% were between 44-65 years old years and 3% older than 65 years. Among the 122 respondents, 48% have university education, 31% have high school education, 19% have master's education and 2% have gymnasium education.

Of the total number of entrepreneurs, 56% own SRL, 11% PFA, 12% II and 22% own entities with other forms of organization (Table 1).

Next, the analysis was carried out based on the answers provided by the respondents to the following 10 questions.

To question no. 6: *On a scale of 1 to 5, how important do you think accounting information is in running your business*? (5 meaning very much, and 1 meaning very little) the answers highlighted the fact that for 71% of the entrepreneurs these are "very important", for 21% they are "important" and for 8% they are of "medium" importance. However, none of the entrepreneurs considered that accounting information would be "little important" or "unimportant", which proves that they are aware of the fact that running a business needs financial information.

From the answers to question no. 7: *On a scale of 1 to 5, to what extent do you use accounting information to make decisions regarding business strategy and planning*? (5 meaning very much, and 1 meaning very little), the result was that 77% of the entrepreneurs answered that this information is "very important" for them when they decide the course or business strategies, 17% appreciated that the information provided by accounting or financial statements are "important", and 6% considered that this information has an "average" importance for them.

Again, none of the respondents considered accounting information as "little important" or "unimportant" when it comes to making decisions related to business management or development (Fig. 1).

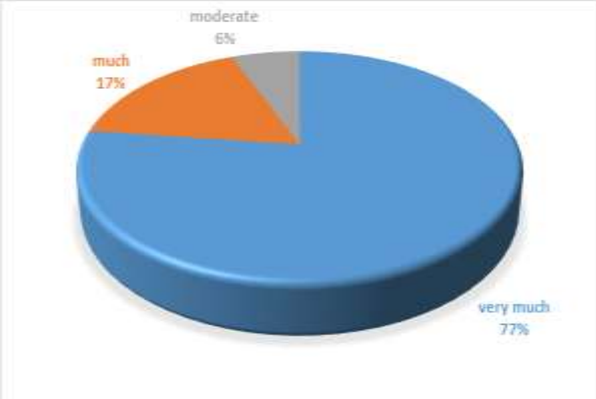

Fig. 1. The weight of the use of accounting information in decision-making
Source: own processing.

To question no. 8: *On a scale of 1 to 5, to what extent do you think accounting information helps you identify the strengths and weaknesses of your business*? (5 meaning very much, and 1 meaning very little), 78% of the respondents considered that accounting helps them "very much", 14% considered that it helps them "a lot", 7% considered that it helps them "moderately", and 1% of the entrepreneurs considered that it helps them "a little" in identifying important aspects or those that hinder their business development (Fig. 2).

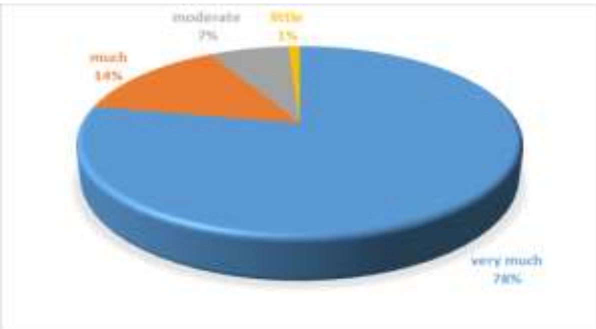

Fig. 2. The importance of using accounting information in identifying the strengths and weaknesses of the business
Source: own processing.

Thus, we find that the entrepreneurs analyze both the financial statements and the other accounting statements, so that they can obtain the most synthetic and relevant information regarding the way of doing business.

To question no. 9: *On a scale of 1 to 5, how confident are you in the accuracy and relevance of the accounting information provided by your accountants or finance*

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

department? (5 meaning very much, and 1 meaning very little), through the answers provided, we found that the entrepreneurs trust the information received and the sources of this information. Thus, 74% of them have "very much" confidence in what is presented to them by accounting specialists and they consult with them when making decisions or when making investments, 19% appreciate that they rely "a lot" on these, and 7% "quite a lot" (Fig. 3).

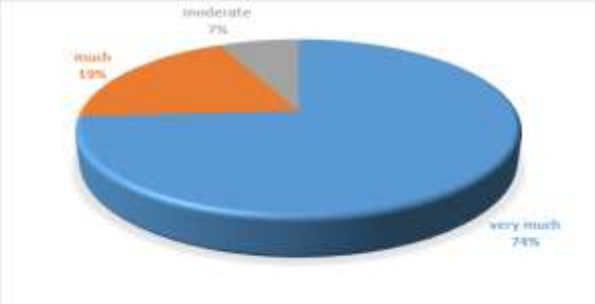

Fig. 3. The share of entrepreneurs' confidence in the accuracy and relevance of accounting information
Source: own processing.

The answers given to question no. 10: *How often do you refer to financial reports and analyzes to assess your business performance?* (5 meaning very much, and 1 meaning very little) demonstrates the fact that entrepreneurs, although they are aware of the importance of accounting information, rely quite a lot on the data resulting from accounting analyses. Thus, from the total of 122 respondents, 36% "always" consult financial reports and analyses, 41% of them consult them "frequently", 18% consult them "occasionally", 3% consult them "rarely" and only 2% " never" (Fig. 4).

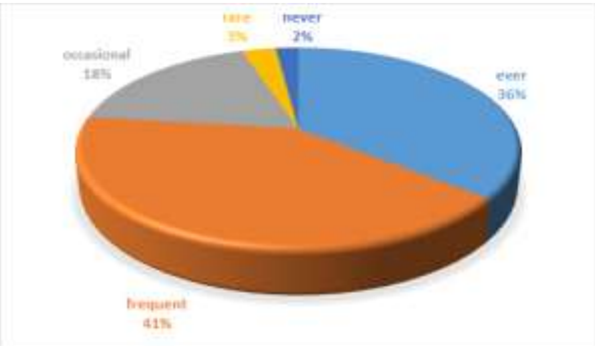

Fig. 4. The share of consultation by entrepreneurs of the information provided by accounting
Source: own processing.

To question no. 11: *On a scale of 1 to 5, to what extent do you consider that the use of accounting information contributes to increasing the profitability of your business?* (5 meaning very much, and 1 meaning very little), 74% of the respondents considered this information to be "very useful", 22% considered it "useful", 3% appreciated it as "moderately" useful, and only 1% of the respondents considered that this information is not "at all" useful to them (Fig. 5).

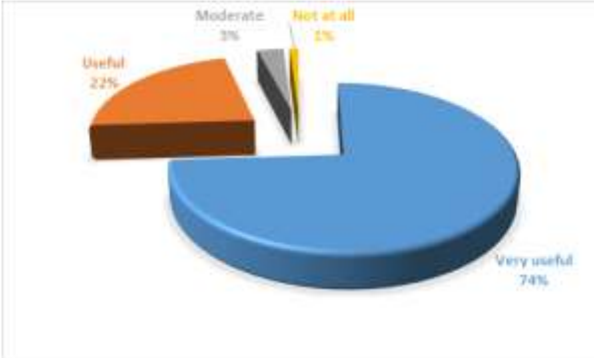

Fig. 5. The share in which the use of accounting information in decision-making contributes to increasing profitability
Source: own processing.

To question no. 12: *On a scale of 1 to 5, to what extent do you think accounting information helps you make more informed decisions about your business's future investments and expenditures?* (5 meaning very much, and 1 meaning very little).
The results are displayed in Fig. 6.

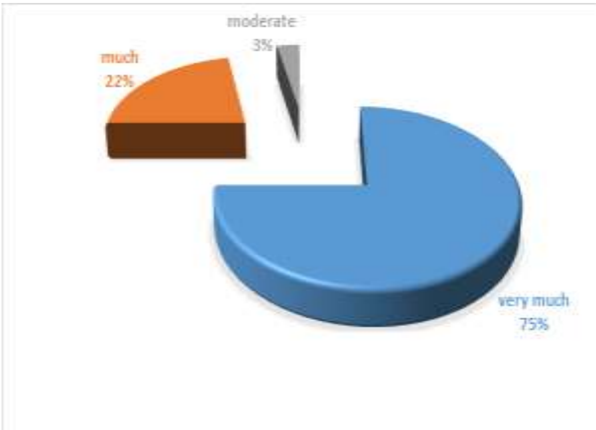

Fig. 6. The share in which the use of accounting information helps entrepreneurs in managing investments and costs
Source: own processing

The answers highlighted the fact that most of the respondents make informed decisions. Thus, 75% of them use accounting information "very much" in making the investment, and 22% use it "a lot". Only 3% of entrepreneurs take decisions being influenced to an "average" extent by the information provided by accounting (Fig. 6).

Question no. 13: *On a scale of 1 to 5, to what extent do you think accounting information helps you identify opportunities for growth and expansion of your business?* (5 meaning very much, and 1 meaning very little), the answers showed that 63% of the entrepreneurs manage to manage their businesses based on this kind of information to a "very large" extent, and 25% of them in a "big" measure. However, there are 12% of the respondents who consider that accounting information helps them to an "average" (8%), "small" (2%) or "not at all" (2%) extent in identifying possible development directions for their own businesses (Fig. 7).

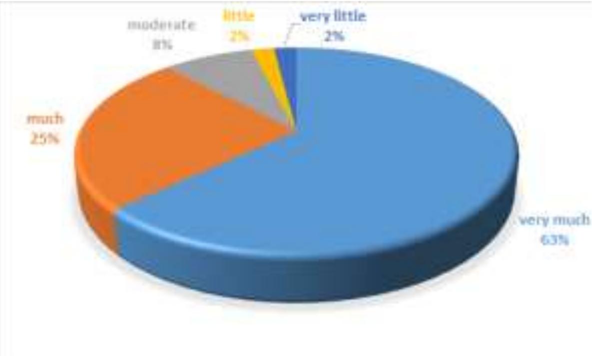

Fig. 7. The share in which the use of accounting information contributes to business development
Source: own processing.

By applying question no. 14 we wanted to find out from the respondents how they appreciate the degree of efficiency of the accounting information provided within their own businesses. We thus found that 45% of them consider them "very effective", 44% consider them "effective" and 11% "moderately" effective. Entrepreneurs are aware of the need to use accounting information in managing their businesses, so none of them consider the efficiency to be "low" or "very low" (Fig. 8).

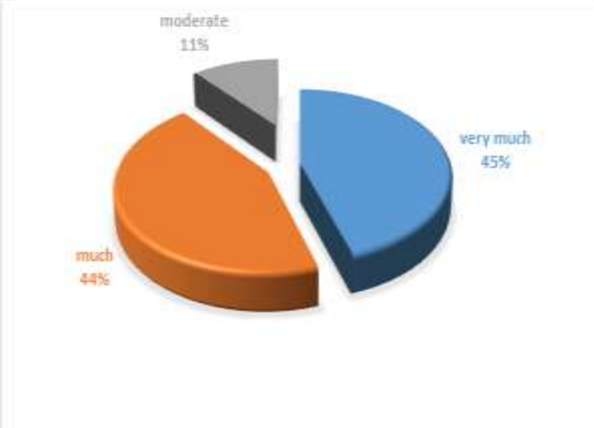

Fig. 8. The weight of the efficiency of the use of accounting information in decision-making
Source: own processing.

To question no. 15: *On a scale of 1 to 5, to what extent do you think that accounting information helps you identify financial risks and implement appropriate strategies to manage them?* 5 meaning very much, and 1 meaning very little), 68% of the respondents considered that this information allows them to a "very large" extent to choose effective strategies and identify risks, while 20% considered that in a "great extent". However, there is a percentage of 6% of respondents who appreciate that the efficiency of using this information is "average" when it comes to risk management, and 3% who appreciate that the information helps them "to a small extent" or "not at all" (Fig. 9).

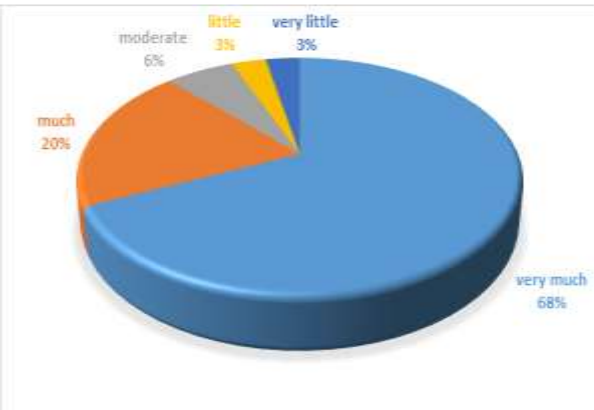

Fig. 9. The share in which the use of accounting information contributes to the identification of business risks
Source: own processing.

We can thus state that accounting information is appreciated by most entrepreneurs and is present in their decisions.

CONCLUSIONS

In conclusion, it is evident that entrepreneurs' understanding of accounting or their mere utilization of accounting information in business management are key factors in achieving entrepreneurial excellence. The implementation of financial management techniques by entrepreneurs not only contributes to the success of businesses but also ensures their long-term sustainability. The knowledge and use of accounting information ensures the background of the business, and the current study has shown us the fact that an overwhelming majority of Romanian entrepreneurs consult, analyze and use the information provided by accounting through various reports, when they make decisions regarding their own their business. Therefore, accounting is not only a legal necessity, but also a strategic tool that contributes directly to the efficiency, growth and sustainability of the business, Additionally, the entrepreneurs surveyed have shown that they comprehend and effectively leverage this tool, which significantly enhances their long-term success prospects. On the other hand, to be truly useful to entrepreneurs, accounting information must be organized in a way that is as clear, accessible and relevant as possible to meet their specific needs. The automation of data collection and processing processes, their advanced analysis, the creation of personalized reports, the taking of fraud identification measures, automated compliance are measures that can significantly contribute to the efficiency of the use of accounting information in decision-making.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

CONSIDERATIONS REGARDING THE STORAGE OF AGRICULTURAL PRODUCTION IN ROMANIA

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Abstract

Storage spaces are economic units where complex activities from reception-storage-delivery are carried out, with the aim of ensuring a constant flow of products downstream, in accordance with the food demand of people and of the animals. The aim of the paper is to analyze the main storage capacities in Romania, starting from general information collected from the Ministry of Agriculture and Rural Development (MARD) and National Institute of Statistics (NIS)database. The research methods used in this study have been the bibliometric analysis, the "bibliographic analysis" and the statistical-mathematical analysis for the calculation of averages by development regions and counties. Romania's agricultural areas are large, the soil and climate being favorable. However, the infrastructure is deficient, the number of operators dealing with the storage of agricultural production is high, but the average storage capacities are rather medium or small.Medium and long-term estimates show that Romania will also be affected by climate change, which leads to the conclusion that in order to keep harvests in optimal conditions and ensure constant production flows, important steps must be taken to develop this segment of activity.The researchers concluded that "storage is the key point of food security around the globe" because it ensures the preservation of products in sufficient quantities and of good quality. Romania's membership in the European Union made it possible to use the specific instruments of the Community Agricultural Policy, majorly influencing the agri-food market, increasing the value of services for agriculture. That is why funds were allocated that allowed our country to produce cereals in quantities that exceed the internal need, becoming one of the most important exporting countries in Europe.

Key words: *warehouse, storage, food safety, preservation, correlation of demand with supply, production process*

INTRODUCTION

Starting from the definition, role and functions of warehouses, in the present paper a brief analysis is made regarding this segment in Romanian agriculture. Economists have defined warehouses as commercial units where certain processes are carried out, starting with receiving, receiving and continuing with storage, conditioning and delivery to other economic agents on the agri-food chain. This activity is intended to ensure the quantity of products necessary to satisfy the demand, so that the flow of products is constant and of quality until the time of delivery.

The existing pedoclimatic conditions in the area of the Black Sea Basin favor the cultivation of cereals. The large quantities produced in this area determine the development of the storage sector in order to sell the surplus [5].

Depending on the weather conditions, culture, economic-social and sanitary conditions, the variation of the demand for a certain product according to the seasonality of the production, it is difficult to estimate with certainty the evolution of the demand for agricultural products. That is why warehouses come to support demand during peak periods, contributing to cost savings, buying a quantity in excess of immediate needs and obtaining quantitative discounts from suppliers. In addition to the traditional function of keeping and providing a buffer stock, the division into lots and the creation of assortment structures according to certain qualitative criteria takes place here: the type of product, humidity, foreign bodies, hectoliter weight, sanitary condition and the types of the warehouse[10].

The storage of each species is done separately, taking measures to avoid mechanical mixing between the products. Within each species, the compartmentalization is done taking into account the destination of the product, the humidity, the content of foreign bodies and the number of necessar operations to remove them, the hectoliter mass important for the industrial processing process (eg: bread wheat 75 gr/hl, pasta 77 gr/hl), the sanitary condition or the type of storage. When distributing the products in warehouses, the influence that each type of warehouse has on the preservation conditions is taken into account [2; 15].

In order to increase the quality of the grains that will be stored, different mechanisms are used. A faster drying, with hot air, leads to a better quality of the grain harvest that will be stored [4].

Al. Buryanov states that using the method of uncovering the plants at the root, before harvesting, leads to an increase in the amount entering the shakers [3].

As it follows from the Special Report no. 11/2008 of the European Court of Auditors "the objective of the public storage of agricultural products is to stabilize the related markets and to ensure a fair standard of living for the agricultural population. When the prices on the market are low, the member states purchase the products offered by the producers or intermediaries at the intervention price established by the Council based on a proposal from the Commission. The products are stored in warehouses until they are sold either on the domestic market or for export." [7]

Storage is a vital technology for any farmer, and choosing the right crop storage method can bring a consistentincome increase.

Until 1987, the subject of storage was practically non-existent in research activity. It was only 20 years ago that the subject slowly began to gain importance, the storage of agricultural products having an essential role in their accessibility throughout the year, in line with the relatively constant consumption demand.

In the period 1987-2023, 574 scientific articles were written, with China in first place with 76 publications, followed by the USA (67 publications), India (55 publications), Italy (48 publications). Romania appears in this ranking with only 10 publications.Vikas Shrotriya's conclusion is that storage is the key point of food security across the globe, with the need to combine management with warehouse design to enhance usability [13].

In their work, Hamel D. and his collaborators show the importance of warehouses for keeping product quantities and ensuring a sufficient amount of good quality food for the population. For many years, the correct and long-term storage of grain was based on the use of various synthetic pesticides. For this reason, measures have been taken to reduce pesticides by 50% by 2030. The "Farm to Fork" strategy aims to reduce pesticide use and risks in agricultural production, as well as improve the application of integrated protection measures, while the use silos and agricultural warehouses for storing agricultural products do not even mention them, these methods being considered irrelevant [9].

Due to the ever-increasing population, food security is the most important issue at the global level, a constant concern for meeting the demand for food for both developed and developing countries around the world. In developing countries, cereals are the staple food and almost 70% of the population depends on agriculture [17]. In India, the most difficult problem is their storage due to insect pests that spoil them during storage. Infestation with insects and pests occurs throughout the year, their appearance being favored by climate conditions. Insect infestation is a major contributor to the deterioration of stored food quality [14].

The accession to the EU and the use of the specific instruments of the CAP have strongly influenced the agri-food market. Accession has allowed the increase in the value of services for agriculture, even if they are still far below the levels of other member states. As a result, important funds were allocated,allowing Romania to produce cereals in quantities which exceed the internal need, becoming one of the most important exporting countries in Europe.In order to benefit from the possibilities offered by the PAC instruments and to improve the management, Romanian farmers made investments regarding the

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

storage and conditioning of cereals. Most Romanian farmers still sell their grain production immediately after the harvest when prices are the lowest. Storage thus appears as a necessity to substantially increase their profits and to distribute the grain supply over a longer period of time [6]. From the analysis of the most relevant articles that had storage as their subject, it emerged that the researchers' interest was focused on storage technologies, in order to prevent the occurence of pests, fungi and microorganisms that affect cereals and their products during storage.

The main purpose of this paper is to present a comparative analysis of the existing storage systems in Romania, currently, as well as the situation of economic operators that exploit storage spaces (number and average storage capacity) carried out by counties and development regions.

The objective of this work is to identify the number and capacity of storage by type, by geographical region and by county in order to assess the concordance between what is needed and what exists.

MATERIALS AND METHODS

Several data analysis and processing methods were used in the paper. The first research method used was the "bibliometric analysis" which was based on the SCOPUS database for searching, filtering and extracting scientific articles relevant to the topic addressed, with the reference period 1971-2023, by studying the identified scientific articles, filtered by title, abstract and keywords. The second research method used is the "bibliographic analysis" which aimed to extract the official data existing in the research scope of the paper. The data was collected by accessing the MARD and NIS databases. The third method used was statistical-mathematical analysis for the calculation of averages by development regions and counties.

RESULTS AND DISCUSSIONS

The increase in demand for agri-food products, the increase in prices, and climate change are just some of the factors that make crops vulnerable.

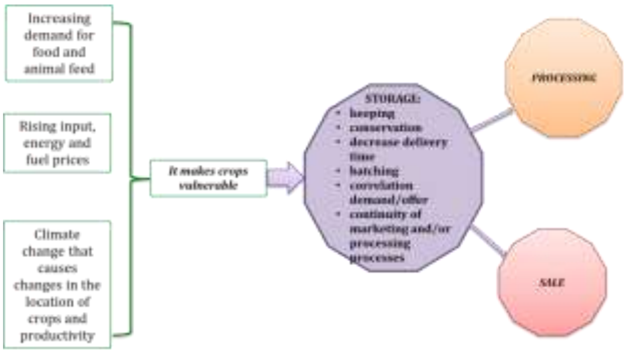

Fig. 1. The role and factors of storage
Source: authors' interpretation based onThe technology of reception [15].

The role of warehousing thus emerges: preservation and/or conservation, reduction of delivery time, allocation of stored/delivered quantities, correlation of demand with supply, continuity in the marketing/processing process (Figure 1).

Warehouses are classified according to several criteria. There are several types which present several construction methods.

Storing the harvest allows flexible times of sale and it can bring a more advantageous price to the seller. That is why we have summarized the main criteria for three storage systems:

-medium and large farmers prefer the metal silo and the metal hall, while the silobag can be used by any category of farmer;

-construction authorization is required for the first two categories of storage systems, while silobags are not;

-the construction time is very different, ranging from 3-5 months, for the metal silo, to 30-60 minutes, for the silo bag;

-the metal silo occupies a small area (12-14 meters in diameter/cell) being developed vertically, while the metal hall and the silobag are placed horizontally and occupy areas between 200-400 square meters;

-the silo-bag has a small storage capacity of 200-400 tons/cell, but it has the advantage of being stored in categories according to the percentage of gluten, humidity or origin; in the other two storage systems, up to 5,000 tons can be stored, but without taking into account the farmer who produced them or the characteristics of the stored grains;

-if in the silo we can only store cereals, oilseeds and fodder, in the metal hall we can also store agricultural machinery; compared to these, waste or road salt can also be stored in the silo bag;
-the loading speed differs depending on the chosen loading method, from 100-150 tons/hour in the case of the metal silo, to 60-100 tons/hour in the case of the silo bag;
-the estimated losses vary between 1-1.5% in the case of the metal silo and the metal hall and are only 0.1% in the case of the silo bag;
-the storage period varies between 1 year in the case of the metal hall and 2-3 years in the case of the silo [8].

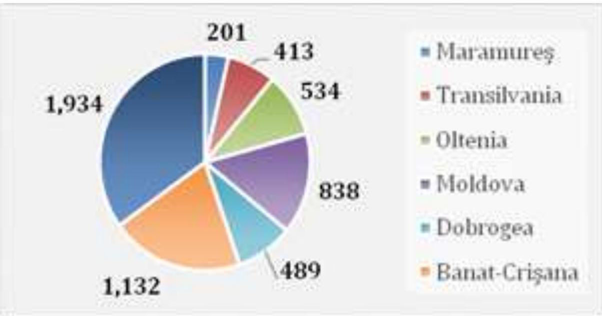

Fig. 2. Number of economic operators operating storage spaces
Source:authors'design based on theList of authorized spaces for the storage of agricultural products MADR [11].

According to the data from MADR, in 2015, Romania had a number of 4,327 authorized storage spaces, while in 2022, their number reached 5,541, resulting in an increase of 1,214 operators exploiting authorized storage spaces(+28.06%) [10].
Currently, most operators 1,934 (35%) are in the Muntenia Region and 1,132 (20%) in the Banat-Crișana Region (Figure 2).The total authorized capacity in silos and warehouses was over 29.5 million tons nationwide [1]. In Muntenia, for example, the silos had a total capacity of 5.23 million tons, and the warehouses 4.72 million tons, totaling 9.95 million tons (33.62%). The lowest capacities are found in Maramureș [11] (Figure 3).

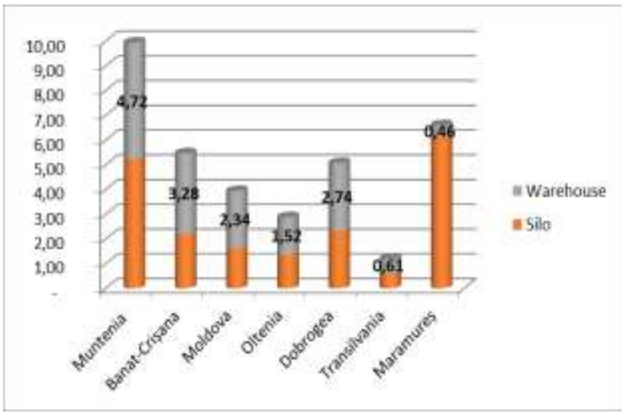

Fig. 3. Total authorized capacity (millions of tons)
Source: authors'design based on theList of authorized spaces for the storage of agricultural products MADR [11].

In the ranking of the number of operators that exploit storage spaces, Timiș County leads with 513 economic agents, followed by Arad County with 396 and Călărași County with 349. In opposition, Sălaj County has only 5 operators and the Municipality of Bucharest only 2 operators (Figure 4).

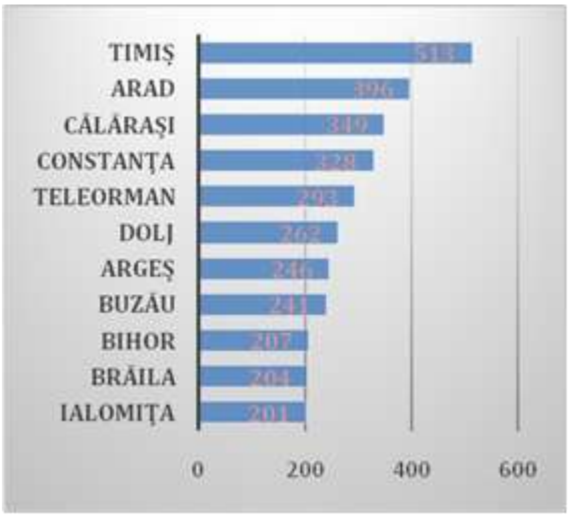

Fig. 4. Top 10 number of operators by county
Source: authors'design based on the List of authorized spaces for the storage of agricultural products MARD [11].

The largest storage capacities are found in Constanța County, with a calculated average of 12,503 tons/warehouse, Caraș-Severin County with 10,396 tons/warehouse and Ialomița County with 8,408 tons/warehouse. The lowest storage capacities are found in the Covasna County - 1,190 tons/warehouse and Bistrita-Năsăud - 788 tons/warehouse.

A study case in Constanta County

We will take as an example the County of Constanța - the first ranked in terms of calculated average storage capacity. The data used in this example comes from INS and MARD [12, 10, 11].

Comparing the number of authorized operators in 2022 with that of 2015, it increased in Constanța County by 68 (+26.15%), reaching 328.

The total storage capacity in silos in Constanța County increased by 475.6 thousand tons (+31 .29%), and in warehouses with 802.6 thousand tons (+61.61%).

Table 1. Number of authorized storaging operators and the storage capacity in silos and warehouses in Contanta County in 2022 versus 2015

	2015	2022	2022/2015 %
Authorized storaging operators (No.)	260	328	126.15
Total Storage capacity (Thousand tons)	2,822.67	4,100.97	145.28
Storage capacity in Silos (Thousand tons)	1,520.04	1,995.64	131.29
Storage capacity in Warehouses (Thousand tons)	1,302.63	2,105.23	161.61

Source: Own calculation based on the data from MARD [11].

The explanation for the sharper growth of authorized warehouses compared to silos, lies in the fact that they require a shorter construction time, they can have other uses than the storage of agricultural production (they can store agricultural machinery, salt for roads, etc.), and the costs of construction and maintenance are much lower.

The authorized storage capacity at the level of ConstanțaCounty increased from 2,822.7 thousand tons in 2015 to 4,100.9 thousand RON in 2022 (+1,278.2 thousand tons, respectively +45.29%).

The agricultural production of Constanța County increased in 2022 compared to 2015 by 588.8 thousand tons (+34.33%). Thus, in grain cereals (wheat, rye) production increased by 345 thousand tons (+31.38%): barley by 165.7 thousand tons (+76.1%), corn by 50 thousand tons (+28.88%) and sunflower with 24.3 thousand tons (+15.99%). Rapeseed production increased the least by 2.9 thousand tons (+3.28%) and soy the most by 823 tons (+165.59%). Relating the productions obtained to the total storage capacities, we obtain 38.4% in 2015, respectively 34.8% in 2022, these indicating the shares in which the warehouses in Constanța County are occupied.

From the list available on the TopFirme websitebased on the balance sheets submitted by them, it stands out that in Constanța County there are a number of large producers specialized in the cultivation of cereals, leguminous and oleaginous plants [16].

Among them is LTA Mondial SRL with a turnover of 399.9 million lei which ranked first place in Constanța County and 5th place nationally. This producer is followed by Carco Grup Agritrade SRL, SMAG GroupSRL,Andra International SRL.

According to the current accounting regulations, the calculation of the storage cost is carried out on the basis of the weighted average of the cost of similar items in stock at the beginning of the period and the cost of similar items produced or purchased during the storage period. This cost can be calculated monthly or after each reception. The storage cost includes reception, conditioning, drying, recirculation, gasification or aeration expenses and is calculated per physical ton. It differs from one plant to another, according to the duration of storage and the type of storage (silo or warehouse). The actual rates are regulated by Government Decisions and are updated periodically.

CONCLUSIONS

Efficient storage of agricultural produce plays a pivotal role in ensuring food safety, optimizing the production process, and maintaining a seamless correlation between demand and supply. The fluctuations in demand, often influenced by various economic and environmental factors, necessitate adaptive and resilient storage solutions.

Preservation methods implemented within these storage facilities not only extend the shelf

life of products but also contribute significantly to mitigating post-harvest losses. As the global population continues to rise, the importance of sustainable and secure products storage becomes even more evident. The success of future agricultural endeavours hinges upon the ability to strike a delicate balance between production, storage, and distribution.
The presented data showed that in 2022, of the total authorized storage capacity at the level of the entire country (29.8 million tons), the share of the main stored agricultural products is only 80% (23.9 million tons).
At the level of the analyzed county (Constanta), the storage capacity is much higher than the production capacity of the county. The degree of occupancy of storage spaces is 34.8%, the difference being able to be used for products in transit (due to the presence of Constanta port on the territory of the analyzed county).

ACKNOWLEDGEMENTS

This research is part of the Research Institute for Agricultural Economy and Rural Development internal research program.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE EFFICIENCY OF RAISING HYBRID PIGLETS OF ENGLISH ORIGIN IN A TWO-PHASE METHOD WITH DIFFERENT DURATIONS

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Abstract

In the article, the efficiency of two-phase rearing of piglets was compared with a change in the feeding system from dry to liquid feeding for different periods of the phases of this production cycle. It was discovered that animals reared in a one-phase system with dry feed had the lowest daily feed intake on average. In contrast, those in a two-phase system, with the second phase involving liquid feed for 9 days, showed a 14.8% increase in average daily consumption. This figure rose to 20.3% with an 18-day duration of the liquid feeding phase and further to 32.4% with a 27-day duration, compared to animals in the single-phase system. It was found that when the piglets were fed liquid feed for 18%, 35% and 53% of the total rearing period in the second rearing phase, their live weight increased by 3.4%, 7.9% and 12.2%, respectively, at the transition to fattening with analogues with single-phase top-up and 100% dry power supply system. The highest income was achieved in animals reared in two phases with a phase duration of 27 days on liquid feed, which was 6.2 % higher than in animals reared in one phase on dry feed, and 16.0 % higher in two-phase rearing with a second phase duration of 9 days and 7.3% higher than in two-phase rearing with a second phase duration of 18 days.

Key words: *piglet, rearing, gain, feed conversion, feed cost, market price, income, profitability*

INTRODUCTION

Pig farming is the most productive branch of animal husbandry in many countries. An important factor in this is the implementation of rational and balanced feeding practices. This includes not only formulating rations correctly and establishing an effective feed base but also utilizing modern and highly efficient systems and technologies [7]. Studying the aspects of pig feeding allows you to significantly increase its productivity, in particular, to accelerate the growth of young animals in rearing, due to scientifically balanced rations in terms of energy intensity and the amount of nutrients and biologically active substances, taking into account the physiological needs of animals [25].

In today's economic conditions in Ukraine, both modern industrial complexes and small farms use different approaches to feeding weaned piglets [10]. However, no matter what technology is used in pork production, piglet feeding is one of the most responsible technological processes, the results of which affect the final economic indicators of large and small pig farms. Proper feeding and care of growing piglets for optimal performance from birth to slaughter is a major goal of pork producers [23]. The efficiency of pig feeding depends on many factors, including the type of feed [12] and the way it is prepared [13], its composition [19] and the management of the growth phase, which takes into account the physiological development of young animals and their readiness to consume and process concentrates [18, 22]. Piglet rearing is a very important period in pork production, as it is during this time that immunity is intensively developed, which is crucial for the further health and productivity of the animals [16]. The ability to maximise productivity results during rearing has a direct impact on the results of pig fattening: herd maintenance, average daily gain, feed conversion and the quality of pig carcasses at slaughter. Therefore, the rational organisation of post-weaning feeding requires great attention and a balanced approach [15, 17].

Weaning is indeed a crucial phase in piglet rearing. It marks the transition from a milk-based diet to solid feed and is a critical period for piglets' growth and development. Proper weaning practices are essential to ensure the health and well-being of piglets and to set them up for successful growth and productivity [1, 30]. In the growth phase up to a weight of 30 kg, producers endeavour to meet the animal's nutritional and energy requirements, paying particular attention to minimising costs. The biggest problems in feeding piglets during rearing occur during the transition from pre-starter to starter feed [8]. The transition to starter feed should take place when the piglet's weight is at least 12 kg. The economy of the pre-starter leads to significant economic losses due to the further extension of the fattening period of pigs [9].

It has been experimentally proven that within 3-4 days after weaning, piglets consume a smaller amount of feed, which is only necessary to maintain vital activity, and that nutrients are distributed during this period not for growth, but to compensate for stress conditions. In the first two days, the piglets use up the reserves of subcutaneous fat that they have built up during the lactation period. And in the third case, they gradually adapt to the new conditions and usually eat to their heart's content. In many cases this leads to diarrhoea. For this reason, post-weaning feeding management is crucial [4, 34].

The generally accepted order of feeding piglets in rearing is to use the feed they received in the last days before weaning until they reach a weight of 9 kg in the next 14 days [24]. In the subsequent stage, for piglets weighing between 9 and 15 kg, the blend should include no more than 15% soybean meal and 3–4% fishmeal or another protein source that is easily digestible, with the exclusion of rapeseed and sunflower seeds. As the piglets progress to the second phase of growth, reaching a weight range of 15 to 30 kg, their diet should consist of a maximum of 22% soybean meal and ideally 1% fishmeal or potato protein. During this period, other protein sources such as sunflower, rapeseed, and peas can be introduced [21, 28, 31].

Also important is the type of feeding and its change when the piglets move from the weaning group to the rearing group and when the piglets move within the rearing group [20, 29]. In particular, there are reports that you can save up to 10–12 of feed by switching the feeding of pigs from dry compound feed to liquid feed. Feed conversion with such feeding reaches 1:2.8, and growth during the fattening period is 800–900 g/day [3].

Three phases of pig breeding are described in the production cycle of the pig industry [6]. Similarly, foreign authors and genetic pig breeding companies [32] also distinguish three main phases of the technology commonly used in industrial pig farms. In phase I, piglets are reared from birth to weaning. Phase II comprises the phase in which the piglets are reared from weaning to transfer to the fattening area. And the III phase lasts from transfer to fattening until the moment of sending fattened pigs to slaughter [33].

At the same time, there are different types of piglet housing in the growth phase, which provide for different lengths of stay for the pigs in the same room. The duration of the stay of animals in the conditions of a group pens in a particular room of the farm depends on the production characteristics of the pig complex, the specifics of the equipment for transportation, feed distribution and feeding, on the size of the group pens and the possibility of changing their size, as well as on the area of the room itself. Australian pork producers report that piglets remain in one room for 9–10 weeks in the first rearing phase. They are then moved to more spacious group pens in another room, where they remain for the next 15–16 weeks [26].

In general, there are two types of rearing technologies: in the first, rearing takes place on one farm; in the second, it is divided into two separate rearing phases on different farms. The first approach involves placing weaned piglets in group pens weekly post-weaning, without mixing different age groups. This method guarantees uniformity in the animals' origins and cuts production costs by eliminating the need for extra piglet transportation. However, it often leads to more pigs per unit area and limited space availability. In the second option for rearing young animals, the piglets are initially reared on a farm until they reach a weight that limits their further effective care and feeding in the pens, without changing their size or configuration. The pigs are then transported to another farm, where group pens allow larger animals to be housed and provide them with sufficient space, and automatic feeders can provide a sufficient feed front per animal [32, 33]. The management of piglet housing in the rearing group thus depends on various factors that determine the length of time young animals remain in one production area and affect the need to move them to another, which can also influence the intensity of animal growth [11, 27]. Fixed housing is usually associated with less free space per animal and the housing of pigs in smaller groups in small group pens, which can reduce their growth rates compared to piglets moved to larger pens in a different space [35, 36]. In contrast, other studies point out that the number of piglets in the rearing group has no influence on the intensity of their growth, but that the survival rate decreases with a decrease in the area of the group pen [5].

The study of the dependence of the indicators of piglet growth intensity on the duration of stay in one or different rearing rooms will make it possible to find a better way to increase it, including the economic results of different approaches during this period.

The aim of this work is therefore to study the duration of rearing of piglets with constant and variable stay in the same room of the farm.

MATERIALS AND METHODS

In order to achieve the set objective, 4 groups of 3,000 animals each were formed at farm No. 1 of LLC "NVP "Globinsky Pig Complex", Poltava Region, Ukraine, using the peer group method. At the time of weaning, all piglets had the same age and weight. They came from crossbred sows of the Great White and Landrace breeds, which were inseminated with boar semen of the synthetic line PIC-337. During weaning, all the piglets studied were fed a dry mix for newborns Superior Neonatal (0–9) and continued to be fed this feed after weaning until they reached a weight of 9 kg. The piglets were subsequently transitioned to the pre-starter feed, 9–12 brand, from the same manufacturer. This feed was provided until the piglets in this group reached a weight of 12 kg. Following this, they were switched to the starter feed, 12–25 formula, from the Cargill brand. This feed was given until the pigs were ready for the fattening stage.

After weaning the piglets of all groups, they were transferred to the rearing station of breeder No. 1, where they were housed in pens for 50 piglets each, with a fully barred floor and an average area of 0.33 m^2 per animal, equipped with incubators to automatically maintain the local microclimate in the piglets' recovery area. All animals were fed dry, fully rationed compound feed from self-fertiliser in the first rearing phase, with a feeding front of 2.5 cm per piglet. Automatic drinkers in the amount of 8 units were set up for feeding the piglets, and waste was managed using a periodic vacuum gravity system. These housing conditions remained consistent for the control group of piglets throughout the rearing period. In contrast, the piglets in the second, third, and fourth experimental groups were moved to pig complex no. 4 on the 42nd, 33rd, and 24th day, respectively, after the first rearing phase ended. They were kept under conditions identical to those of the control group but were fed liquid feed mixtures in the second rearing phase. These mixtures had a ratio of 2.8 parts water to 1 part feed and were provided at a feeding front of 0.08 m per pig, using the same feed as the control group.

During the trial, all aspects of feeding conditions, animal husbandry and other zoological and veterinary procedures were carried out in accordance with EU and Ukrainian regulations for pig husbandry.

Data on the health status, excretions, reason and weight of the excreted animals were recorded throughout the experiment.

For regular monitoring of growth intensity in all experimental groups, two control pens with 50 animals each were selected according to the principle of analogue groups. After aligning the control pen's weight to the group average, all animals were individually weighed and marked. Additionally, these piglets were individually weighed when they were placed at the feeding trough. The average daily feed intake and feed conversion, piglet survival rate, and the weight of the animals at the transition to another rearing phase in the experimental groups were calculated based on group weighing. The biometric indicators for the control pens were determined using individual weighing data. Experimental results were calculated, using personal computers and application programs in the MS Excel.

RESULTS AND DISCUSSIONS

The results presented in Table 1 show that the growth intensity of the piglets and, consequently, their weight in the different rearing phases depends on the phased nature of the process and the duration of these phases. Thus, the average live weight of the piglets at the beginning of rearing was approximately the same in all groups. However, at the end of the first growth phase, the weight of the animals was different due to the different duration of these phases and the different intensity of growth during this time. While the difference in the live weight of the piglets at the end of the first rearing phase between the analogues of the I and the II experimental group was already 3.50 kg, it was 6.60 kg in the III experimental group and already 11.80 kg in the IV. At the end of piglet rearing, the live weight of the pigs in the I group was 23.35 kg, while the piglets in the II group, which were fed liquid feed for 18% of the entire rearing period in the II rearing period, had a live weight 0.80 kg or 3.4% higher than the I group at the transition to fattening. The animals in the III group, in which the second rearing phase with liquid feed accounted for 35% of the total rearing period, had a live weight that was 1.85 kg or 7.9% higher than the pigs in the I group at the finish of this phase ($p \leq 0.001$).

At the same time, the live weight of the piglets in the IV experimental group, which was reared in the second rearing phase, which accounted for 53% of the total rearing period, was 2.85 kg or 2.85% ($p \leq 0.001$) higher than that of the control analogues.

Table 1. Productivity of piglets in the first phase of rearing

Indicators	Group I	Group II	Group III	Group IV
The initial piglet count at the start of the experiment, pigs	3,171	2,974	3,089	3,150
The average weight of a single piglet at the beginning of the trial, in kilograms	5.57±0.113	5.57±0.129	5.60±0.093	5.52±0.073
The average weight of piglets at the start of the second phase of rearing, in kilograms	23.35	19.85	16.75	11.55
The average live weight of a single piglet at the end of the rearing period, in kilograms	23.35±0.267	24.15±0.311	25.20±0.294***	26.20±0.354***

*** – P <0.001.
Source: own calculations.

When the piglets were fed a liquid ration for 18%, 35% and 53% of the total rearing period in the second rearing phase, their live weight increased by 3.4%, 7.9% and 12.2% respectively at the transition to fattening compared to the analogous systems with single-phase supplementation and 100% dry feed supply.

The average daily feed consumption in the first rearing phase depended significantly on the duration of this phase for a group of piglets and, accordingly, on the increase in the live weight of the piglets during this phase. As depicted in Figure 1, it is evident that pigs in Group II, where the initial phase was 9 days shorter than in Group I, consumed approximately 0.03 kg less feed. Conversely, pigs in Group III, with a first growth phase 18 days shorter, consumed an average of 0.18 kg less feed per day compared to Group I. Meanwhile, piglets in Group IV, with a first growth phase 27 days shorter, consumed 0.19 kg less feed than those in Group I. Taking into account that the piglets had a greater mass in the second rearing phase than in the first phase, they consumed relatively more feed. And the shorter the second growth phase, the older the pigs were at this time. As can be clearly from the diagram, the pigs in the II and III groups consumed almost the same amount of feed (1.03–1.06 kg) during the second growth phase, while the apigs in the IV group gained an average of 0.04–0.07 kg less per day. Despite the same duration of the entire growth phase, feed consumption was higher in the animals that spent most of the growth phase on the liquid feeding system. Thus, the animals of the I group consumed the least amount of feed, 0.52 kg, while their counterparts from the second group had an average daily consumption of 0.08 kg, the third by 0.11 kg, and the fourth by 0.17 kg compared to the control counterparts.

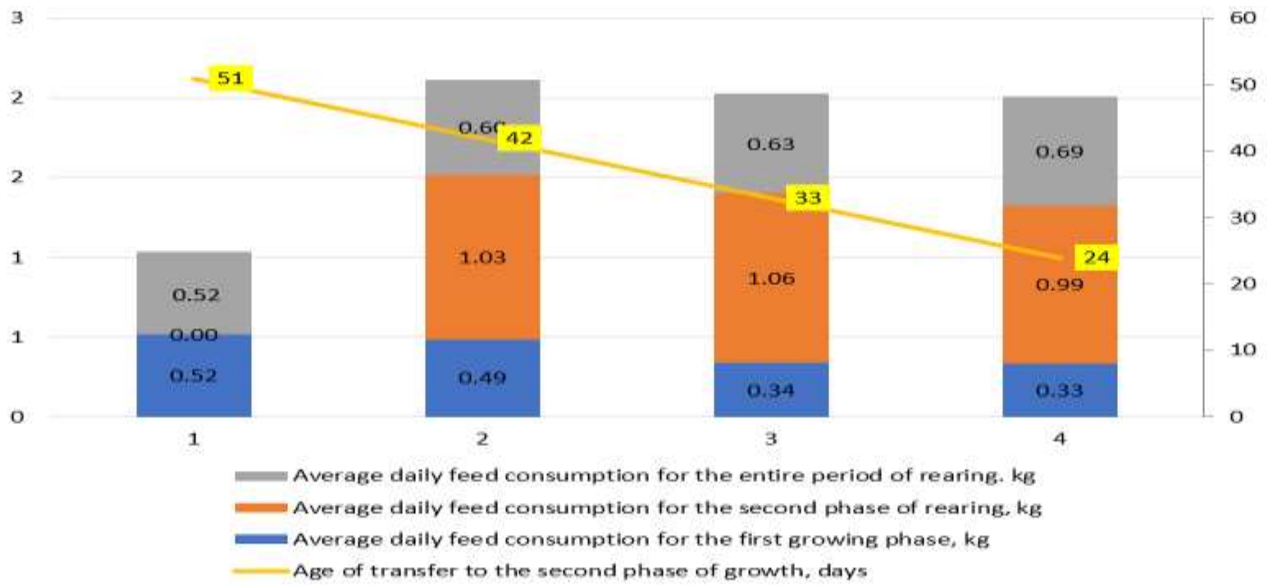

Fig. 1. Average daily feed consumption during different phases of rearing
Source: own calculations.

The absolute increase in the first growth phase also depended more strongly on the duration of these phases (Fig. 2). For instance, pigs in Group I, with a first rearing phase lasting 51 days, achieved an absolute gain of 17.78 kg. In contrast, pigs in Group II, where the rearing phase was 9.00 days shorter, had an absolute gain 6.54 kg less than their Group I counterparts. Similarly, piglets in Group III, with a first rearing phase lasting 33 days, had an absolute gain 11.73 kg less than those in Group I.

Absolute growth also depended on the duration of the second phase. Pigs of group III, in which the growth phase lasted 9 days longer than in group II, had an absolute gain of 4.16 kg more than animals of group II. In contrast, pigs in group IV, where the second phase lasted 18 days longer than in group II, showed an absolute gain of 10.36 kg.

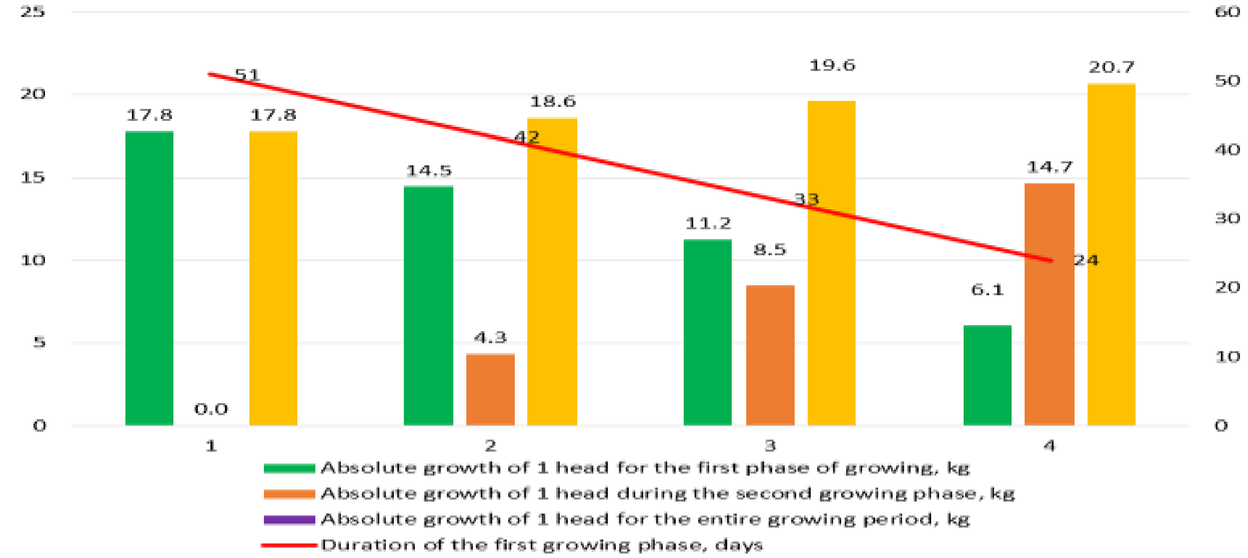

Fig. 2. Absolute growth during different phases of growth
Source: own calculations.

With the same duration of the entire growth period, the absolute gain during this time is defined by the different growth intensity caused by the unequal duration of the feeding methods during the first and second phase. The absolute growth of the pigs in the I group, which were reared on dry feed for the entire period, was 0.80 kg, 1.82 kg and 2.90 kg lower than that of the animals in groups 2, 3 and 4, which were partly reared on liquid feed.
Given the same duration of the entire growth period, the difference in the consumption of an animal is due to the different average daily consumption in each of the groups (Fig. 3). For example, the pigs in the I group, in which the daily consumption was 0.52 kg, ate 26.55 kg of feed during the entire rearing period. Pigs in Group II, with a daily feed consumption of 0.60 kg, consumed a total of 30.47 kg of feed. In Group III, where feed consumption was 0.63 kg, 31.95 kg was allocated for the growth of one pig. For Group IV, with the highest feed consumption (0.69 kg), 35.16 kg was used for the growth of one pig.

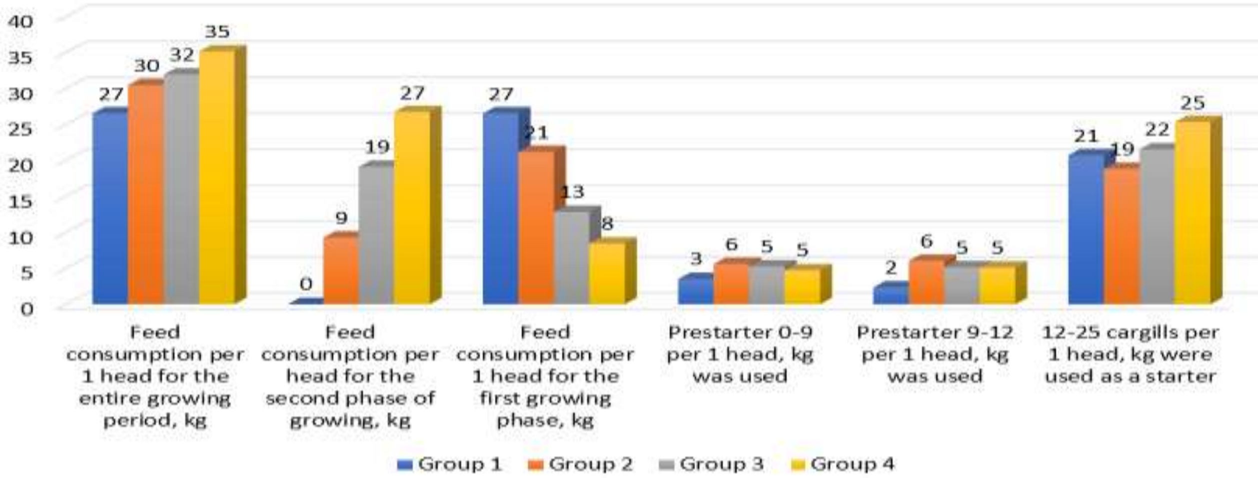

Fig. 3. Feed consumption of different recipes during different phases of growing
Source: own calculations.

The amount of feed consumed and its cost, which depended on the use of different compound feed formulations, also caused different feed costs for rearing an animal and a growth unit during this period, which in turn affected the cost of the entire rearing process and the cost of a pig after its completion. As shown in Table 2, the phasing of watering affected the feed consumption of the animals and their cost per animal. The piglets in the I group were characterised by the lowest feed costs when they were fed dry feed and did not move during rearing. An amount of 2.61 EUR less was spent on the training of one pig from this group than the analogues of the second group, 3.07 EUR less than the third group, and 3.52 EUR less than the fourth group, which were transferred to another division and changing the way of feeding. In the two-phase method of rearing with a change in the feeding system, the costs per kilogramme of growth were also higher. The costs were 0.11 EUR higher for Group II pigs, 0.1 EUR higher for Group III pigs, and 0.08 EUR higher for Group IV pigs compared to Group I pigs, which were fed in a single phase with a consistent feeding method.

Considering that the proportion of feed in the total operating costs for growth was nearly identical across all groups, this influenced the variation in rearing costs per animal. Therefore, the operating costs for rearing Group I pigs were 14.12 EUR. This cost was 3.17 EUR higher for Group II pigs, 3.66 EUR higher for Group III piglets, and the difference was 3.66 EUR for Group IV pigs. Also considering that the cost price of one piglet at the time of placement for rearing was equal, the same difference remained between the cost of one pig after finishing rearing.

Table 2. Feed consumption of different recipes during different phases of growing

Indicators	Group I	Grou p II	Grou p III	Grou p IV
Feed costs per head during rearing, EUR	10.88	13.49	13.95	14.40
Operating costs for 1 piglet, EUR	13.43	16.66	17.22	17.78
Cost of the 1st piglet upon completion of rearing, EUR	23.18	26.41	26.97	27.53
Market value without VAT of the 1st piglet upon completion of rearing, EUR	43.78	45.28	47.25	49.13
Profit from raising the 1st piglet, EUR	20.61	18.88	20.28	21.60
Profitability of growing the 1st piglet, EUR	2.22	1.79	1.88	1.96
Feed cost of 1 kg of gain, EUR	0.61	0.73	0.71	0.70

Source: own calculations.

The varying final live weights of the piglets, despite the consistent price per kilogram of live weight during this period, led to a considerable disparity in the market value of an animal at the end of the experiment. In this scenario, the cost was also the lowest among the animals in the control group, who were outperformed in this regard by 1.5 EUR compared to the second group, 3.46 EUR compared to the third group, and 5.34 EUR compared to the fourth group. The variation in the market value of a piglet at the end of the rearing period, coupled with different cost levels, resulted in varying income amounts from rearing a piglet by the end of this period. Thus, the highest income from rearing a piglet was obtained from animals in the IV group, which totalled 21.14 EUR. Meanwhile, the cost difference was 1.23 EUR for the first group, 2.91 EUR for the second group, and 1.43 EUR for the third group compared to the fourth group. These discrepancies in costs and market values at the end of rearing led to differing levels of profitability in this stage of the production process. Hence, the pigs in Group I, raised under dry feeding conditions and a single-phase system, showed the highest profitability at 83.39%, which was 15.97% higher than that of Group II, 11.82% higher than Group III, and 7.80% higher than Group IV.

Therefore, in a 2-phase rearing system with a transition from dry to liquid feeding, piglets exhibited 4.5–16.3% higher absolute gains, leading to a 3.4–12.2% increase in live weight at the end of the rearing period and a consequent 2.4–12.2% higher market value for the piglets. However, this approach also resulted in 14.8–32.4% higher feed costs due to increased average daily feed consumption, a 9.4–14.1% less efficient feed conversion ratio, and a 24.1–32.4% higher cost of feed consumed during the rearing period. This translated to 22.5–29.1% higher operating costs for rearing an animal, 13.8–18.7% higher costs per kilogram of growth, and 13.3–17.2% higher costs per piglet at the end of the period. Consequently, the profitability of rearing one animal per period decreased by 7.80–15.97% compared to animals fed a single-phase diet with dry feed. With regard to the amount of income from the rearing of a pig during the 72 days of life, no clear regularity was found between animals with single-phase growth and two-phase growth with different durations of the phases. The highest income was obtained in biphasic rearing animals with a phase duration of 27 days on liquid feed, which was 6.2% higher than in monophasic rearing animals on dry feed, and by 16 in biphasic rearing with a second phase duration of 9 days and by 7.3% compared to biphasic rearing with a second phase duration of 18 days.

Our data on the higher growth intensity of piglets in biphasic rearing, where the animals were moved back and forth between two farms, compared to piglets kept in the same room without movement, are consistent with the results [35] related to the growth of animals transferred to larger pens in different farms. However, the expression of the growth intensity indicator we found contradicted the results describing a lack of dependence of the growth rate of piglet live weight on the size of the group pens and the density of animals in it, indicating the inappropriateness of additional production space and moving piglets between farms of different sizes [5].

In addition, our results differed from reports [2] which indicated that pigs kept unchanged on a farm in pens with an initially large area performed better in terms of weight gain than pigs transferred from pens with a smaller area to another farm in group pens with a larger area. that matched the age and weight of the experimental animals but did not provide additional space.

Housing pigs for rearing with two-phase fattening also led to an increase in the amount of feed consumed and a deterioration in feed conversion efficiency, as noted in the paper [35]. However, our findings contradicted the results reported in [14], which suggested that moving piglets to larger pens and maintaining a consistent number of piglets per feeder did not impact feed consumption. However, the feed conversion ratio deteriorated at higher stocking densities, a characteristic of single-phase piglet rearing.

Additionally, piglets that remained on the same farm from weaning to transfer to fattening exhibited a decreased survival rate attributed to limited space and higher piglet density per pen, aligning with the findings of the study mentioned [5].

CONCLUSIONS

It was found that animals reared under a single-phase system with dry feeding exhibited the lowest average daily feed consumption, while those under a two-phase system with liquid feeding showed a reduction in this indicator by 14.8–32.4% compared to those under single-phase rearing.

When piglets were fed a liquid diet in the second phase of rearing, their weight at the transition to fattening increased by 3.4–12.2% compared to counterparts reared with a single-phase and 100% dry feeding system.

The study demonstrated that piglets under two-phase rearing experienced higher absolute gains, leading to increased live weights at the end of rearing and consequently a higher market value.

Higher feed costs during the growth period, poorer conversion rates, increased cost of consumed feed per period, higher operational costs per pig, higher cost per kilogram of growth, higher cost per piglet, and lower profitability compared to animals reared under a single-phase system with dry feeding were observed.

It has been proven that no clear regularity has been established in terms of the level of income from growing one pig during 72 days of life between animals with one-phase rearing and two-phase rearing with different durations of phases.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

NON-AGRICULTURAL GAPS IN THE PROFILE OF THE REGIONS OF THE REPUBLIC OF MOLDOVA

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Abstract

The study addresses the issue of developing non-agricultural activities in the Republic of Moldova, a region defined by the polarizing power of an area, through the convergence of current and historical socio-economic relations, which made urban areas the right choice for developing the methodology for establishing the role of non-agricultural activities in regional development. The paper aims to highlight the polarizing potential of some rural regions, which adds to the influence potential of predominantly urban regions. The non-agricultural rural economy offers the theoretical model. For the analysis, the complexity of non-agricultural activities was used, through which we identified three levels of development of these activities in the communes under study. The case study highlights how the urban area polarizes the labor force from the nearby rural area.

***Key words**: non-agriculture, rural development, gaps, Republic of Moldova*

INTRODUCTION

The Central Region of the Republic of Moldova significantly contributes to the national economy, representing approximately 20-22% of the country's GDP.
With a population of about 1.2 million, the region is characterized by diversified agriculture, including grape, fruit, and vegetable crops. The wine sector is vital, with the area being known for the production of quality wines. The local industry includes food production, textiles, and building materials. The unemployment rate in the Central Region is relatively low, at around 3%. Infrastructure is better developed compared to other regions, facilitating access to services and markets. Foreign direct investments and projects funded by the European Union and other international organizations support regional development, promoting infrastructure modernization and increasing productivity in agriculture and industry.
Rural disparities in the Republic of Moldova are deepened by several key issues affecting the quality of life and economic development of rural communities [3].
Many rural communities in Moldova face severe shortages in basic infrastructure, including paved roads, water and sewerage networks, and access to electricity and internet. Access to quality medical and educational services is limited in rural areas, with a small number of hospitals and schools, and those that exist are often underfunded and under-equipped [10].
The poverty rate is significantly higher in rural areas compared to urban areas. Employment opportunities are limited, with few industries and jobs available outside the agricultural sector [8].
Agriculture remains the main source of livelihood for many rural inhabitants, but productivity is low due to outdated technologies and inadequate infrastructure.

Table 1. Indicators Characterizing the Level of Development and Economic Potential of the Central Region of Moldova in the year 2022

Indicators	Central Region	Regional Average
I. Overall level of economic development		
GDP per person (2022) (euro)	2,561	4,301.8
II. Infrastructure		
1. Density of public roads/100 km (%), (2023)	34.0	18.8
2. Share of national roads in total public roads (%), (2023)	64	65.4
3. Localities with sewerage system (%)	12.2	27.34
4. Localities with hot water network (%)	-	-
III. Labour resources and employment		
1. Average number of employees, of which:		
- in agriculture (thousands)	8.8	6.76
- in industry (thousands)	26.3	25.8
2. Share of employed population/total population	18%	26.2%
IV. Unemployment		
1. Unemployment rate (%)	2.5	13.6
2. Female unemployment rate (%)	1.6	11.66

Source: National Bureau of Statistics of the Rep. of Moldova [9].

The macroeconmic development in terms of its specific indicators was also analyzed in the Republic of Moldova by [7].

Young people leave villages in search of job opportunities in cities or abroad, leaving behind an aging and vulnerable population. Access to credit and other financial services is limited, hindering the growth of small and medium enterprises in rural areas. Women in rural areas face multiple barriers to education and employment opportunities, contributing to the perpetuation of poverty. Waste, pollution, and unsustainable agricultural practices can worsen environmental problems in rural areas, affecting the health and well-being of communities. Modern technologies, such as high-speed internet and other technological innovations, are rarely available in rural areas, limiting access to information and opportunities. Many rural development projects rely on external funding and infrastructure, which may not be sustainable in the long term. These issues reflect the serious challenges faced by rural communities in Moldova and require effective government strategies and policies to promote sustainable development and inclusion in all regions of the country. The development of the rural area in the Republic of Moldova requires a multidimensional approach, including investments in infrastructure, education, and health, effective agricultural support policies, and programs to combat migration and support the return of those who have left. Additionally, good governance and the fight against corruption are essential to ensure that available resources are efficient and benefit rural communities.

In this context, the purpose of the paper is to identify and highlight the economic and social gaps between non-agricultural regions compared to the average of the regions, highlighting the differences between agricultural and industrial activities, together with establishing a model for monitoring and evaluating economic progress, so that policies and implement measures to be more effective and sustainable.

MATERIALS AND METHODS

Evaluating the development gaps between the Central Region and other regions of the Republic of Moldova can be approached through various methodologies and analytical tools, such as:

- Using a diverse set of socio-economic indicators to measure regional performance in areas such as GDP per capita, unemployment rate, access to education and health, infrastructure, etc.
- Comparing the performance of different regions based on relevant socio-economic indicators to identify regions with low levels of development and potential for interventions.
- Using the Human Development Index (HDI), which combines income, education, and health indicators, to assess the quality of life and human development in regions.
- Using Geographic Information Systems (GIS) to map and analyze the distribution and accessibility of infrastructure, resources, and services in different regions.
- Using economic modeling to assess the impact of various economic and development

policies on regions and to forecast potential economic growth.

- SWOT analysis (Strengths, Weaknesses, Opportunities, Threats): Identifying strengths, weaknesses, opportunities, and threats for each region to develop appropriate regional development strategies and policies [1].
- Conducting comparative studies between similar regions in the Republic of Moldova and other countries or regions with comparable socio-economic situations to extract lessons and best practices.
- Involving the local community in the evaluation process and identifying development needs and priorities to ensure the relevance and sustainability of proposed policies and projects.
- Using economic models and forecasting technologies to estimate future trends and the potential impact of various interventions and regional development policies [6].
- Implementing a continuous monitoring and evaluation system of the progress made in addressing development gaps to adjust and improve policies and projects as the situation evolves.

These methodological approaches can be applied in an integrated manner to achieve a comprehensive evaluation of development gaps between the regions of the Republic of Moldova and to guide regional development efforts in the right direction.

RESULTS AND DISCUSSIONS

In this context, we aimed to analyze the stage of development of non-agricultural activities in the Central Region compared to the regional average and each region within it compared to a reference level - the regional average [3].

The adopted method allows the quantification of the state of an economic process based on its actual manifestation parameters, expressed through a multitude of specific technical-economic indicators, supplemented by qualitative data and information.

For the use of the multi-criteria diagnostic method in the analysis of regional agricultural development, the available indicators were ordered into 8 groups or typologies or directions of analysis as shown in Table 2 [13].

The disparities were closer between the North and South regions regarding trade activities (Figure 1).

This is due to the high heterogeneity of the regions in this country in terms of natural conditions, which will produce a series of economic effects on the population's living standards and the development of secondary economic sectors – the food industry, agritourism, etc.

Table 2. Importance coefficients/specific weights by criteria for calculating the global estimator of regional non-agricultural development in the Republic of Moldova

Indicators	**Specific weight**
Average number of employees	0.1
Turnover	0.2
Gross value added of activities	0.18
Household structure	0.17
Area per individual farm	0.06
Availability of Human Resources in agriculture	0.15
Food industry activities	0.08
Animal density	0.16
Total	1.0

Source: own calculations.

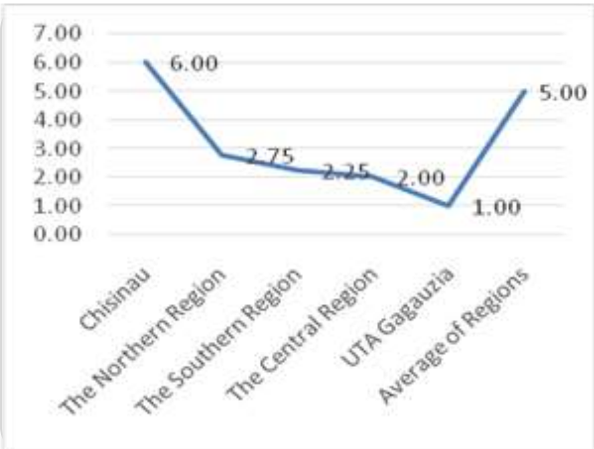

Fig. 1. Disparities in the number of employees in non-agricultural activities between the regions of the Republic of Moldova
Source: own processing based on [9].

The North region has some industrial centers, but most are small and medium-sized, and the infrastructure is often less developed compared to the central region, with roads and public facilities needing modernization [11].

The community in Chișinău municipality can become more attractive by increasing the probability of real earnings from non-agricultural activities.

Very large disparities between Chișinău Municipality and the Central Region refer to all selected categories of economic activities (Figure 1). For salaried employees, the disparity is 6 to 2 in favor of the former.

The turnover from non-agricultural activities in Moldova (Figure 2) is an important indicator of the diversity and resilience of the country's economy. The non-agricultural sector significantly contributes to the national GDP, providing jobs and stimulating economic development through innovation and investments. Supportive policies, foreign investments, and integration into the global economy are key factors that will continue to positively influence this sector [5]. Very large disparities between Chișinău Municipality and the Central Region refer to all selected categories of economic activities. For turnover, the disparity is 6 to 1.6 in favor of the former.

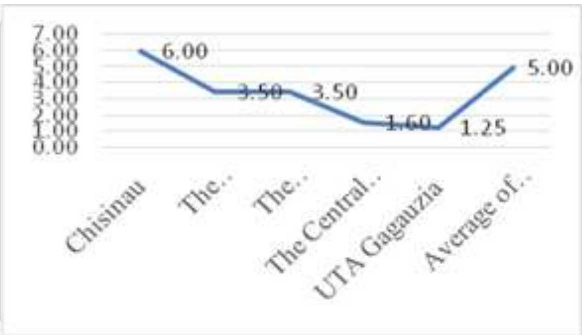

Fig. 2. Disparities in turnover of major non-agricultural activities by region
Source: statistical data consultations [9].

Moldova benefits from a strategic position, facilitating the transit of goods between Eastern and Western Europe. The transport and logistics sector significantly contributes to GVA due to import-export and transit activities. Although affected by the COVID-19 pandemic, the tourism and hospitality sector has the potential to generate considerable GVA as it recovers.

Microenterprises and small and medium-sized enterprises (SMEs) play a crucial role in Moldova's economy, generating significant GVA and contributing to job creation. Compared to the regional average, Chișinău Municipality ranks highest in accommodation and food services, trade, and transport activities, while other regions are below the regional average for each category. The average aggregated score (AAS) for GVA in Moldova is 5.0, with the disparity between the specific regional AAS and the minimum AAS from the North Region being 5.0 to 1.0 in favor of Chișinău Municipality [2]. These results indicate that for the GVA indicator group, regional disparities are significant compared to the regional average (Figure 3). Rural households are often larger, with an average of 4-5 members, frequently including extended family members. Agriculture is the predominant economic activity.

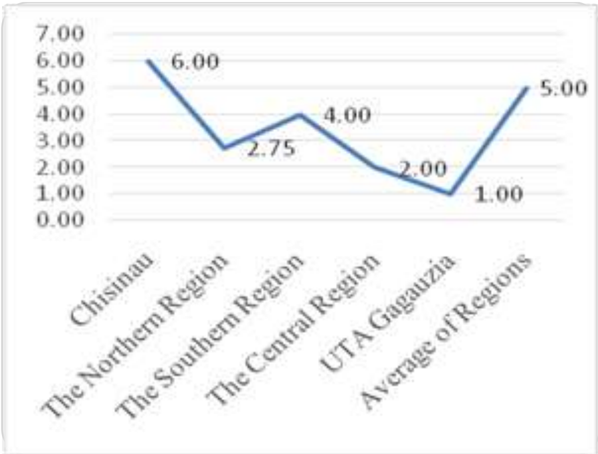

Fig. 3. Disparities in GVA of major non-agricultural activities by region in Moldova
Source: own processing based on [9].

Many rural households are involved in land cultivation, animal husbandry, and food production for both self-consumption and sale [12]. Incomes in rural households are generally lower, often supplemented by remittances sent by family members working abroad.

Compared to the regional average, there is some balance in household size. The UTA Gagauzia region lacks data, which is why the regional average is lower in each category. The average aggregated score (AAS) for household size in Moldova is 2.35, with the disparity between the specific regional AAS and the minimum AAS from the Central Region being 2.35 to 4.25 in favor of the Region; the disparity between the specific regional AAS and the maximum AAS from the Chișinău Region is 2.35 to 4.5 in favor of the Region.

Considering these results, it can be stated that for the group of indicators related to household size, the disparities between regions are not large compared to the regional average (Figure 4), with a lack of potential being noted for UTA Gagauzia.

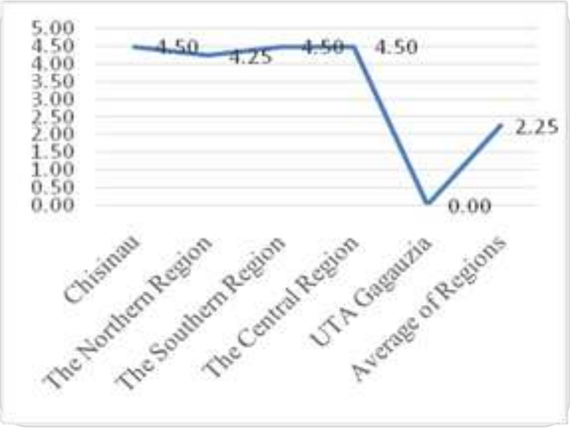

Fig. 4. Disparities in household size by region in Moldova
Source: statistical data consultations [9].

Investments in land modernization and consolidation are limited. Access to finance and technology is essential for increasing the average area of farms and improving productivity. Land consolidation policies could help reduce fragmentation and increase the average farm size [4]. These policies should encourage land consolidation and support farmers in this process.

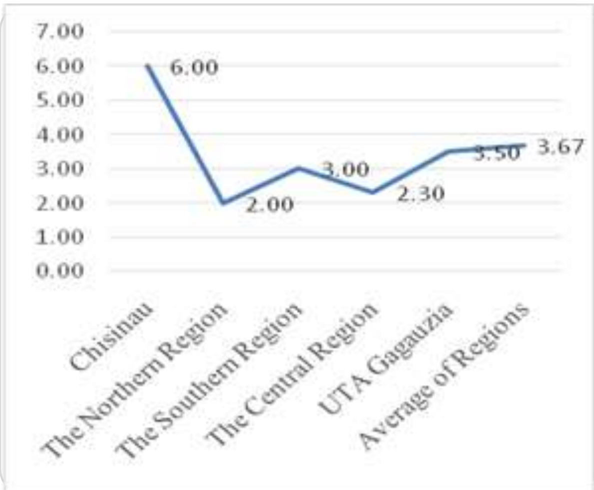

Fig. 5. Disparities in farm area between regions in Moldova compared to the regional average
Source: own processing based on [9].

The UTA Gagauzia region recorded the highest rank regarding the area per individual farm, which is 2.99 ha, with a disparity of 5 to 3 compared to the Central Region at 1.6 ha (excluding Chișinău Municipality) (Figure 5).
Very large disparities are recorded between the Chișinău region (low rurality) and the North region, with a ratio of 6 to 1.
Regarding aggregated scores, the disparity between the regional average AAS and the Central AAS is 4 to 3. UTA Gagauzia has a rurality degree (rank 2), which further accentuates the disparities between Regions and the regional average (Figure 6).

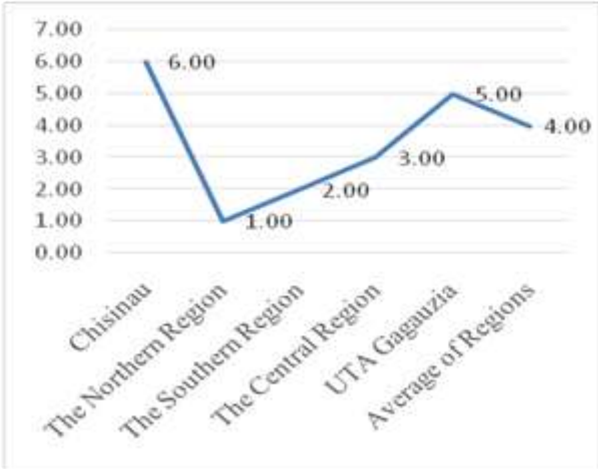

Fig. 6. Disparities in human resources between regions and the regional average
Source: statistical data consultations [1].

Agricultural product processing activities, more commonly practiced by agricultural farms, include milling activities (North), followed by meat processing activities (Central), dairy processing activities (UTA Gagauzia), vegetable and fruit processing (North), and grape processing (South). Agrotourism, fish farming, and crafts have a very low share.

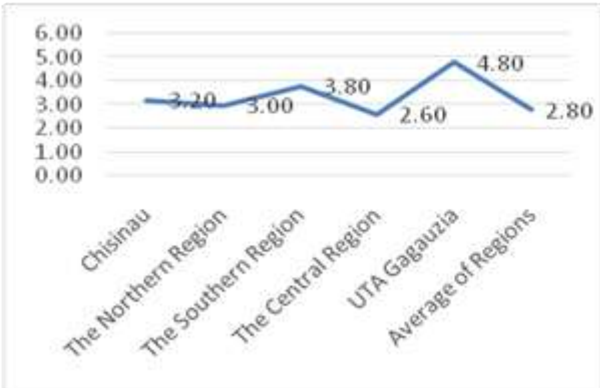

Fig. 7. Disparities in processing activities between regions and their average.

Source: statistical data consultations [9].

The availability and qualification of the workforce can influence the performance of the processing sector. The emigration of skilled labor is a problem.

Investments in modern technology and equipment can improve production efficiency and quality (Figure 7).

Animal density per hectare in Moldova varies depending on the type of animals and specific agricultural practices. In general, density is influenced by resource availability, pasture management, and animal husbandry practices [14].

To ensure sustainable and efficient animal growth, it is crucial to adopt modern and sustainable land and resource management practices.

The study "Agricultural Disparities in the Regions of the Republic of Moldova" analyzed the situation of agriculture and rural development, examining their significant proportion and importance for the national economy, as well as directions for investment in the coming period [15].

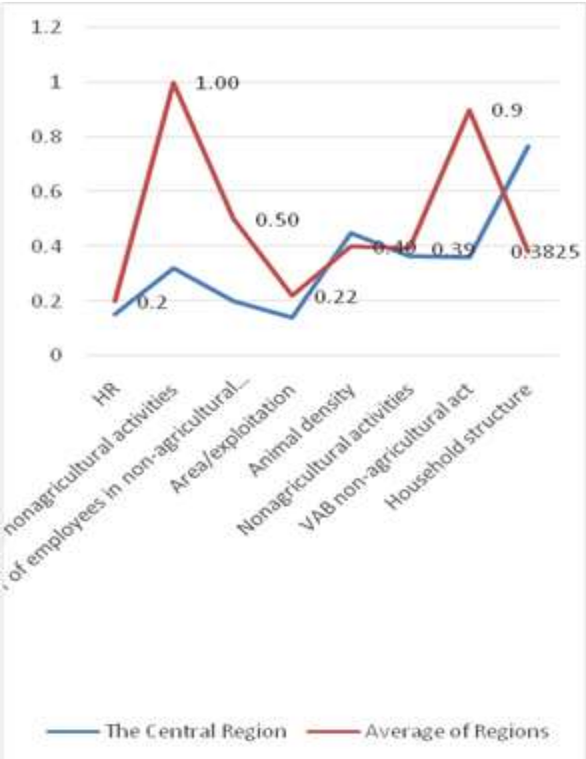

Fig. 8. Summary of non-agricultural potential in the Central Region

Source: statistical data consultations (NBS) [9].

Figure 8 presents a summary of the non-agricultural potential in the Central Region of the Republic of Moldova.

The study's results allowed us to outline some directions for reducing regional disparities, and we consider some aspects of rural development as specified.

Firstly, it is particularly important to increase employment in sectors other than agriculture, which will absorb the workforce released from the agricultural economy. Consolidation of agricultural farms will increase their economic efficiency in response to market pressures.

CONCLUSIONS

The major problems of non-agricultural activities in Moldova are driven by small and medium-sized enterprises (SMEs) in rural areas, which often face difficulties in accessing credits and financing necessary to start or develop non-agricultural activities.

The lack of adequate infrastructure, including roads, telecommunications networks and public utilities, is a significant barrier to the development of non-agricultural activities.

Managerial capacity and reduced skills:

The lack of entrepreneurial and managerial skills among the rural population may limit the success of non-agricultural businesses. European experiences have shown that vocational training and continuing education are essential to overcome this problem.

Limited access to markets, both locally and internationally, can restrict the growth of nonagricultural businesses. Promotion of local products and creation of efficient distribution networks are necessary.

Complex bureaucratic procedures and restrictive regulations can discourage entrepreneurial initiative. Simplifying administrative processes and creating a favorable business environment are essential for stimulating non-agricultural activities.

Economic and political instability in the Republic of Moldova may adversely affect investment in the non-agricultural sector and create an uncertain business environment.

To overcome these problems and stimulate the development of non-agricultural activities, coherent government policies, investment in infrastructure, vocational training programs and support for entrepreneurship are needed. An integrated and coordinated approach can significantly contribute to revitalizing the rural economy and improving the living conditions of the population of the Republic of Moldova.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

EFFECTIVENESS OF REARING AND FATTENING OF LOW-WEIGHT PIGLETS DUE TO CHANGES IN THEIR FEEDING SYSTEMS

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Abstract

The article contains the results of a study on the conservation, growth dynamics from birth to slaughter and economic efficiency of growing and fattening pigs depending on their live weight at birth and different feeding systems during the production cycle. It was found that piglets with a birth weight of just under one kilogram at weaning at 21 days of life had 30.3 % lower average and absolute gains, 29.4 % less live weight at this time and 4.5 % poorer maintenance in the post-weaning period compared to piglets whose live weight at birth was at the level of the line standard. During the suckling period, the weight difference between the animals at the beginning and end of the suckling period increased by 3.5 % in favor of the heavy piglets. During the rearing period and in the previous suckling period, animals with a lower birth weight had a 2.9 % worse preservation, grew 13.8 % slower and had a 13.8 % worse absolute weight at the end of rearing and at this time had a 17.7 % lower live weight and a 16.2 % worse feed conversion ratio at the same daily consumption, compared to animals born with a normal live weight. With the same costs for piglets with different birth weights and in the weaning phase, the difference according to this indicator is 8.4% in the rearing phase, 16.7% in the fattening phase and 13.2% for the entire production cycle in favor of the animals with normal birth weights. At the same time, these animals have a 3.2 % lower sales value, which leads to a 22.3 % lower income and a 31.4 % lower profitability of rearing and fattening a pig.

***Key words*:** *piglet, pig, conservation, growth, conversion to coma, cost, income, profitability*

INTRODUCTION

Intensive genetic selection for hyperproductive traits over the last thirty years has focused mainly on improving reproductive qualities and has led to a constant increase in the number of piglets at birth [17, 20]. With the emergence of the latest generation of hyperproductive sows bred in Northern Europe and represented by the genetics companies Topigs Norsvin 70 or DanBred [7], the pig industry has now entered a new phase. Grace to this progress, commercial pig farms around the world can see litters of up to 20 piglets per sow [18, 19, 21]. However, the first disadvantage of selecting for a large offspring is not only a decrease in the average weight of piglets at birth, but also an increase in the weight variability of piglets in the nest [23], leading to an unevenness of the group by weight. In previous studies on the effects of multiple fertility and nest orientation on the productive and reproductive traits of sows, a dependency between two traits was found: Multiple fertility and high fertility. The higher the fertility, the lower the fertility and vice versa [14]. With the increase in multiple fertility, the proportion of little piglets in large nests were growing, as does the frequency of piglets with intrauterine developmental delay [24]. In addition, the majority of piglets with low weight at birth and intrauterine growth retardation can adverse impacts on the structure of organs and growth after birth and later feed efficiency [3]. Other scientists also point out that one of the characteristics of perennial animals is the uneven development of their offspring. In each nest with unequal weights of piglets, there are usually animals of different sexes, with high, medium and low live weights and correspondingly different growth energy, whose development varies over the course of rearing. These differences in development in turn determine the later fattening, meat productivity or reproductive capacity of the animals [15].

Growth retardation in newborn piglets can lead to increased labour and equipment costs in the post-weaning period. Unfortunately, the negative effects can be long-lasting and lead to financial losses at the end of fattening and slaughter if the pigs have poor slaughter characteristics [17, 37].

In addition, heterogeneous groups of commercial pigs cause further problems of an economic nature: a significant difference in weight within a group forces the farm to overstock some of the animals in the feed store, which ultimately reduces the indicator "number of kilogrammes of pork grown per m^2". It can also prevent the application of the "empty-busy" principle [34]. The weight of piglets at birth determines the subsequent growth rate of piglets during the suckling period, which was confirmed by regression analysis [13].

The development of piglets in the first days after birth shows an uneven change in the weight of each individual. Inconsistency of the initial weight with the recommended or set as a norm over time is manifested by a noticeable deviation at weaning [35]. This is due to the so-called "amplification effect". According to some studies, a weight difference of 0.73 kg at birth can increase to 4.73 kg by the end of the weaning period, and a difference of 1.1 kg in weaning weight can turn into 3.8 kg at 138 days of age [8]. It is important to note that the weight difference between piglets born to the same group of sows in the same period can be significant. For example, between the 5% of the lightest piglets at weaning (less than 3 kg) and the 5% of the heaviest weaners (over 9 kg), it can be up to 6 kg. The difference in weight at birth and weaning affects the growth rate and has a significant impact on piglet survival. In general, the mortality rate of low weight piglets (less than 3 kg at weaning) is 33% between 0 and 138 days (and 25% before the transition to fattening), while the mortality rate of heavier piglets (over 9 kg) is almost 0% [2]. So there are two main reasons why pig farmers should aim for maximum homogeneity of nests and groups of piglets by mass. The more homogeneous the piglets are at the time of birth and weaning, the more homogeneous groups of animals will reach slaughter. The lower the proportion of underweight piglets, the higher the preservation of the animals in the group [5].

The existing studies showed that animals reared in levelled nests had higher indicators of average daily growth and preservation of piglets at the time of weaning. The data obtained indicate that the orientation of the nest has a great influence on the growth energy indicators of young pigs [25]. The highest growth rates were observed in pigs that came from homogeneous groups of animals with lower live weights at birth and showed compensatory growth compared to pigs with higher initial weights at birth that were kept in mixed groups [32]. However, the theory of the effect of compensatory growth in low weight piglets has been questioned as there are reports that piglets with a low birth weight (less than 1 kg) lose the ability to grow compensatory growth if the growth rate during suckling was below the average level [39]. A similar opinion on the dependence of piglets' growth intensity on the homogeneity of the nest in terms of mass was also expressed by other scientists [12]. Contrary to what was said, conclusions about the lack of a positive effect of nest uniformity by mass on the growth indicators of pigs were found in other published works. In particular, it has been reported that dividing pigs into groups of equal weight does not increase the overall performance of the herd [22, 38]. In particular, it was found [4] that dividing piglets into groups of equal weight at weaning had no effect on the intensity of their growth.

The treatment of low birth weight piglets is becoming a common practice worldwide. The main compensatory measures aimed at increasing the efficiency of using low birth weight piglets are the use of step sows [30], extending the suckling period [27], dividing the herd into groups of equal weight [25], the use of special super prestarter feed mixtures before weaning [26] and others.

It is currently estimated that 15% of piglets weigh less than 1 kg at birth. Their survival and weight gain is a real challenge.

However, today's pig feed manufacturers are exploring new strategies to support the vitality of low weight piglets [36].

Adding a highly bioavailable source of zinc to the diet can reduce intestinal inflammation and increase growth performance of underweight piglets after weaning [11, 31].

Given the high mortality rate and slow growth, effective herd management practices need to be combined with appropriate feeding strategies [1]. Since lightweight piglets consume only a minimal amount of feed, it is very important that every gram has the optimal nutrient composition and density. Among these nutrients, trace elements play an important role in tissue and organ development, as well as in strengthening immune function, maintaining gut integrity, and minimizing inflammation [9, 29]. In addition, in order to improve the adaptability of the gastrointestinal tract of young pigs with a low initial growth weight at birth, pork producers are switching to the use of liquid feed for rearing instead of traditional dry feed mixtures, which allows implementing a strategy of soft adaptation and reducing the stress of piglets after weaning [28, 33].

The use of variable feeding methods in rearing and fattening pigs that had low and normal birth weight showed that in light weight animals, lower growth intensity, less feed consumption, worse feed conversion and higher fat content in the carcass than in counterparts born heavier [10].

Thus, taking into account the increasing influence of selection on high fertility of sows, which, as a result, It leads to bigger litters and more piglets born with low weights, further study of adaptation strategies and effective use of such piglets remains relevant.

MATERIALS AND METHODS

The experiment is dedicated to the study of the fattening indicators of pigs before slaughter, derived from sows of the cross of large white and landrace breeds and boars of the synthetic line PIC-337. The research was carried out in the Limited Liability Company "Scientific Production Enterprise "Globinsky Pig Complex" of the Poltava region, Ukraine.

The experiment was achieved on July 20, 2023 on commodity number 2 in the village Obiznivka, Poltava region, Ukraine. During the farrowing of a weekly technological group of sows, piglets were weighed individually in two adjacent sections of the farrowing shop in the amount of 120 pigs. During weighing, the mass of the animals was recorded on their backs and in the accounting table with a special marker. Upon completion of the weighing, the parameters of the mass of the control and experimental groups closest to those specified by the method were determined (Table 1).

Experimental piglets were included in 2 groups with a live weight of 1.4 kg and 1.0 kg, four hundred and fifty animals each. Ranking and selection of piglets into groups was carried out on the basis of individual weighing and tagging with clips of different colors and indicating the weight on the back. The animals in the control group received red clips, the animals in the experimental group blue clips.

During the suckling period, the piglets in both test groups were kept in two separate farrowing areas, each with 60 animals in individual pens measuring 1.8 m x 2.5 m. The maintenance of the microclimate in the farrowing rooms was supported by the negative pressure ventilation system of the company Big Dutchman.

Heating mats were used to maintain an optimal microclimate in the piglets' resting area, and infrared lamps were also used during the first week of the piglets' lives.

Table 1. Scheme of the experiment

Indicators	A group of pigs	
	Group I	Group I
Breed and consanguinity of the mother	(♀L×♂LW)	(♀L×♂LW)
Genetic line of boars	PIC-337	PIC-337
Genotype of piglets	♀ (L×LW)×♂ PIC-337	♀ (L×LW)×♂ PIC-337
Initial number of piglets, pigs	450	450
Initial age of piglets, days	1	1
Technology of feeding before weaning	liquid milk substitute	liquid milk substitute
Initial weight of piglets, kg	1.4	1.0
Duration of suckling period in piglets, days	21	21
Duration of growing, days	50	50
System of holding piglets during rearing	floor-loom, 150 pigs per pen on a partially latticed floor	floor-loom, 150 pigs per pen on a partially latticed floor
Piglet feeding system during rearing	dry feeding system from Hog Slat self-builders with granular pre-starter and starter compound feed	dry feeding system from Hog Slat self-builders with granular pre-starter and starter compound feed
Age of piglets at the end of rearing, days	71	71
The system of holding pigs during fattening	floor-loom, 50 pigs per pen on a partially solid lattice floor	floor-loom, 50 pigs per pen on a partially solid lattice floor
Pig feeding system during fattening	liquid feeding system using the Megamix feed kitchen of the Austrian company Schauer with grower and finishing compound feeds	liquid feeding system using the Megamix feed kitchen of the Austrian company Schauer with grower and finishing compound feeds
Age of pigs at the time of removal from fattening, days	180	180

LW is a large white breed; L is a landrace breed;
Source: own calculations.

The sows were fed an unlimited amount of complete compound feed, balanced in terms of the most important nutritional components, in a suitable composition using coma feeders from the American company Hog Slat, to which the feed was fed three times a day via a chain disc conveyor. From the second day of life, the piglets were fed Opticare Milk liquid milk replacer via stationary automatic feeders located at the rear of the pen, which was prepared on the farm using the Cullina Mix Pro feed kitchen in accordance with the recipe and feeding curve. The sows were fed using automatic nipple feeders located near the feeders at the front of the pen and the piglets were fed using automatic bowl feeders which were placed in the back of the pen near the feeder with liquid milk substitute.

The manure was removed from the site using a vacuum gravity system with periodic action.

At the end of the piglets' suckling period of 21 days of life, all shorn animals were weighed individually and additionally marked with tags of the appropriate colour with numbers similar to those of the clamps and taken to the rearing station no. 2 in the village Babichivka, Poltava region, Ukraine and housed in 3 looms with 150 animals each. The piglets of both control groups were kept in pens during rearing on a partially slotted floor with a standard area of 0.35 m^2 per animal. Each pen was equipped with a recovery area for piglets with parts. Solid floor with heating 16.3 m^2. The maintenance of microclimatic parameters in the rooms where the experimental animals were kept was carried out with the help of negative pressure geothermal ventilation equipped with Big Dutchman devices. During the rearing phase, the experimental piglets were fed dry mixed feed using self-feeders from the American company Hog Slat. The dry feed was transported to the feeders using a chain and disc conveyor and weighed for each test group using a torsion scale. From the first day after weaning until the piglets reached a weight of 9 kg, the animals in both test groups were given the first pre-starter of the 0-9 kg formula, which they were fed in the last week of the weaning period. At the same time, during the first five days of rearing, the piglets in both test groups received warm, moist compound feed mixtures at a ratio of 3 kg water to 1 kg compound feed five times a day in parallel with unlimited access to the self-breeders. After the piglets of the corresponding group had reached an average weight of 9 kg, feeding of the second pre-starter feed of formulation 9-12 was started, using the same distribution system for feeding. When the average weight of the corresponding group reached 12 kg, they were switched to the feeding of starter compound feed of formula 12-25, which was fed before the piglets of both groups were transferred to fattening. The experimental piglets were watered with automatic cup drinkers and the faeces were removed with a periodic vacuum gravity system.

On the 72^{nd} day of life, after being weighed individually, the experimental piglets were transferred to fattening farm no. 4 near the village Hrynky, Poltava region, Ukraine. Here they were housed in group pens with an area of 36 m^2 on a fully barred floor with 50 animals each. The room was ventilated with a Big Dutchman negative pressure valve system.

Manure removal with a periodic vacuum gravity system.

The feed was prepared, transported and distributed using equipment from the Swiss company Schauer's feed kitchen, 10-12 times per day, with a feeding front of 0.18 m per 1 experimental animal. The consistency of the feed was produced by adding 1 kg of dry pulp to three parts of water. The feed was calculated using the feed kitchen software in the form of dry feed with a moisture content of 14%.

When the test animals were transferred from rearing to finishing at the age of 122 days, their group weight was determined.

When the animals in each experimental group had reached a weight of almost 130 kg, they were weighed individually and sent to slaughter. Throughout the research period, all veterinary and technological procedures were the same for the animals in the two controlled groups and were carried out according to a fixed protocol. The conditions of feeding, watering, maintenance, care and prevention of animals in the experiment were carried out in accordance with the EU legislation on animal welfare [6].

Throughout the experiment, the number of piglets that died or were eliminated due to a technological defect, their weight and the date of elimination were recorded. The weighing data were used to analyse the growth intensity and survival of the piglets. Feed utilisation was calculated on the basis of feed cost accounting. Based on feed accounting, its average daily consumption was calculated, and taking into account their share in the operating cost, this cost was calculated for rearing and fattening one pig of pigs and the profitability of rearing standard and low-weight piglets.

For a comprehensive evaluation of the fattening qualities of experimental pigs, the index of fattening qualities was calculated according to the formula [16]:

$$I=A^2/(B\times C)\qquad(1)$$

where:

A – gross weight gain during the fattening period, kg; B – the number of days of fattening; C – feed consumption per 1 kg of growth.

The system of manure removal, watering, air conditioning and air heating in the rooms were identical for animals of all experimental groups.

Microsoft Office Excel 2016 was used for data analysis. Indicators were considered significantly different when the significance levels corresponded to $p<0.05$, $p<0.01$ and $p<0.001$.

RESULTS AND DISCUSSIONS

We can observe (Table 2) the different intensity of growth in piglets, the cause of which we believe is the unequal initial weight of the animals. It was found that piglets with a 0.36 kg lower initial birth weight were likely to have lower average daily gains during rearing by 81 g ($p<0.001$) compared to standard weight animals. In our opinion, this is due to the fact that piglets with a lower weight are usually born later and retain fewer mammary glands. The absolute growth of piglets in the weaning period decreased by 1.66 kg ($p<0.001$), and, as a result, their weight decreased by 2.02 kg

($p<0.001$) during this period. In our opinion, this was caused by the lower intensity of growth of the specified animals. The indicator of live weight of born piglets was higher in the herd of the experimental group by 25.9% at the beginning and by 29.4% at the end of the suckling period. It is known that piglets born with a lower live weight usually have a poorer health status and are less adapted to the conditions of the external environment, which causes an increased proportion of their offspring in the post-weaning period.

Table 2. Growth and survival of piglets with different initial weights in the weaning period

Indicators	Group I	Group I
The number of piglets at the beginning of the experiment, pigs	450	450
Piglets weight at birth, kg	1.39±0.0027***	1.03±0.0036
Piglets age at weaning, days	20.4	20.4
Piglets average weight oat weaning, kg	6.87±0.076***	4.85±0.111
Absolute growth of suckling piglets, kg	5.48±0.069***	3.82±0.012
Average daily growth of suckling piglets,	269±10.3***	187±14.8
Piglets preservation, %	93.6	89.1

*** – p <0.001.
Source: own calculations.

In our studies, piglets with a standard live weight had a 4.5% better survival rate during the subsystem period compared to piglets with a low weight.

Piglets with a birth weight of just under one kilogram had 30.3% lower average daily and absolute gains, 29.4% less live weight at this time and 4.5% poorer maintenance in the 21st post-weaning period compared to piglets whose live weight at birth was at the level of the line standard. In the weaning period, the difference in the weight of animals at the beginning and at the end of the weaning period increased by 3.5% in favor of heavier piglets.

Heavier piglets showed a 3.5% increase in weight during the suckling period compared to their counterparts from the control group. Piglets that had a low initial weight in the weaning period also lagged behind their peers in terms of this indicator during rearing (Table 3). Livestock of group I prevailed over analogs from group II in terms of average daily growth by 57 g ($p<0.001$), absolute growth by 2.92 kg ($p<0.001$), initial live weight at the beginning of growing by 2.02 kg ($p< 0.001$), the indicator of live weight at the end of growing by 4.94 kg ($p<0.001$). As in the previous technology period, the survival rate of piglets born with a weight of just under one kilogram was 2.9% worse than that of animals with a standard live weight.

Table 4. Feeding qualities of pigs

Indicators	Group I	Group I
The initial number of pigs, pigs	411	401
The number of days of pig life from birth to the beginning of fattening, days	71.5	71.5
Number of fattening days, days	27.98±0.365***	23.04±0.571
Number of pigs before slaughter, pigs	103	112
The initial number of pigs, pigs	401	386
Saving of pigs during fattening, %	97.5	96.3
Age at which weight is 120 kg, days	159.9	172.2
Age at removal from fattening, days	174.5	183.5
Weight of pigs when removed from fattening, kg	135.2±1.07**	130.8±1.14
Weight of pigs at 180 days of life, kg	140.5	127.2
Absolute gain in fattening, kg	107.2±1.07	107.8±1.12
Average daily gains in fattening, g	1,041±15.3***	963±19.7
Average daily feed consumption in fattening, kg	2.72	2.76
Feed conversion at fattening, kg	2.61	2.87
Index of fattening qualities, points	42.8	36.1

** – p <0.01; *** – p <0.001.
Source: own calculations.

Animals with a lower initial weight at birth reached a weight of 120 kg 12.3 days earlier and at the age of 180 before slaughter weighed 13.3 kg more compared to counterparts that were heavier at birth.

In contrast to the growth period, the average amount of feed consumed per day during the fattening phase was 0.05 kg lower in animals with a lower birth weight, and due to their significantly lower growth intensity, feed utilisation during fattening was 0.26 kg lower.

Pigs of the II group, which were heavier at birth, demonstrated a 6.6-point higher value of the complex index of fattening qualities compared to peers from the I group.

For example, piglets with a 0.36 kg lower birth weight during fattening had a 7.5% lower growth rate, an 8.7% longer fattening period and a 3.2% lower weaning weight when they consumed 1.7% less feed and utilised 10.0% less feed, reached a marketable weight of 120 kg 7.7% later and had a 9.4% lower weight at 180 days of age and differed by 15.5% from animals that had a standard weight at birth.

Piglets with a lower birth weight had lower growth rates throughout their lives. As can be seen from the diagram in Fig. 1, the weight difference in the pigs increased with age. It was 0.36 kg at birth, 2.02 kg at weaning, 4.94 kg at the transition to fattening, 5.8 kg at 120 days of age and 13.3 kg at 180 days of age. This means that a relative reduction in the difference in live weight was observed in piglets with a low birth weight due to compensatory growth in the following stages of life.

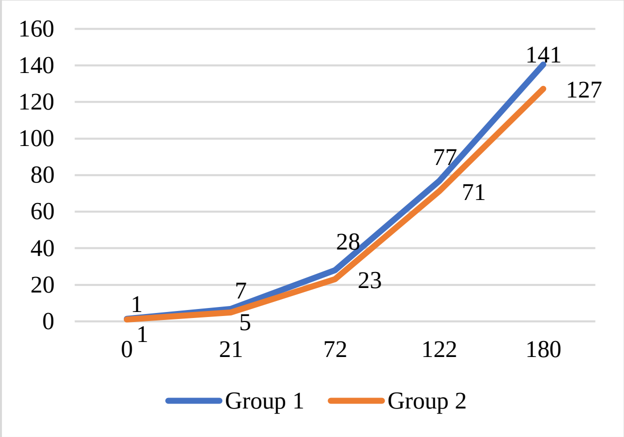

Fig. 1. Dynamics of the average weight of one piglet from birth to 180 days, kg
Source: Own determination.

That is, in relative units, the difference in live weight between piglets with a standard live weight at birth and piglets with a low weight at birth was 29.4%, at weaning it remained at the same level, during the transition to fattening it decreased to 17.7%, after reaching the age of 120 days it decreased to 8.2% and at the age of 180 days it was 9.4%.

When analyzing the growth intensity, conservation and feed payment of piglets with different live weights at birth over the entire period of their lives, we found that piglets with low birth weights had a 9.0 days longer duration of this cycle, while we found 59.4 g ($p<0.001$) lower average daily weight gain, 4.0 kg ($p<0.01$) lower absolute weight gain, 7.6 worse piglet survival from birth to slaughter, 0.07 kg less feed consumption during rearing and fattening and 0.12 kg worse utilization (Table 5).

Table 5. Growth and preservation of piglets with different weights at birth in the period of life

Indicators	Group I	Group I
Duration of the production cycle from birth to slaughter, days	174.5	183.5
Preservation of piglets for the entire production cycle,%	88.9	81.3
Absolute growth over the entire period of life, kg	134.0±1.14**	130.0±1.16
Average daily growth for the entire period of life, g	767±10.3***	707±14.2
Average daily feed consumption during the period of rearing and fattening, kg	2.03	2.10
Conversion of fodder for growing and fattening, kg	2.43	2.71
Duration of the production cycle from birth to slaughter, days	174.5	183.5

** – $p<0.01$; *** – $p<0.001$.
Source: own calculations.

When analyzing the profitability of rearing piglets with different birth weights, it was found that if the costs of rearing these piglets at birth were the same as the costs of rearing them in the weaning period, there was a difference in the costs of rearing and fattening these animals in the subsequent periods of the production cycle.

As can be seen from Table 6, the operating costs for rearing low-weight piglets are 1.42 EUR higher than for analogous piglets with a standard weight at birth due to lower growth intensity and poorer feed conversion efficiency, while the difference in operating costs for fattening already amounts to 11.11 EUR. Operational expenses at the end of fattening amounted to 94.74 EUR in group I and 107.24 EUR in group II. The sale price of piglets in the control group was 176.33 EUR, which is due to a higher live weight of animals. On the other hand, the piglets of the research group were lighter, so their price was lower and amounted to 182 EUR.

Table 6. Growth and preservation of piglets with different weights at birth in the period of life

Indicators	Group I	Group I
Operating cost of one piglet at birth, EUR	9.43	9.43
Operating cost of rearing one piglet until weaning, EUR	1.63	1.63
Operational cost of raising one piglet, EUR	16.97	18.40
Operational cost of fattening 1 pig, EUR	66.69	77.80
Operational cost of obtaining and raising and fattening 1 pig, EUR	94.72	107.25
The cost of 1 pig without VAT upon completion of fattening, EUR	176.33	170.66
Income from raising and fattening 1 pig, EUR	81.62	63.40
Profitability of raising and fattening 1 pig, EUR	2.16	1.48

Source: own calculations.

Due to the lower cost price and higher sales value, the income from the sale of an animal in the control group was EUR 0.45 higher than that of the experimental group, and the profitability of rearing piglets with normal live weight was 27.05% better than the profitability of rearing piglets with low weight.

With the same costs for piglets with different birth and weaning weights, the difference according to this indicator is therefore 8.4% in the rearing phase, 16.7% in the fattening phase and 13.2% for the entire production cycle in favour of the animals with normal birth weight. At the same time, these animals have a 3.2% lower sales value, which leads to a 22.3% lower income and a 31.4% lower profitability of rearing and fattening a pig.

The results we obtained confirm the observations [3] on the influence of the weight of piglets at birth on the intensity of postnatal growth and the efficiency of their further fattening. In addition, our study confirmed the findings [34] that a significant difference in the weight of piglets caused by their unevenness at birth and subsequent growth forces producers to keep some of the animals on the fattening farm for too long. In our study, such a delay was found to be 9 days. In addition, the results of our research were consistent with the findings [13] that the growth rate of piglets from birth to weaning is determined by their birth weight. In our trials, piglets that weighed 25.9% less at birth increased this shortfall to 29.4% before weaning. Our results confirmed the report [35] stating that the weight loss of piglets at an early age increases over time in the later stages of the production cycle. In our experiment, a weight difference of 0.32 kg at birth resulted in a deficit of 4.94 kg at the end of rearing and 13.3 kg at 180 days of age, which partly agrees with the data [8], according to which the weight difference in weanlings is 1, 1 kg can translate into 3.8 kg at 138 days of age, but it contradicts the conclusions of [32] regarding the compensatory growth of low weight piglets in the later periods of the production cycle and partially confirms the conclusions of [39] and [12] about the lack of compensatory growth in low birth weight piglets. In our research we also found no confirmation of the opinion [25] that the division of animals into groups of equal weight increases the growth intensity of piglets in the later periods of the production cycle, and on the contrary, the conclusions [4] were confirmed that the division of piglets at weaning into groups of equal weight has no effect on their growth intensity.

In addition, our research partially confirmed the report [2] of a significant difference in survival of piglets with different birth weights, with our trials showing that the survival of low weight piglets was 7.6% worse than that of normal birth weight piglets. However, in contrast to the indicators reported [2] for the survival rate of low-weight piglets in the pre-weaning group (67%) and in the rearing group (75%), we found slightly better values for this indicator for the technological groups reported, namely 89.1% for low-weight piglets in the suckling group and 94.7% for low-weight piglets in the rearing group.

Our research confirmed the findings [17, 37] on the negative effects of lower piglet weight at birth leading to financial losses at the end of fattening and slaughter.

In our experiment, the piglets with low weight at the end of fattening had a 13.2% higher cost per animal, a 3.2% lower sales value, a 4.1% lower profit from the sale of a fattened animal and a 27% lower profitability of breeding and fattening. We consider it necessary to continue this research and apply other innovative methods for rearing low-weight semi-pigs.

CONCLUSIONS

It was found that piglets with low birth weight at weaning had significantly lower average daily and absolute gains, lower live weight and poorer conservation than their counterparts whose live weight at birth was at the level of the line standard. During the suckling period, the weight difference between the animals at the beginning and end of the suckling period increased by 3.5% in favor of the heavier piglets.

It has been shown that animals with a lower weight at birth had poorer preservation during the rearing period, grew more slowly and had a significantly lower live weight and poorer feed conversion ratio before weaning than their counterparts born with a normal live weight.

It was proven that lower birth weight in pigs is the cause of a decrease in slaughter weight, increases feed consumption per 1 kg of gain, increases the duration of fattening up to a weight of 120 kg, reduces fattening productivity at the age of 180 days and, as a result, reduces indicators of a complex index of fattening qualities.

It was found that the difference in live weight between animals with different live weights at birth decreased as the animals aged.

Better costs were found in the growing period, in fattening and for the entire production cycle in favor of animals with a normal weight at birth. They had a higher sales value, a higher income and a better profitability in the rearing and fattening of one pig.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

EVALUATION OF HUMAN CAPITAL IN THE ENTREPRENEURIAL ECOSYSTEM OF THE REPUBLIC OF MOLDOVA: THE URBAN-RURAL PERSPECTIVE

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Abstract

Human capital is a vital element of the entrepreneurial ecosystem, playing a significant role in promoting economic growth and innovation. This study aims to investigate the distinctive features of human capital as a component of the entrepreneurial ecosystem, with a focus on urban and rural locations in the Republic of Moldova. Additionally, it aims to identify the challenges entrepreneurs encounter when accessing human capital. The assessment of human capital within the business ecosystem was based on primary data collected from surveys of 204 entrepreneurs in the Republic of Moldova between June and October 2022. The analysis was supplemented with secondary data sourced from the National Bureau of Statistics. The study's results indicate major obstacles in terms of human capital. These include a declining workforce, outward migration and a scarcity of highly-skilled employees, particularly in rural areas. Entrepreneurs in urban and rural regions of the Republic of Moldova expressed concerns about the availability of highly qualified specialists, the competence of graduates from educational institutions and the influence of migration on both the labor market and the business landscape.Disparities exist in the assessment of the competence of graduates from educational institutions, with urban entrepreneurs tending to be more pessimistic. On the other side, rural entrepreneurs place a greater emphasis on the impact of migration and emigration.

Key words: *human capital, entrepreneurial ecosystem, competence of graduates, entrepreneurship, workforce*

INTRODUCTION

Entrepreneurial ecosystems have received a lot of attention in recent years as one of the most interesting issues for practitioners, government policy makers and academics [16, 17].
At present, there is no agreed definition of an entrepreneurial ecosystem, no consistent technique for identifying its main components, and no standardized way of assessing them. Although there are multiple versions of the concept of an 'entrepreneurial ecosystem', most versions tend to emphasise the importance of the closeness and interconnectedness of the various participants and essential elements within an entrepreneurial ecosystem [5].
Furthermore, there is a lack of clarity regarding the appropriate scope for analysing an entrepreneurial ecosystem [10]. In terms of geography, it can encompass an urban settlement, a region or extend to a national scale. It may also encompass other, less spatially bounded systems, such as industries or technologies that create opportunities for business creation and expansion.
Human capital is an important component of the entrepreneurial ecosystem. For years, researchers and specialists have sought to comprehend, study and analyse human capital as one of the primary determinants of economic development and competitiveness. The notion of “human capital” refers to the set of knowledge, experience and characteristics that demonstrate an individual’s ability to generate economic value [11]. In the context of entrepreneurship, the significance of human capital becomes particularly pronounced, as it encompasses not only formal education and technical skills but also the mindset, creativity, and adaptability essential for driving innovation and business success. Over time, numerous policy proposals have emerged that aim to cultivate and enhance human capital. In particular, Heckman (2000) highlights the benefits of early intervention programmes, mentoring initiatives and motivational programmes targeted at youth [7]. Unger JM et

al. (2011) define human capital as the knowledge and skills acquired through schooling, on-the-job training and other types of experience [21]. Hitt M.A. et al. (2001) assert that human capital, comprising education, experience, skills, and the effect of leadership, is a key driver of competitive advantage and firm performance [8].

Lately, Isenberg (2011) proposes the entrepreneurial ecosystem as a framework for examining human capital, which is viewed as crucial for fostering a practical, innovative, and entrepreneurial economy [9]. Isenberg (2011) further discussed entrepreneurial ecosystems and defined 'entrepreneurial ecosystems' as an organic system that includes a group of tangible and intangible elements such as customers, capital market, leadership and culture that are organised in complex ways to interact with venture creation and entrepreneurship development. Isenberg (2011) identified 13 essential elements of an entrepreneurial ecosystem: leaders, governments, culture, success stories, knowledge, capital, non-profit and industry associations, educational institutions, infrastructure, geographic location, networks, venture-oriented professionals and potential customers [9]. In his approach to the entrepreneurial ecosystem, the human capital component consists of 2 elements: labour and educational institutions. Labour examines: skilled and unskilled, serial entrepreneurs, later generation family. Educational institutions examines: general degrees (vocational and academic), specific entrepreneurship training.

The World Economic Forum (2013) found that local and international markets, human capital and financing, mentoring and support systems, robust regulatory frameworks and leading universities are the key pillars of an ecosystem. Management talent, technical talent, entrepreneurial business experience and access to immigrant labour are the elements of human capital. Similarly, the education and training component is based on the available workforce with pre-university education, available workforce with university education, entrepreneur-specific training [22].

The Global Entrepreneurship and Development Index, developed by George Mason University, analyses entrepreneurial ecosystems at the level of entrepreneurial attitudes, abilities and aspirations. Entrepreneurial attitudes, abilities and aspirations are built on a foundation of 14 pillars. Each pillar includes both individual and institutional variables, reflecting the micro and macro dimensions of entrepreneurship. Within the Global Entrepreneurship and Development Index, the "human capital" pillar is illustrated by the variable of educational level, which emphasises the quality of entrepreneurs. The consensus is that individuals with higher levels of education are more likely and motivated to start and run high-growth businesses.

At the institutional level, the variable that addresses human capital is the labour market. This aspect has two key components: labour freedom, which measures labour freedom from a regulatory perspective, and human capital development, which measures a country's investment in business training and employee development. Specifically, significant investment in employees is expected to yield favourable returns, while training initiatives increase the competence of employees, thereby improving business development, innovation and growth prospects [2].

Entrepreneurial activity plays an important role in shaping regional economic development as it impacts economic growth, fosters employment opportunities, and encourages innovation. As a result, there is significant scholarly and governmental attention directed towards comprehending entrepreneurial endeavours holistically. This places, as well, specific emphasis on the local elements that facilitate the establishment and evolution of entrepreneurial ecosystems [1, 6, 16].

Existing research analyses the link between entrepreneurial activity and regional development. Nevertheless, it is important to stress that entrepreneurial activity is not uniformly concentrated in different countries or regions, as many studies have shown [3, 20]. Studies of entrepreneurial ecosystems typically concentrate on the national level [18], metropolitan regions or well-known business hubs [14].

The analysis of entrepreneurship research shows that entrepreneurship tends to flourish more in urban areas than in rural areas [4]. In contrast to urban areas, rural areas face specific challenges in promoting entrepreneurial activity. These obstacles include geographical, institutional, social and financial barriers, inadequate infrastructure, technical support issues, difficulties in sourcing raw materials and securing human resources [13].

The aim of this study is to explore the specificity of human capital as a component of the entrepreneurial ecosystem, with focus on urban and rural locations in the Republic of Moldova, as well as to identify the difficulties entrepreneurs encounter in accessing human capital.

The main research questions in this paper are:
(1)What are the main challenges faced by entrepreneurs in terms of human capital?
(2)How do rural areas differ from urban areas in terms of human capital for entrepreneurial activities?

MATERIALS AND METHODS

The primary data for the assessment of human capital as a component of the entrepreneurial ecosystem were obtained using the survey method. A total of 204 entrepreneurs from the Republic of Moldova were interviewed. The questionnaire was filled in by the owners or managers of the enterprises, who know the situation in the respective enterprise well. The survey was conducted in June-October 2022.

To measure the impact of entrepreneurial ecosystem components, such as human capital, on business development in Moldova, a five-point Likert scale with five possible scores was used: the scale ranged from 1 (minimum) to 5 (maximum), minimal ratings of 1 and 2 were considered to represent the human capital barriers faced by entrepreneurs.

The questionnaire for entrepreneurs included 9 indicators for the human capital component. They were divided into three categories: 1) indicators characterising the level of availability of different categories of personnel; 2) indicators characterising the level of competence of personnel and the organisation of training in the workplace; 3) indicators characterising the level of influence of population migration and emigration on the business.

The required number of completed questionnaires was calculated on the basis of the total number of 60.3 thousand units (the number of enterprises in the Republic of Moldova according to the data of the National Statistical Office in 2021), with a confidence level of 95%. The sample structure was designed to match the overall structure in terms of the main characteristics of the selection. The results were then aggregated and analysed using the SPSS statistical analysis programme. Additionally, the study examined secondary data from the National Bureau of Statistics, with a focus on the active and inactive populations by place of residence. The research also analysed the educational attainment levels of the workforce in both urban and rural environments.

RESULTS AND DISCUSSIONS

Characteristics of the workforce in the Republic of Moldova

The table below presents the main aggregated quantitative indicators characterising human capital in Moldova.

The active population provides the necessary labour force for society and especially for entrepreneurial activity (its share is 41.8% in 2022). It includes the employed population (40.5% of the population aged 15 and over) and the unemployed (1.3%), defined according to the criteria of the International Labour Organisation. The inactive population (all persons, regardless of age, who did not work at least one hour during the reference period and were not unemployed) had a share of 58.2% in 2022 by republic, significantly exceeding the active population by 16.4 p.p. The same situation was recorded for individual groups - in urban areas (the inactive population exceeds the active population by 1.1 p.p.), in rural areas by 25.8 p.p., for men by 7.3 p.p. and for women by 24.4 p.p.

The inactive population in rural areas significantly exceeds that in urban areas and the active population. One of the main reasons for the large number of economically inactive individuals in rural regions could be attributed to the scarcity of employment opportunities in the country, particularly in rural settings, along with the unattractiveness of the available jobs. Consequently, the working population tends to engage in informal work activities that offer higher income and satisfaction, rather than accepting poorly compensated, often insecure jobs with limited prospects for career advancement. Such a substantial number of inactive population inevitably compromises the development of human potential in rural areas and considerably diminishes the prospects for establishing and developing viable, competitive businesses.

Table 1. Population aged 15 and over by economic status, sex and place of residence, 2022

	Whole country	**Urban**	**Rural**	**Men**	**Women**
Total, thous.pers.	**2,130.1**	**831.5**	**1,298.6**	**993.2**	**1,137.0**
Active, *thous.pers.*	890.0	408.2	481.8	460.1	430.0
Share, %	*41.8*	*49.1*	*37.1*	*46.3*	*37.8*
Employed, *thous.pers.*	862.3	393.6	468.8	443.7	418.6
Share, %	*40.5*	*47.3*	*36.1*	*44.7*	*36.8*
Unemployed, *thous.pers.*	27.7	14.6	13.1	16.3	11.4
Share, %	*1.3*	*1.8*	*1.0*	*1.6*	*1.0*
Inactive, *thous.pers.*	1,240.1	423.3	816.8	533.1	707.0
Share, %	*58.2*	*50.9*	*62.9*	*53.7*	*62.2*

Source: National Bureau of Statisitcs data, Labour Force Survey - Employment and Unemployment, 2019-2023.

The prevalence of highly educated individuals is a characteristic of the presence of talented human capital [16]. It can be measured as the percentage of highly educated individuals in the labour force. The National Bureau of Statistics' data show that the favourable trend in the educational structure of the workforce over the past decade has persisted, with an increase in the segment with higher education. In 2022, the percentage of the population with higher education was 28.3% of the working population, an increase of 2 percentage points compared to 2014, including in this period it increased by 2 percentage points in rural areas. International comparisons show that Moldova still has a very low share of people with tertiary education in the labour force. For comparison, the share of employed persons aged 25-64 with tertiary education in EU countries is about 2.5 times higher than in Moldova (85% in France, 85.2% in Estonia, 85.6% in the Czech Republic, 86.8% in Latvia, 89.9% in Lithuania) [12]. There is a significant discrepancy in the distribution of the tertiary-educated employed population by place of residence (73.2% in urban areas compared with only 26.8% of tertiary-educated employed in rural areas) (year 2022) (Figure 1). The rural population is characterised by a lower level of education than the economically active population in urban areas. In rural environments, approximately 64% of the economically active population has attained secondary vocational and secondary school education, while 76.1% have completed gymnasium. The difference in educational attainment levels within the economically active population, with a smaller percentage having higher education and a larger proportion having lower educational qualifications, may be the reason for the lower economic activity in villages.

As in other countries, young people in the Republic of Moldova face challenges in getting stable jobs that pay a living wage. Employment possibilities for young people are mainly concentrated in urban areas. The lack of job prospects in rural regions and that young people migrate massively either to cities or abroad to find work explains the reasons for the lower inflow of young people from rural areas into the labour market.

According to statistics, women and young people from villages are the most discouraged in the labour market. Thus, there is gender inequality in the labour market among young

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

people in rural areas: the employment rate for young men in rural areas (15-24 years and 25-34 years) is about 17.4% and 48.8% respectively (in 2022), and for young women in the same age groups it is 9.5% and 36.7%. The employment rate of young women in rural areas is 7.3 p.p. (15-24 years) and 15 p.p. (25-34 years) lower than that of young women in urban areas. Reasons for the lower labour market participation of young women include longer periods of education, marriage at a younger age, childbirth and childcare. At the same time, despite having higher levels of education than men, young women are paid less than men, even under similar conditions and in similar occupations.

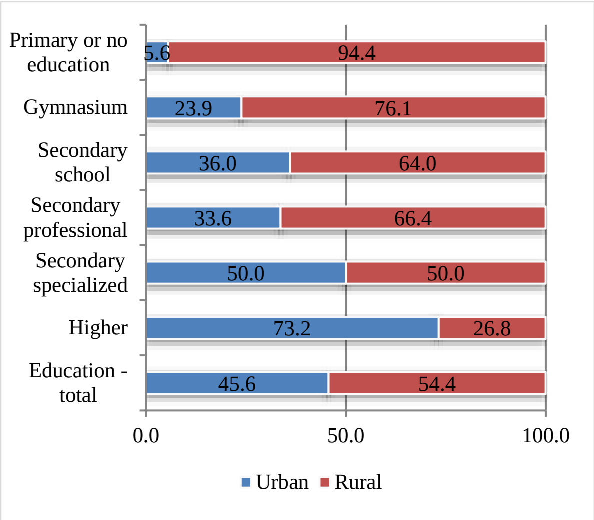

Fig. 1. Structure of the employed population by educational level and residence area in 2022, %
Source: based on National Bureau of Statisitcs Labour Force Survey data.

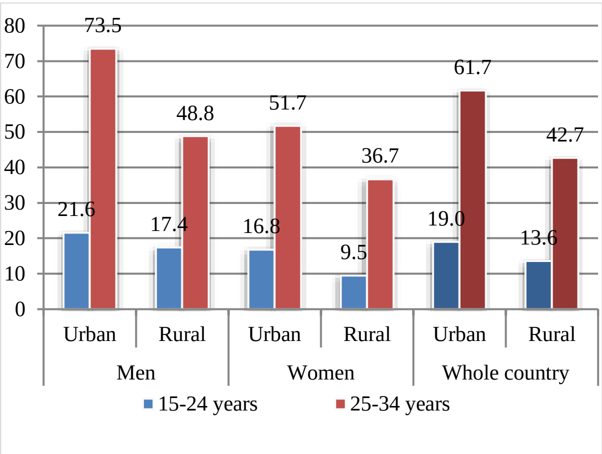

Fig. 2. Youth employment rate by residence areas, 2022, %
Source: National Bureau of Statisitcs data, Labour Force Survey, 2022.

Human capital: entrepreneurs' perception

The survey covered 204 entrepreneurs. The sample was dominated by micro enterprises (66.7%) and small enterprises (25%), but medium-sized enterprises (5.9%) and large enterprises (2.5%) also participated in the survey. More women (59.8%) than men (40.2%) participated in the survey. The largest age group of entrepreneurs is the middle-aged respondents aged 35-54 years, representing about 51% of the respondents. The category of young entrepreneurs, aged 25-34, represented around 25% of the survey, which is still a significant proportion of the sample. The largest age group of entrepreneurs is in the urban area (73%) and 27% in the rural area.

Table 2 shows the heat map of challenges faced by entrepreneurs (most negatively rated indicators with 1 = 'minimum'; 2 = 'relatively low') in the Republic of Moldova, across urban and rural areas. The most pressing problems are migration and emigration of the population, availability of highly qualified specialists, availability of personnel with certain specialisations, competence of graduates of educational institutions (it should be noted that the competence of graduates is more of an obstacle for urban entrepreneurs, according to the entrepreneurs' assessments).

The higher the percentage of respondents experiencing a challenge in the measured area, the redder the heatmap.

The lower the percentage of respondents experiencing a challenge, the greener the heatmap.

For both urban and rural entrepreneurs, the most positively rated factors were the digital skills of staff.

The professional level of staff, formal on-the-job training of staff and the availability of unskilled labour were mostly rated as neutral, with some positive ratings.

In the following, we analyse in more detail the main indicators of human capital characteristics assessed by entrepreneurs in urban and rural environments (Fig. 3).

Table 2. Heat map of challenges percieved by entrepreneurs to the entrepreneurship ecosystem component „human capital" *(respondents that evaluated the indicators with 1 = "minimum level"; 2 = "relatively low")*

Indicators	Urban	Rural	National
Level of availability of different categories of staff on the labour market	50.2%	49.1%	49.9%
Availability of highly qualified specialists	66.2%	58.2%	64.0%
Availability of unskilled personnel	34.0%	38.2%	35.1%
Availability of staff with certain specialities	50.7%	50.9%	50.7%
Level of competence of staff and organisation of training	37.2%	31.3%	35.6%
Competence of graduates of educational institutions	60.7%	38.0%	54.7%
Proffesional level of staff	34.9%	35.3%	35.0%
Digital competence of staff	21.1%	21.8%	21.3%
Formal on-the-job training of employees	33.1%	30.9%	32.5%
Level of influence of labour migration and emigration of the population on business	74.1%	90.9%	78.8%
Labour migration	73.6%	92.7%	78.9%
Population emigration	74.6%	89.1%	78.7%

Source: prepared by the authors on the basis of survey of entrepreneurs, 2022.

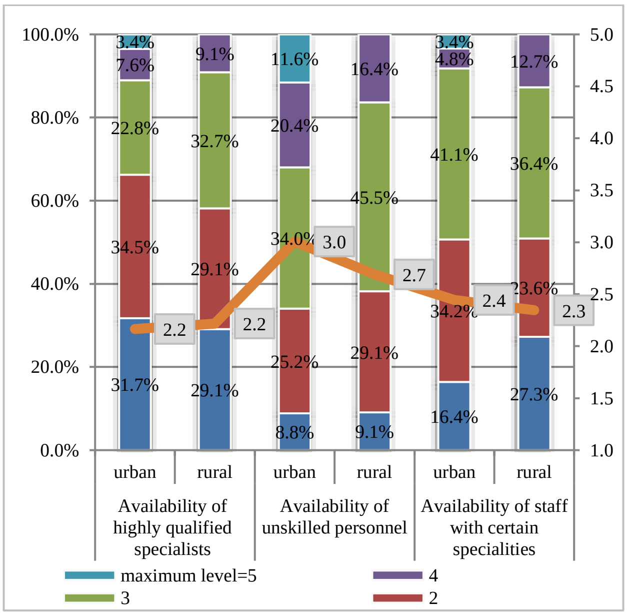

Fig. 3. Evaluation of indicators characterising the level of availability of different categories of personnel on the labour market, %

Source: prepared by the authors on the basis of survey of entrepreneurs, 2022.

Characterising the ***level of availability of different categories of personnel on the labour market*** in the Republic of Moldova, around 50% of entrepreneurs indicated that they faced challenges in this respect.

Entrepreneurs rated the availability of highly qualified specialists more negatively, with 64% of respondents giving a minimum score of 1 or 2 and an average score of 2.18. The availability of staff with certain specialisations was also rated poorly by 50.7% of the entrepreneurs surveyed, with a minimum score of 1 or 2 and an average of 2.42.

The assessment of the indicator availability of unskilled labour is rather ambiguous. For just over a third of respondents, the availability of unskilled labour was an obstacle, while around a third of entrepreneurs rated access to unskilled labour as neutral (average=2.92).Depending on the residential environment of the entrepreneurs, the following situation can be observed regarding the availability of different categories of personnel on the labour market.

-Availability of highly qualified specialists:

In urban areas, 66.2% of entrepreneurs rated the availability of highly qualified specialists with a minimum score of 1 and 2, indicating an important barrier to access to highly qualified specialists. Only 11.0% of urban respondents gave the maximum score (4 and 5), indicating a favourable situation in this area.

In rural areas, 58.2% of entrepreneurs face a problem with the availability of highly qualified specialists (8 percentage points lower than in urban areas). Approximately one-third of the surveyed entrepreneurs from rural locations ranked the accessibility to qualified professionals as neutral.

Therefore, access to highly qualified employees is more challenging in urban locations than in rural ones, and the favorable evaluation of this indicator is low in both settings.

-Availability of unqualified workforce:

Enterprises in urban locations assessed the availability of unskilled labour higher (average = 3.0) than those in rural locations (average = 2.7). In urban areas, 34.0 % of entrepreneurs gave a score between 1 and 2 and 32.0 % gave a maximum score, indicating a balanced situation between negative and positive assessments.

In rural areas, access to unskilled labour is a challenge for a relatively higher proportion of entrepreneurs, with 38.2% rating it as such. In addition, 16.4% gave it the maximum score

(15.4 percentage points less compared to urban locations).

The rating indicates that availability of low-skilled labour is more challenging in rural locations, as the positive evaluation is lower in these places.

-Availability of employees with certain specialities:

In both urban and rural areas, the availability of staff with certain specialities is a challenge for about half of the respondents, but the positive rating is slightly lower in urban areas.

Overall, we see that entrepreneurs in both environments perceive access to highly qualified and specialised staff as a significant barrier. Positive ratings for these categories of staff are relatively low. On the other hand, access to unskilled labour is more balanced, with similar numbers of positive and negative ratings, especially in urban areas. However, fewer entrepreneurs in rural areas rated access to unskilled labour positively than in urban areas.

Regarding ***the level of competence and organisation of on-the-job training of employees*** in the Republic of Moldova, some 35.6% of entrepreneurs indicated that they faced challenges in this respect.

Entrepreneurs were more negative in their assessment of the competence of graduates from educational institutions (54.7% of respondents indicated the minimum score of 1 or 2; average = 2.35).

Enterprises in rural areas rated this indicator more neutrally (average = 2.6) than enterprises in urban areas (average = 2.3), which rated the competence of graduates of educational institutions at a minimum level. Possible causes for discrepancies in the assessment of the level of competence of graduates in relation to their place of residence could be related to: differences in job requirements, cultural differences, and higher expectations. For example, job requirements may vary according to region and sector. In rural areas, enterprises may specialise in different areas than in urban areas and therefore require different skills and competences from graduates, i.e. entrepreneurs in urban areas may have higher expectations of graduates' skills. At the same time, cultural differences between urban and rural areas may affect the way entrepreneurs perceive graduate skills. For example, entrepreneurs in urban areas may have higher expectations of graduates and these higher expectations may lead to lower ratings.

The entrepreneurs surveyed gave a mostly negative and neutral assessment of the professional level of staff with an average score of 2.75 (35% of respondents gave a minimum score of 1 or 2 and 44.7% gave a neutral score of 3). No significant differences were found in the assessment of this indicator according to location in urban or rural areas. However, entrepreneurs in rural areas rated this indicator slightly more positively (positive ratings 25.5%; average=2.8) than those in urban areas (positive ratings 18.5%; average=2.7).

The digital skills of employees were rated quite highly by entrepreneurs: 40.6% of respondents gave a maximum score of 4 and 5, 38.1% - neutral with 3; average = 3.2). There were no significant differences in the rating of this indicator according to the location in urban or rural areas.

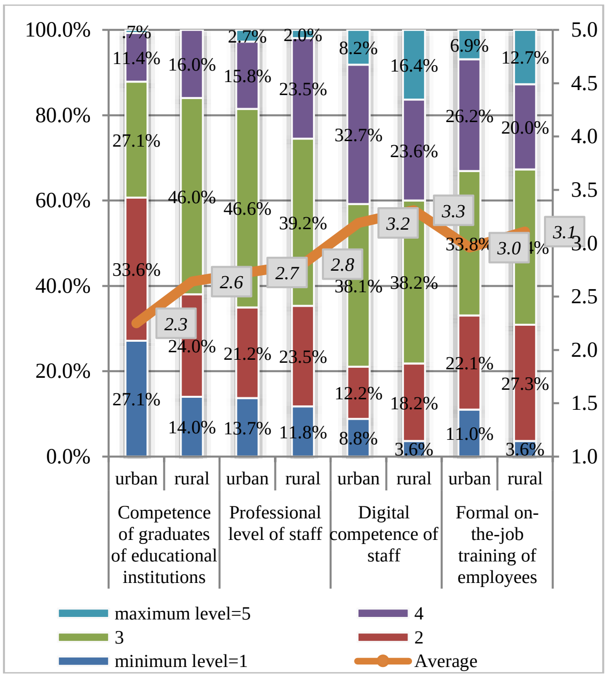

Fig. 4. Evaluation of indicators characterising the level of competence of staff and the organisation of trening

Source: prepared by the authors on the basis of the survey of entrepreneurs, 2022.

The level of formal on-the-job training of employees in the workplace was rated closer to the average: 67.5% of respondents rated the formal training of employees with a score of 3 or more, indicating a neutral or positive assessment of this indicator (average =3.0). There are no significant differences in the rating of this indicator according to location in urban or rural areas, but a higher proportion of entrepreneurs in urban areas rated this indicator negatively (with a score of 1 and 2), with 33.1% negative ratings (average= 3.0), compared with those in rural areas, with 30.9% negative ratings (average= 3.1). This may indicate that although there is a greater variety of formal training opportunities for employees in urban areas, there are also higher expectations from employees (Fig. 4).

We find that enterprises in rural areas tend to be slightly more positive in their assessment of graduate skills and employee skills, while those in urban areas are more critical in their assessment. On the other hand, no significant differences were found in the assessment of digital skills of employees and the level of formal training of employees according to urban or rural location, with entrepreneurs in both locations giving neutral to positive assessments.

The ***level of impact of population migration and emigration on business*** was rated most negatively by entrepreneurs, indicating a major challenge in terms of access to human capital (about 79% of entrepreneurs rated these indicators negatively with a minimum score of 1 and 2, average =1.84 and 1.83 respectively).

It is worth noting that there are significant discrepancies in the assessment of these indicators by place of residence, with the proportion of rural entrepreneurs for whom labour migration is an obstacle being assessed negatively by 92.7% of respondents, which is 19.1 p.p. higher than the proportion of urban respondents (73.6%). A similar discrepancy is observed in the assessment of the impact of emigration on business, with a significantly higher proportion of rural entrepreneurs rating the impact of population emigration on business development as negative (89% of rural entrepreneurs compared to 74.6% of urban entrepreneurs).

The main factors influencing labour migration are primarily economic: low wages, limited employment opportunities in rural areas (except in agriculture), and living conditions in rural communities. The lack of job opportunities and the unattractiveness of the jobs available often lead to the 'depopulation' of rural areas through internal and international migration. The majority of internal migration is strongly oriented towards urban areas, especially from the central region of the country towards Chisinau, contributing to the process of urbanisation, but also to asymmetric regional development [19].

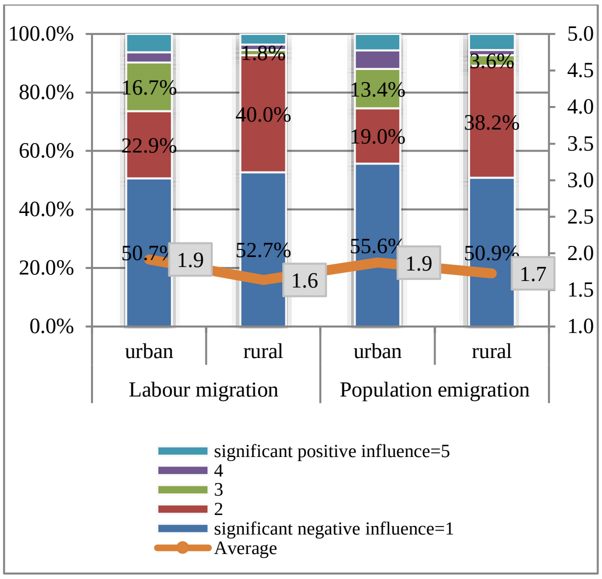

Fig. 5. Evaluation of indicators characterising the degree of impact of population migration and emigration on the business

Source: authors' elaboration based on entrepreneurs' survey, 2022.

International migration for work is mostly a result of the lack of employment opportunities and low wage levels in the domestic market. By 2019, about 17.6% of Moldova's total population was living abroad, of which more than half (56.5%) were aged between 20 and 64 [15].

CONCLUSIONS

The main challenges in the area of human capital are mainly related to the following aspects:

-The decline in the labour force poses a serious threat to business development, which is exacerbated by the fact that the number of inactive people significantly exceeds the number of active people. This can also affect economic development, innovation capacity and consequently business development.

-Adding to the complexity of human resource issues is the brain drain. Current data suggest that emigration is indeed a significant phenomenon. While migration has a major impact on employment, including in urban areas, entrepreneurs believe that the impact is particularly strong in rural areas. In particular, young people from rural areas are less likely to find employment, leading them to migrate massively to cities or abroad. The disproportionate migration of young talent from rural to urban settings or abroad not only limits the pool of skilled workers available to enterprises but also diminishes the innovation potential and competitiveness of rural-based businesses.

-The prevalence of people with a high level of education is a crucial aspect of human capital. However, the share of people with higher education in the labour force is much lower in Moldova than in the Member States of the European Union, and discrepancies in the distribution of the labour force by level of education and place of residence can threaten the development and competitiveness of businesses, especially in rural areas.

-The results of the questionnaire addressed to entrepreneurs in Moldova suggest that there are three main concerns related to human resources: the level of availability of different categories of human resources, the level of competence of human resources, and the degree of impact of migration and emigration on enterprises.

-The perception of highly skilled professionals' availability and accessibility is generally negative in both urban and rural areas. While opinions on the availability of unskilled labor vary, it can pose a significant barrier, especially in rural regions where access to such labor is perceived as challenging by a slightly higher proportion of entrepreneurs.

-The competence of graduates from educational institutions is generally assessed negatively, indicating concerns about adequate preparation for current needs. Significant contrasts exist between urban and rural settings. Urban entrepreneurs are more pessimistic on this topic. The difference in job requirements could explain why entrepreneurs in urban and rural locations in the Republic of Moldova assessed the competence of graduates differently. Enterprises in urban areas may have different specialisations than those in rural areas, which could lead to a need for different skills and competences among graduates.

-Migration and emigration of the population remains a major concern for most entrepreneurs, with a negative impact on the labour market and the business environment. The differences between urban and rural areas are significant, with entrepreneurs in rural areas feeling the impact of this phenomenon on their businesses more acutely.

Addressing these human capital challenges is vital to improve entrepreneurs' access to the human resources and for enhancing the competitiveness of Moldovan enterprises. Implementing targeted solutions, such as training and education programs, employment incentives, and rural infrastructure development, can help bridge the gaps in human resources availability and stimulate economic development, thereby bolstering the competitiveness of businesses in both urban and rural environments.

ACKNOWLEDGEMENTS

The research was performed within the framework of Subprogram 030101 „Strengthening the resilience, competitiveness, and sustainability of the economy of the Republic of Moldova in the context of the accession process to the European Union" and the research project "Multidimensional assessment and development of the entrepreneurial ecosystem at national and regional level to boost the SME sector in the Republic of Moldova" (20.80009.0807.38), institutional funding.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ANALYSIS OF FACTORS INFLUENCING THE SUSTAINABLE COMMERCIALIZATION OF NON-TIMBER FOREST PRODUCTS BY RURAL HOUSEHOLDS IN DELTA STATE, NIGERIA

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Abstract

The research was on the analyses factors influencing sustainable commercialization of Non- Timber Forest Products (NTFPs) among rural households in Delta State, Nigeria. The sampling techniques used to select 340 rural households was the multistage random sampling. Data were gathered with the aid of a structured questionnaire and analysed using descriptive statistics and regression analysis. Results showed that about 66.5% men and women of active age were involved with respect to NTFPs commercialization. There were more head of households with formal education (51.8%), though they were more of First School Leaving Certificate (FSLC). The study found the mean household size of 8 persons. Commercialization of NTFPs was not sustained. Forest conservation was poor and deforestation was high (72.5%). The regression analysis with an R^2value of 0.948 and F-ratio of 254.712 implied a significant impact between the dependent and independent variables at 0,05 level. The explanatory coefficients and t- values (in parenthesis) of educational qualification 0.437 (2.758), access to technology 2.695 (2.324), access to credit4.415(5.721), total household size 2.421(3.677), amount of NTFPs resources owned 2.68 (4.434) and extension services received 2.593 (3.316) were significant. Recommendations include improvement in technology used in NTFPs production. Adopting participatory approach towards NTFPs management.

Key words: *factors, sustainability, commercialization, NTFPs, rural household*

INTRODUCTION

There are many off-farm activities but the rural people especially the poor are dependent on forest for most of their livelihood. Forest are those resources that can produce forest products which are farm bush, and bush fallow, trees on farms, woodland and scrubland. They also include ecosystem dominated by trees [7]. Forest plays important role in rural household employment, consumption and income. The roles include the use of forest for building materials animal fodder and live fencing. Forest provides additional income to the rural households through the sale of processed products especially food products. Forest act as food security before harvest and during hunger periods [5]. In recognition, the United Nation millennium development goal included the forest because of its role in livelihood and stability of the environment through forest conservation. Over 90% of the rural population in Nigeria depends on forest for their economic survival and livelihood [19]. Among the forest products is a group known as non-timber forest products (NTFPs). Apart from the commercially exploited timber, all other forest products are called non-timber forest products (NTFPs) [7]. NTFPs can originate from animals or plants. Examples of NTFPs are fuelwood (which include charcoal, sawdust and firewood), chewing stick, tanning extracts, latex, fodder, sponges, medicinal plants, jute fibres, honey, cocoons, natural vanish, cloth, bee wax, rubber, mushrooms, resins and gums, decorative beads, forest games, bast fibres, bark and lacs, tooth cleaners, clean water, wine, fruits beverages, nuts and oil. NTFPs account for so many animal and plant species which are collected from cultivated, semi-wild and wild areas. In order to reduce the scope of the study and paucity of data that will be generated and managed within the period, only NTFPs from plant origin will be considered. [9] found that NTFPs from plant origin serve as medicine, food and raw materials to rural households and their cottage industries. Fuelwood is very significant and very commercialized among the plant NTFPs and depended upon by rural households for cooking. Findings from [1] showed that in Nigeria about 60-70% of domestic energy supply comes from fuelwood. [12] found that the values of NTFPs were higher when compared to the values of cultivated crops and when income from NTFPs was excluded from the total income of the rural household income generating activities, poverty increased in the rural household. Similarly in a study that compared the contributions of the various rural income sources to rural household total income, it was observed that while Agriculture contributed 39.3%, NTFPs contributed 33.8% [13]. Sustainable commercialization of NTFPs is possible with the availability of NTFPs. This can only be possible with a well conserved NTFP s. Sustainable management of species for the product they yield and to ensure their availability in future is called conservation [17]. Conservation may be ex-situ or in-situ. Conservation of species outside their natural habitat is known as ex-situ while conserving species in their natural habitat is known as in-situ conservation [11]. [2] stated that successful conservation will happen if the rural people are allowed to participate. This is because much will be gained by drawing on their knowledge of NTFPs which can in turn lead to building upon a stainable system. That commercialization of NTFPs by rural households will improve their income and livelihood is not in doubt. However, the sustainable availability of the NTFPs at their primary resource base which will in turn sustain their commercialization needs investigation. [10] stated that NTFPs is dependable source of food supply and income to the rural household however NTFPs as a resource is diminishing. The Government, environmentalists and users involved in the management of plant NTFPs have expressed concern about how to sustain the availability of the product. This because of the fact that the products are used increasingly without being replaced coupled with the ever-expanding deforestation and degradation of the forest and threatening product availability. [14] observed that only 4% of Nigeria's forest cover is remaining. In fact, many species have been extinct because a substantiative portion of the Nigeria's rich vegetation has been removed [18]. Natural forest loss by far exceeded afforestation and secondary forest growth on previously cleared lands. This has caused a lot of the products not to be available. Harvesting of the products are not controlled and majority of them are over-harvested. Harvesting is also carried out with very destructive methods. Rural households are hardly considered when planning new policies either for the management of forest resources or sustaining the community own forest. The study therefore, investigates what factors affect the sustainable commercialization of NTFPs by rural households.

The main purpose of the study is to analyse factors influencing the sustainable commercialization of NTFPs by rural households Delta State. The research will also address the following specific objectives: Specific objectives include to: (i) determine the socio- economic characteristics of rural households engaged in NTFPs commercialization; (ii) determine the extent of sustainable availability of NTFPs for commercialization; (iii)examine factors that hinder sustained commercialization of NTFPs and (iv) ascertain socio- economic factors influencing sustainable commercialization of NTFPs.

MATERIALS AND METHODS

Area of study

Study area was Delta State. It is estimated that 70 percent of the state population is rural of which 75 percent is engaged in one form of farming or the other [3]. Apart from agriculture majority of the rural population were engaged in non-agricultural activities which include artisanship, business, employment in both public and private sectors, forestry and other forms of wage labour [3]. The state has relatively moderate forest resources in existence [4]. Vegetation of the state ranges from mangrove swamps along the coast to rainforest in the central and northern areas of the state. The state's wide coastal belt is interlaced with numerous rivers, creeks and creek lets while the hinterland has many perennial rivers and streams which form part of the Niger Delta. The total land area of Delta state is estimated at 17,698 square kilometres The annual average rainfall is 241.52mm, temperature is 28.64^{O}C while humidity is 81.14%.

Sample and Sampling Techniques

The State is divided into 3 Agricultural zones with 25 Local Government Areas (LGA). The 3 Agricultural Zones include Delta North (9 LGAs), Delta Central (8 LGAs) and Delta South (8 LGAs). Multistage sampling technique was used for the study. The first stage was the selection from the 3 Agricultural zones, 2 local government areas each giving a total of 6 LGAs. These LGAs were purposively chosen since they were identified from Delta State Ministry of Environment to have forest resources. The next stage was the selection of villages. Through random sampling techniques 4 rural villages were selected from each of the LGAs chosen from the list of villages compiled by the Delta State Ministry of Lands and Survey, Asaba. These villages and their LGAs were Oshimili South – Obiokpu, Oko-Anala, Oko-Ogbele and Akpako. Ndokwa East – Utchi, Abala, Oshimili and Asaba-Ase. Ethiope West – Ovade, Otefe, Jesse and Oghareki. Okpe – Jakpa, Aragba, Ometan and Jeddo. Patani – Bulou-Angiama, Koloware, Odorubu and Toru-Angiama, Isoko South – Irri, Uro, Uzere and Ada. This selection gave 24 villages.Households formed the final sampling stage.Selection of households will be done through simple random sampling. With the assistance of the village heads, the list of the total number of households in each village was compiled. There was a total of 1,488 households in the 24 villages selected for the study. The sample for the study will be determined using the equation: [6]

$$n = \frac{N}{1 + N(e^2)} \quad \text{.............................(1)}$$

where:
n = the sample size
N = population size
e = the level of precision

With a population size of 1,488 rural households and precision level of ± 7% at P = 0.5for maximum variability, the sample size was obtained as follows:

$$n = \frac{1{,}488}{1 + 1{,}488(0.07^2)} \ldots. = 179$$

This infers that 179 households will be adequate for the study. However, in order to be within the sample frame and effectively achieve the objectives of the study, a sample size of

Fifteen (15) households will be randomly selected from each of the24 villages giving a total of 360 household respondents that will be used for the study.

Data Collection

Data was collected through questionnaire, oral interviews and group discussions. The questionnaire was administered on 360 respondents. 20 respondents were unable to complete the questionnaire correctly making such questionnaire to be incomplete and invalid. Such questionnaire was discarded and was not used for computations. The remaining 340 respondents' questionnaire was successfully completed and was used for data analyses.

Analysis of data

Data was analysed with descriptive statistics and multiple regression analysis. Descriptive statistics include frequency distribution, percentages and mean.

The extent of availability of plant NTFPs to rural households for commercialization was analysed using a 4-point Likert scale of 1 – Not available (Na), 2 – Diminishing availability (Da), 3 – Available (A) and 4- Very available (Va)

The assigned mean value is 1+2+3+4= 10
The number(n) = 4
Mean = 10/4 = 2.5.

Decision rule: Any mean above 2.5 is accepted while means below 2.5 is rejected.

Multiple Regression Analysis

$$Y_1 = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9) + U \quad \text{...(2)}$$

where:

Y_1 = Sustainable commercialization of NTFPs
The independent variables include:
X_1 = Educational qualification of household head (Number of years spent in formal education)
X_2 = Access to technology
(1 = modern, 0 = otherwise
X_3 = Access to credit (₦)
X_4 = Access to extension services (1 = access, 0 = otherwise)
X_5 = Total household size
X_6 = Number of members of household engaged in NTFPs employment
X_7 = Hours spent on NTFPs employment
X_8 = Gender of household head
X_9 = Amount of NTFPs resources owned (₦)
Various functional forms such as linear, semi-log and double-log were fitted to the data to obtain model estimates.
The model with the best fit, in terms of F-value, R^2 and individual coefficients was the linear form and was selected for detail interpretation.

RESULTS AND DISCUSSIONS

Socio- economic characteristics of rural households engaged in NTFPs commercialization

On age, findings revealed that households between the ages of 31 – 60 years constituted 79.7% and were the active age of the household involved in NTFPs activities.

The implication is that for any meaningful intervention in NTFPs activities the target group should be households between the ages of 31 – 60 years.

Findings also revealed that 80% of rural household heads were married. High rate of married households will result to large household size which in turn may influence the population engaged in NTFPs activities.

A mean household size of 8 persons was obtained. Household size of 8 persons has been found to have direct relationship to NTFPs exploitation [8]. The study also found that majority of the respondents had formal education. However, a further breakdown showed that majority of those with formal education are those with First School Leaving Certificate (FSLC) with a rating of 45.6%. The implication is that with time these FSLC respondents tend to forget what they have learnt since they hardly practice them due to the kind of activities they are engaged. This may influence enlightenment on controlled extraction of NTFPs, conservation of NTFPs, value addition and commercialization of NTFPs.

Table 1. Socio- economic characteristics of rural household respondents

Characteristics	Frequency	Percentage	Mean
Age			
20 – 30	19	5.60	
31 – 40	90	26.50	
41 - 50	101	29.70	
51 - 60	80	23.50	
61 – 70	43	12.60	
Marital Status	272	80.0	
Married	36	10.60	
Widowed	4	01.2	
Single	28	8.20	
Divorced			
Sex			
Male	142	41.80	
Female	198	58.2	
Household Size	11	3.24	8 persons
Less than 4 persons	80	23.52	
4 – 6	187	55.0	
7 – 9	62	18.24	
10 – 12			
Educational Qualification	29	8.60	
Post-Secondary	76	22.40	
Secondary	155	45.60	
Primary	80	23.50	
Non- Formal			
Occupation			
Main Occupation	340	100	
Agriculture	340	100	
Forest and Tree Products			
Other Occupations	75	22.10	
Artisan	121	35.60	
Business	78	22.90	
Agricultural Labour	66	19.40	
Public and Private sector employment			

Source: Field Survey, 2023.

Table 1 also showed the common occupations engaged in by rural households. The main occupations were Agriculture and Forest and Tree Products (FTPs) activities. Other occupations engaged in by rural households include business with the highest proportion of 35.6%. This was followed by agricultural labour and artisans. In [12] Forest and Tree Products activities were usually grouped with agriculture but in this study, they were separated to find out the contributions of each sector to the rural economy.

Extent of sustainable availability of NTFPs for commercialization

Among the NTFPs identified by the rural households in the study area as commercialized, the study selected 24 NTFPs for analysis. The result was as presented below in Table 2.

Table 2. Extent of sustainable availability of NTFPs for commercialization

S/N	Common Name	Local Name (Igbo)	Botanical Name	Uses	Mean	Remark
1	Fuel wood			Fuel	3.15	A
2	Chewing stick	Atu	*Massularia acuminate*	Mouth cleaning	1.65	NA
3	Walnut	Ukpa	*Juglans regia*	Fruit	2.10	DA
4	Pear	Ube Igbo	*Canarium schweinfurth*	Fruit	2.18	DA
5	Mai-Mai leaves	Akwukwo Uma	*Thaumatococusdanielli*	Wrapping	2.05	DA
6	African plum	Mbebe Igbo	*Vitex donianu*	Fruit	1.85	NA
7	African kino tree	Ora	*Pterocarpus spp*	Leaf/food	2.15	DA
8	Kolanut	Oji	*Cola acuminate/nitida*	Entertainment	3.04	A
9	Hot leaf	Uziza	*Piper guineense*	Spice/food	2.05	DA
10		Uda	*Xylopia aethiopica*	Spice/food	2.06	DA
11	Mushroom	Elo		Food	2.35	DA
12	Native pear	Ube	*Dacyodis edulis*	Fruit/food	3.05	A
13	Locust bean	Ukpaka	*Penaclatramacrophylia*	Food	2.45	DA
14	Raffia palm	Ngwo	*Raffia soup*	Wine/building materials	1.35	NA
15	Oil palm	Nkwu	*Elaeisguineensis*	Wine/building material	3.12	A
16	Salad	Okazi	*Gnetumafricanum*	Leaf/food	2.25	DA
17		Utazi	*Gongronema latifolia*	Spice/food	3.10	A
18	Alligator Pepper	Ose Oji	*Affromomumspp*	Entertainment/Medicine	2.08	DA
19	Bitter Kola	Akuilu	*Garcina Kola*	Entertainment/Medicine	2.44	DA
20	Bush Mango	Ogbono/Ugiri	*Irvingiagabonensis*	Food	2.02	DA
21	Bread Fruit	Ukwa	*Treculia Africana*	Food	2.18	DA
22		Icheku Oyibo	*Tramarindusindics*	Fruit	2.18	DA
23	African Apple	Udara	*Chrysophyllum Albidum*	Fruit/Food	3.05	A
24	Sponges			Washing	1.65	NA

Source: Field Survey, 2023.

Table 2 showed that the mean values of 6 of the items used namely, fuel wood (3.15), Kola nut (3.04), Oil palm (3.12), Africa Apple (3.05), *Gongronema latifolia* (3.10) and native pear (3.05) were rated to be very available, 13 of the items namely: Bread fruit (2.18), bush mango (2.02), Alligator pepper (2.08), Bitter kola (2.44), *Tramarindusindics* (2.18), Hot leaf (2.05), *Xylopia aethiopica* (2.06), Mai-Mai leaves (2.05), Locust Bean (2.45), *Gnetum africanum* (2.25), *Ptercarpusspp* (2.15), *Canarium schweinfurth* (2.14), Walnut (2.10), Sponges and Mushroom (2.35) were rated as having diminishing availability while 4 namely, *Vitex donianu* (1.85), Sponges (1.65), Raffia Palm (1.35) and Chewing stick (1.65) were rated as not being available

Factors hindering sustained commercialization of NTFPs

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 3 showed that deforestation with a rating of 74.44% was a major hinderance to sustainable availability of NTFPs and hence their sustainable commercialization.

Table 3. Factors that hinder sustained commercialization of NTFPs

S/N	Description	Frequency	Percentage
1	Deforestation	253	74.44
2	Paying attention to conservation	89	26.17
3	In-situ and ex-situ tree planting culture	95	27.94
4	Technology used for NTFPs	123	36.17
5	Adopting participatory approach to forest management	95	27.94
6	Enforcing regulations on NTFPs removal and replacement	111	32.64
7	Price at which NTFPs are sold	141	41.47

Source: Field Survey, 2023.

Diminishing forest means alteration of ecosystem and depletion of forest resources. [18] observed that a greater proportion of Nigeria's forest has been removed and many species have gone into extinction. Findings also showed that paying attention to conservation received a low rating of 26.17%. The implication is that NTFPs commercialization will not be sustained since it will be difficult to maintain regular supply of the NTFPs from primary resource base. There was also poor in-situ and ex-situ tree planting with a rating of 27.94%. Planting of NTFPs will ensure availability and sustainability. [14] recommended consciously planting forest resources and being highly committed to afforestation. Technology for NTFPs received low rating of36.17% showing that poor technologies were used. Use of poor technology will affect efficiency in harvesting, processing and marketing which will in turn affect value addition to the NTFPs and income generated. Findings also revealed that participatory approach which will include the rural households was not adopted in forest management with a rating of 27.94. This showed that availability and sustainability of the NTFPs will be uncoordinated and in the long run affect commercialization. [15] stated that top – bottom approach is being used in the conservation of the forest with little or no participation from the rural communities.

[2] recommended that rural households should be allowed to participate in forest management for good result to be achieved. This is because the indigenous knowledge of forest and forest products possessed by these locals which can help to create a sustainable system. The study also found that regulations on NTFPs removal and replacement was not enforced with a rating of 32.64%.

[16] reports that State Department of Forestry (SDF) and Local Governments are responsible for the regulation and control of NTFPs extraction but that these regulations were not enforced which brings about lack of management and for some NTFPs unsustainability of their harvesting. Prices at which NTFPs are sold had reasonable rating of 41.47%. [12] found that the values of Forest and tree products were usually higher than the cultivated crops. A major reason is that NTFPs demand is high while their supply is unsustainable which drives the price high for the quantity available.

Socio-economic factors influencing sustainable commercialization of NTFPs

To ascertain the socio-economic factors influencing sustainable commercialization of NTFPs, multiple regression analysis was carried out. The four functional forms – linear, double log, semi-log and exponential were used. Linear functional form was selected since it provided higher number of variables with significant levels and also based on its records of having best R^2, F- ratios and also best coefficients when signs and significant were considered. From the linear regression analysis result in Table 5, the R^2 value of 0.948 revealed that 94.8% of the variations in dependent variable (Sustainable commercialization of NTFPs was accounted for by variations in the independent variables put together. The adjusted R^2 also supported the claim with a value of 0.964 or 96.4%. This implied that the independent variables explained the behaviour of the dependent variable at 96% level of confidence. The calculated F-ratio of 242.817

was greater than any critical F-ratio value and implied that there was significant impact between dependent variable and the independent variables.

Table 4. Regression estimates of socio-economic factors influencing sustainable commercialization of NTFPs'

S/N	Explanatory Variables	Coefficients	Std Error	t-ratio
1.	Educational qualification of household head	0.437	0.188	(2.758) *
2.	Access to technology	2.695	0.964	(2.324) *
3.	Access to credit	5.415	1.146	(5.721) *
4.	Extension services received on NTFPs	2.593	0.898	(3.316) *
5.	Household size	2.421	0.574	(3.677) *
6.	Number of members of household engaged in NTFPs employment	0.030	0.123	-0.243
7.	Hours spent on NTFPs employment	-0.242	0.039	(6.152) *
8.	Amount of NTFPs resources owned	2.683	0.000	(4.347) *

Constant term = 27.455
R^2 = 0.948
Adjusted R^2 = 0.964
F-Value = 242.817
* = 0.05 level of significance
( ) Number in parenthesis is t-value
Source: Estimated from Field Survey, 2023.

The coefficients and t-values (values in parenthesis) of educational qualification of household head 0.537 (2.858); access to technology 2.596 (2.694) access to credit 5.514 (4.811); total household size 2.166 (3.776); amount of FTP resources owned 2.83 (4.34) were all positively signed and significant at 0.05. These variables conform with *apriori* expectations. That is, they were significant and positively affect sustainable commercialization of NTFPs resource base. Analysis showed that education as a human capital development makes an individual to be more informed which attracts better options and diversify methods of sustainable availability from NTFPs resource base. Access to technology was also significant and positive. Technology aids planting and maintenance at both in-situ and ex-situ conservation. Technology is also important in communications and information dissemination which are important in commercialization.

Access to credit was positive and significant. Credit improves production, processing and marketing. It also influences the quantity that is eventually planted and replenished. Credit will be used for planting and replanting of NTFPs when they are depleted in quantities from their natural resource base Credit could also be used to procure technology. Household size was also significant and positive. Household size influences commercialization since the more the number in the household the higher the chances of more members engaging in commercialization. Amount of NTFPs resources owned was positive and significant at 0.05. Generally, resources owned influences sustainable commercialization. Resource ownership will help to control harvesting and maintenance of the NTFPs resource base. Resource owners could use their land to raise plantation of economic trees or leave them as forest for availability of NTFPs. Receiving extension advise will help the rural households to manage the NTFPs resource base which in turn will help sustained availability of NTFPs for commercialization.

However, the coefficient of hours spent on NTFPs employment was negatively signed with a value of -0.242 (6.152) but significant. The number of hours spent on NTFPs employment negatively affect sustainable availability of NTFPs since members of the rural households may concentrate more on collections than replenishment. From the explanatory variables analyzed thus far, the t-values were all significant and the probability of rejecting any of them was less than 1% confidence level. The standard errors of these explanatory variables were also very low.

Coefficients and t-values of number of members of household engaged in NTFPs employment (0.030) were insignificant at 0.05. They were therefore ignored. It implied that they do not have effect on sustainable commercialization of NTFPs.

CONCLUSIONS

Sustainable commercialization of NTFPs is possible if there is sustainable availability of the products from the primary resource base. Findings of the study revealed that NTFPs were a diminishing resource. NTFPs were collected from their resource base without planed replacement. These were due to certain factors such as deforestation, poor tree planting culture, poor methods of forest conservation, use of poor technology and not adopting participatory approach to forest management among others. Hence there is urgent need to rebuild and restore the degraded forest in order to sustain availability of NTFPs. Recommendations include the involvement of youths in the plan to restore the forest since they are active and major culprits of deforestation activities in the rural areas. Introduction of "permmitteeship" system to regulate NTFPs removal and rural communities should work with State Government in ensuring that only permitted members were allowed to harvest NTFPs sustainable in the forest. Improvement in technology used in NTFPs production, processing and marketing. Adopting participatory approach towards NTFPs management. Enlightenment and education of rural households on deforestation and the need for forest conservation. There should be research into ways of improving values of NTFPs to attract sustainable commercialization.

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COMPARISON OF YIELD AND QUALITY OF PINEAPPLE FRUIT UNDER IRRIGATED AND RAINFED CONDITIONS IN GHANA: A PERSPECTIVE FROM FARMERS' FIELD CONDITIONS

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Abstract

While most commercial pineapple farms in Ghana cultivate under rainfed conditions, few supplement the rains with irrigation, which is a good agronomic practice. In this study, pineapple fruit yield and quality (brix and weight loss) were assessed in rainfed and irrigated fields in Ghana's Coastal Savannah agroecological zone in 2022 production period at Bomarts Farms. Forty (40) matured pineapple fruits from a 50 × 50 m plot were sampled under drip and rainfed conditions each. Weight of fruits were in the range of 609 g and 1,524 g inclusively. The average least fruit weight for drip-irrigated and rainfed fields were 652 g and 609 g, respectively. The variation of fruits weight under both conditions was not significant (p-value = 0.815). Generally, the weight loss was high in fruits from irrigated (drip) fields during the storage period. The brix for drip-irrigated pineapple was lower (12.8 ^{0}Bx, 15.6 ^{0}Bx and 19.8 ^{0}Bx) than pineapple cultivated under rainfed conditions (13 ^{0}Bx, 16 ^{0}Bx, 21 ^{0}Bx). Annual rainfall in the study area (840.7 mm) compared to requirement (1,000 mm) for pineapple plants poses a challenge to year-round production, and presents an opportunity for farmers to adopt good agronomic practices to sustain production in the coming years.

Key words: *coastal savannah, irrigation, pineapple, rainfed*

INTRODUCTION

More than 95 % of agricultural production in Africa is rainfed, providing employment to about 65 % of the people in the region in the last decade [20]. Projections from other studies [2, 10, 12] have shown that climate variability will worsen in the future because of population growth, urbanization, industrialization, and nature-based extremities such as floods, drought, amongst others [17]. These extremities affect crop production and warrant the adoption of good agronomic practices to sustain production [14].

Pineapple (*Ananas comosus*) is a Crassulacean Acid Metabolism (CAM) plant with a photosynthetic adaptation which makes it drought-tolerant. It is commercially propagated for its nutritious fruit [7] and it is the only specie in the *Bromeliad* family that is widely grown for its fruit [16]. Pineapple is considered as the third most important tropical fruit after banana and citrus, in terms of global production [13]. The exceptional aroma and flavour, appealing appearance, and important nutritional makeup (vitamins, minerals, fibre) makes it the consumer's preferred choice of tropical fruit [1].

Pineapple is an important export crop in Ghana with a well-developed and structured sector [15]. The main production area is the country's Coastal Savannah agroecological zone where most cultivation is rainfed [22]. Its growth can be retarded due to seasonal drought and water shortage [24, 11], and this will affect the fruit yield [3]. According to [8], pineapple cultivated under irrigation produces high fruit yield and good quality. It is therefore important for farmers to consider the incorporation of appropriate irrigation practices, and adjust planting calendar to account for the impact of rainfall variability [24, 14].

Good pineapple fruit quality is attributed to growing sites having a combination of relatively cool night temperatures, sunny days, and high day temperatures [11]. According to [22], climatic conditions such as rainfall and temperature have a significant impact on pineapple production, especially in the tropics, with a suitable temperature and rainfall range of 18 to 32 ^{0}C and 1,000 to 1,500 mm/annum of rainfall, respectively [3]. Generally, according to [4], pineapple requires a minimum monthly rainfall total of 50 to 100 mm. If the annual rainfall is less than 500 mm, irrigation is required for better yield [4]. Thus, tropical countries with enough water available for crop production are found to be most suitable for the fruit's cultivation [3, 24]. In this study, pineapple fruit yield and brix and weight loss were assessed under both rainfed and irrigated fields in Ghana's Coastal Savannah agroecological zone.

MATERIALS AND METHODS

Pineapple production in Ghana is concentrated in the Coastal Savannah (CS) agroecological zone. This zone lies between latitude of 4.5^{0}N and 6^{0}N, and longitude of -0°13'56" to 0°58'42" W, and it is distinguished by its relatively low rainfall of 800 mm distributed in two seasons (major and minor) and grassland savannah vegetation [6]. The study was carried out at Bomarts Farms in the CS agroecological zone, where pineapple is produced both under rainfed and drip irrigation.

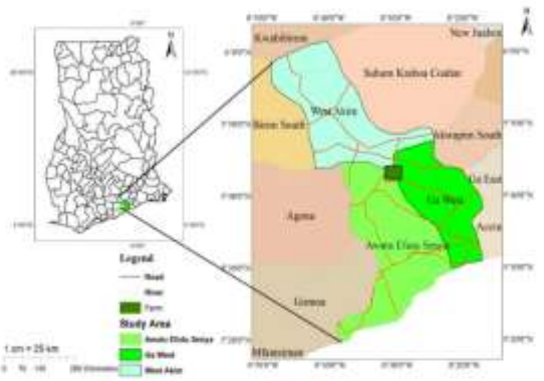

Fig.1. Map of Study Area Showing Bomarts Farms in the Coastal Savannah (CS) agroecological zone
Source: Author, 2022.

The average yearly rainfall in the agroecological zone is 800 mm. While the minor season's rainfall peaks in October and its dry phase lasts from December to March, the major rainy season spans from April to mid-July and is followed by a one-to-two-month dry period. The rainfall dispersion varies and rainfall fluctuations are a major setback for agricultural production. The zone experiences high temperatures which are about 26.5 °C on average throughout the year. Humidity is high in general (65–95 %), although it is lower during the warmer months, especially in January, when the northeast harmattan winds are prevailing [18]. Pineapple cultivation is supported by the type, texture, and composition of the soil in this area, which is home to a number of sizable pineapple farms, including Bomarts Farms, which was chosen for this study. Climate data (1989 – 2019) for the Coastal Savannah Agroecological zone, presented in Table 1 were sourced from the Ghana Meteorological Agency.

Table 1. Monthly means of climate data for the Coastal Savannah Agroecological Zone, from 1989 to 2019

Month	T_{min} **^{0}C**	T_{max} **^{0}C**	Humidity **%**	Wind **km/day**	Sun **hours**	Rainfall **mm**
Jan	23.0	32.3	88	210	6.5	12.0
Feb	24.3	33.0	89	273	7.4	27.1
Mar	24.5	33.0	90	261	7.1	56.4
Apr	24.5	32.8	90	240	7.5	99.0
May	24.1	31.9	91	226	6.9	164.9
Jun	23.6	30.1	92	230	5.3	204.0
Jul	23.0	29.0	93	274	5.2	65.1
Aug	22.6	28.9	93	276	4.5	22.0
Sept	23.1	30.0	92	304	5.5	45.3
Oct	23.3	31.0	91	273	7.4	85.9
Nov	23.5	32.1	90	219	8.1	38.0
Dec	23.4	32.3	89	187	7.4	21.0
Avg/Tot.	**23.6**	**31.4**	**91**	**248**	**6.6**	**840.7**

Source: Ghana Meteorological Agency, 2022.

As shown in Table 1, from 1989 to 2019, minimum daily temperature was about 23.6 °C and maximum 31.4 °C, with relative humidity ranging between 88 % and 93 %, with an average of 91 %. January had the lowest monthly rainfall (12.0 mm), while June had the greatest (204 mm). Six months (January, February, August, September, November, and December) had rainfall values below 50 mm, and this is below the monthly water requirement for pineapple plants in the tropics. [3] considers annual rainfall of 1000-1,500 mm as suitable for proper growth and good yield, and in every month, according to [4], rainfall of 50-100 mm is appropriate.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Pineapple Yield and Fruit Quality Assessment

Fruit Yield and Percent Weight Loss

(i). Fruit yield: Forty (40) matured fruits were sampled from a 50 x 50 m area under both rainfed and rainfed conditions during harvesting. The fresh weight for both conditions were determined and the yield for the two fields were computed as:

$$Y_{FF} = \frac{FF}{A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (1)}$$

where:

Y_{FF} – Fresh fruit yield [t ha^{-1} or kg m^{2}],

FF – Total pineapple fresh fruit harvested [ton or kg],

A – Area covered by crops used in FF sampling [ha or m^{2}]

(ii). Percent weight loss of fruit: Percent weight loss was calculated by using the following formula:

Percent weight loss (%WL) =

$$\frac{IW-IF}{IW} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (2)}$$

where:

%WL – percent weight loss,

IW – Initial fruit weight with crown and

FW = Final fruit weight with crown

Moisture content: The percent moisture content was calculated using the following formula:

$$\text{Percent moisture} = \frac{IW-IF}{IW} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

where:

IW – Initial fruit weight with crown and

FW – Final fruit weight with crown

Fruit Quality

Five (5) fully grown pineapple fruits that had not yet turned yellow at the base and had fresh, green crown leaves were randomly chosen from a 50 m × 50 m drip-irrigated pineapple field and that of rainfed field each. The same storage conditions (temperature and relative humidity) were applied to these fruits. Using a digital thermometer-hygrometer clock, the temperature and relative humidity (RH) in the storage area were recorded three times a day – at 6:00 am, 12:00 pm, and 6:00 am – during the course of the 14-day storage period. Before storing each fruit, its weight and diameter were measured using a vernier calliper and a measuring scale, respectively. These measurements were taken every two days. Using a handheld refractometer, the total suspended solids (Brix) was measured.

RESULTS AND DISCUSSIONS

Fruit Weight and Yield

The weight (g) of 40 matured pineapple sampled under drip irrigation and rainfed conditions is presented in Figure 2. The area coverage of the field during the sampling of fresh fruits was 50 m × 50 m.

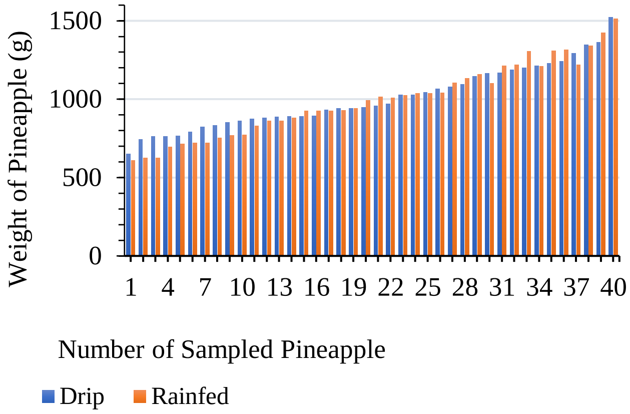

Fig. 2. Weight of fruits from drip irrigated and rainfed plots

Source: Field Studies, 2022.

Fruit weight ranged from 609 to 1,524 g, with 652 g and 609 g, respectively, being the lowest weight of examined fruits from drip-irrigated and rainfed farms. The highest fruit weights from rainfed and drip-irrigated crops were 1,512 g and 1,524 g, respectively. Under drip irrigation, most (10) of the sampled fruits were in the 800 g range as shown in Figure 3. The highest fruit weight was in the 1,500 g range, same as for fruits under rainfed conditions.

As seen in Figure 3, fruit samples from the rainfed field were distributed in weights ranging from 600 to 1,500 g. From drip-irrigated fields, most fruits weighed around 800 g. This could be profitable in instances when the customers require particular fruit size. The outcome of the study agrees with a study by [5] who investigated the effect of irrigation frequency on the growth and yield of pineapple. [9] and [4], indicated that the minimum monthly water requirement of pineapple for good growth and yield is around 50 mm, and if this quantity is not met, the average fruit weight will be compromised.

Table 2 presents the statistics of pineapple weight under both conditions. There was very little variation (11.4 g) in the average fruit weight between the two settings.

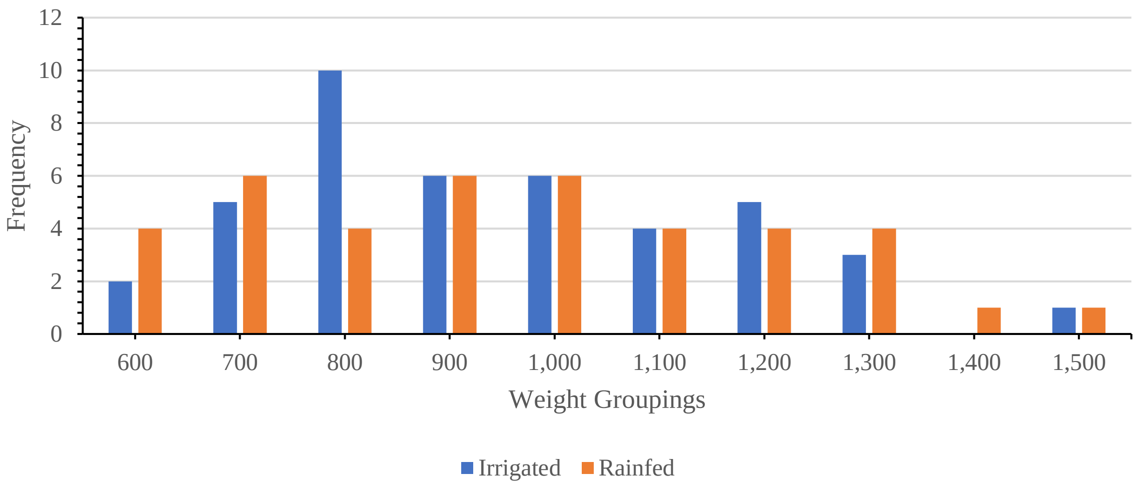

Fig. 3. Pineapple weight distribution under rainfed and drip irrigation
Source: Field Studies, 2022.

Table 2. Statistical analysis of pineapple fruit weight

Variable	Obs	Mean	Std. Dev.	Min	Max	Mean Diff
Weight (g)						11.49
Drip Irr.	40	1,006.4	198.78	652	1,524	
Rainfed	40	995	234.06	609	1,512	

Source: Field Studies, 2022.

Fruit weights under drip irrigation and rainfed conditions did not differ significantly at a 95% confidence interval, according to the independent samples t-test presented in Table 2 (p-value = 0.815).

Weight loss over time

Figure 4 shows pineapple weight loss over a period of 14 days under ambient conditions (28-31 ^{0}C and 60-75 % RH).

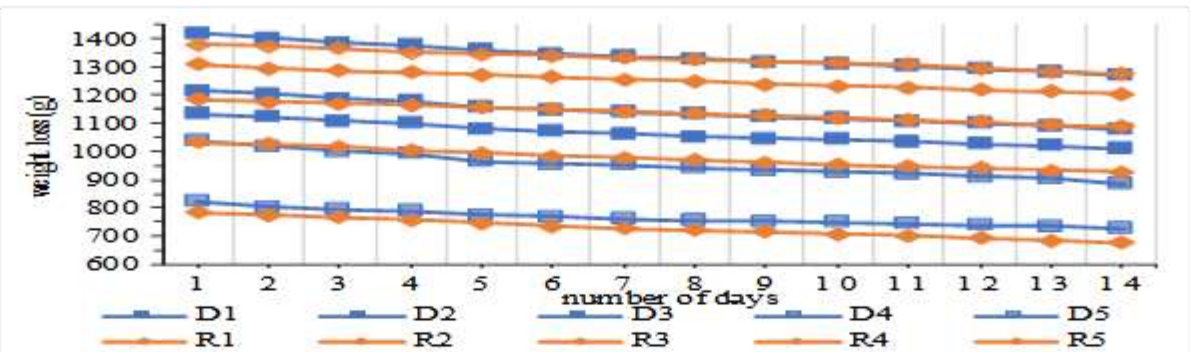

Fig. 4. Weight loss in sampled fruits under each condition, rainfed and drip-irrigation (R1, R2, R3, R4 and R5) and (D1, D2, D3, D4 and D5), respectively over a 14 days period
Source: Field Studies, 2022.

During storage, a noteworthy decrease in the overall weight of pineapples grown with drip irrigation was observed. Fruits from fields with drip irrigation often lost more weight overall over the course of storage (Figure 4). For pineapple grown with drip irrigation, weight loss was greater in the first seven days of storage than it was in the next seven. In contrast to irrigated fruits, fruits grown under rainfed settings showed a range of weight loss values during the course of the storage period. This tendency was different for these fruits. However, the common effect across both drip irrigated field and rainfed field is that the highest weight loss was seen in bigger fruits. These findings supported the work of [19]. Maturity stage and storage conditions play a crucial role in the weight loss of food crops.

Brix content over the storage period

Table 3 Pineapple brix cultivated in rainfed and drip irrigation conditions

Test days	**Brix, ^{0}Bx**		
	Day of harvest	7th day	14th day
Drip Irrigated	12.8	15.6	19.8
Rainfed	13	16	21

Source: Field Studies, 2022.

Three days during the storage process were used to measure the brix: the day of harvest, which also signalled the start of the pineapple's storage; seven (7) days after harvesting; and fourteen (14) days after harvesting. On harvest day, the pineapple planted with drip irrigation had a brix of 12.8 ^{0}Bx, whereas the pineapple grown with rainfed circumstances had a brix of 13 ^{0}Bx as shown in Table 3. After seven days, the readings for pineapple that was grown under rainfed and drip irrigation rose to 15.6 ^{0}Bx and 16 ^{0}Bx, respectively. Customers' chosen range of values was represented by the brix readings in the first week following harvest. Yet, following the first week, the brix values increased significantly to 19.8 Bx for drip feeding circumstances and 21 Bx for rainfed conditions, respectively. The common trend of increase in Total Soluble Solids (TSS) content whilst the fruit changes colour from dark green to yellow has been observed in this and several other studies [21, 23]. In the study by [21], the TSS for ‘Mauritius’ pineapple variety was observed to be 14.73 % whilst the pineapple shell was 100 % dark green. Nonetheless, the TSS was recorded as 17.32 % after 20 % of the shell became yellow, which is consistent with the pattern seen in this investigation.

CONCLUSIONS

Ghana’s coastal savannah is the production hotspot for pineapple cultivation. However, annual rainfall in this area poses a challenge to year-round production. Field study carried on Bomarts Farms showed no significant difference between the weight of pineapple cultivated under drip irrigation and rainfed conditions. Irrigation adoption alone will not produce the desired outcome if other important agronomic practices are not adopted.

ACKNOWLEDGEMENTS

This publication was made possible through support provided by the West African Centre for Water, Irrigation and Sustainable Agriculture (WACWISA), University for Development Studies, Ghana with funding support from the Government of Ghana and World Bank through the African Centres of Excellence for Development Impact (ACE Impact) initiative.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE PLACE AND ROLE OF THE SOUTH-WEST OLTENIA DEVELOPMENT REGION WITHIN THE NATIONAL CEREAL PRODUCTION (2017-2023)

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Abstract

The study focused on assessing the South-West Oltenia region's significance as a key cereal producer in Romania. Data on cultivated areas and cereal production, sourced from the National Institute of Statistics, were analyzed and interpreted for the period 2017-2023 using fixed-base and structural indices along with trend dynamics. The South-West Oltenia region encompasses a total area of 2,921,169 hectares (ranked 7th nationally, accounting for 12.25% of the total), with an agricultural area of 1,796,634 hectares (7th nationally, 12.28%) and an arable area of 1,251,902 hectares (4th nationally, 13.32%).The region has convenient agro-productive conditions for practicing cereal crops, given the climatic factors and some soils found in the region (sandy soils, from the Danube meadow and from the left bank of the Jiu River, for rye cultivation).The region cultivated cereal crops on 5,294,357 hectares (averaging 15.14% of the national total) and produced a total of 24,956,413.71 tons (14.74% of the national output). The average yield per hectare was 4,588 kg (97.33% of the national average). Thus, the South-West Oltenia Region is a significant player in the national cereal market, but there is a need to enhance current performance levels to fully capitalize on the region's potential.

Key words**:** *cereals, total production, cultivated surface, average production,*

INTRODUCTION

The South-West Oltenia Development Region is located, as its official name suggests, in the South-Western part of Romania, covering the entire territory of the historical region of Oltenia. The region is made up of five counties (Dolj, Gorj, Mehedinți, Olt and Vâlcea), which present a rather accentuated diversity of relief (meadow, plain, hill, plateau and mountain areas), somewhat variable climatic conditions (if we refer to the influence of altitude on climate), a differentiated socio-economic development degree (taking into account the existence of development poles around urban centres, such as Craiova, Râmnicu Vâlcea, Slatina, Târgu Jiu or DrobetaTurnu-Severin). The region stands out for a total area of 2,921,169 ha (7th place nationally – 12.25% of the total), an agricultural area of 1,796,634 ha (7th place nationally – 12.28%) and an arable area of 1,251,902 ha (4th place nationally – 13.32%). Taking into account the aforementioned aspects, as well as the agro-productive characteristics, it can be said that the region presents favourable conditions for the practice of cereal crops, even if the current climatic conditions can lead to the manifestation of drought that influences, in a negative sense, the productive potential of these species [1]. It is worth mentioning that some cereal species (in this case grain corn) have a marked ecological plasticity, and it can be successfully cultivated for the region in question [13]. The region is characterized by the existence of a wide range of soils, for which cereal species can be cultivated, as some authors specify [3], even if some of these species are somewhat sensitive to extreme meteorological phenomena [18].
In this context, it must be said that climate change is a threat to the level of agricultural crop production [2]. Climatic factors influence the level of cultivated areas of total production, as well as the economic results obtained by producers [9].
The regional analysis of cereal production within the national context is grounded in

Romania's status as a major cereal producer.[8, 15, 19], and as a result of this aspect, cereal production is preponderant within the vegetable sector and implicitly within agricultural production [5, 10, 11].

At the regional level, but more precisely at the level of Dolj County, the variation in total cereal production is related to the fluctuation of environmental factors [7], such as lack of water (drought) – to which sorghum is more resistant compared to other species, especially due to the particularities of its root system [17].

The importance of cereals is underlined by the versatility of their use at the socio-economic level [4]. For example, cereals play an essential role in human nutrition, but they can also have industrial, fodder, technological importance, etc. [6]. Also, in general, cereals are very much traded, but especially maize and wheat [14, 16].

MATERIALS AND METHODS

The conception and writing of the paper start from the defining aspects of cereal production (cultivated area - ha, total production - t, average production - kg/ha) that were extracted from the official national database [12]. The indicators refer to the overall level of the group and then to wheat, rye, barley and barley, oats, corn grains, sorghum, rice and "other cereals". The analysis presents the state of affairs specific to the period 2017-2023, at the level of each indicator presenting the situation by species for the average of the period.

To develop the paper, thorough documentation was conducted, along with data processing using methods such as percentage analysis and temporal comparison (highlighting indicator dynamics through specific indices) and spatial comparison (determining the region's position within the national context based on its share of area and total production, as well as comparing average yields to the national benchmark).

RESULTS AND DISCUSSIONS

Table 1 shows information on the cultivated area, for the whole group of crops.

The total national area ranged from 5,168,467 ha in 2023 to 5,569,090 ha in 2019. The indicator showed an increase from 2017 to 2021, with varying growth rates: +1.25% in 2018 (reaching 5,257,168 ha), +7.26% in 2019, +2.81% in 2020 (5,338,067 ha), and +3.07% in 2021 (5,351,547 ha), after which it decreases in the case of 2022 and 2023 (-0.16 and -0.46% effective levels of 5,183,820 and 5,168,467 ha respectively). This state of affairs, the uneven evolution, is also evidenced by the levels of the indices with a moving base, which were supra-unit for the years 2018, 2019 and 2021 (101.25, 105.93 and 100.25% respectively) and sub-unit for the other components of the dynamic series (95.85% in 2020, 96.87% for 2022 and 99.70% in the case of 2023).

Table 1. Cultivated area (ha)

Year	Romania			South-West Oltenia Region			
	Effective*	Dynamics **		Effective*	Dynamics **		Share at national level (%)**
		Ibf	Ibm		Ibf	Ibm	
2017	5,192,340	100	100	816,332	100	100	15.72
2018	5,257,168	101.25	101.25	822,223	100.72	100.72	15.64
2019	5,569,090	107.26	105.93	833,352	102.08	101.35	14.96
2020	5,338,067	102.81	95.85	837,868	102.64	100.54	15.70
2021	5,351,547	103.07	100.25	780,482	95.61	93.15	14.58
2022	5,183,820	99.84	96.87	761,261	93.25	97.54	14.69
2023	5,168,467	99.54	99.70	759,953	93.09	99.83	14.70

Source: National Institute of Statistics, online data base, *http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table,AGR108A – Cultivated Area for Major Crops, Classified by Ownership Type, Macro-Regions, Development Regions, and Counties, Accessed on 26.06.2024 [12]. **own calculation.

In the case of the South-West Oltenia Region, the area occupied with cereals was between 759,953 and 837,868 ha in the case of 2023 and 2020, respectively. We can talk about years in which the indicator did not reach the level of 800,000 ha (2023, 2022 – 761,261 ha and 2021

– 780,482 ha), as well as years exceeding this level (2017 – 816,332 ha, 2018 – 822,223 ha, 2019 – 833,352 ha and 2020). The dynamics of the indicator reveal that for the years 2018, 2019, and 2020, the component indices consistently exceeded one (100.72%, 102.80%, and 101.35% respectively, followed by 102.64% and 100.54%). However, for the remaining years in the series, the indices were below one, with values of 95.61% and 93.15% in 2021, 93.25% and 97.54% in 2022, and 93.09% and 99.83% in 2023. On a national scale, the region's contribution varied, ranging from 14.58% in 2021 to 15.72% in 2017 (Fig. 1). Of the seven years that make up the dynamic series, in the case of three years, the share of 15% is exceeded (2017, 2018 – 15.64% and 2020 – 15.70%), and for 4 years the share varied between 14 and 15% (2019 – 14.96%, 2021, 2022 – 14.69% and 2023 – 14.70%).

Table 2. Cultivated area – average of the period, structure by species

Specific.	Romania		South-West Oltenia Region		
	Effective ha	Str. %	Effective ha	Str. %	Share at national level (%)
Total	5,294,357.00	100	801,638.71	100	15.14
Wheat	2,164,875.14	40.89	410,157,86	51.16	18.95
Rye	10,845.57	0.21	2,657.29	0.33	24.50
Barley and two-row barley	448,990.00	8.48	56,118.29	7.00	12.50
Oats	118,832.29	2.24	16,341.00	2.04	13.75
Corn grains	2,461,894.71	46.51	300,641.43	37.51	12.21
Sorghum	10,734.57	0.20	1,857.57	0.23	17.31
Rice	5,992.29	0.11	550.43	0.07	9.19
"Other cereals"	72,192.43	1.36	13,314.84	1.66	18.44

Source:own calculation.

As for the average for the period (Table 2), it was, at national level, 5,294,357 ha, presenting the following structure: 46.51% grain corn (2,461,894.71 ha), 40.89% wheat (2,164,875.14 ha), 8.48% barley and barley (448,990 ha), 2.24% oats (118,832.29 ha), 1.36% "other cereals" (72,192.43 ha), 0.21% rye (10,845.57 ha), 0.20% sorghum (10,734.57ha) and 0.11% rice (5,992.29 ha). In the case of the analysed region, the average area cultivated with cereals was 801,638.71 ha, for which the component elements were: 0.07% rice (550.43 ha), 0.23% sorghum (1,857.57 ha), 0.33% rye (2,657.29 ha), 1.66% "other cereals" (13,314.84 ha), 2.04% oats (16,341 ha), 7.0% barley and barley (56,118.29 ha), 37.51% corn grains (300,641.43 ha) and 51.16% wheat (410,157.86 ha).

In the national context, the region contributed with variable weights, by species, to constitute the general level of the indicator.

Thus, we are talking about shares of: below 10% in the case of rice (9.19%); between 10 and 20% for grain corn (12.21%), barley and barley (12.50%), oats (13.75%), sorghum (17.31%), "other cereals" (18.44%), wheat (18.95%); over 20% at rye level (24.50%). At the global level of the crop group, the South-West Oltenia Region held 15.14% of the national cultivated area (Fig. 2).

The information on total production is presented in Table 3.

The total cereal production, at national level, was between 18,153,714 t in 2020 and 31553279 t in 2018. It can be seen that the indicator increased in 2018 compared to 2017 (+16.27% compared to 27,138,884 t), decreased in 2019 compared to the previous year (-3.72%, effective level of 30,412,426 t), a decrease that is also manifested in the following year (2020 – reductions of 32.11 and 40.31% compared to the reporting bases), after which there is an increase for the year 2021 (+2.40 and +53.09% beside the terms of comparison, an effective level of 27,791,258 t), then in 2022 year, the indicator decreases compared to the reference bases (decreases by 30.50 and 32.13%, effective level of 18,860,679 t), following this, in the final term of the dynamic series, the indicator shows an increase compared to the previous year (+10.20%), reaching an actual level of 20,784,656 tons. At the level of the South-West Oltenia Region, the total production ranged from 2,929,924 t in 2022 to 4,653,133 t in 2018. Outside these limits, there are years with total productions between 3 and 4 million tons (3,076,028 t in 2023, 3,211,456 t for 2020 and 3,345,688 t in 2021), as well as years in which the indicator exceeded the threshold of 4 million tons (4,197,585 t in 2019 and 4,330,567 t for 2017). The dynamics of the indicator is dominated by the sub-unit levels of the component indices, the reference terms being exceeded only in 2018 (+7.45%), 2021 (+4.18%) and 2023 (+4.99%).

Table 3. Total production (t)

Anul	Romania			South-West Oltenia Region			
	Effective*	Dynamics **		Effective*	Dynamics **		Share at national level (%)**
		Ibf	Ibm		Ibf	Ibm	
2017	27,138,884	100	100	4,330,567	100	100	15.96
2018	31,553,279	116.27	116.27	4,653,133	107.45	107.45	14.75
2019	30,412,426	112.06	96.38	4,197,585	96.93	90.21	13.80
2020	18,153,714	66.89	59.69	3,211,456	74.16	76.51	17.69
2021	27,791,258	102.40	153.09	3,345,688	77.26	104.18	12.04
2022	18,860,679	69.50	67.87	2,929,924	67.66	87.57	15.53
2023	20,784,656	76.59	110.20	3,076,028	71.03	104.99	14.80

Source:National Institute of Statistics, online data base,*http://statistici.insse.ro:8077/tempo-online/#/pages-table,AGR109A –Agricultural production of vegetable main crops, by property, development regions and counties (26.06.2024) [12].**own calculation.

This situation highlights the fluctuating evolution of the indicators, marked by specific decreases as follows: -3.07 and -9.79% in 2019, -25.84 and -23.49% for 2020, -22.74% in 2021 beside the first term of dynamic series, -32.34 and -12.43% in 2022, -28.97% for the year 2023 relative to the initial term of the dynamic series.

Compared to the national situation, the region contributed to the total production with weights ranging from 12.04% in 2021 to 17.69% in 2020 (Fig. 1). During the analysed period, only three years exceed the 15% threshold (2022 – 15.53%, 2017 – 15.94% and 2020), and 4 years are below it (2023 – 14.80%, 2018 – 14.75%, 2019 – 13.80% and 2021).

If we analyse the total production in terms of the average of the period (Table 4), we find a general national level of 24,956,413.71 t, a level that is based on sequential contributions of: 0.11% rice (28,011.14 t), 0.12% rye (30,143.43 t), 0.17% sorghum (42,237.29 t), 1.08% each oat and "other cereals" (269,485.57 and 270,163.57 t), 7.15% barley and barley (1,783,382.14 t), 37.56% wheat (9,372,880.57 t),52.73% corn grains (13,160,110 t).

At the regional level, the total production, as an average for the period, reached 3,677,768.71 t, for which the component elements were: 48.32% wheat (1,777,226.14 t), 42.68% corn grains (1,569,678.29 t), 6.25% barley and barley (229,916.29 t), 1.40% "other cereals" (51,355.42 t), 0.97% oats (35,841 t), 0.18% rye (6,615.71 t), 0.13% sorghum (4,644.86 t) and 0.07% rice (2,491 t).

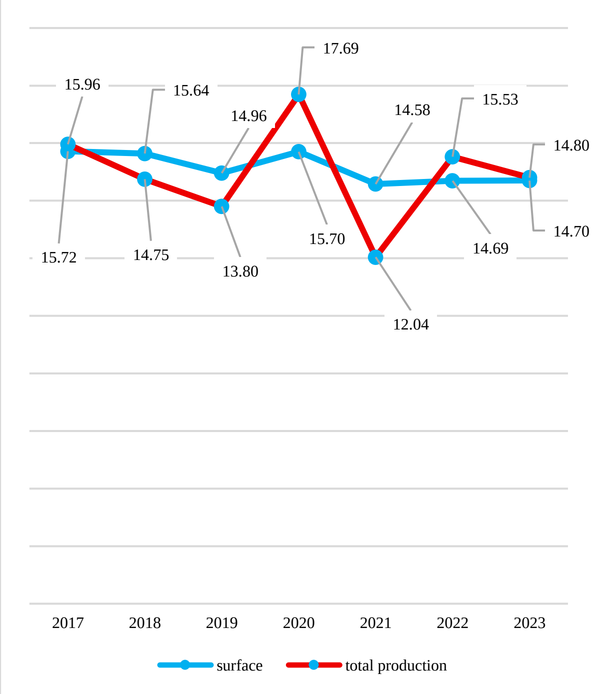

Fig. 1. Cultivated area and total production – regional shares at national level (%)
Source: own calculation.

Compared to the national situation, the region had variable shares, by species, in the direction of achieving the general level of the indicator.

Table 4. The total production – average of the period, structure by species*

Specif.	Romania		South-West Oltenia Region		
	Effect. t	Str. %	Effec. t	Str. %	Share at national level (%)
Total	24,956,413.71	100	3,677,768.71	100	14.74
Wheat	9,372,880.57	37.56	1,777,226.14	48.32	18.96
Rye	30,143.43	0.12	6,615.71	0.18	21.95
Barley and two-row barley	1,783,382.14	7.15	229,916.29	6.25	12.89
Oats	269,485.57	1.08	35,841.00	0.97	13.30
Corn grains	13,160,110.00	52.73	1,569,678.29	42.68	11.93
Sorghum	42,237.29	0.17	46,44.86	0.13	11.0
Rice	28,011.14	0.11	2,491.00	0.07	8.89
"Other cereals "	270,163.57	1.08	51,355.42	1.40	19.01

Source: *own calculation.

Thus, we are talking about shares of: over 20% at rye level (21.95%); between 10 and 20% for sorghum (11.0%), corn grains (11.93%), barley and barley (12.89%), oats (13.30%), wheat (18.96%), "other cereals" (19.01%); less than 10% in the case of rice (8.89%).

As for the total cereal production, the South-West Oltenia Region achieved 14.74% of the national level of the indicator (Fig. 2).

The average production per production unit (kg/ha) is presented in Table 5.

At the national level, general of the plant group, there are positions between 3,400 and 5,999 kg/ha in the case of 2020 and 2018, respectively, the indicator has increased since 2017 (effective level of 5,225 kg) in 2018 by 14.81%, then in 2019 and 2020 there are successive annual decreases of 9.02 and 37.71% (effective levels of 5,458 and 3,400 kg respectively), then in 2021 there is a recovery of the indicator (+52.59% compared to the previous year – effective level of 5,188 kg), followed by a decrease in 2022 (-29.94% - effective level of 3635 kg) and an increase for 2023 (+10.62% - effective level of 4,021 kg).

For the South-West Oltenia Region, the indicator fluctuates between 3,833 kg/ha in 2020 and 5,659 kg/ha in 2018.

The dynamics of the indicator is dominated by the subunit levels of the component indices, while the advances of the terms of comparison were manifested only in 2018 (1.06 times compared to 2017), in 2021 and 2023 (1.11 and 1.05 times compared to the previous terms of the dynamic series).

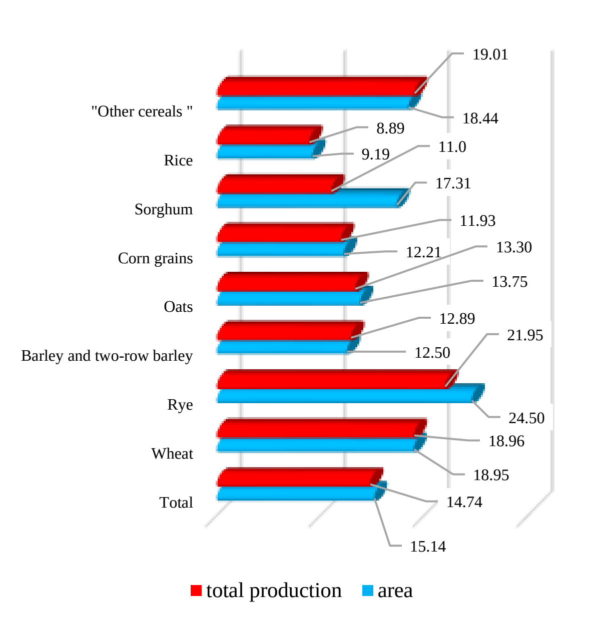

Fig. 2. Cultivated area and total production averages of the period – regional shares at national level by species (%),
Source: own calculation.

Table 5. Average production (kg/ha)

Anul	Romania			South-West Oltenia Region			
	Effective*	Dynamics **		Effective*	Dynamics **		positioning compared to the national level (%)**
		Ibf	Ibm		Ibf	Ibm	
2017	5,225	100	100	5,305	100	100	101.53
2018	5,999	114.81	114.81	5,659	106.67	106.67	94.33
2019	5,458	104.46	90.98	5,037	94.95	89.01	92.29
2020	3,400	65.07	62.29	3,833	72.25	76.10	112.74
2021	5,188	99.29	152.59	4,287	80.81	111.84	82.63
2022	3,635	69.57	70.06	3,849	72.55	89.78	105.89
2023	4,021	76.96	110.62	4,047	76.29	105.14	100.65

Source:National Institute of Statistics, Tempo online data base, *http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table,AGR109A – Vegetable agricultural production for the main crops, by property forms, macro-regions, development regions and counties, Accessed on 26.06.2024[12]. **own calculation.

The decreases during the analysed period ranged from small ones (5.05% in the case of 2019 by comparing to the first term), to more significant variations, such as a 27.75% increase in 2020 compared to the 2017 figures.

Compared to the national situation, the region achieved average productions, per productive unit, higher or lower, as follows (Fig. 3): 82.63% in 2021, 92.29% for 2019, 94.33% in 2018, 100.65% in 2023, 101.53% in 2017, 105.89% for 2022 and 112.74% in 2020.

Based on our own calculations, the average levels of the period were determined, at a general level and by cultivated cereal species (Table 6).

As for the national situation, there is a general level of 4,714 kg, a level that was exceeded only by grain corn (+13.41% - 5,346 kg), the rest of the species being positioned below it: 4,675 kg rice (-0.83%), 4,330 kg wheat (-8.15%), 3,972 kg barley and barley (-15.74%), 3,935 kg sorghum (-16.53%), 3,742 kg "other cereals" (-20.62%), 2,779 kg rye (-41.05%) and 2,268 kg oats (-51.89%) (Fig. 3).

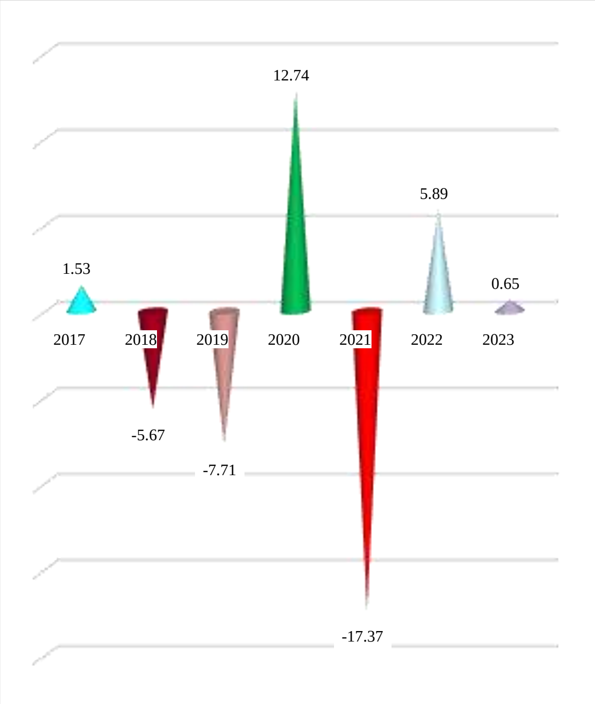

Fig. 3. Average production – the region compared to the national production level (±%)
Source: own calculation.

Table 6. Average production – period average*

Specif.	Romania		South-West Oltenia Region		
	Effect. kg/ha	% in relation to the general level	Effect. kg/ha	% in relation to the general level	positioning when compared to the national level (%)
Total	4,714	100	4,588	100	97.33
Wheat	4,330	91.85	4,333	94.44	100.07
Rye	2,779	58.95	2,490	54.27	89.60
Barley and two-row barley	3,972	84.26	4,097	89.30	103.15
Oats	2,268	48.11	2,193	47.80	96.69
Corn grains	5,346	113.41	5,221	113.80	97.66
Sorghum	3,935	83.47	2,501	54.51	63.56
Rice	4,675	99.17	4,526	98.65	96.81
"Other cereals"	3,742	79.38	3,857	84.07	103.07

Source: *own calculation.

For the South-West Oltenia Region, the general level of the indicator reached 4,588 kg, being surpassed, as at national level, only by grain corn (+13.80% - effective level of 5,221 kg). The relative decreases of the other species, compared to the general regional situation, were 1.35% for rice (4,526 kg), 5.56% for wheat (4,333 kg), 10.40% for barley and barley (4,097 kg), 15.93% for "other cereals" (3,857 kg), 45.49% for sorghum (2,501 kg), 45.73% for rye (2,490 kg), 52.20% for oats (2,193 kg).

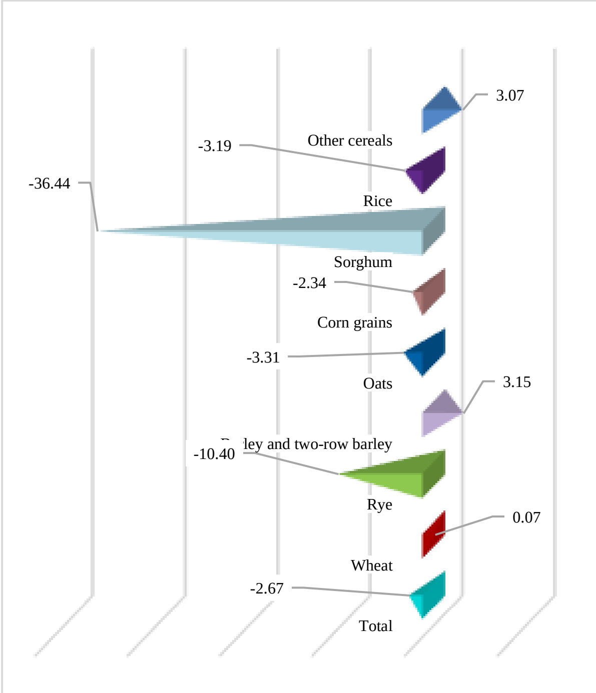

Fig. 4. Average production per hectare, average for the period –
positioning of the region in relation to the national level by species (±%),
Source: own calculation.

If we relate the regional situation to the existing realities at national level, the following can be observed:
- advances of the national situation in the case of wheat, barley and barley respectively for "other cereals" (100.07, 103.15 and 103.07% - Fig. 4);
- below the reference level: 97.66% for grain corn, 97.33% for the crop group, 96.81% for rice, 96.69% for oats, 89.60% for rye, 63.56% for sorghum - Fig. 4).

CONCLUSIONS

From the point of view of the cultivated area, the fluctuating evolution of the indicator at regional level is noted, an aspect that is in line with the national situation. The region held 15.14% of the national cereal area, a share that was exceeded in rye, wheat, "other cereals" and sorghum. In the case of this indicator, the region was placed in the national context as follows: position 2 for rye and sorghum; position 3 at general level, for wheat, barley and barley, oats, rice; position 4 for grain corn.

The total production, both at national and regional level, has evolved unevenly, similar to that manifested for the cultivated area, which may show the existence of a direct correlation between the two indicators. The region accounted for 14.74% of the total national production (-0.40% compared to the share of the area, which indicates a lower level of performance of regional producers compared to the existing state of affairs at national level, an aspect that is found in the case of average production). In terms of shares, within the total production, the regional situation has exceeded the levels recorded for the area of wheat, barley and barley and other cereals, while for the rest of the crops the situation is less favourable, an aspect that can be generated by the technological deficiencies of the producers in the area (in our opinion especially for sorghum), by the lower suitability of the crops to pedo-climatic requirements (see the case of oats, of rye). Nationally, the region ranked as follows: 2nd place for rye and sorghum; 3rd place for total production, wheat, barley, and rice; 4th place for oats; and 5th place for corn.

Regarding average production per hectare, the trends are similar to those observed for the previous indicators, with the region generally performing below the national average in most cases, except for wheat, barley and barley and "other cereals". For this indicator, the region was placed in the national context as follows: position 2 for rice, position 3 for barley and barley, position 4 for wheat, position 5 at general level and for grain corn, position 6 for oats, position 7 for sorghum and position 8 for rye.

We can say that the South-West Oltenia Region is one of the essential areas for cereal production in Romania, but there is a need to improve the results obtained, in order to adequately capitalize on the potential of the area in terms of cultivation and obtaining cereal products.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

EVOLUTION OF POPULATION AND GROSS DOMESTIC PRODUCT IN THE SOUTH-WEST OLTENIA REGION, ROMANIA, IN THE PERIOD 2020-2023

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Abstract

The purpose of the paper was to study the dynamics of the population as a whole and by urban and rural area and of Gross Domestic Product (GDP) for a better understanding of the long-term sustainability of regional development, given that in a globalized economy, labor mobility and capital flows are dynamic, and regions that do not effectively manage the interdependencies between GDP and population risk losing competitiveness. The importance of the subject is given by the fact that these two variables can serve for strategic planning and sustainable development in the future. The study is based on the data provided by the National Institute of Statistics for the period 2020-2023 which were processed in their dynamics reflecting the growth rate in the whole period. Important comments were made on the population and GDP evolution both at the level of the South West Oltenia region, and in the urban and rural area. The South West Oltenia region is located in the South of Romania, and includes the Dolj, Gorj, Mehedinți, Olt and Vâlcea counties. It plays an important economic role. Its activity is based on agriculture and industries such as energy, but it faces economic challenges, with a GDP per capita below the national average and an infrastructure in need of modernization. The region is experiencing depopulation and an aging population, which affects its economic development. During the analyzed period, a general trend of the population decline was observed in the region, attributed to the overall decrease in both urban and rural zones, with Dolj county being the most impacted. While the rural population experienced a slight decline across the region, Gorj and Dolj counties demonstrated signs of stability or even growth, whereas Mehedinți, Olt, and Vâlcea counties experienced a sharper drop. Despite this, the South-West Oltenia Region continued its economic growth between 2020 and 2023, indicating an expanding regional economy driven by various industries, trade, and specialized services.

Key words**:** *population, GDP, economic development, South-West Oltenia Region*

INTRODUCTION

Studying the interdependence between GDP and population in the development regions of Romania is important for understanding the economic and social dynamics at the regional level [2, 4].

GDP, as an indicator of economic performance, represents a region's capacity to generate economic value and is strongly influenced by demographic factors, including population size and structure [3, 9]. A growing population may indicate increased potential for economic growth due to an expanding labor force and domestic consumption, but on the other hand, a declining population may signal structural problems such as migration or demographic aging that could undermine economic sustainability in the long term.

Examining these relationships is vital for crafting effective public policies, as demographic factors shape the demand for goods and services, which subsequently affects economic production and investment in the region [5, 11]. In regions where the population is declining or aging, there is a risk that GDP will be negatively affected, which can lead to a vicious circle of underdevelopment and depopulation [16, 13]. Understanding these trends allows decision makers to take proactive measures to stimulate the economy, such as attracting investment, improving infrastructure or implementing policies to support demographic growth [14]. Also, the study of these relationships offers a perspective on regional disparities in Romania, given that some regions have registered significant economic growth, while others lag behind, affected by economic stagnation and demographic decline [11, 18]. Analyzing these phenomena can reveal the need for more targeted interventions to address disparities and promote equitable development nationwide, as reducing these inequalities is a key goal for achieving balanced and sustainable national growth [8]. Considering the fact that disparities are manifested by significant differences in terms of the level of economic development, access to resources and services, infrastructure and employment opportunities between different regions of a country, the ways to reduce these disparities are multiple and include interventions both at the level of public policies, as well as at the level of private initiatives.

One of the main ways to reduce regional disparities is investment in infrastructure. The development of transport, communication and energy infrastructure is crucial for connecting underdeveloped regions with national and international markets. Adequate infrastructure can facilitate access to resources and markets, attracting investment and creating jobs [15]. Also, the development of social infrastructure, such as schools and hospitals, is essential to improve the quality of life and to attract and retain the population in less developed regions.

Another important aspect is the regional cohesion policy promoted at national and European level, which aims to allocate funds and resources to less developed regions to reduce economic and social gaps. European structural and investment funds, for example, have a significant role in financing infrastructure, innovation and social inclusion projects in regions that need additional support.

Reducing regional disparities is important not only from the perspective of social equity, but also for ensuring sustainable economic development at the national level. Underdeveloped regions may contribute to internal migration, depopulation, and social instability. Conversely, addressing disparities can result in a fairer distribution of resources, a more cohesive national market, and more balanced economic growth that benefits the whole country. Regarding South West Oltenia region, the literature reflects that there are authors who studied the dynamics of the population as a whole, and by urban and rural area in various periods [1, 6, 7]. Other authors showed the evolution of GDP in the South West Oltenia region [17].

In this context, the purpose of this study is to investigate the evolution of the population and GDP in the South West Oltenia region during the period 2020-2023 in order to identify the main trends and to enable authorities to set up a future forecast of the demographic and economic development in this part of Romania.

MATERIALS AND METHODS

The research methodology involved the use of descriptive analysis, along with the calculation and interpretation of indicators related to the population and GDP value in the South West Oltenia Region for the period 2020-2023. Descriptive analysis is a useful tool for any statistical research process, providing a solid basis for understanding the data and for carrying out more complex subsequent analyses, simplifying the data and making the interpretation more accessible for further investigations. Also, the time series analysis involved the examination of data from the period 2020-2023 in order to identify trends, seasonality and cyclical fluctuations.

To understand the rate of change, we calculated the annual growth rates of GDP and population by comparing consecutive annual values and expressing the percentage change, which were the basis for calculating the annual growth rate.

Graphical representation was also employed to visualize the evolution of the analyzed indicators, namely GDP and population. This method, though simple, proved highly effective in clearly identifying trends and significant changes over time, providing a comprehensive view of their progression.

RESULTS AND DISCUSSIONS

The South-West Oltenia region, located in the south of Romania, consists of Dolj, Gorj, Mehedinți, Olt and Vâlcea counties, being characterized by a significant geographical diversity, including both fertile plains in the south and mountainous areas in the north, dominated by Southern Carpathians.

The economy is predominantly agrarian, but also has important industrial sectors, such as energy, contributing significantly to national energy production. However, the region faces economic challenges, with a lower GDP per capita level compared to the national average, and an infrastructure in need of modernization.

Demographically, the region is characterized by a trend of depopulation and aging of the population, a common phenomenon in many rural regions in Romania. This influences economic development and requires the implementation of policies that attract investment and stimulate sustainable development.

Understanding the population dynamics of a region is vital for predicting the economic, social, and demographic changes that shape its development.

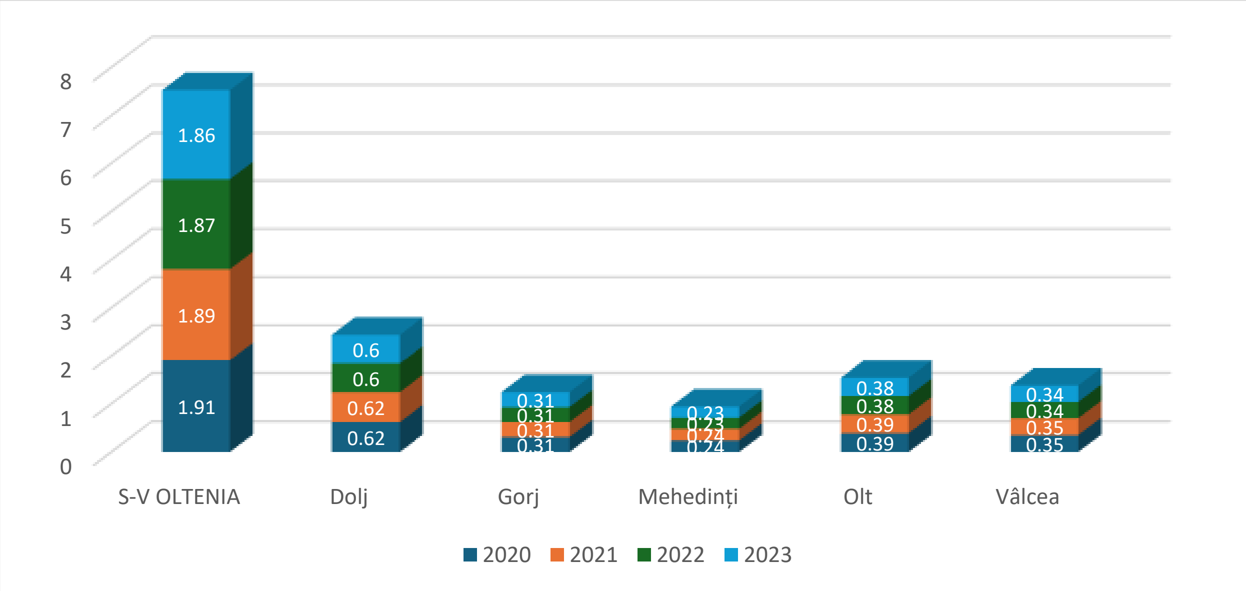

Fig. 1. Evolution of the population in Reginea Sud West Oltenia in the period 2020-2023 (millions of inhabitants)
Source: INSSE, own processing [12].

The total population of the South West Oltenia region decreased from 1.91 million in 2020 to 1.86 million in 2023, which represents a reduction of 2.61% over these years. This decline is reflected in every county in the region, although the rate of decline varies. Thus in Dolj county, the population decreased from 0.62 million in 2020 to 0.60 million in 2023, registering a decrease of 3.22%, this being one of the smallest percentage decreases in the region, thus indicating relative stability higher compared to other counties. In Gorj county, the population remained constant during the analyzed period. In Mehedinți county, the largest percentage decrease of the population was recorded, of 4.16%, from 0.24 million in 2020 to 0.23 million in 2023, which indicates a sharp demographic decline, which can be attributed to migration or the rate low birth rate.

In Olt county, the population decreased from 0.39 million in 2020 to 0.38 million in 2023, a decrease of 2.56%, which indicates a similar trend to that in Mehedinți. In Vâlcea county, the population decreased from 0.35 million in 2020 to 0.34 million in 2023, registering a decrease of 2.85%, relatively moderate compared to other counties. Overall, the population decline in the Southwest Oltenia region reflects a general trend of demographic decline, which is caused by factors such as external migration, population aging and declining birth rates, which lead to negative implications on the regional economy, reducing the available labor force and affecting the potential for long-term economic development.

Examining the relationship between urban and rural populations within a development region is crucial for understanding socio-economic dynamics and developing effective policies. This analysis allows the identification of internal migration trends, providing information on population mobility and the causes that determine the transition from rural to urban or vice versa. At the same time, the balance or imbalance between urban and rural populations directly influences resource allocation and infrastructure development, as the different needs and priorities of these communities must be addressed accordingly. In addition, analyzing this relationship helps to understand the impact of regional development policies, highlighting areas that require interventions to balance development between rural and urban, thus ensuring sustainable economic growth and increased social cohesion, which is essential for reducing economic disparities and for the promotion of harmonious development throughout the region.

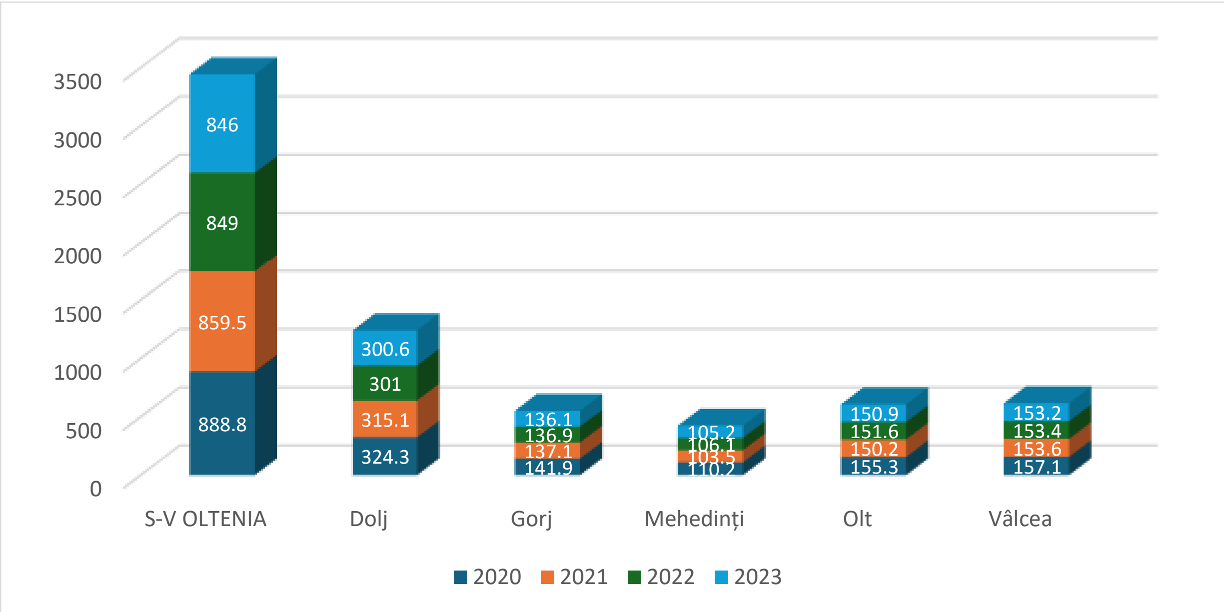

Fig. 2. Evolution of the urban population in Reginea Sud West Oltenia, in the period 2020-2023 (thousands of inhabitants)
Source: INSSE, own processing [12].

Analyzing the data regarding the urban population, we find a general tendency of its decrease in all the counties of the region, with variations in the intensity of this decline. Thus, for the South West Oltenia Region, the total urban population decreased from 888.8 thousand inhabitants in 2020 to 846 thousand in 2023, which represents a decrease of 4.81%. This decline reflects both urban migration and the drop in the birth rate, as common phenomena in many regions of Romania.

In Dolj county, the urban population decreased significantly, from 324.3 thousand in 2020 to 300.6 thousand in 2023, marking a reduction of 7.3%, being the biggest decline among the counties in the region, which has a economic and social impact. In Gorj county, the urban population decreased moderately, from 141.9 thousand in 2020 to 136.1 thousand in 2023, which represents a reduction of 4.08%. In Mehedinți county, the urban population decreased from 110.2 thousand in 2020 to 105.2 thousand in 2023, registering a decrease of 4.53%. Although relatively stable in 2022, the overall decline is comparable to that in Gorj County. In Olt County, the decrease in the urban population is moderate, from 155.3 thousand in 2020 to 150.9 thousand in 2023, with a reduction of 2.78%. Vâlcea County had an urban population that decreased slightly, from 157.1 thousand in 2020 to 153.2 thousand in 2023, marking a reduction of 2.48%, being the smallest percentage decrease in the region, which shows a relative stability.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

From the analysis of the data on the rural population of the South West Oltenia Region, it was found that it decreased slightly from 1,022.6 thousand inhabitants in 2020 to 1,015.7 thousand inhabitants in 2023, marking a reduction of 0.67%. Thus, we find a relative stability of the rural population, compared to the urban population. The rural population of Dolj county increased slightly, from 297.9 thousand inhabitants in 2020 to 299 thousand inhabitants in 2023, representing an increase of 0.36%. In Gorj county, the rural population increased from 170.1 thousand inhabitants in 2020 to 175.2 thousand inhabitants in 2023, which represents an increase of 0.99%, this being the highest percentage increase in the region, indicating a revival of the rural environment in this county. The rural population of Mehedinti County decreased from 128.6 thousand inhabitants in 2020 to 126.2 thousand inhabitants in 2023, registering a reduction of 1.86%. In Olt county, the decrease was more pronounced, from 234.6 thousand inhabitants in 2020 to 227.6 thousand inhabitants in 2023, with a reduction of 2.98%, indicating demographic problems of the rural environment due to migration to urban areas, to other regions of the country, but especially outside Romania. In Vâlcea county, the rural population decreased from 191.4 thousand inhabitants in 2020 to 187.7 thousand inhabitants in 2023, which represents a reduction of 1.93%.

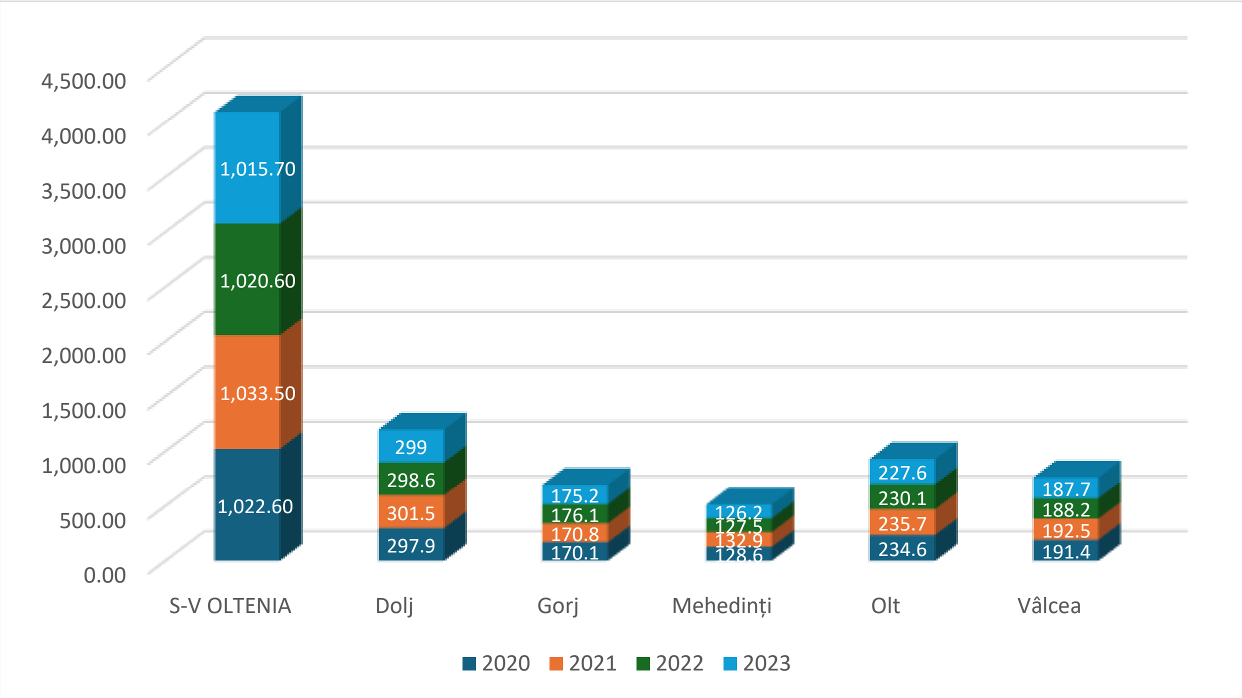

Fig. 3. The evolution of the rural population in the South West Oltenia Region, in the period 2020-2023 (millions of inhabitants)
Source: INSSE, own processing [12].

To comprehend the impact of demographic decline on the South-West Oltenia region, we extended the analysis to examine the structure of the regional economy. Population dynamics directly influence economic performance, resource allocation, and the region's capacity for sustainable development. The structure of the economy determines the types of jobs available, the level of wages, opportunities for training and professional development, all of which directly influence the attraction, retention or loss of population in the region. The size and structure of the population influences the demand for various goods and services, thus shaping the economic structure of the region.

A growing population can spur expansion of the construction, education, and health sectors, while a declining population can lead to reduced demand and stagnation in certain economic sectors.

The role of this relationship is essential in regional strategic planning, because understanding the interactions between the economy and the population allows the development of policies that stimulate sustainable economic growth and ensure social cohesion. An economic structure well adapted to the needs and characteristics of the local population can generate prosperity, reduce regional disparities and create an attractive environment for investment and residents alike.

In this sense, it was analyzed the GDP value for the period 2020-2023, with the mention that the values for the years 2022 and 2023 are the estimated values, considering the lack of published data.

Table 1. GDP evolution at current prices in the South-West Oltenia Region, in the period 2020-2023 (millions Lei)

Specification	**2020**	**2021**	**2022**	**2023**	**2023/ 2020 (%)**
Agriculture, forestry and fishing	5,541.40	6,570.60	6,900	7,200	129.93
Extractive industry; manufacturing industry; production and supply of electrical and thermal energy	20,157.80	22,613.70	24,500	26,000	128.98
Construction	6,018.10	6,199.00	6,500	6,800	112.99
Wholesale and retail trade	14,292.90	17,026.30	18,250	19,250	134.68
Information and communications	1,469.00	1,354.60	1,450	1,500	102.11
Financial intermediation and insurance	974.5	1,065.70	1,125	1,175	120.57
Real estate transactions	5,970.80	6,141.80	6,400	6,700	112.21
Professional, scientific and technical activities	3,049.90	3,525.60	3,800	4,000	131.15
Public administration and defense; social insurance from the public system	14,458.10	14,201.40	14,100	14,100	97.52
Performance, cultural and recreational activities	1,531.00	1,734.40	1,800	1,850	120.84
Regional gross added value (VABR)	73,463.50	80,433.10	83,000	85,500	116.38
Product taxes	7,599.90	8,613.80	9,100	9,400	123.69
Duties on imports (customs duties)	156.5	240.3	270	290	185.30
Subsidies per product	-221.8	-244.3	-255	-265	119.48
Regional gross domestic product (GDP) - total	**80,998.10**	**89,042.90**	**92,000**	**95,000**	**117.29**

Source: INSSE, own processing [12].

Note: Exchange rate according to the National Bank of Romania, 1 Euro = 4.9744, October 2nd, 2024.

The data on the evolution of the gross domestic product highlight the fact that the agriculture, forestry and fishing sector had an increase of 29.93% between 2020 and 2023, representing a significant consolidation of the activity, due to several factors, including the modernization of agricultural technologies and the increase in productivity. Regarding the extractive and processing Industry sector, energy production and supply, it had an increase of 28.98%, due to the increase in demand and production in the industrial field, as well as the investments made in energy production capacities. The construction sector expansion of construction activities, driven by infrastructure projects, but also by the increase in housing demand. Wholesale and retail trade had one of the largest increases, of 34.68%, due to an intensified commercial activity, in the conditions of the increase in domestic consumption and the expansion of retail networks, a situation found throughout the country. Although the Information and communications sector had a growth of only 2.11%, it demonstrates the fact that the market has reached a maturity but continues to evolve. With a growth of 20.57%, the Financial Intermediation and Insurance sector reflects an improvement in financial and insurance services due to the increasing complexity of the regional economy and the need for such services. The real estate sector grew by 12.21%, due to the constant demand for properties, both in urban and rural areas. The Professional, Scientific and Technical Activities sector had an increase of 31.15%, which indicates an increased demand for professional and technical services, due to an economy that is increasingly complex and oriented towards specialized services. The only sector that decreased was that of Public Administration and Defense; social insurance, the decrease being 2.48% and which was due to the reduction and efficiency of public expenses. In the performance, cultural and reactive activities sector, the 20.84% increase was due to the revitalization of this sector, on the one hand due to the relaxation of pandemic restrictions, and on the other hand to the increase in the population's income and interest in cultural activities.

Therefore, the regional gross value added (VABR) increased by 16.38% against the background of recording the general improvement in the economic performance of all sectors that contributed positively. The intensification of the general economic activity, but also the change in the method of taxation, led to a greater contribution to the tax revenues from commercial activities, contributing to a 23.69% increase in taxes on products. Also, the digitization and improvement measures of the collection activity, against the background of the internal fiscal reforms, but also those of alignment with the European legislation, had a direct impact on this sector.

The data published by INSSE highlight a significant increase in customs duties, which is 85.30% and which was due to both the increase in import activities and the integration of the regional economy more and more into international trade. We also noted a 19.48% increase in subsidies that was due to government support granted for certain products or sectors.

The increase in GDP was 17.29%, reflecting a global improvement in the regional economy, given that all sectors contributed to this economic growth, despite the challenges and declines in certain areas.

CONCLUSIONS

The analysis of the relationship between population evolution and GDP in the South-West Oltenia region highlighted several important aspects for understanding the regional economic and social dynamics. First, the increase in GDP, observed in most economic sectors between 2020 and 2023, shows that the region has managed to diversify and strengthen the economy, which can be a determining factor in counteracting the negative effects of demographic decline. Secondly, the stability or even the growth of the population in certain counties contributed to the maintenance of internal demand, essential for supporting trade and the construction industry, sectors that have important records in the analyzed period.

On the other hand, sectors such as Public Administration and Defense recorded decreases, which was due on the one hand to improvements in public spending, and on the other hand to the decrease in the population and, implicitly, the need for public services. This aspect underlines the importance of a stable and active population to sustain a sustainable economic activity.

At the same time, the expansion of the professional, scientific, and technical sectors reflects an evolving economy that requires skilled labor. However, population decline is a factor that puts pressure on these sectors, affecting their ability to grow and innovate. Moreover, the significant growth in the agricultural and industrial sectors demonstrates that despite the falling population, the region has managed to increase productivity, which underlines the importance of technological investments and infrastructure upgrades.

The analysis shows once again the fact that, to support and amplify economic growth, regional policies need to simultaneously address the problem of demographic decline and promote measures to attract and maintain the active population, essential for the economic future of the region.

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METHODS OF OPTIMIZING THE MANAGEMENT OF AGRICULTURAL FARMS OF MEDIUM ECONOMIC DIMENSIONS- A REVIEW

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Abstract

In the context of modern agriculture, medium-sized farms play a crucial role in ensuring economic sustainability and food security. These farms are large enough to benefit from modern technologies and economies of scale, but still small enough to be flexible and innovative. However, they face specific challenges, including access to finance, technology and markets, resource and labour management, and adaptation to climate change and government regulations. Optimizing the management of these farms is essential to ensure long-term productivity, sustainability and profitability. This article aims to explore management optimization methods for medium-sized farms, as well as a SWOT analysis of these methods based on which we will provide a series of conclusions for improving their performance. Agricultural management optimization requires as farmers to integrate new technologies and sustainable practices, to adapt to market and environmental changes, to invest in innovation and development. Only in this way, medium-sized agricultural farms can become models of efficiency and sustainability, contributing significantly to food security and environmental protection.

Key words: *farm management, economic optimum, medium-sized farm*

INTRODUCTION

Medium-sized farms are those agricultural holdings that, by their size and production capacity, have sufficient resources to benefit from economies of scale and invest in modern technologies, but do not have the same financial resources and infrastructure as large corporations agricultural. In the context of modern agriculture, the efficient management of an agricultural farm of medium economic size is essential to ensure long-term sustainability and profitability [14, 18].

Management optimization methods in agriculture include a combination of technological, organizational and ecological strategies aimed at increasing operational efficiency, reducing costs and improving product quality [4, 6].

Modern agriculture faces multiple challenges, including climate change, volatile markets and pressure on natural resources [2]. In this context, the adoption of effective management methods becomes crucial to respond to market demands and maintain competitiveness.

Advanced technologies such as precision agriculture, digitization, use of data [9], and application of sustainable practices play a vital role in transforming medium-sized farms into a sustainable and innovative business model [10]. Data-driven decisions enable optimal use of resources, reducing costs and waste. The use of advanced technologies allows precise monitoring and management of variability within the farm [20, 21].

Sustainable practices such as crop rotation improve soil fertility and reduce the risk of erosion.

The use of renewable energy and the reduction of dependence on fossil resources contribute to reducing the carbon footprint and protecting the environment [1].

Precision agriculture focuses on the precise application of agricultural inputs, reducing waste and maximizing crop yields. Digital marketing and social media help increase farm visibility and connect directly with consumers, which can lead to increased sales and customer loyalty.

The purpose of the paper is to explore management optimization methods for medium-sized farms, as well as a SWOT analysis of these methods based on which we will provide a series of conclusions for improving their performance.

MATERIALS AND METHODS

To achieve the main purpose of the work, the qualitative analysis method was used regarding the collection and analysis of non-numerical data regarding the context and phenomena related to the application of management optimization methods in agricultural farms. A SWOT analysis was also carried out, which provided the premise of a superior understanding of the management of farms of medium economic size, which provided the basis for the formulation of relevant conclusions.

RESULTS AND DISCUSSIONS

Characteristics of the medium-sized farms

Medium-sized economic farms have several specific characteristics: usually, medium-sized farms have a diverse range of crops and/or livestock, which gives them the advantage of optimizing the use of resources. Due to the annual income they can have (up to EUR 250,000), these farms have sufficient financial resources to invest in modern technologies such as irrigation equipment, high-performance agricultural machinery and farm management software. Medium-sized farms tend to be more efficient than small farms because they can implement more advanced farming practices, have the flexibility to adapt to market changes, and do not have the same infrastructure constraints as large farms. Thus, we can affirm the fact that medium-sized farms play an important role in the rural economy, contributing to the creation of jobs and the development of local communities.

Farm classification is essential to understand the agricultural structure of a region and to develop appropriate agricultural policies. This varies according to the local and economic context, but common criteria include agricultural area, income, number of employees and value of production.

Based on these specific characteristics, a series of methods can be established to optimize the management applied to them:

1. Organizational structure and human resources management

Medium-sized farms need a well-defined organizational structure to ensure operational efficiency and facilitate strategic decision-making. The main aspects of the organizational structure include:

- *Functional departments*: the creation of specific departments for production, technology, finance, human resources and marketing. This allows for a more efficient management of activities and a clear allocation of responsibilities.
- *Training and professional development*: investment in the continuous training of employees to ensure the necessary skills to use modern technologies and implement sustainable agricultural practices.
- *Employee motivation and retention*: offering attractive benefits packages and creating a positive work environment to keep employees motivated and engaged.

2. Use of advanced technologies

- *Precision farming* involves using modern technologies to monitor and manage variability within a farm. This includes the use of sensors, drones and GPS systems to collect data on soil, plant and climate conditions. This information allows farmers to make informed decisions, optimizing resource use and maximizing crop yields [11].
- *Digitization and use of data*: the implementation of farm management IT systems helps to collect, store and analyze data on agricultural activities. These systems facilitate the tracking of daily operations, inventory management and production planning. Using historical data and predictive analytics helps improve decision-making processes and anticipate potential problems [19].
- *Automating agricultural processes* such as irrigation, fertilization and harvesting reduces the need for manual labour and increases operational efficiency. The use of agricultural robots and automated equipment helps to improve the accuracy and speed of task execution while reducing labour costs [15].
- *Modern technologies* can play a crucial role in optimizing the management of medium-sized farms. Their implementation can

improve productivity, reduce costs and minimize environmental impact. The main relevant technologies include precision technologies: the use of GPS systems, drones and sensors for precise monitoring and management of crops and resources [7].

Modern technologies allow precise application of fertilizers, pesticides and water, thus reducing waste and costs; agricultural management software. Implementation of IT solutions for monitoring agricultural operations, inventory management, data analysis and informed decision-making. This software can integrate data on weather conditions, crop health and financial performance; modern equipment: Investing in advanced farm equipment such as state-of-the-art tractors and combines that can increase efficiency and productivity.

3. Resource management strategies

- *Water management*: water management is essential for agricultural sustainability. Implementing efficient irrigation systems, such as drip irrigation and the use of moisture sensors, helps to reduce water consumption and ensure an even distribution of water. Also, the collection and use of rainwater is an ecological and efficient method of managing water resources [17].

- *Fertilization and soil management*: the use of soil analysis to determine the exact nutrient requirements and the precise application of fertilizers contribute to the optimization of fertilization. Crop rotation practices and the use of cover crops improve soil structure and fertility while reducing the risk of soil erosion and degradation [16].

- *Renewable energy and resources*: The adoption of renewable energy sources such as solar and wind power helps reduce dependence on fossil energy sources and lower operational costs. Installing solar panels to power farm equipment and using bioenergy from agricultural waste are examples of sustainable energy management practices [3].

- *Planning and crop rotation* are essential to maintain soil fertility, prevent disease and pests and maximize yields. Annual planning: establishing a detailed plan that includes crop selection, crop rotation and the calendar of activities. This plan must take into account the specifics of the soil, climatic conditions and market requirements.

Crop rotation: implementing crop rotation to prevent soil depletion and reduce the risk of disease and pests. Proper rotation can improve soil structure and biodiversity [16].

- *Soil conservation practices*: adoption of conservation agriculture practices, such as covering the soil with cover crops and minimizing tillage, to protect the soil and maintain its fertility [5].

4. Organizational and marketing approaches

- *Diversification of crops and agricultural products* helps reduce the risks associated with market fluctuations and adverse climatic conditions. Farms that diversify production can benefit from multiple sources of income and varied market opportunities, thus ensuring greater financial stability [13].

- *Cooperation and partnerships*: the formation of agricultural cooperatives and partnerships between farmers contributes to increasing bargaining power in the market and access to resources and advanced technologies. Cooperation allows costs and risks to be shared while facilitating access to larger markets and more favourable trading conditions [8].

- *Marketing, branding*: developing an effective marketing and branding strategy is essential to attract and retain customers. Promoting local, organic and sustainable agricultural products can increase their perceived value and provide a competitive advantage in the market. Using digital marketing channels and social media helps increase visibility and connect directly with consumers [12].

- *Access to markets and the development of effective marketing strategies* are essential to ensure the sale of agricultural products at competitive prices. Key approaches include diversifying sales channels: using local, regional and online markets to reduce reliance on intermediaries and increase profit margins; certifications and branding: obtaining ecological certifications and developing your brand to access premium product markets and benefit from higher prices; direct contracts: concluding direct contracts with retail chains, restaurants and other entities to ensure a constant and stable market for agricultural products [13].

SWOT analysis of the role of technology application in agricultural farm management

Strengths

1. Increased operational efficiency:

- Implementation of advanced technologies and modernized management practices lead to more efficient use of resources and reduction of losses.
- Automation and precise monitoring allow for improving the productivity and quality of agricultural products.

2. Cost reduction:

- Optimizing processes and using resource-saving technologies such as drip irrigation and precision fertilization help reduce operational costs.
- Crop diversification and crop rotation minimize risks and protect the soil, which reduces the need for costly long-term interventions.

3. Adaptability and resilience:

- Optimization methods allow the farm to be more flexible and adaptable to market changes and climatic conditions.
- Sustainable and ecological practices improve the long-term resilience of the farm.

4. Access to markets and certifications:

- The use of modern technologies and effective management methods can help to obtain quality and ecological certifications, facilitating access to premium markets.
- Digital marketing and branding strategies can increase the visibility and appeal of agricultural products.

Weaknesses

1. High initial costs:

- Investments in technological equipment and staff training can be significant and difficult to bear for medium-sized farms.
- The initial costs for implementing advanced management systems can be a barrier for some farms.

2. Complexity of implementation:

- Integrating and coordinating different technologies and practices requires careful planning and specialized technical skills.
- Change management can be difficult, requiring considerable effort to change traditional practices and adopt new methods.

3. Dependence on technology and infrastructure:

- Technology reliability and access to the necessary infrastructure (internet, electricity) are essential for the success of optimization methods.
- Technical failures and connectivity issues can adversely affect farm operations.

4. Risks related to data security:

- The use of digital platforms involves risks related to data protection and security.
- Effective cyber security management requires additional measures and may involve additional costs.

Opportunities

1. Continuous innovation and technological development:

- Continuous technological progress provides opportunities for the continuous improvement of farm management and the adoption of new innovative solutions.
- Partnerships with research institutions and collaborative development can lead to the implementation of the latest technologies.

2. Access to funding and subsidies:

- There are numerous funding programs and grants available to farmers who wish to adopt advanced management methods.
- Government and international organization support can facilitate access to resources and funds needed for optimization.

3. Increasing demand for sustainable products:

- Consumers are becoming increasingly concerned about the sustainability and quality of food products, which creates an opportunity for farmers who adopt sustainable practices.
- Marketing and branding of organic and local products can attract new market segments and increase profitability.

4. Improving relations with the community and the environment:

- The implementation of sustainable management practices contributes to the protection of the environment and the development of the local community.
- Community engagement and education programs can improve public perception and create positive relationships with consumers and local partners.

Threats

1. Market volatility:

- Price fluctuations of agricultural inputs and final products can affect the profitability and sustainability of investments in advanced management methods.
- Uncertain economic and business conditions can negatively influence long-term profitability.

2. Climate change and extreme weather conditions:

- Extreme weather events such as drought, floods and extreme temperatures can adversely affect crops and productivity.
- Adaptation to climate change requires additional investment and long-term planning.

3. Regulations and compliance:

- Changes in agricultural legislation and environmental regulations can create uncertainty and additional costs for farmers.
- Compliance with new regulations and standards may require significant adaptations and financial resources.

4. Resistance to change and cultural barriers:

- Conservatism and reluctance to adopt new technologies and practices can delay the implementation of optimization methods.
- Lack of adequate education and training in the use of modern technologies can limit the efficiency and success of their implementation.

CONCLUSIONS

Optimizing the management of an agricultural farm of medium economic size requires an integrated approach that combines advanced technologies, efficient management of resources and innovative organizational and marketing strategies. Precision agriculture, digitization and use of data, automation, sustainable water and soil management, adoption of renewable energy sources, production diversification, cooperation and partnerships, as well as effective marketing and branding strategies are key elements in this process.

The implementation of these methods not only improves the efficiency and profitability of the farm but also contributes to the long-term sustainability of agriculture, reducing the negative impact on the environment and ensuring the necessary resources for future generations. Farmers who adopt these practices will be better prepared to face future challenges and capitalize on the opportunities offered by an ever-evolving agricultural market.

In conclusion, we can state that the success of agricultural management optimization depends on the ability of farmers to integrate new technologies and sustainable practices into their daily operations, continuously adapting to market and environmental changes. By investing in innovation and development, medium-sized agricultural farms can become models of efficiency and sustainability, contributing significantly to food security and environmental protection.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE IMPORTANCE OF USING GIS IN INCREASING THE EFFICIENCY OF AGRICULTURAL FARMS - A BIBLIOMETRIC APPROACH

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Abstract

Modern agriculture faces many challenges, including the need to feed a growing global population, cope with climate change, soil degradation and biodiversity loss. GIS technology provides solutions to these problems through its ability to collect, analyze and visualize complex geospatial data. This technology allows farmers and researchers to make informed decisions based on accurate and up-to-date data, which is why they play an essential role in modern agriculture, enabling the development of innovative solutions to global challenges, contributing to more efficient, sustainable and productive agriculture higher. In this work, we proposed that, starting from the existing data in the WOS and Scopus international databases, to analyze the existing research with the aim of identifying the major trends in GIS-related research, which includes both the evaluation of the volume and the temporal distribution of publications and the identification of popular and emerging research topics, by analyzing citations and impact factors, we can evaluate the influence and relevance of research in the field of GIS. Additionally, through a comprehensive review of existing literature and the application of bibliometric analysis, this research has identified gaps and highlighted future research needs within the GIS domain, this being essential for the direction of future research directions and for the development of new projects and initiatives that to address these gaps as well. Following the restrictions applied, it started from a number of 81,566 articles, the refinement establishing a number of 903 articles that address issues related to the use of GIS in agricultural farms, of which only 19 are those that analyze their role in assessing the efficiency of our activities, the results demonstrate that GIS is a dynamic and expanding research field with broad applicability and significant impact. Our analysis of collaboration networks indicates that the United States, China, the United Kingdom, and Australia lead in international publications and collaborations, essential for the innovative application of GIS. Our research shows a significant increase in GIS-related publications, reflecting growing academic interest and the integration of fields such as environmental monitoring, natural resource management, and precision agriculture.

Key words: *GIS, advanced technologies, agriculture, profitability, bibliometric analysis*

INTRODUCTION

The world is under the impact of rapid progress in terms of the development and use of data and information sources, an important role played by globalization that has facilitated access to technology and data, improved international collaboration and contributed to addressing complex problems with humanity is facing. Additionally, it has enhanced the availability of international geospatial data sources, such as satellite images and remote sensing data, that are essential for the application of GIS. At the same time, it also facilitated the distribution of technologies advanced by these systems worldwide, allowing access to resources not only in developed countries, but also among developing countries. Thus, GIS has become indispensable for resource management, urban and rural planning, disaster response, and environmental monitoring, thereby supporting sustainable development and effective global resource management.

Geographic Information Systems (GIS) also play a crucial role in agriculture by offering advanced tools and techniques for managing and analyzing spatial and non-spatial data, allowing both accurate mapping of agricultural land and continuous monitoring of the state of crops. By using satellite imagery and remote sensing data, farmers can get up-to-date information on plant health, soil moisture levels and weather conditions. The fact that these systems contribute to the analysis of soil properties and the distribution of natural resources, is a help for farmers, as a result of the fact that they ensure the optimization of the use of fertilizers and pesticides, contributing to a more efficient use of resources, but also to a reducing the costs and impact of agriculture on the environment [1, 16]. The creation of detailed land maps, including information about plots, irrigation and infrastructure, have a direct impact on crop rotation planning, irrigation management and yield monitoring, but also on the analysis of the spatial variability of agricultural factors (soil, humidity, nutrients, etc.)) [6, 7, 29]. By identifying areas with different performance, farmers can apply precision farming practices, adjusting inputs according to the specific needs of each area. By evaluating crop productivity, informed decisions can be made to manage risks associated with climate change and extreme weather events, such as droughts and floods, while also measuring their environmental impact (soil erosion, water pollution), practices can be developed sustainable and conservation measures can be implemented [12].

Completed by other categories of agricultural-specific software, daily, weekly and seasonal activities in agriculture can be followed, optimizing the use of resources, but also reducing downtime in the activity carried out, expenses and income can be followed, making it easier thus making economic decisions. Another advantage is related to monitoring the performance of equipment in real time, which contributes to maintenance planning and the prevention of breakdowns, to ensuring the traceability of products from the farm to the consumer, to improving transparency and compliance with food safety regulations, to the efficient management of supply chain, optimizing delivery routes and reducing post-harvest losses, etc [17, 18, 19, 28].

In this context, the aim of the paper is to identify the major trends in GIS-related research, which includes both the evaluation of the volume and the temporal distribution of publications and also the emerging research topics, by analyzing citations and impact factors, which reflect the influence and relevance of research in the field of GIS.

MATERIALS AND METHODS

Bibliometric analysis is a powerful tool for evaluating and understanding the dynamics of scientific research, which uses statistical and mathematical techniques to analyze scientific publications. Bibliometric methodologies and indicators allow the identification of trends in the field, the evaluation of their impact and the facilitation of collaborations.

The study we carried out followed the analysis of the relevance of GIS in the most relevant specialized research, identified starting from the scientific articles in the Web of Science and Scopus databases, these being the most popular platforms for scientific research and which are used internationally. Another advantage of them is the fact that they allow finding articles whose appearance begins in the early years of the 19th century.

Through the research carried out, we followed the outline of a critical image regarding the existing studies, out of the desire to identify their future challenges and opportunities.

The objectives of the research were the following:

1: Identification of the main research groups in the field of GIS application in the management of agricultural farms

2: Identification of the distribution of scientific production regarding the application of GIS in agriculture

3: Identifying the gaps related to the use of GIS in the management of agricultural farms

The two databases were consulted on April 30, 2024. The first keyword used in the bibliometric analysis was "agricultural farm" and a number of 81,566 articles and works were identified in the Scopus database. The search was also carried out in the WOS database. Further, the research was refined based on the keyword, "GIS system", a number of 903 researches being identified. The refinement was achieved by using the term "Efficiency", obtaining a number of 19 articles that were analyzed with the help of the VOSviewer software. In the conceptual maps made, the size of the network nodes indicates the relevance within the research, and the thickness of the curves and the distance between the nodes provide information about the connection established between the elements under analysis.

RESULTS AND DISCUSSIONS

The topic of the GIS approach applied in agriculture began to be researched starting with 1999, through a number of 3 articles which then grew exponentially.

The largest number of articles on this topic were published in 2021, their number being 222, with 6,429 citations.

In 2023, 195 articles were published, cited 7,378 times, and in 2024, until May 25, 64 articles appeared in the WOS database, cited 2,435 times (Figure 1).

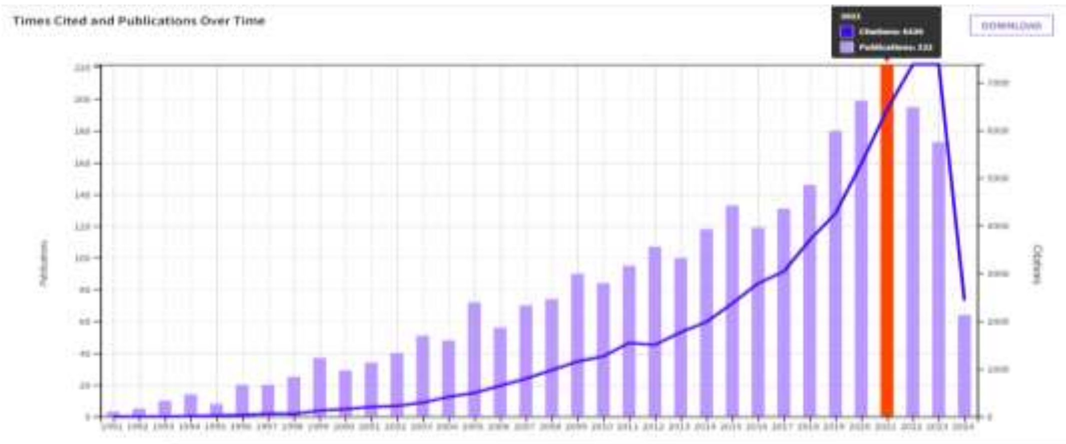

Fig. 1. Evolution of the number of articles published in the field of GIS systems in agriculture
Source: WOS [30].

By examining the correlation between co-authorship and authors, we can gain insights into the dynamics of scientific collaboration, the structure of academic networks, and the influence of these collaborations on scientific output. Thus, we can establish the situations in which 2 or more authors collaborate for the publication of a research.

In the present case, putting as a restriction the publication of a minimum number of 5 articles per author, the result was that out of the 3,149 authors, 20 met this criterion, Wang Y. standing out, with 11 published articles and 13 total links strength.

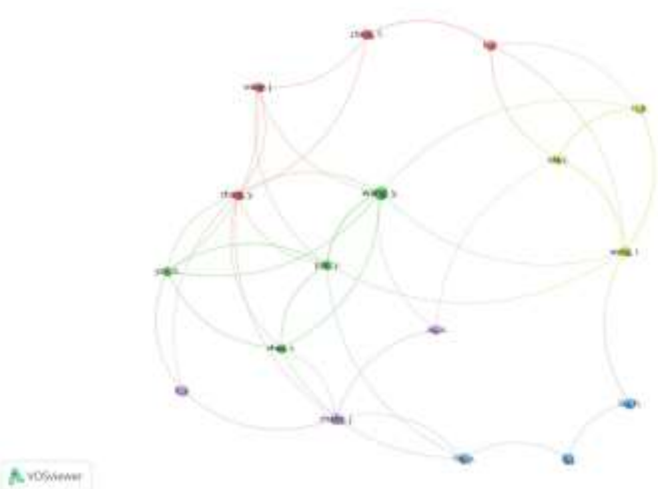

Fig. 2. Distribution of scientific research according to co-authors
Source: VOSviewer own processing.

The authors were grouped into 5 clusters between which 40 links were established. Although Zhang Y. published a number of 9 articles, the total link strength was 7, which is why Pan Y. and Wang I. occupy the 2nd and 3rd places (although they only have 6 articles each, but having total link strength of 12, respectively 11) (Fig. 2).

Co-occurrence measures the frequency with which 2 or more keywords appear together in the same publication. In the current analysis of the 7,608 keywords appearing in the selected articles, and having the condition that a keyword has a minimum number of 5 occurrences, we found that this was fulfilled by 674 words. The most used keyword was GIS, with 512 occurrences and a total link strength of 6,878, followed by "geographic information system" with 372 occurrences and a total link strength of 5,631 and agriculture with 232 occurrences and a total bond strength of 3.723. The 674 items were grouped into 5 clusters, with a total power of 95,129 links established between the 47,071 links (Fig. 3).

Therefore, "GIS" is a central term in recent research, with a large number of occurrences and a dense network of connections. The clustering of the articles indicates the various research subfields, demonstrating the complexity and interconnectivity of studies related to the use of GIS both in agriculture and in other fields, some related. This bibliometric analysis thus gives us a comprehensive perspective on the importance and influence that GIS have in academic research.

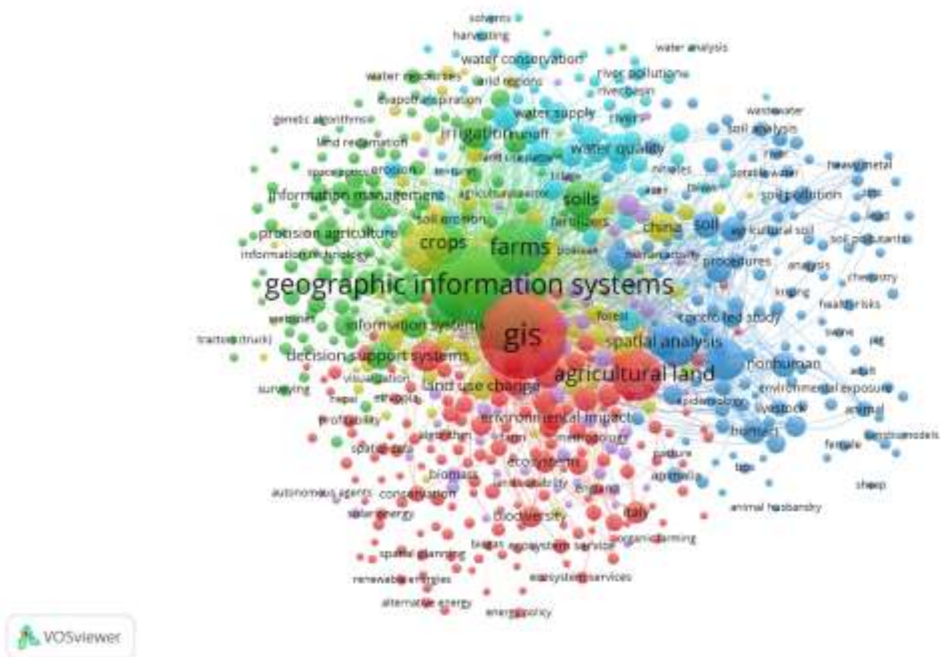

Fig. 3. Distribution of scientific research according to keywords
Source: VOSviewer own processing.

Analyzing the relationship between the key terms selected by the authors and the frequency with which they appear together in the same publication, and setting as a restriction the appearance of a minimum number of 5 keywords, it resulted that out of the 2,858 keywords, only 80 met this criterion. The first 3 positions were "GIS", "remote sensing" and "agriculture", with 247 occurrences, 80 and 38 respectively. The total intensity of links was 284, 119 and 64, respectively. These were grouped in 11 clusters between which 363 links were established and which had a total intensity of 715.

Thus, the keywords, having a significant number of occurrences and links, underline the interconnectedness and importance of the the efficiency of the activ covered. Clustering and dense network of links highlight complexity

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

and collaboration in GIS and remote sensing research in agriculture (Fig. 4).

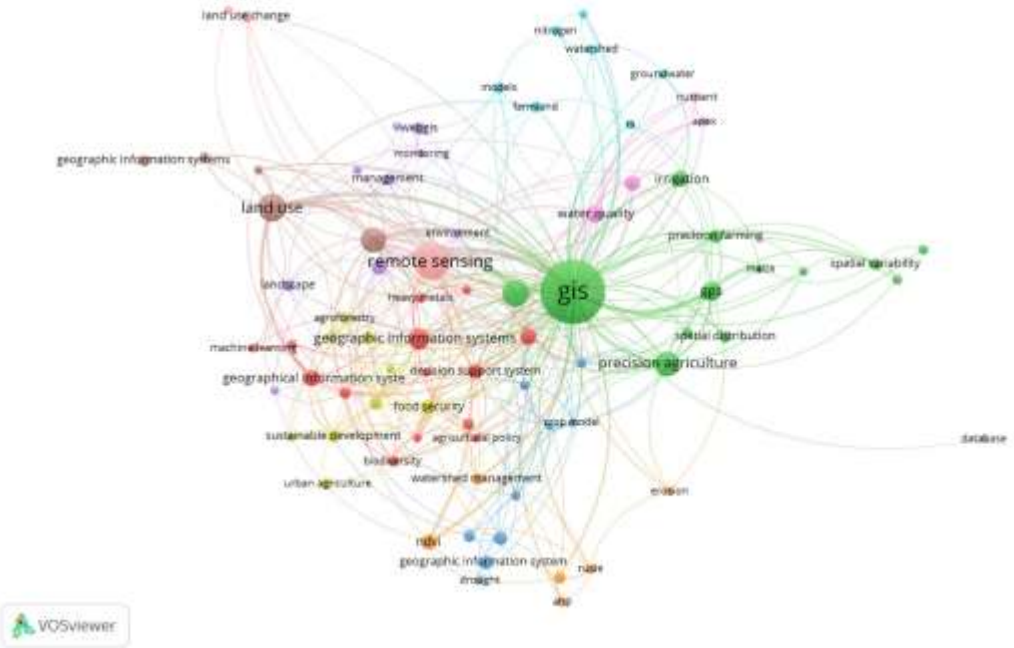

Fig. 4. Distribution of scientific research according to keywords and authors
Source: VOSviewer own processing.

The link between citations and the article's country of origin allowed us to determine the influence and impact of scientific research at the national level, facilitating the understanding of global contributions, as well as that of international collaboration networks. Thus, the leading countries were highlighted, as well as the trends of transnational collaboration. Starting from a minimum number of 25 citations per country, out of the 104 countries, only 48 fulfilled this condition. The highest number of citations belongs to the USA, with a number of 169 articles, cited 3,968 times, which occupies the leading position in addressing the subject related to the application of GIS in agriculture. It is followed by China, with 161 published articles and 2,665 citations and Italy with 70 articles and 1,340 citations.

In order to identify the similarity between scientific documents that have a number of common references, we made the correlation between bibliographic coupling and sources, and using a minimum number of 10 citations, as well as a number of 5 articles per source, it resulted that out of the 492 articles, only 30 met these criteria.

These were grouped into 8 clusters, establishing a number of 59 links between them.

Thus, the keywords, having a significant number of occurrences and links, underline the interconnectedness and importance of the topics covered.

The clustering and dense network of linkages highlight the complexity and collaboration in GIS and remote sensing research in agriculture. We thus account for the existence of a narrow but well-connected network of articles that share common references.

Clustering reflects distinct research subfields and collaborations between them (Fig. 5).

In order to determine the research gaps, given and with the aim of developing new research directions in the field of using GIS to increase the profitability of the activity carried out within agricultural farms, we analyzed the most relevant works in this field. After applying the filters, 19 articles resulted. The main findings of the analysis undertaken are presented in Table 1.

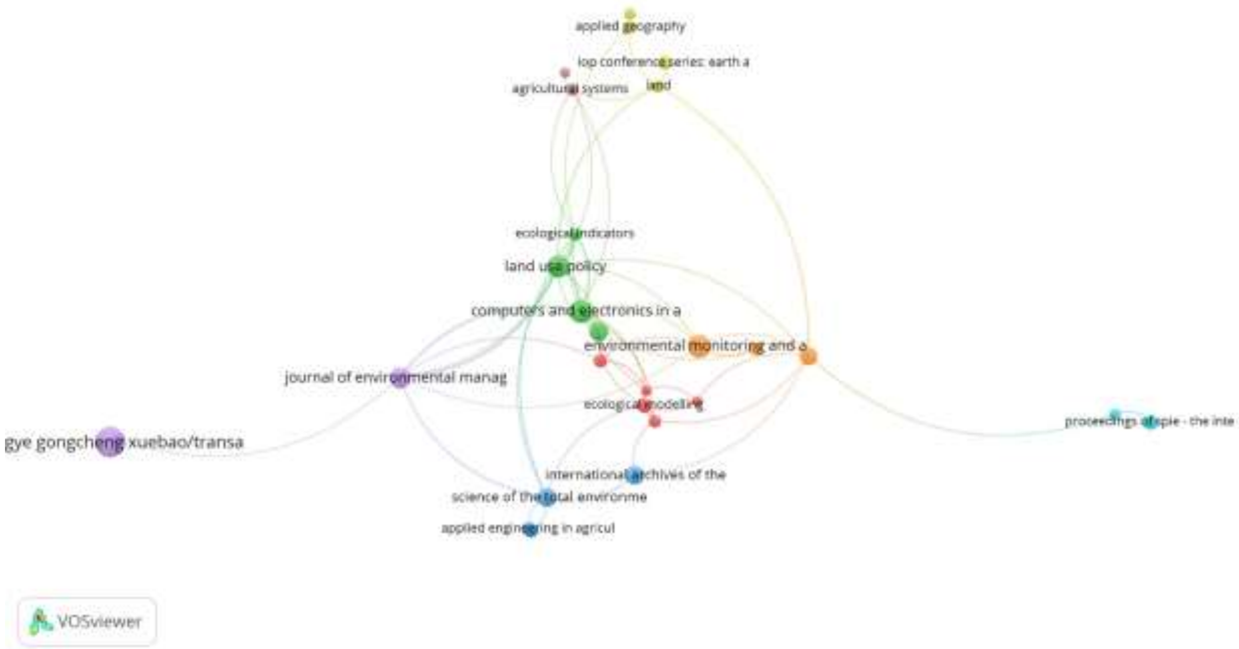

Fig. 5. Distribution of scientific research according to bibliographic coupling and sources
Source: VOSviewer own processing

Table 1. Summary of research results in the field of "GIS" use in agricultural farms and their economic efficiency

Author(s)	Year of publication	Title	Number of citations	Main findings
Shahhoseini, H., Ramroudi, M., Kazemi, H	2023	Emergy analysis for sustainability assessment of potato agroecosystems (case study: Golestan province, Iran)	2	The analysis of GIS system usage in the research involved collecting and interpreting data related to the spatial distribution of urgency indices, which were calculated based on the provided inputs and outputs of the agrosystems specific to the cultivation of autumn potatoes in the Golestan region, in Iran. Based on the case study carried out, the authors were able to make recommendations regarding the application of sustainable technologies, aiming both at increasing the economic efficiency of farms and protecting the environment [24]
Sbahi, M.K., Ziboon, A.R.T., Hassoon, K.I.	2021	Evaluation of the Efficiency of Circular Wheat Crop Farms Using GIS and Remote sensing Techniques	2	In the research, GIS systems were used to estimate the areas cultivated with wheat in the region of Ain al-Tamur, Iran, a hard-to-reach area, which makes this possible due to the use of technology. At the same time, an evaluation of the quality of the productions was carried out, using different remote sensing indicators [23]
Longo, M., Dal Ferro, N., Lazzaro, B., Morari, F.	2021	Trade-offs among ecosystem services advance the case for improved spatial targeting of agri-	12	Starting from the importance of ecological agriculture for protecting the environment, the research performs a comparative analysis of some BAU and AEM scenarios, for the Veneto region,

		environmental measures		Italy. In this sense, high-resolution spatial data related to pedo-climatic conditions, agricultural land management and environmental data were integrated with the aim of identifying recommendations on how to efficiently exploit ecosystems [15]
Ghosh, S., Mistri, B.	2020	Drainage induced waterlogging problem and its impact on farming system: a study in Gosaba Island, Sundarban, India	23	The research examines the causes of waterlogging and their implications for coastal agriculture in the Sundarban area. The remote sensing and GIS techniques allowed the authors to identify the spatio-temporal changes of the drainage network resulting from the overlay analysis performed, related to the multi-temporal vector layers [11]
Babajanov, A.R., Abdivaitov, K.A.	2020	Organizational support for automation of land management projecting in irrigated areas of Uzbekistan	-	The research analyzes the ways of creating automated agricultural land management systems. Additionally, the paper explores the integration of artificial intelligence systems to evaluate the economic efficiency of agricultural projects, which includes the use of GIS technologies. The conclusions reached by the authors highlight the reduction of costs and the elimination of some deficiencies, which recommends, from an economic point of view, their use in the design of agricultural land management [2]
Gaudėšius, R.	2016	Drawing up maps of infertile soil plots using geographic information systems	1	Recognizing the significance of practicing efficient agriculture, there is a need for detailed maps that illustrate soil fertility and land use, the paper creates such a map using geographic information systems, but proceeding to the preparation of maps of agricultural holdings. Cercatrea also highlights the advantages and disadvantages of the software used, being rather a case study addressed to specialists [10]
Dong, Z., Zhou, Q., Wang, D., Chen, Z.	2015	Optimization of spatial sampling schemes and elements for estimating farmland area	-	Starting from the importance that the information related to the mapping of agricultural lands has in the development of food policies and in economic planning in China, but also on the application of an efficient management of crops, the authors of the work highlight the importance of the use of geographic systems in achieving this objective, insisting on the application correctness of information collection methodologies. Thus, the paper presents a case study regarding the application of sampling, proving that sampling errors can have consequences on the economic efficiency of agricultural holdings, thus providing a theoretical basis regarding the improvement of the spatial survey

				methodology with a role in estimating the cultivated agricultural area [8]
Karunaratne, A.S., Walker, S., Azam-Ali, S.N.	2015	Assessing the productivity and resource-use efficiency of underutilised crops: Towards an integrative system	3	The research presents the advantages of using a platform for managing the situation regarding the different categories of underutilized crops, offering support regarding different decisions that can be taken, starting from a quantitative basis that is the basis for determining their economic efficiency and productivity. The application also allows the integration of different indicators that measure the effects of climate change and their impact on agricultural activity, as a result of both the use of GIS and major models for crops from around the world. CropBASE case studies provide yield and water use productivity predictions for various crops in Saharan and Sub-Saharan Africa [13]
Calvert, K., Mabee, W.	2015	More solar farms or more bioenergy crops? Mapping and assessing potential land-use conflicts among renewable energy technologies in eastern Ontario, Canada	102	The research is an integrated approach to land use and energy planning, carrying out a regional analysis. Based on an elaborated methodology, we try to locate the land that can support the production of bioenergy and solar photovoltaic production, but also to identify the ways in which the land must be used so that its potential can be reached on the market. At the same time, the advantages and disadvantages associated with choosing one of the systems over the other are estimated and evaluated. GIS systems, as well as overlay techniques, are used to locate mutual lands, highlighting once again their important role in current conditions [5]
Sharma, S., Manhas, S.S., Sharma, R.M., Lohan, S.K.	2014	Potential of variable rate application technology in India	8	The paper analyzes the possibility of more efficient use of different categories of inputs related to agricultural production with the aim of improving the efficiency of their application, on the one hand for economic reasons, and on the other hand as a measure to reduce environmental pollution. Based on the study, it turns out that what can contribute to changing the way farmers manage both culture technologies and the results obtained are global positioning systems (GPS), as well as geographic information systems (GIS) [25]
Kokkinidis, I., Hodges, S.C.	2013	Calculating ecosystem services provided by agricultural land using GIS and remote sensing methods	-	The work, based on the study of agricultural farms in an area of Virginia, is a complex one, having several objectives. One of these is the estimation of productions for 15 crops starting from the existing information

				in the databases and which were collected with the help of GIS. Another objective was to determine the conservation value of cultivated land. Those parcels whose destination can be changed, with the aim of obtaining biofuel, without this affecting production requirements, were also identified. Different economic indicators were also calculated, and the effects of carbon flows on the obtained productions were also measured. [14]
Farrow, A., Risinamhodzi, K., Zingore, S., Delve, R.J.	2011	Spatially targeting the distribution of agricultural input stockists in Malawi	10	The research aims to analyze 3 key aspects related to the distribution of agricultural inputs in the Malawi region of Africa. The obtained results demonstrate the fact that a spatial analysis can contribute to the expansion of the distribution network of inputs, and based on the evaluation of the degree of coverage with outlets, the optimal locations for them could be obtained. The study used both spatial analysis and different location-allocation models [9]
Nahry, A.H.E., Ali, R.R., Baroudy, A.A.E.	2011	An approach for precision farming under pivot irrigation system using remote sensing and GIS techniques	58	The paper analyzed the efficiency of the use of agricultural land and water based on a case study carried out in the Ismailia area of Egypt. At the same time, the economic and ecological profitability of practicing precision agriculture in an experimental field that uses pivot irrigation for the corn crop was monitored, proving its effectiveness [21]
Shinners, T.J., Digman, M.F., Panuska, J.C.	2010	Overlap loss of manually and automatically guided mowers	-	The work analyzes the losses due to overlaps in the case of the use of agricultural machinery. Based on a controlled experiment and a case study carried out at the farm level and using several categories of machinery, it has been demonstrated that the use of automatic guidance systems contributes to the reduction of overlap losses [27]
Shi, Z.-H., Chen, L.-D., Hao, J.-P., Wang, T.-W., Cai, C.-F.	2009	The effects of land use change on environmental quality in the red soil hilly region, China: A case study in Xianning County	26	The research analyzes the effects of climate change in the Xianning region of China, due to the change in land use. The data that formed the basis of the case study were collected with the help of remote sensing technologies, geographic information systems and from the analysis of the main spatial components, proving their importance in the collection and interpretation of information [26]
Barton, D.N., Faith, D.P., Rusch, G.M., Paniagua, L., Castro, M.	2009	Environmental service payments: Evaluating biodiversity conservation trade-offs and cost-efficiency in	40	The work demonstrates the role of GIS in the collection and analysis of data related to environmental protection costs in Costa Rica. In the present case, their use together with a software application (TARGET), analyzes the

		the Osa Conservation Area, Costa Rica		PES allocation criteria, demonstrating the fact that they were much more effective in the period 2002-2003 compared to those in the period 1999-2001 [3]
Bongiovanni, R.G., Robledo, C.W., Lambert, D.M.	2007	Economics of site-specific nitrogen management for protein content in wheat	19	The research analyzed the established relationships between crop yield, protein and nitrogen quantities, using both regression analysis to monitor yields. They were converted with the help of geographic information systems (GIS), which proves the necessity and importance of their use [4]
Murray, R.I., Yule, I.J.	2007	Developing variable rate application technology: Economic impact for farm owners and topdressing operators	12	The paper analyzes the costs and economic efficiency of using modern aerial systems in the agricultural activity of farmers, demonstrating that these costs are not prohibitive and that they are efficient from an economic point of view [20]
Padgitt, S., Petrzelka, P., Wintersteen, W., Imerman, E.	2001	Integrated crop management: The other precision agriculture	3	The research analyzes the opportunity of applying precision agriculture and their dependence on the use of GPS and GIS. The study emphasizes that implementing integrated crop management can enhance both the economic efficiency of farms and the effectiveness of environmental protection measures. This conclusion is supported by a case study conducted in Iowa [22].

Source: Own precessing.

The analysis of the 19 articles on the role of GIS in enhancing the competitiveness of agricultural farms highlights a strong focus on evaluating the impact of these tools to improve the efficiency of precision agriculture. This demonstrates a significant concern with understanding how GIS applications can optimize agricultural practices and increase farm productivity, monitoring and analyzing processes in real time, planning activities and making decisions starting from computerized information, but also the impact they have on reducing costs, increasing profitability, sustainability and resource conservation. However, we found that there are certain limits related to the availability of data, the complexity of the technology used, its cost, the adaptability of these solutions, but also the social impact of their use, which makes a holistic approach necessary to eliminate these challenges and to maximize the positive impact of GIS on the agricultural sector.

It is noteworthy that most studies are based on case studies or other secondary research methodologies, which lead to solutions that can be implemented in practice.

CONCLUSIONS

The analysis of scientific articles confirms that GIS is an important tool in increasing the competitiveness of agricultural farms, as a result of improving resource management, optimizing production processes and facilitating computerized decisions, which make GIS contribute to increasing the efficiency and sustainability of modern agriculture.

We would like to note the growing interest of researchers regarding the subject of GIS and its role for agricultural activity.

Analyzing the relationship between GIS and the increase in the profitability of agricultural holdings will allow not only the optimization of resources, the improvement of management decisions, the monitoring and anticipation of some problems, but also the adaptation to climate changes and the promotion of sustainability, current aspects that concern both the scientific and the business environment. Providing useful and necessary tools to farmers will contribute to finding solutions related to how they will be able to face modern challenges, but also to maximize the efficiency and profitability of agricultural activity.

- the contributions brought by this research are represented by the fact that:
- the paper also contributes to the scientific understanding of how GIS can enhance the performance of agricultural farms, which results from the systematization of existing knowledge
- the work allows the measurement of gaps in the field of research, requiring the completion of new studies
- the current research has identified gaps, highlighting opportunities for expanding scientific exploration in the analyzed field.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE INTEGRATION OF ARTIFICIAL INTELLIGENCE IN THE ACTIVITY OF AGRICULTURAL FARMS: A NEED TO ENSURE SUSTAINABILITY

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Abstract

Humanity is currently facing numerous challenges, one of the most important being that of ensuring food security, which is why agriculture is becoming one of the important branches of the economy of any country. Ensuring a sustained agricultural production, which meets both the requirements related to respect for the environment and sustainability, but also those related to food sufficiency, are aspects for which researchers are constantly looking for solutions, and the transition from traditional practices to the use of digitization, innovative technologies or of artificial intelligence, represent current and interesting topics, which is why we have the right to deepen this topic in the present work. The methodology used was based on one hand on the analysis of specialized studies, and on the other hand, quantitative research was employed for the analysis of statistical data, facilitating a detailed and substantiated understanding of the impact of AI in agriculture. This approach entailed collecting data using descriptive statistics, followed by meticulous processing and analysis of the information. It included calculating growth rates and thoroughly examining the results. These methods enabled the development of well-founded opinions, conclusions, and recommendations regarding the application of artificial intelligence in agriculture. Through this comprehensive analysis, valuable insights were gained to inform and guide the effective integration of AI technologies in the agricultural sector. The study revealed valuable insights into the benefits and challenges associated with AI in this field, which can aid in developing more efficient and sustainable agricultural practices. Evidence of the growing interest in this area includes the significant rise in investments in intelligent agricultural equipment and artificial intelligence, which surged from 1.7 billion dollars in 2019, to 4.9 billion dollars in 2021, being estimated to reach 9.6 billion dollars this year. At the same time, the conducted study also allowed us to identify the advantages and challenges facing agriculture in the adoption and implementation of digitization and artificial intelligence in specific activities.

Key words: *agriculture, farm, AI, digitization, sustainability*

INTRODUCTION

Sustainable agriculture involves the exploitation of current resources in conditions of efficiency, protecting the environment, but aiming to ensure the right of future generations to enjoy all these aspects in their turn [18]. These desires have made scientists and decision-makers constantly look for new solutions by which they can fulfill these objectives. Therefore, modern technological discoveries have also been implemented in the agricultural sector, and artificial intelligence, as the new frontier of this field, has been reached, but new solutions are still being sought to contribute to increasing the efficiency of this sector of activity that is faced with numerous challenges (climate changes, global population growth, workforce reduction, etc.) [4, 13, 16, 17].

The existence of data provided by satellites, by various sensors in the field, the accessibility to the information provided by meteorological systems have made the agricultural system have important sets of data, which have contributed to the development of artificial intelligence in this field as well, which promises important opportunities regarding the development of more sustainable agricultural practices, increasing resilience to climate change, promoting collaborative research and developing more effective policies [5, 7, 21, 24]. Artificial intelligence thus appears as a new paradigm, having a transformative role in agriculture, which joins other technologies with a role in connecting devices and digitally activated agricultural machinery through and with the help of the Internet [6, 19].

The use of this information has contributed to the development of predictive models, systems used to detect diseases or pests, their degree of infestation, the use of intelligent irrigation systems, the optimization of resources, the reduction of the impact of agricultural activities on the environment, etc. At the same time, it is possible to increase the yields and the efficiency of the activities carried out within the agricultural farms [3, 9, 10, 12].

The role of AI in farm decision-making is complex, contributing to real-time data monitoring and analysis, forecasting and predictive modeling, resource utilization optimization, farm planning and management, decision support and process automation [1, 8, 15, 22].

Studies show that the introduction of artificial intelligence in agriculture has both opportunities and challenges, as well as the need for fair access to this type of innovative technology, which also raises ethical and ethical issues [2, 20, 25].

Interdisciplinary collaboration between researchers, farmers and decision-makers is important for the advancement of the efficient and correct use of digitization and artificial intelligence in agriculture. By promoting the exchange of information and encouraging innovation, all stakeholders in the agricultural sector can collaborate effectively. This collaboration allows them to make well-informed decisions and implement strategies that are both effective and efficient. These strategies can be applied not only at the level of individual farms but also on a global scale, ensuring a cohesive approach to agricultural development and sustainability [11, 14, 23].

MATERIALS AND METHODS

To conduct this research on the use of artificial intelligence in agriculture, we employed both documentary analysis, drawing from scientific literature, and statistical data analysis. The aim was to quantify the impact and level of AI adoption in agriculture, utilizing empirical data as a foundation.

The calculation of the annual growth rate allowed us to measure the changes related to the AI market from one year to another and to evaluate its performance over time. To calculate the percentage value, we used the formula:

$$Percentage\ increase\ (\%) = \frac{Current\ Year\ Value - Previous\ Year\ Value}{Previous\ Year\ Value} x100$$

Calculating the annual growth rate of AI in agriculture market is essential to understand the market dynamics, plan strategically, attract investments, innovate and develop relevant technologies, thus giving us a clear picture of market performance and potential, helping to to outline an image of the current situation and the development potential of this market. Additionally, it aims to enable stakeholders in Romania's agricultural sector to make informed decisions and contribute to the sustainable development of agriculture, aligning with existing European and global directions.

RESULTS AND DISCUSSIONS

Statistical data highlight the fact that artificial intelligence has the potential to revolutionize the way farms and agricultural crops are managed. According to reports published worldwide and at the European level, the adoption rate of AI technologies in agriculture is increasing, with an increasing number of farms implementing precision agriculture solutions, agricultural robots and AI-based management platforms.

Although the published data varies, the global market of artificial intelligence used in agriculture was evaluated in a report by Global Market Insight (GMI8092) published in 2024 as having a value of 1.37 billion dollars in 2022 and 1.69 billion dollars in 2023 [27]. Another report published by Market.us estimated a value of this market that was 1.2 million dollars in 2022 and 1.5 million dollars in 2023 [26].

The increase is significant, however, considering the fact that in 2018 this market was estimated at a value of 682.1 million dollars, and that of 2019 at a value of 750 million dollars. What we find is that the global market of smart agriculture technologies will have significant annual growth rates in the coming years, these being between 20% and 33.33%.

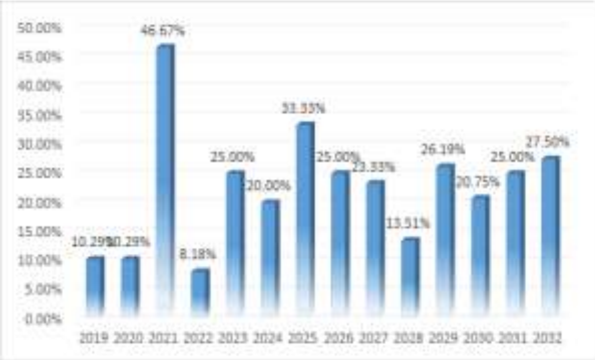

Fig. 1. The evolution of the growth rates of the use of AI in agriculture (%)
Source: own processing [26].

A determining factor in the use of technology and in the transition to digitization was the Covid-19 pandemic, also in agriculture, primarily due to the fact that people became much more open about the use of various devices that were growing anyway, and on the other hand, the fact that consumers have become more and more selective regarding the origin and quality of the food they consume, which has had an impact on monitoring the health status of crops, animals, etc. requiring the adoption and development of new technologies, which respond to market demand and leading to the development of this market. Thus, it can be seen that from growth rates of 10.29% in 2019 and 2020, in 2021 a rate of almost 47% was reached, the absolute value being 1.19 billion dollars (Fig. 1).
The size of the AI market in agriculture in $ billions is shown in Fig. 2.

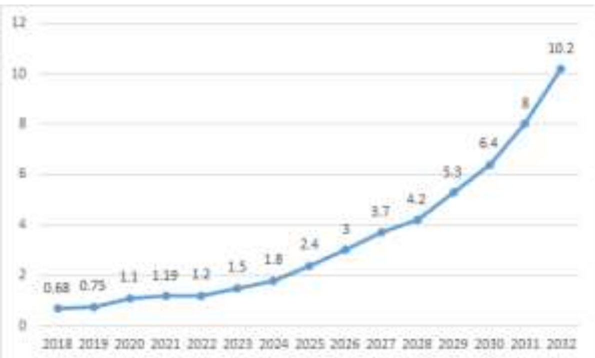

Fig. 2. Size of the AI market in agriculture ($ billions)
Source: own processing [26].

Analyzing the use of artificial intelligence by category of agricultural activities (field farming, liverstock farming, indoor farming and other activities), we find that there are no significant changes in the period 2019-2024.

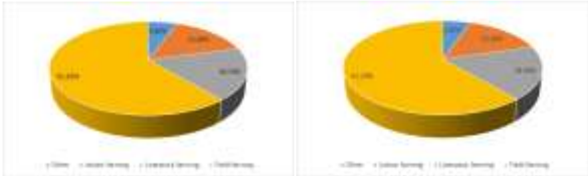

Fig. 3. The market share of AI, by category of agricultural activities, in 2019 and 2020
Source: own processing [26].

Field agriculture held and will continue to hold the largest shares, these being between 61.1% in 2019 and 2020 and 61.5% in 2023 and 2024 (Fig. 3).

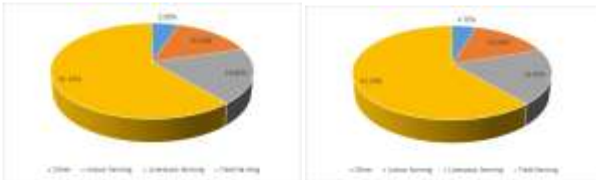

Fig. 4. The market share of AI, by category of agricultural activities, in 2023 and 2022
Source: own processing [26].

The second category of activity, highlighting the significance of artificial intelligence, is animal husbandry. During the analyzed period, this sector held shares ranging from 18.1% in 2019 to 19.1% in 2024. Similar values were recorded in the use of artificial intelligence in the field of agriculture in protected spaces, these being approximately 15% in the period 2022-2024, in insignificant decrease compared to the previous period (15.2% in 2019 and 15.1% in 2020 and 2021).

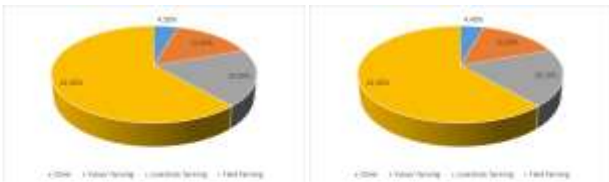

Fig. 5. The market share of AI, by category of agricultural activities, in 2023 and 2024
Source: own processing [26]

The category of other agricultural activities that use artificial intelligence also decreased during the analyzed period, from 5.6% in 2019 to 4.4% in 2024.

The data collected from different databases highlighted the fact that if in 2019, the largest share of the application of artificial intelligence was owned by precision agriculture (with approximately 30% of the total), it is estimated that in 2024 decreased by 3% of the total. However, significant decreases were recorded in the share held by the use of AI in Labor management. Thus, from a share of approximately 15% of the total held in 2019, it reached an estimated share of 8% for the current year. These changes in the weights held by the different categories of agricultural activities are due to the fact that the weights due to the introduction of drones or robots in agricultural activities have increased. If in 2019, the share held by drones, of the total, was approximately 20%, in the current year it is estimated that they hold 34% of the total, while robots, which had a share of approximately 10% in 2019, ended up they currently hold approximately 17% of the market. Market share fluctuations were recorded in the Liverstock Monitoring category, with weights between 12% in 2022 and 18% in 2021.

Other categories of agricultural activities that involve the use of artificial intelligence currently account for approximately 4%, a decrease from 2019, when they represented nearly 10% of the total.

Fig. 6. The share of fields of use of AI in precision agriculture (estimate for 2024)
Source: own processing [26].

In the field of precision agriculture, the most used applications of artificial intelligence are those related to farm management (for the current year they are estimated to hold 35% of the total), followed by those related to weather forecasts (20%) and those related to the field educational (15%) (Fig. 6).

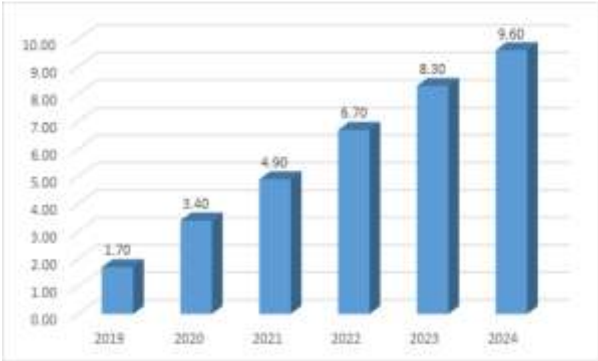

Fig. 7. The value of the investments made in intelligent agriculture in the period 2019-2024
Source: own processing.

Investments made in intelligent agriculture systems have increased significantly in the analyzed period. If in 2017 they were almost 1 billion dollars, in 2019 they reached 1.7 billion, the growth rate being 70% (Fig. 7). However, it can be observed that in 2020 the growth rate was 100%, the reason being, as we show above, the outbreak of the Covid-19 pandemic, but also the natural technological evolution. Although later the growth rates decreased to 44.12% in 2021, to 36.73% in 2022, to 23.88% in 2023 and to 15.66% in 2024 (estimated value), the value of investments increased from 1.7 billion dollars in 2019 to 9.6 billion of dollars in 2024. It was thus found that investments in smart agricultural equipment and artificial intelligence continued to grow, reaching approximately 6.7 billion dollars in 2022, as a result of the increased adoption of advanced technologies and AI solutions in agriculture. In 2023, investments rose to $8.3 billion, reflecting increased interest and expanding use of artificial intelligence and smart technologies, growth supported by continued improvements in drones, agricultural robotics, and data analytics platforms. Projections point to a continuation of the upward trend due to innovations and streamlining of agricultural processes, as more farms adopt AI solutions to optimize production and manage resources.

The analysis of this field, statistics and research allowed us to find that the applications of artificial intelligence in agriculture are diverse, covering areas such as precision agriculture, crop monitoring, livestock management and weather forecasting, etc. For example, in precision agriculture, sensors and

AI-equipped drones are used to gather various information, but there are other activities that can be adapted to these technologies (Figure 8).

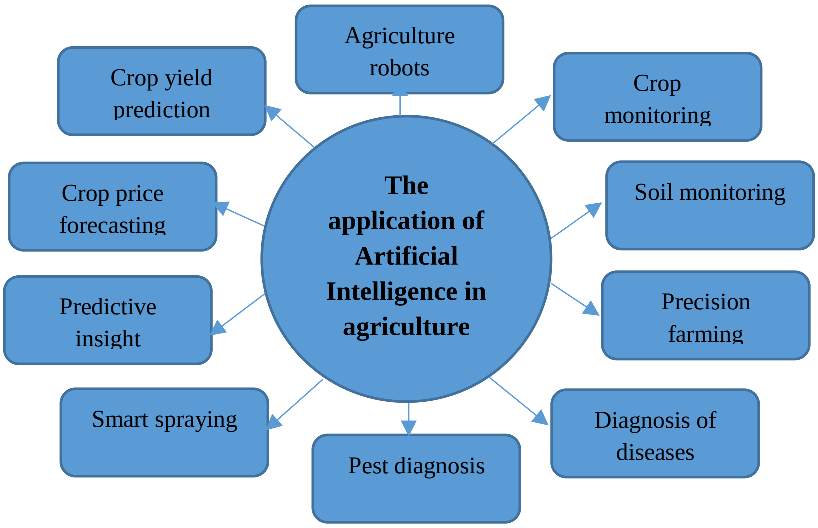

Fig. 8. The application of Artificial Intelligence in agriculture
Source: Own design and content.

Artificial Intelligence (AI) can be used in agricultural crop yield prediction through a variety of advanced methods and technologies. Thus, sensors placed in the soil can collect data about moisture, soil temperature, nutrient levels and other environmental conditions, and AI can analyze this data to predict how these factors will affect crop yields. It can also process images captured by satellites and drones to monitor plant health, identifying areas affected by disease or nutrient deficiencies, and then this data is used to make accurate predictions about future crop yields.

Machine learning algorithms can be trained on large sets of historical crop data, including factors such as soil type, crop rotation, farming practices and weather conditions, and once trained, these algorithms can predict crop yields based on current and forecast conditions.

AI can integrate current climate data and weather forecasts to predict their impact on crops. Advanced climate models can also be used to simulate different climate scenarios and see how they would affect crop yields in the long term.

AI can simulate crop growth under different conditions to predict yield based on various environmental and management variables, or assess the risks associated with different farming practices and climate conditions, giving farmers valuable information to make informed decisions.

By integrating robots and establishing links between them and artificial intelligence, soil and weather data can be analyzed to determine the optimal time and place for sowing. They can also plant seeds at the right depth and spacing, ensuring maximum crop yield, apply fertilizers and pesticides exactly where they are needed, reducing waste and minimizing environmental impact, analyze data on soil moisture and weather conditions to adjust the amount of water applied in real time, detect and eliminate pests precisely, or apply chemical or biological treatments only to areas affected by disease or pests, minimizing pesticide use and reducing costs.

Agricultural robots can also be used in the harvesting or post-harvesting process. Thus, they can identify ripe fruits and vegetables by harvesting only them, without damaging the plants, or they can classify and sort agricultural products based on size, shape and color, ensuring a superior quality of products delivered to the market. These robots can work around the clock, increasing efficiency and reducing the need for manual labor. Therefore their use can bring many advantages, including increasing efficiency, reducing costs, improving yield and minimizing environmental impact.

Another important area is related to price forecasting. Thus, artificial intelligence can be integrated into trading platforms to provide farmers and traders with recommendations on the optimal time to sell or buy, based on price forecasts, analysis of historical production price data to identify seasonal patterns and trends, or on time series of price data. In this way, future fluctuations can be predicted, based on past behavior.

Moreover, artificial intelligence can analyze global news and events, such as geopolitical conflicts, economic crises or pandemics, or even analyze market and investor sentiment in relation to global events, which can have a direct impact on crop prices. Agriculture.

However, it is important to present the empty side of the glass, and the weaknesses that accompany the use of artificial intelligence.

Thus, the researchers of this topic draw attention to the confidentiality of data, their security, considering the fact that these technologies collect, process and analyze large volumes of sensitive data, thus it is essential that farmers and technology companies adopt rigorous measures to protect this information. Farms are thus susceptible to cyber attacks that can compromise sensitive data and therefore the implementation of cyber security measures is needed. Furthermore, farmers need to be educated and trained on the importance of data security and the measures they need to take. Implementing and maintaining such data security measures can be expensive for small farmers, leading to increased costs.

In Europe, the GDPR imposes strict requirements on the collection, processing and storage of personal data. Farmers and technology companies must ensure that they comply with these regulations.

Regarding the availability and quality of data, they are essential for the effective implementation of artificial intelligence (AI) in agricultural farms, allowing accurate analyses, forecasts and useful recommendations to optimize agricultural production. The availability of data depends on farmers' access to advanced technologies, as we know, in many countries or regions, farmers do not have the necessary resources to acquire and implement these technologies, the existence of an adequate infrastructure for data collection, storage and transmission being essential. In rural areas, internet connectivity can be limited, affecting the availability of real-time data. Also, errors in data collection can lead to incorrect analysis and predictions or ineffective decisions.

Using integrated platforms that combine data from various sources can improve data availability and quality. Also, adopting uniform standards for data collection and management or ensuring collaboration between agricultural organizations and technological companies, would be aspects that could facilitate the integration and analysis of relevant information.

The integration of technical expertise in data interpretation by AI in agriculture is another sensitive aspect, necessary to ensure the relevance and accuracy of predictions and recommendations, which can be achieved through close collaboration between experts and AI developers, through the use of labeled data sets, through the development hybrid algorithms, by using simulation platforms, by creating decision support systems and by continuously calibrating models. Thus, farmers can benefit from the best agricultural practices combined with the most advanced technologies available.

Another sensitive aspect is that of ethical considerations related to the use of artificial intelligence in agriculture, which requires a holistic approach, which takes into account data privacy and security, equity in access to technology, impact on the workforce, transparency of algorithms, ecological sustainability , data ownership rights and fair distribution of benefits.

Advanced AI technologies can be expensive, which can create a disparity between large and small farmers, and between developed and developing regions. There is a risk that smallholder farmers will be excluded from the benefits of AI due to the high costs and lack of resources to implement these technologies. Automation of agricultural processes can lead to a reduction in the number of jobs available to agricultural workers, thus affecting their livelihoods. It is important to ensure training and reskilling programs for workers affected by automation to enable them to adapt to the new demands of the labor market. Sharing data between farmers, technology companies and researchers can bring significant benefits, but it must be done responsibly and with respect for property rights.

The advantages of AI in agriculture should be equitably shared among all stakeholders, including small farmers and local communities. AI technologies should enhance the quality of life for farmers and rural communities, not merely boost the profits of large corporations. By tackling these issues, we can ensure that AI's application in agriculture delivers genuine and sustainable benefits to everyone involved in the process.

CONCLUSIONS

Artificial intelligence is an important tool that can contribute to the realization of an intelligent climate in agriculture, which can ensure a sustainable agricultural future.

The use of artificial intelligence and advanced technologies allow farmers to manage resources sustainably and ensure high-quality agricultural production, but also allow them to reduce uncertainties, optimize sales strategies and improve profitability, through more effective risk management and faster adaptation to market changes.

Continued investment growth is supported by improvements in drones, agricultural robotics and data analytics platforms. Also, initiatives such as the launch of new products and partnerships between large companies and agritech startups stimulate the development of this sector.

However, alongside the advantages of using artificial intelligence in agriculture, there are also numerous challenges. These include data confidentiality and security concerns, the high costs, and consequently the limited accessibility of these technologies, the quality of the data collected and used, but also their interpretation and the degree of confidence in what concerns the accuracy. And last but not least, ethical considerations must also be taken into account when we talk about the use of artificial intelligence.

There are solutions that will contribute to improving the current situation. Thus, we believe it is essential to invest in training farmers and agricultural staff to effectively use AI technologies and smart equipment. Also, subsidies and financial support should be provided at the policy level to help small farms adopt these advanced technologies. It is also necessary to develop clear standards and regulations for the collection and use of data in agriculture to ensure its confidentiality and security.

In conclusion, the use of artificial intelligence in agriculture has the potential to radically transform agricultural practices, providing solutions to optimize resources and enhance productivity. However, to fully achieve these benefits, challenges related to cost, education, and regulations must be addressed.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

BEEHIVES AND HONEY PRODUCTION - A BRIEF STATISTICS IN THE WORLD AND EUROPEAN UNION 2000-2022 AND HONEY BEES BETWEEN INTERLINKED CRISIS OF BIODIVERSITY, POLLUTION AND CLIMATE CHANGE

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Abstract

The paper analyzed the number of beehives and honey production at the global level and in the European Union as well as the main problems honey bees are facing nowadays and how they could be solved. The statistical data for the period 2000-2022 provided by FAOStat, Knoema, Eurostat and other official data bases have been processed using fixed basis and structural indices, trend regression equations (linear and polynomial), R square, descriptive statistics, regression analysis, correlation coefficient, comparison method. Compared to 58.8 million beehives in the world in the year 2000, in 2022 their number reached 102 million (+76.3%). The share of beehives by continent is: Asia 44.6%, Europe 24.7%, Africa 17.7%, Americas 11.4% and Oceania 1.4%. The highest number of bee hives is in India, China Mainland, Turkey, Iran (Islamic Rep.), Ethiopia, Russian Federation, Argentina, Tanzania (U. Rep.), USA and Mexico. In 2022, the EU had 20.27 million beehives, meaning +19.44% versus 2016. The largest number of bee hives in the EU is in Spain, Romania, Greece, Poland, Italy, France, Hungary, Germany, Bulgaria and Czechia. From 1.25 million tons in the year 2000, the global honey production reached 1.83 million tons in 2022 (+45.8%). The regression equation: $y = 0.0148 x + 0.4064$ shows that an increase by one million beehives will determine a growth by 0.0148 million tons of honey at the global level. From the peak of 22.5 kg honey per bee hives in the year 2005, in 2022, it was registered 17.9 kg at the global level. Honey production by continent in 2022 was: Asia 48.2%, Europe 22.8%, Americas 18.5%, Africa 8.5% and Oceania 2%. In 2022, the top 10 honey producing countries at the global level were: China, EU-27, Turkey, Iran (Islamic Rep.), India, Argentina, Russian Federation, Mexico, Ukraine and Brazil, all together representing 73.6% of the world honey production. In 2014, the EU produced 235 thousand tons honey and in 2022 it achieved 286 thousand tons (+21.7%). The top honey producing countries are Germany, France, Romania, Spain, Hungary, Italy, Poland, Greece, Bulgaria and Portugal. A bee hives produces 21 kg honey in average, but there are EU countries with higher yields: Finland, Germany, Belgium, Denmark, Estonia, Austria, Italy, Lithuania, Latvia and France. To solve the crisis of biodiversity, pollution and climate change, specific recommendations are destined to improve the ratio between the managed honey bees and wild bees so that the wild bees to have access to flowering sources, to benefit of a suitable habitat to live and reproduce and biodiversity not to suffer. Special measures have to be taken in the cities so that the balance between honey and wild bees to be preserved and the residents and tourists not to be affected. Severe cleaning and hygiene in the apiary, avoiding bees imports, making treatments based on organic medicines could avoid diseases and pests. Farmers have to avoid the use of Neonicotinoids pesticides to help apiculturists not to have bees losses. Beekeeping technology must be adapted to the local conditions and weather alerts, assuring flowering sources, bees reproduction and food storage, as the bee families to pass easier over the winter. An intensified consultancy service, investments in new technologies, a balanced transhumance, more effective marketing actions could increase honey production and quality and stimulate consumption in the EU.

Key words: *beehives, honey production, biodiversity, pollution, climate change*

INTRODUCTION

Bees are very important on our Planet playing a special role in assuring human existence by sustaining agriculture, food security, health and also preserving biodiversity.

Besides the horse and the dog, the bees contributed to the history and civilization of mankind. Beekeeping is one of the oldest activities carried out by people for millennia [3].

Bees are spread on all the continents where the habitats offer them flowering plants which could be pollinated by the bees species. To live they need food, that is nectar rich in energy and pollen as a source of protein.

The habitats should be not only rich in food sources, but also they must offer places for nesting, reproduction and food storage.

The preferred habitats by bees are the ones where the flowering flora is abundant, that is: fruit trees, orchards, technical crops (sunflower, rape, mustard, flax, cotton), vegetables (cabbage, onion, radishes), leguminous seeds (alfalfa, clover), melons, pumpkins, strawberry, blackberry, raspberry, meadows, blueberry, forestlands, gardens, parks etc.

Photo 1. Apis Mellifera Carpatica

The domesticated honey bees produce honey for human consumption all over the world in different habitats [5, 38, 69].

For assuring a balanced development of honey bees, between the number of bee colonies and forage resources should be an optimal relationship [29].

Pollination made by bees is very important both from an economic point of view, because they pollinate an important weight of agricultural crops and fruit trees and also from an ecological point of view because they pollinate wild plants preserving biodiversity.

From the 200,000 species of pollinators, bees represent about 20,000 species and by the pollination service they carry out, they contribute to the maintenance of the balance of the eco-systems [34, 58].

It is officially recognized that 80% of the world plants depend on pollinators and 35% of the world crop production is sustained by the activity of bees and other pollinators [22, 71].

It is estimated that about 98 % of the economic benefice obtained from honey bees is the result of pollination which increases agricultural production, favors plant reproduction and maintains biodiversity, and only the rest of 2% is the value of bee products.

About 264 species of cultivated plants are totally of partially dependent on pollination and production from 75% of the cultivated crops, which assure traded products on the international market, depend on pollination.

In case of over 90 agricultural crops like: cotton, medicinal plants, agricultural crops which produce fruits, vegetables, nuts, seeds, forages for animals, bees could increase production by at least 30%. More than this, about 10% of entomophilous agricultural crops totally depend on pollination made by bees [7].

In Table 1, there are shown the production gains obtained by various plants due to pollination made by bee families.

Table 1. Production gains due to pollination made by bee colonies

Entomophilous plants	No. of bee families per ha	Production gains due to pollination made by honey bees (%)
Fruit trees	2-3	50-60
Alfalfa	8-10	50-60
Clover	4-5	200-300
Sunflower	1-2	30-50
Rape, mustard	4	25-50
Cotton	1-2	25
Cabbage, onion, radishes	3	200-300
Melons, pumpkins	0.6-1	200-400

Source: [38].

A more detailed presentation of the multiple role of bees is provided in Table 2.

Table 2. The role of bees on our Planet

	ROLES
1	Provide natural pollination service of the agricultural crops on 40% of the Earth land and also of other wild plant species, both in warmer areas and cold zones
2	Assure food security offering a large variety of natural and high nutritive value food products such as: honey, pollen, royal jelly
3	Offer important products with medicinal effect used in the treatments of various diseases (pollen, propolis, royal jelly, bee venom etc)
4	Bee products are used in various fields like: nutrition, medicine, cosmetics, food industry etc
5	Sustain human life, health and longevity of billions of people
6	Increase agricultural production
7	Sustain biodiversity assuring a balanced link among pollinators, their abundance and maintenance of other species and the growth of cultivated and wild plants
8	Promote the beauty of the landscapes
9	Offer subject of inspiration for human culture (in art, music, song lyrics, movies, festivals etc
10	Are tools of war to attack the enemies, for fighting against invaders and protecting the ancient citadels
11	Contribute to the creation of jobs, involving pleasant activities in fresh air
12	Empower women and youth as labour
13	Reduce migration
14	Reduce poverty and food insecurity in the developing countries
15	Develop hobbies
16	Develop social relationships between the apiculturists and bee lovers (associations, clubs etc)
17	Create networking among beekeepers
18	Increase household income
19	Contributes to the development of rural areas
20	Support forest conservation
21	Provide information about the environment quality giving signals about the presence of pollutants
22	Create opportunities for export

Source: Own conception adapted based on: [1, 2, 8, 24, 26, 27, 32, 42, 47, 49, 50, 52, 53, 56, 62, 70].

The development of apiculture across the time could be quantified in the increased number of bee hives and honey production which were stimulated by the higher and higher honey demand and measures taken by various states to sustain beekeepers.

An increased number of apiaries, and also a higher and higher apiary size than 100-150 bee hives are compulsory for assuring economic efficiency in beekeeping [40, 41].

In a large-sized apiary, the difference between gross product, representing the value of honey and other bee products obtained in the farm, and variable costs could led to a higher gross margin [43, 46].

From beekeeping, the apiculturists obtain not only honey, but also other products like: pollen, beewax, propolis, royal jelly, bee venom which could be an important income source. Also the apiarists could get income from selling bee queens, package bees, bee hives etc.

These products could be commercialized both on the internal market, but also in the international trade. However, the most traded bee product is honey.

The main supplier of honey is China, while the main importer is the EU [44, 45, 55].

The intensive agricultural systems based on high levels of chemicals, especially pesticides have become polluting factors which affect environment quality (soil, water, air) and in addition the global warming has disturbed the balance in agro-eco-systems diminishing the habitats, forage resources and the number of pollinators [36].

These negative aspects confirmed by scientists have led to the need to raise the awareness that without bees and other pollinators life cannot be sustained. Even the quota mis-attributed to Albert Eistein affirmed that "If the bees will disappear off the face of the Earth, man would only have four years left to live", which is not quite true [59].

Many scientists suggested that people dealing with agribusiness and environment protection have to change crop technologies adapting them in such a way to reduce the amount of pesticides which affect environment quality, high value wild flora and agricultural crops which are forage sources for pollinators, and also diminish the population of pollinators and disturb its density and variety, and by default, will affect food security, biodiversity, health and beauty of our Planet.

Joint efforts are made to internationally cooperate in protecting honey bees [4, 9, 11].

Since 2018, every year it is celebrated the World Bee Day, as established by UN General Assembly, at the proposal of the Republic of Slovenia and with the support of the International Federation of Beekeepers Association-APIMONDIA and on this occasion the big problems of apiculture are discussed [21].

In this context, the paper aimed to analyze the evolution of bee hives and honey production at the global level and in the EU, in the period 2000-2022 in order to establish the main trends, emphasizing the distribution by continent, regions and in the main honey producing countries. In this study, the big problems of bees in relation to intensive agriculture, pollution, diseases and pests and climate change are also approached.

MATERIALS AND METHODS

The paper was set up based on the empirical data provided by FAOStat, Knoema, Eurostat and other official data sources for the period 2000-2022, concerning the number of bee families and honey production worldwide, by continent and regions. Also, a special attention was paid to the European Union as the second honey producer in the world after China and the top importer of honey. The top 10 countries for these two indicators were nominated.

Regarding the methodological aspects, we could mention: fixed and structural indices, descriptive statistics in terms of mean, standard error, standard deviation, kurtosis, skewness, minimum and maximum value. Also, the trend equation suitable to the evolution of each indicators, in terms of linear or polynomial regression as well as the coefficient of determination, R square, were calculated.

More than this, the correlation coefficient and the regression equation between the dependent variable, Y, honey production and independent variable, X, the number of bee hives were determined and interpreted.

Illustrations in terms of graphics and tables have been used for a better understanding of the analyzed indicators.

Finally, the obtained results were correspondingly interpreted.

RESULTS AND DISCUSSIONS

Number of bee hives

Dynamics of the number of beehives worldwide

In the 1990, at the global level there were 69.2 million beehives. In the year 2000, there were 58.8 million beehives, but across the time it increased so that in the year 2022 it accounted for 102 million, which means a surplus by 73.46% (Fig. 1).

The dynamics reflects an ascending trend with small inflexions, and the determination coefficient confirms the change in number of bee hives across these 23 years.

This growth was stimulated by the increase in human population, requiring higher agricultural production both in vegetal and animal sector, a higher demand for pollination services.

In terms of descriptive statistics, the main results regarding the number of beehives at the global level are shown in Table 3.

On the whole period of 23 years taken into account, the average number of bee hives was 78.58 million with a standard deviation of 13.59. The level of this indicator ranged between the minimum of 58.8 million and the maximum of 102 million.

The coefficient of variation was 17.07 %, reflecting a good result and that the variability of the data is low around the mean, suggesting a high degree of consistency and reliability.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

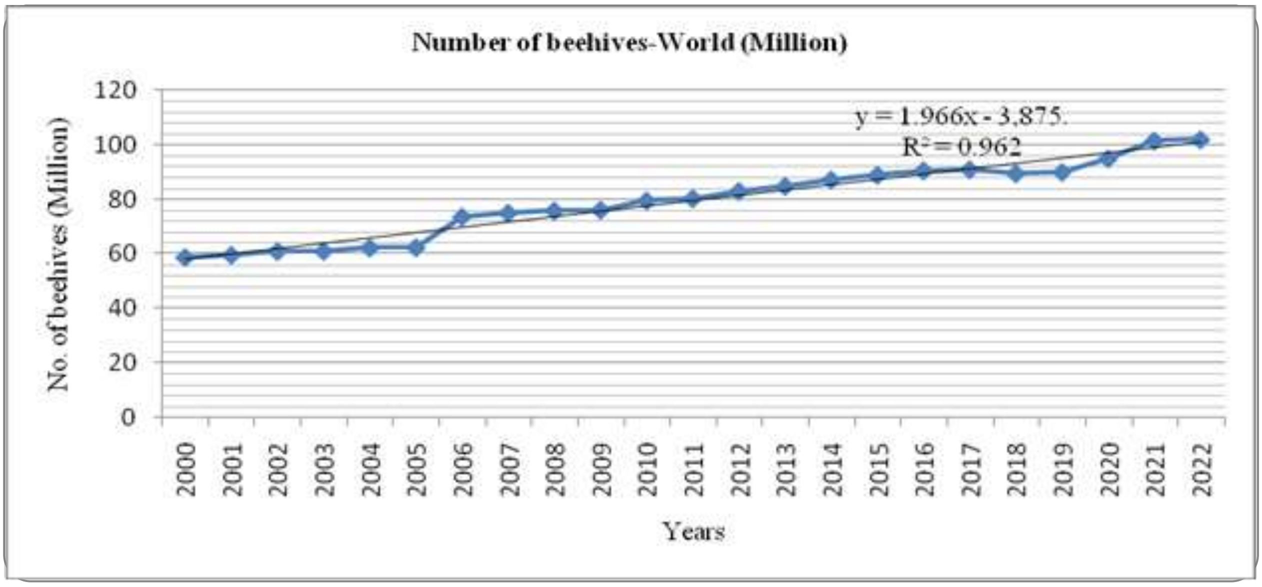


Fig. 1. Dynamics of the world number of bee hives (million)
Source: Own design and calculation based on the data from: [10, 65].

Table 3. Descriptive statistics for the world number of beehives, 2000-2022

Mean	St. Error	St. Dev.	Kurtosis	Skewness	Min	Max	Coef. of Var. (%)
79.58	2.83	13.59	-1.064	-0.1604	58.8	102	17.07

Source: Own calculation.

Dispersion of the number of bee hives by continent

The distribution of the bee hives at the global level differs from a continent to another and from a country to another.

In 1990, the top position was kept by Asia with 33.4%, followed by Europe with 32.5%, on the 3rd position came Africa (14%) and finally Oceania (1%).

In the year 2021, Asia preserved its leading position with 45.1%, despite that in the period 1990-2000 it registered a decline, but then, it has recorded a growth by 11.7 percentage points versus 1990.

On the 2nd position comes Europe, keeping 24.7% share after a decrease from the year 2000 to 2013, but now the number of bee hives has recovered. In case of Europe, in 2021 versus 1990, the reduction accounts for - 7.8 percentage points.

Africa came the 3rd with 17.9% in the year 2021, but this share is by -1.2 percentage points smaller than 19.1% in 1990.

The Americas are ranked the 4th for 11.4%, recording a continuous lower share in the global number of bee hives across the studied period.

Oceania had a negative trend, in 2021, its number of bee hives being by -0.1 percentage points lower than in 1990 (Table 4).

Table 4. Distribution of the number of bee hives by continent (%)

	1990	2000	2007	2013	2021	2021- 1990 (pp)
Africa	19.1	23.4	21.8	20.4	17.9	-1.2
Americas	14.0	17.4	13.8	14.1	11.4	-2.6
Asia	33.4	28.3	41.5	43.9	45.1	+11.7
Europe	32.5	29.5	21.7	20.7	24.7	-7.8
Oceania	1.0	1.4	1.2	0.9	0.9	-0.1.

Source: Own calculation based on [65].

As mentioned before, the variability of the number of bee hives from a geographical point of view on the world map is very large depending on the continent, region, country and of course on the climate conditions, tradition an experience in beekeeping, apiary power and apiculturist financial resources and desire to extend its apiary size.

Figure 2 shows the share of the number of bee colonies by continent in the global number in 2021 versus 1990.

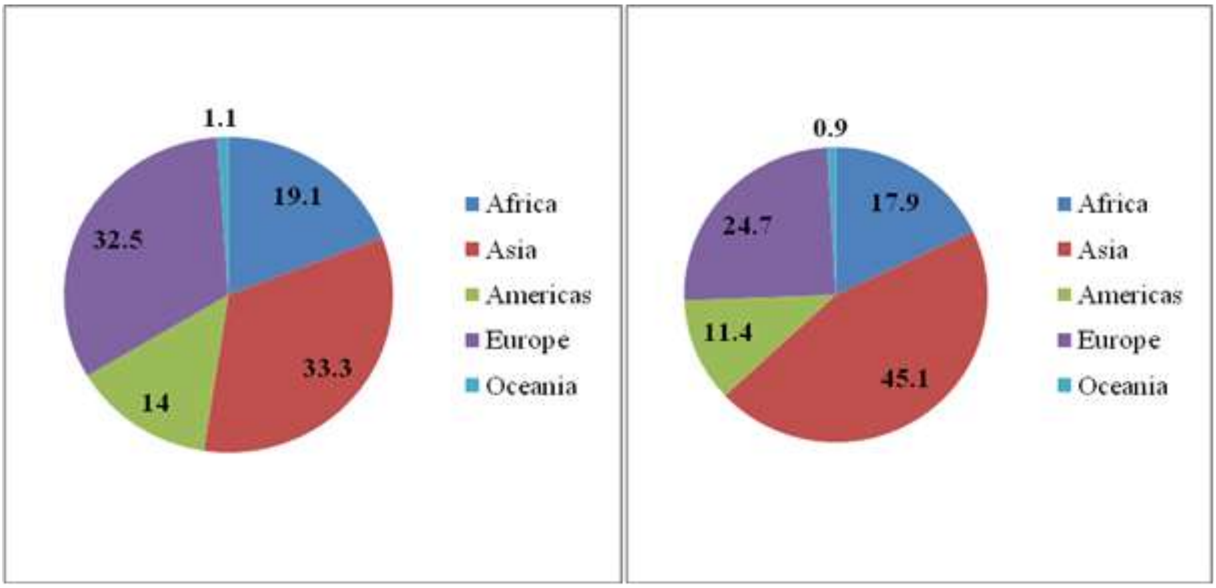


Fig. 2. The share of the number of bee colonies by continent in the global number in 1990 (Left) versus 2021 (Right) (%)
Source: Own design and calculation.

Distribution of beehives by region in each continent

Judging this aspect by region in the year 2021 versus 1990 within each continent, the situation looks as mentioned below.

In Africa, in this interval the number of bee colonies increased by +37.87%. The most numerous bee colonies (12.1 million) are in Eastern Africa, where in these 41 years, their number increased by 51.25%. In Central Africa, the growth was +26.92%, in Western Africa by 300%, in Southern Africa remained at the lowest level (0.1 million) and in Northern Africa declined by -4% (Table 5).

Asia recorded a surplus of 96.10% bee colonies in 2021 versus 1990 and it deserves to specify that in all the regions of this continent the number of bee colonies increased as follows: +89.9% in Southern Asia, +42.16% in Eastern Asia, +300% in South Eastern Asia, +205% in West and +100% in the Central part. The most numerous bee colonies are in the South (20.8 million), East (11.8 million) and West (11.3 million) (Table 5).

In the Americas as a whole, the number of bee colonies increased by 19.58%. while in the Central part it remained at the same level (2.6 million). In the Caribbean area, it increased by 33.3% and in South America went up by 74.3%. In Northern America, the number of bee colonies declined by 8.11%. However, South America comes on the top position with 5.2 million bee colonies, being followed by Northern America (3.4 million) and Central America (2.6 million) (Table 5).

On the European continent, the number of bee colonies raised by 11.55% from 1990 to 2021, but with different growth rates from a region to another. While in the North region, their number became six times higher and in the Southern Europe increased by 23.91%, in Eastern Europe it was noticed a decline by 24.65% and in West part also a decrease but by only 2.86%. In 2021, the highest number of bee colonies is in Eastern Europe (10.7 million) and in Southern Europe (10.3 million) (Table 5).

Oceania doubled its number of bee colonies, which accounted for 1.4 million in the year

2021. All the bee colonies are located in Australia and New Zealand (Table 5).

Table 5. Distribution of bee colonies by geographical region within each continent in 2021 versus 1990 (Million)

Continent	Geographical Region	1990	2021	2021/1990 %
Africa	North	2.5	2.4	96.0
	Central	2.6	3.3	126.9
	East	8.0	12.1	151.2
	West	0.1	0.4	400.0
	South	0.1	0.1	100.0
	AFRICA	13.2	18.2	137.8
Asia	Central	0.5	1,0	200.0
	East	8.3	11.8	142.2
	South	11.0	20.8	189.1
	South-East	0.1	0.4	400.0
	West	3.7	11.3	305.4
	ASIA	23.1	45.3	196.1
America	North	3.7	3.4	91.9
	Central	2.6	2.6	100.0
	Caribbean	0.3	0.4	133.3
	South	3.0	5.2	173.3
	AMERICAS	9.7	11.6	119.6
Europe	West	3.5	3.4	97.1
	North	0.1	0.6	600.0
	East	14.2	10.7	75.3
	South	4.6	10.3	223.9
	EUROPE	22.5	25.1	111.5
Oceania	Australia and New Zealand	0.7	1.4	200.0
	OCEANIA	0.7	1.4	200.0
WORLD	TOTAL	69.2	101.6	146.8

Source: Own calculation based on the data from [10].

Top countries in the world for the number of beehives

In 2019, the main countries with the highest number of bee hives, in the decreasing order, were: India, China Mainland, Turkey, Iran (Islamic Rep.), Ethiopia, Russian Federation, Argentina, Tanzania (U. Rep.), USA and Mexico (Fig. 3).

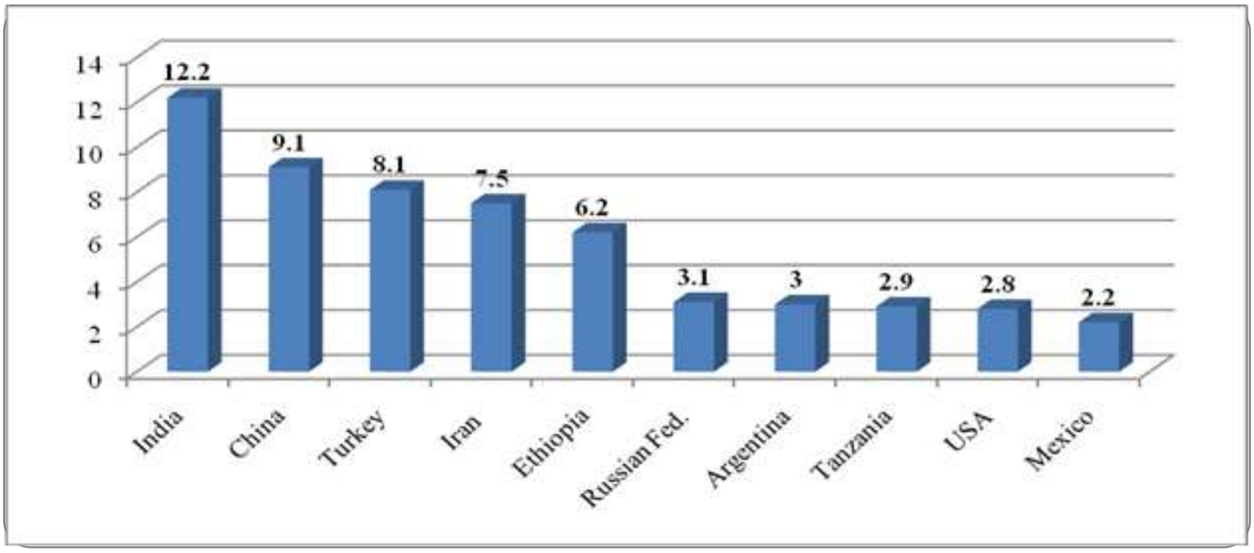
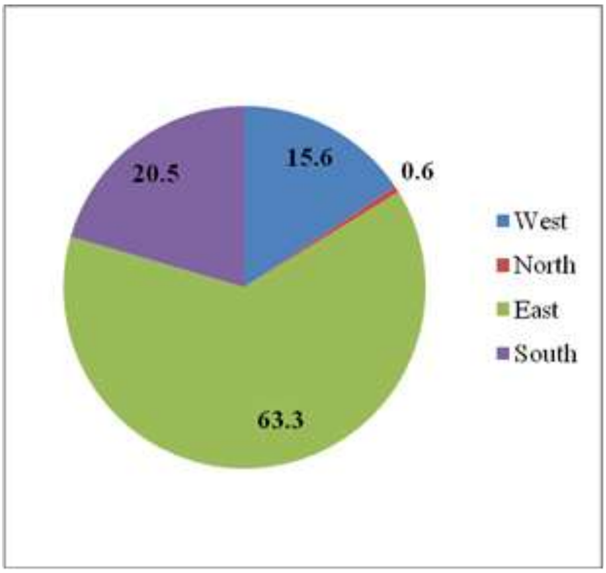


Fig. 3. The top 10 countries in the world with the highest number of beehives in 2019 (Million)
Source: Own design based on the data from [35, 60].

The number of beehives in Europe

According to FAO, 2024, in 1990, Europe had 22.5 million bee hives, but in 2021 it reached 25.1 million (+11.5%).

Beekeeping is practiced in many European countries, but the most numerous are concentrated in the East part (10.7million) and in the South region (10.3 million). In the Western part, there were only 3.4 million (Table 5 and Figure 4).



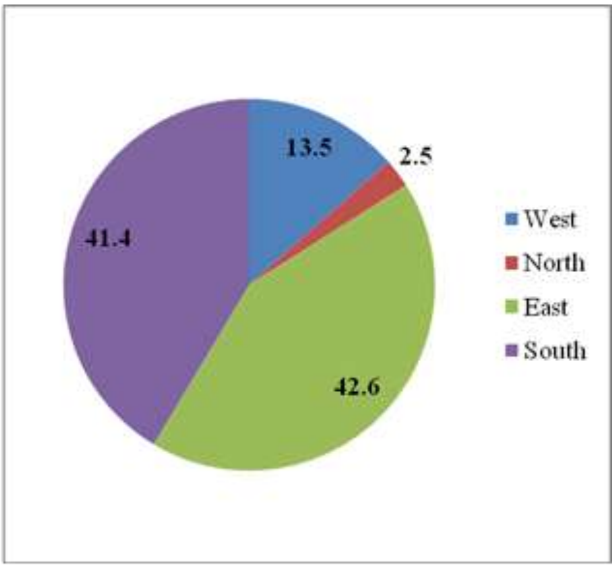


Fig. 4. The distribution of the share of bee hives by geographical region in Europe in 1990 (Left) and 2021 (Right)(%)
Source: Own design and calculation based on the data from [10].

Dynamics of beehives in the European Union

The EU beekeeping is practiced in almost all the member states, but in different geographical conditions which determine that the abundance and density of the bee colonies to vary from a country to another and a large range of beekeeping practices to be carried out in apiaries of various sizes with a deep impact on honey yield and production.

At the EU level, beekeeping development was favored by the increased honey consumption. However, the offer is not satisfactory so that the subsidies offered to the apiarists to increase the number of bee hives and apiary size has continuously stimulated apiculture.

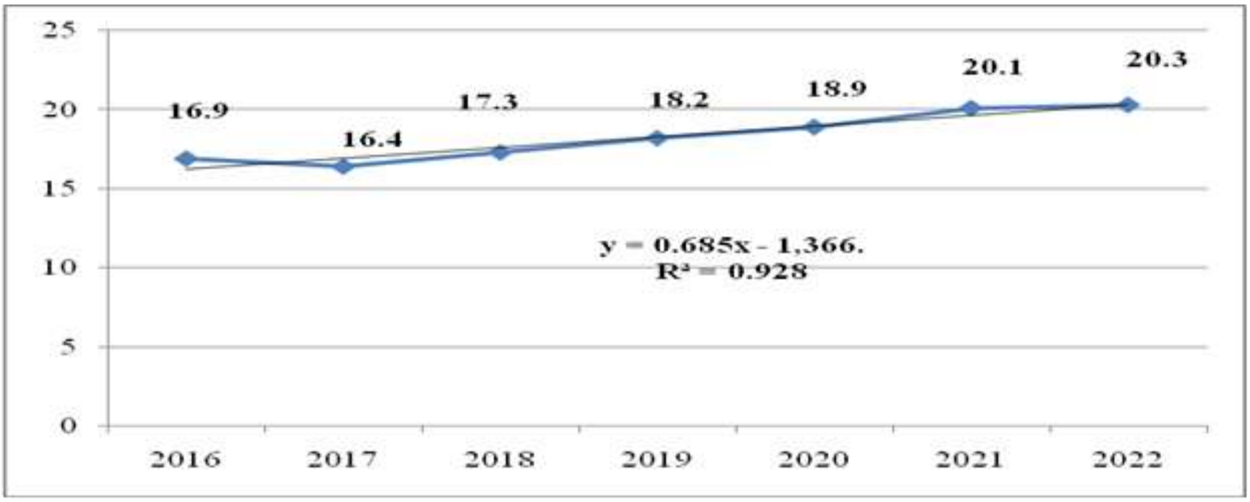


Fig. 5. Dynamics of the number of bee hives in the European Union, 2016-2022 (Million)
Source: Own design based on the data from: [15, 19].

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

In 2022, the EU had 20.27 million beehives compared to the year 2016, when it had 16.97 million, meaning and increase by 19.44% (Fig. 5).

The top 10 member states with the largest number of bee hives in the EU are: Spain, Romania, Greece, Poland, Italy, France, Hungary, Germany, Bulgaria and Czechia [51].

This is a consequence of the fact that the number of beekeepers increased in the EU from 635.6 thousands in the year 2010 to 710.8 thousands in the year 2022, meaning by 11.83% more.

The most numerous beekeepers (in thousands) are in the following countries: Germany (149.1), Poland (91), Italy (81.7), Czechia (65), France (61.7), Spain (36.5), Austria (34.4), Romania (31.2), Slovakia (11.9) and Greece (11.7).

Taking into account the levels of the two indicators mentioned above, in the year 2022, the average number of bee hives per beekeeper in the EU is 29, but there are member states where this figure exceeds the EU mean. It is about: Greece (99), Cyprus (81), Bulgaria (81), Spain (80), Romania (73), Poland (62), Hungary (57), Croatia (50), and Latvia (34).

More than this, in 2022, in many EU countries, the number of beekeepers keeping more than 150 beehives increased. It is about Germany, Poland, Italy, Czechia, France, Spain, Austria, Romania, Slovakia and Greece) [19].

Honey production

Global honey production

In the studied period, 2000-2022, honey production increased at the global level. If in the year 2000, it accounted for only 1.25 million tons, in the year 2022, it reached 1.83 million tons, meaning a surplus of +0.58 million tons, that is +45.8% (Fig. 6).

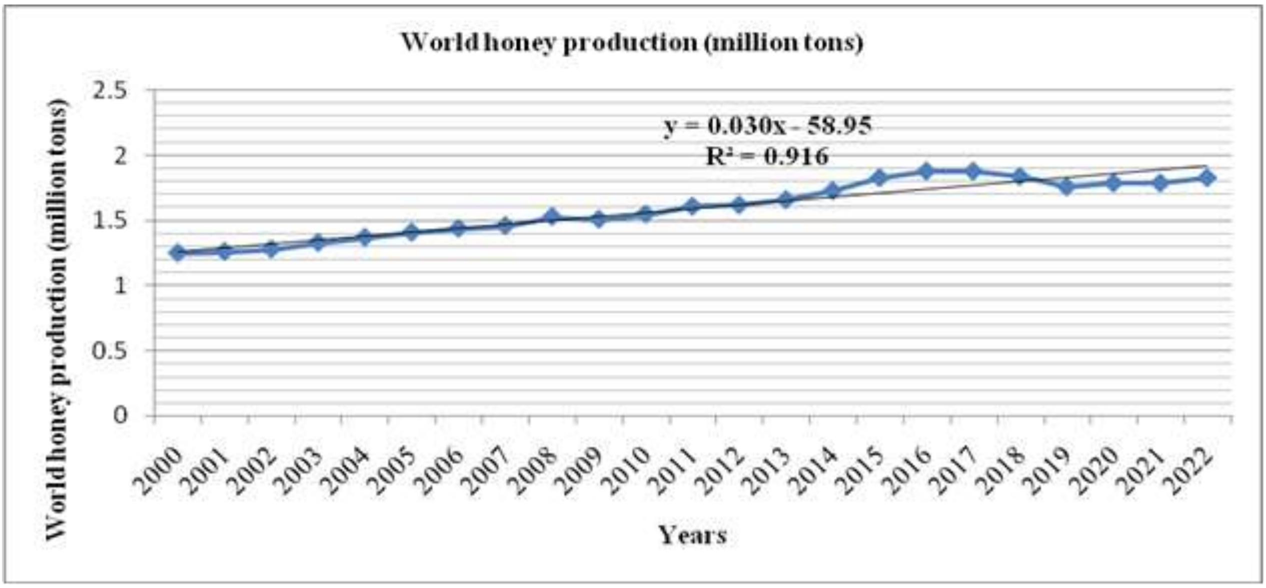


Fig. 6. Dynamic of the world honey production, 2000-2022 (million tons)
Source: Own design based on the data from [28].

In terms of descriptive statistics, the main results regarding the world honey production are shown in Table 6. On the whole interval, the mean was 1.59 million tons, with variations between 1.25 and 1.88 million tons. The variability is weak around the mean (13.2%).

Table 6. Descriptive statistics for the world honey production, 2000-2022

Mean	St. Error	St. Dev.	Kurtosis	Skewness	Min	Max	Coef. of Var. (%)
1.59	0.04	0.21	-1.359	-0.177	1.25	1.88	13.20

Source: Own calculation.

Regression equation reflecting the determination relationship of global honey production (y) by the world number of bee hives (x)

The regression equation reflecting the connection between the global honey production, considered Y- the dependent variable, and the number of the bee hives at the world level, considered the independent variable X, is shown in Table 7.

The regression equation shows that an increase by one million beehives will determine an increase by 0.0148 million tons of honey at the global level.

The determination coefficient, R square = 0.901 tells us that 90.1 % of the variation in the global honey production is determined by the variation in the number of bee hives.

The correlation coefficient r = 0.949 reflects that between honey production and the number of bee hives it is a positive and very strong link.

Table 7. Regression statistics for Y- raw silk production depending on x- silkworm cocoons production

Variable	Coefficient	St. Error	t - stat	Prob.
Regression analysis for Y- Global honey production; X- Global number of bee hives				
C-constant	0.4064	0.0867	4.682	0.0001
X - Number of bee hives	0.0148	0.0010	13.8457	4.986
R squared	0.901	Mean of dependent var. Y	1.59	
Adjusted R squared	0.8965	St. Dev. of dependent var.	0.21	
St. Error of regression	0.0685			
Sum squared residuals	0.0987			
Regression equation: y = 0.0148 x + 0.4064				

Source: Own calculation.

Average honey production per bee hive at the global level

Taking into consideration honey production and the number of bee hives, it was easy to determine the dynamics of honey yield per bee hive.

In the analyzed interval, the maximum honey yield per bee hive was 22.5 kg recorded in the year 2005. In fact, in the period 2000-2005, honey production had an ascending trend. In the following five year, 2006-2010, the yield declined and varied between 19.4 kg in 2006 and 2010 and 20.1 kg in 2008.

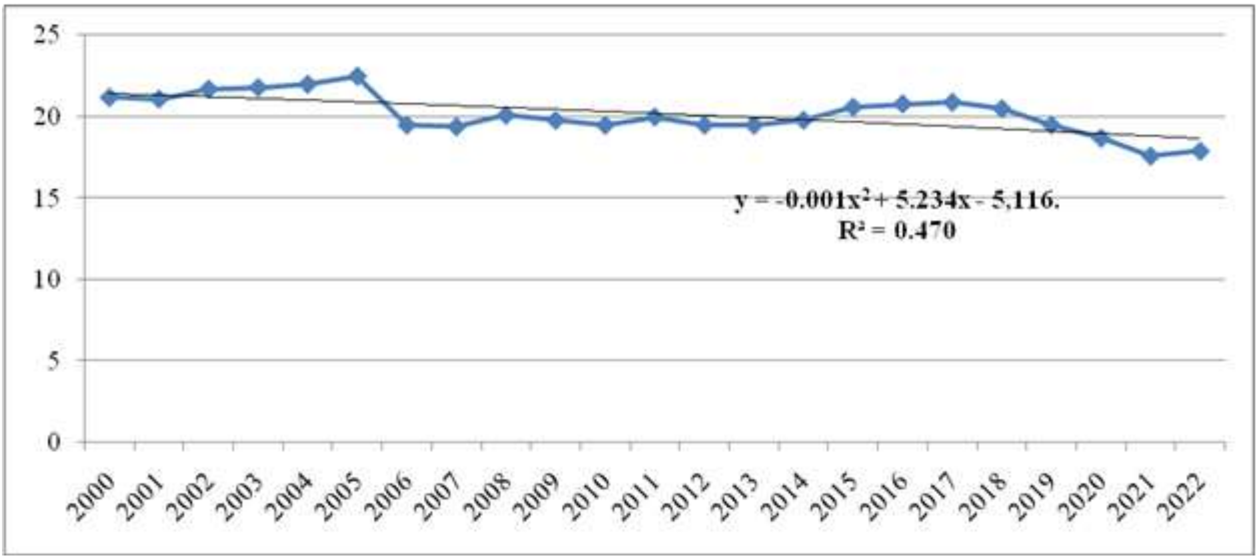


Fig. 7. Honey yield per bee hive at the global level (kg/bee hive)
Source: Own calculation.

This period was a critical one, when the syndrome called "bee colony collapse disorder" appeared in the United States from various causes such as: the use of pesticides in agriculture, attack of the parasite varroa and pathogens (mites and viruses), loss of habitat, genetic factors etc. In this case, the bee queen and a few nurse bees were left by the majority of worker bees to raise the immature bees, leading to the death of the colony [66].

A slight recover to 20 kg/beehive was noticed in the year 2011, but then till 2015, the yield varied between 19.5 and 19.8 kg. In the period 2015-2018, yield increased and varied between 20.6 in 2015 and 20.9 kg in 2017.

Starting from 2019, honey production per bee hives started to decline again reaching the minimum level of 17.6 kg in the year 2021, the smallest in the whole period of 23 years. In 2022, yield increased a little to 17.9 kg per bee hive (Fig. 7).

Distribution of the global honey production by continent

As the number of bee hives varies from a continent to another it is expected as honey production to differ as well.

The major producing continent of honey is Asia, whose share in the global production increased by +12.5 pp, from 35.7% in the year 2000 to 48.2% in the year 2022.

On the second position comes Europe whose share in the world honey production accounted for 22.8% in 2022, but being by -0.3 pp smaller than in the year 2000.

The contribution of the Americas registered a continuous reduction from27.1% in the year 2000 to 18.5% in 2022 (-8.6 pp). Africa comes on the 4th position with only 8.5% and a continuous declining trend. Finally, Oceania registered a decline accounting for only 2% in the global production of honey (Table 8).

Table 8. Distribution of honey production by continent (%)

	2000	2007	2013	2022	2022- 2000 (pp)
Africa	11.4	11.0	10.1	8.5	-2.9
Americas	27.1	21.5	19.9	18.5	-8.6
Asia	35.7	43.5	45.7	48.2	+12.5
Europe	23.1	22.0	22.3	22.8	-0.3
Oceania	2.7	2.0	2	2	-0.7

Source: Own calculation based on [64].

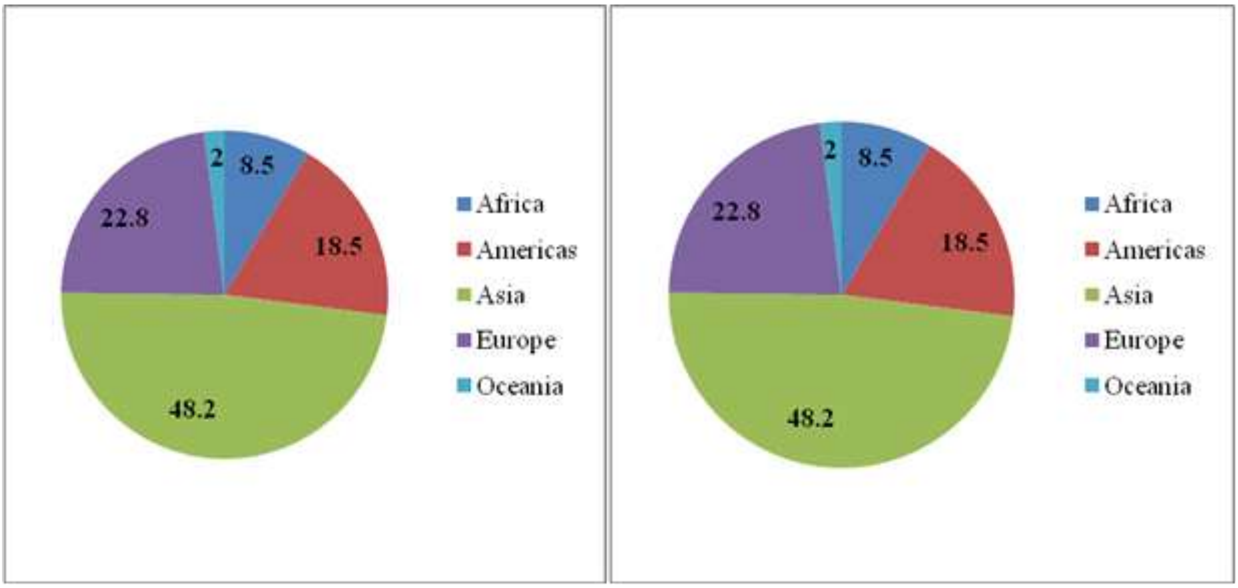


Fig. 8. Share of continents in the global honey production in the year 2000 (Left) versus 2022 (Right) (%)
Source: Own calculation.

The top honey producing countries in the world

In the year 2022, the top 10 honey producing countries at the global level were: China (27.4%), EU-27 (16%), Turkey (6%), Iran (Islamic Rep.) (4%), India (4%), Argentina (3.8), Russian Federation (3.4%), Mexico (3%), Ukraine (3%), Brazil (3%), all together carried out 1,357 thousand tons, representing 73.6% of the world honey production [64].

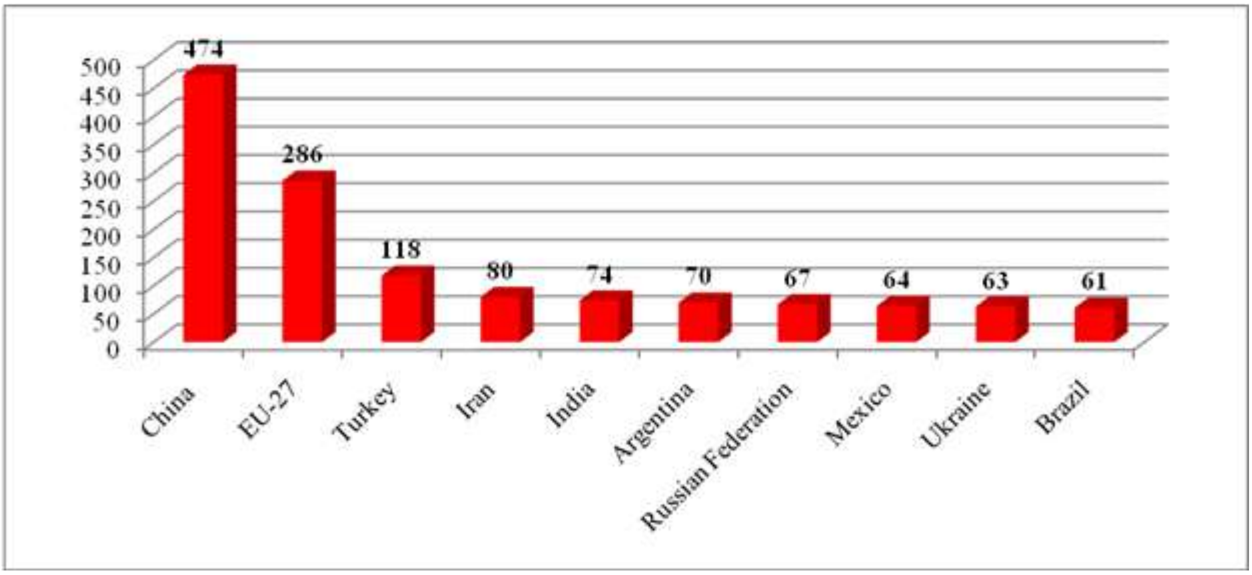


Fig. 9. Honey production in the top 10 producing countries in the world in the year 2022 (Thousand tons)
Source: Own design based on the data from [64].

In the top producing countries, honey production per bee hive is higher than the world average.

In 2019, in five countries honey yield exceeded 25 kg per bee hive: Canada 56 kg, China 52 kg, Mexico 29 kg, Argentina 29 kg and USA 26 kg [35].

Honey production in Europe

Europe is the 2nd honey production after China. If in the year 2000, Europe produced 289.7 thousand tons honey, in the year 2022, its production accounted for 418.3 thousand tons, representing 22.8% of the world production.

Also, Europe is the largest honey importer, due to the high demand for consumption. Self-sufficiency rate is small which request as more honey to be purchased from other countries.

The main suppliers of honey for Europe are the developing countries.

The most preferred honey by the Europeans is organic honey [68].

Honey production in the European Union

The EU has suitable geographical position, various types of relief, various climate, high potential to produce honey, large utilized agricultural area for a large diversity of crops, wild melliferous flora, various flower sizes, blooming periods, *Apis Mellifica Carpatica*, a bees species with a high potential for producing honey and not only.

All these factors have favored the development of beekeeping, which was also sustained by a constructive policy and strategy in the field.

The number of beekeepers increased, also the number of apiaries, average apiary size, honey yield is over 24 kg per bee hive, and total honey production increased. Organic honey is the most preferred by European consumers and the need for high quality honey is very high.

Therefore, the EU is an important honey producer in the world, coming on the 2nd position after China. But, it is also the main importer of honey for satisfying the consumption demand [14, 16, 18].

Honey production in the EU recorded an ascending trend, but the self-sufficiency rate shows that EU must import honey to cover the requirements on the internal market [54].

However, honey production varied across the years mainly in the period 2014-2022 in closely connection with the number of apiaries and beekeepers, apiary size and other factors whose presence had a negative impact on honey production such as: the Covid-19 pandemic, the relative decline in the number of honey bees caused by diseases, the use of pesticides in agriculture and climate change which brought extreme meteo phenomena: higher temperatures, heat waves, droughts, fires, huge rainfalls, floods etc. In addition inflation rate and energy price have had also a relative negative impact [12, 13].

In 2014, the EU produced 235 thousand tons honey and starting from 2015, production increased to a peak of 275 thousand tons in the year 2018. Then, honey production entered in a deep decline, the lowest level being attained in 2019 and accounting for 226 thousand tones. In the coming year, it was noticed a slight recover so that in the year 2022, honey production reached 286 thousand tons [68].

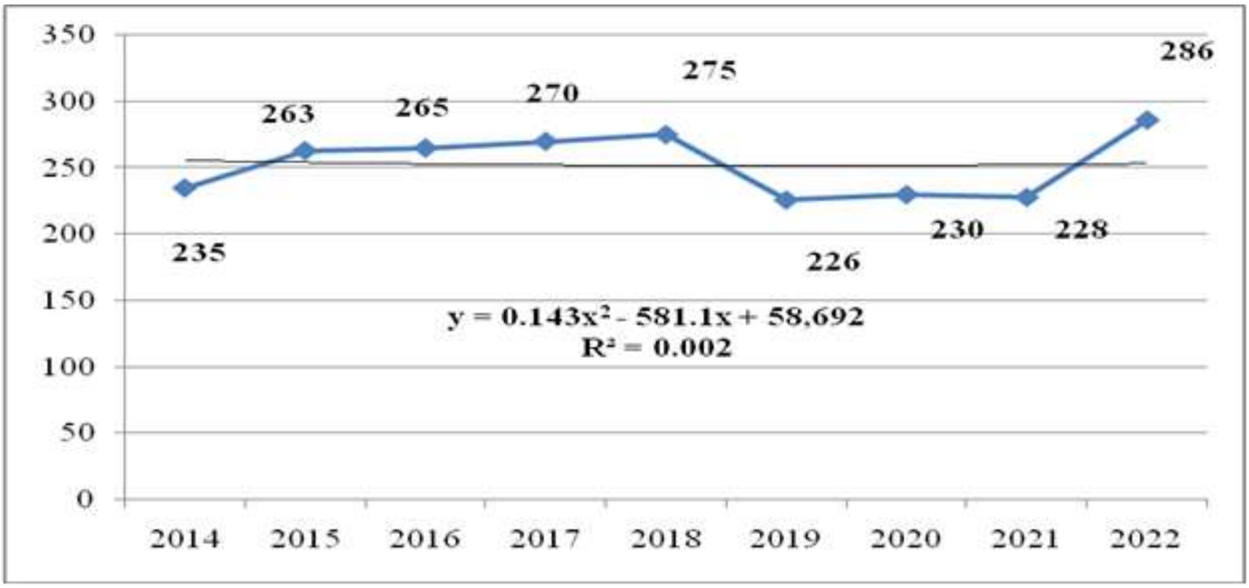


Fig. 10. Dynamics of honey production in the EU, 2014-2022 (Thousand tons)
Source: Own design based on the data from [19, 13].

In the year 2022, the top honey producing countries were: Germany, France, Romania, Spain, Hungary, Italy, Poland, Greece, Bulgaria and Portugal (Fig. 11).

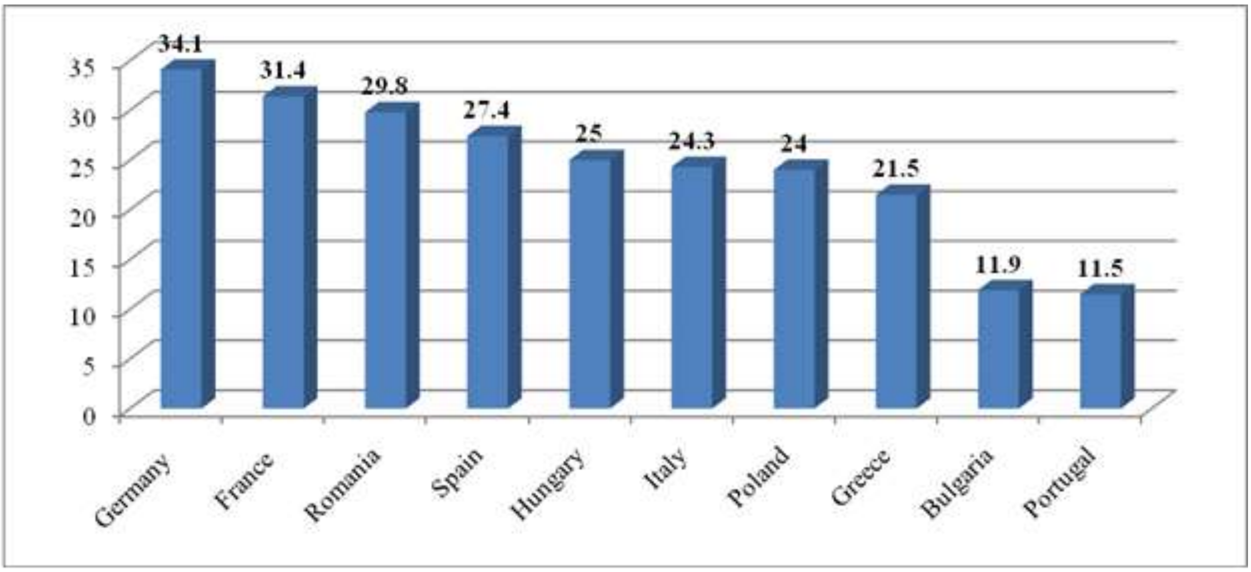


Fig. 11. Honey production in the top 10 EU countries (thousand tons)
Source: Own design based on the data from [19].

Romania is one of the top honey producing country in the EU, having a long tradition, a large variety of landscapes and floral resources, a important number of beekeepers. The country is situated on the 2nd position in the EU for the number of beehives and on the 3rd position for honey production. Romanian honey is of high quality for which it is highly appreciated for export in the Western European countries [39, 48].

EU honey yield per bee hive

The EU average accounts for 21 kg honey per bee hive, but there are countries with a stronger beekeeping where yield is higher. It is about Finland, Germany, Belgium, Denmark, Estonia, Austria, Italy, Lithuania, Latvia and France (Fig. 12).

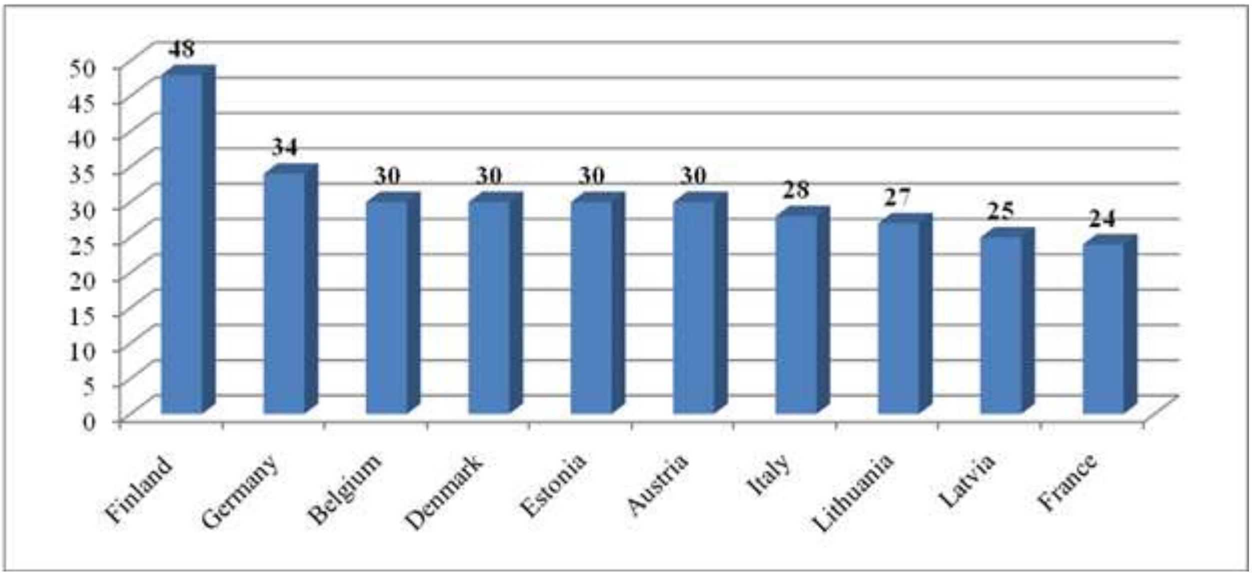


Fig. 12. The top 10 EU countries with the highest honey yield per bee hive (kg/bee hive)
Source: Own design based on the data from [19].

The EU pays a special attention to honey quality, which is severely analyzed in order to detect adulteration with sugar, if it is overheated and if traceability from beekeeper or importer to consumer is assured. Labeling must provide information about honey geographical origin.

Honey bees between interlinked crisis of biodiversity, pollution and climate change

Competition between managed honey bees and wild bees and other pollinators

The increased number of honey bees has affected the number of wild bees and other pollinators because they compete in finding and using the floral sources of nectar and pollen. In consequence, the wild bees and other pollinators have a lower chance for finding the food they need, and their number is damned to a continuous decline as well as the variability of their species.

This has happened mainly during the last decade when beekeeping has been intensified especially in Europe.

The subsidies allowed by the EU have stimulated beekeeping sector looking for an increased honey production to better satisfy the market requirements. This led to an increased number of apiculturists, apiaries and their size in terms of number of bee hives. In many EU countries, as mentioned before, there are apiarists keeping more than 150 bee hives to assure a high economic efficiency in their business.

As a result, it was noticed that in the South part of Europe, more exactly in the Mediterranean countries like Greece, Portugal and Spain, the number of managed bee colonies has substantially increased. In this part of the continent, the number of managed bees reached 10.3 million in 2023, being 2.23 times higher than in the year 1990. Also, in the Eastern part of Europe, there are other 10.7 million honey bees, but their number continue to decrease.

Lazaro et. (2021), examining the density of the managed honey bees and the visitation rate in the Aegean archipelago in the period 2005-2015, found a disturbance of biodiversity in 41 sites on 13 Cycladic Islands in the sense that a higher visitation rate of the honey bees had a negative impact on the wild bee species and abundance [31].

Density and abundance of wild bee colonies versus manage honey bee colonies

Without denying the important role of the honey bees whose number increased, Visisk and Ratnieks (2023), studied the density and abundance of wild colonies compared to the honey bees in 41 locations worldwide and concluded that the number of wild colonies is 2-3 times higher than the number of honey bee colonies at the world level, except Europe and Asia and suggested that the problem should be deeply approached at a smaller scale (Table 9).

Table 9. Density of bee colonies versus wild colonies by geographical area worldwide (number per km^2)

	Wild bee density	Managed honey bee density	Ratio wild bee colony/Managed bee colony
Europe	0.3	1.2	0.25/1
N America	1.4	0.3	4.66/1
Latin America	6.7	0.5	13.4/1
Oceania	4.4	0.2	22/1
Africa	6.8	1.0	6.8/1
Asia	No data.	2.2	-

Source: Ratio calculation based on the data from [67].

Also, the same authors noticed that in the larger areas and in the regions with a colder climate, the density is smaller.

Beekeeping in the cities

Patterson (2020) affirmed that the driver of the wild bee decline is the exponential growth of the world honey bee colonies. He studied the honey bees in the cities, especially in United Kingdom where people like to keep bees as a hobby, for producing home honey, for selling honey and getting an additional income and for treating nervous diseases. More than this, the beekeeping lovers like to socialize, developed close friendships and created clubs and associations where to enjoy spending time together.

He noticed that in London, but also in other European cities like Berlin, Brussels, Paris and in the South of France, the honey bees are more numerous than the wild bees, which led to a increased competition for finding food and in consequence to an unbalanced biodiversity, as in the cities there are also wild bee and other insects in the home gardens and parks.

The higher number of bee colonies in the city has also become a disturbing factor for the residents and even for tourists who like to enjoy sitting on the restaurant terraces. To avoid complains, the local authorities have limited the number of apiaries in the urban area.

Actions and measures to avoid the negative impact of honey bees on biodiversity

To preserve biodiversity and ecosystems balance, it is recommended:

- to create natural and semi-natural habitats, a bee friendly area, knowing that bees love wild flowers, grass and weeds;
- to diversify the flower resources, improving flora structure by including plant species agreed by bees and wild bees; these flowers could be cultivated in pots, at the windows, on the terraces, in the gardens, on the house roofs, in the city flower beds and in the parks.
- to establish a flower conveyer along all the seasons from early spring to late autumn;
-the landscapes to be designed in various shapes, colors and bloom times to attract the bees;
-bees need space where to land and drink water, and this must be in beekeeper's mind all the time;
- to set nesting habitats for breeding and hibernating of the wild bees; also to provide shelters for rest and reproduction and food storage;

It was proved that the lack of natural habitats for 1 km distance from fields could reduce the number of pollinators by 255, the fruit production by 16% and crop yield by 9% [5].

- to keep a severe hygiene and cleaning, eliminating the wastes;
- to limit the number of apiaries and the number of bee hives per apiary in the cities, in order to assure a similar chance for wild bees and honey bees for pickings;
-do not use chemical-based products, but organic products like vinegar and cayenne pepper for protecting the bees against other insects;

-to plant trees like Acacia and Tilia which could be a good source of nectar and also make great shelters [37].

-In case of farms, the reduced use of chemicals is required to protect both honey bees, wild bees and other pollinators;

-Also, farmers have to avoid monoculture and to pass to policulture with a beneficial biodiversity, strengthening the sources of nectar and pollen and favoring the extent of nesting sites, maintaining the number of pollinators and their health.

-Farmers have to apply environment friendly technologies to protect soil, water and air amd maintain the balance in agro-eco-systems.

Diseases and pests are a big problem both for honey bees and for wild bees and other pollinators.

These factors could reduce or kill bee families, reduce honey production and beekeeper's income.

Diseases are caused by pathogens like varroa which can affect a bee family or even an apiary. The viruses could be spread by the imports of queen bees and bee families, and for this reason they have to be avoided.

To prevent varrosis, the mites control has to be done in the fall for having a strong bee family during the winter. Also, treatments with organic formic acid, oxalic acid and botanical oils of thymol could be beneficial.

Environment pollution is another risky factor and a big problem for beekeepers and also for the bee families and wild bees.

Pollution created by intensive agriculture where pesticides are used for sustaining production performance could deeply affect both honey bees and wild bees and other pollinators.

To protect beekeeping of this danger, the EU launched the slogan: "Save bees and farmers" with the goal to diminish soil, water and air pollution, to preserve environment quality and biodiversity [17].

The use of less chemicals is welcome, especially of Neonicotinoids class, which are neuro-active insecticides which could kill the bee families and produce disasters to beekeeping [33, 61].

The use of clothianidin, imidacloprid and thiamethoxam (used as seed treatment or as granules), has acute and chronic effects on bee colony survival and development (especially on bee larvae and bee behaviour). This is why this risk needs to be quantified [20].

Fauzi and El-Kazafi (2023) affirmed that among the top hazard categories in Rapid Alert System for Food and Feed (RASFF) notifications for honey from 2002 to 2022, there were found: unauthorized residues of veterinary medicinal products, adulteration/fraud, foreign bodies, pesticide residues. This regards especially honey coming from China, Turkey, Ukraine, Argentina and Bulgaria. Also, they found in honey chemicals (chloramphenicol, streptomycin, sulfathiazole, tylosin, sulfadimidine) used by beekeepers to control infectious diseases of bees Strict restrictions should be imposed to reduce the risk of finding these contaminants in honey [23].

Using less chemicals and intensify the advertising alerts, bee families and other useful insects could be saved, the agro-eco-systems could preserve their balance, for assuring sustainability of food and food security.

Floral resources should be chemically-free and habitats for honey and wild bees to be preserved.

Climate change has disturbed human and animals life during the last decades but also it has affected agriculture, beekeeping, environment and biodiversity.

More and more effects resulting from extreme climate phenomena have become more visible with a deep economic, social and environment impact [25].

Huge rains, floods, storms, winds, high temperatures, hot waves, cold winters, etc have disturbed the habitats, destroyed the hives, have diminished the food resources, made bees more sensitive to pests and diseases and even killed bee colonies and other valuable insects and pollinators [6].

What is worse is the fact that the weather patterns cannot be predicted so well, except in a relative level based on the statistical data for a long period of time regarding temperatures and precipitations, but climate change has led to unpredictable phenomena. Extreme weather events increased their occurrence, localized warming and cooling, long and severe droughts, aridity, desertification, the gap of the seasons.

Due to this it has appeared a difference between the moments when the plants are in bloom and the bees and other pollinators need food and reproduction. As noticed the last year, the weather became warmer early and the bees and other pollinators emerge early, but the flowering period will appear later. This dis-synchronization affect the insects and also the effect of pollination.

The long and severe droughts diminish the flower resources, and the bees spend a lot of time and energy visiting the blooms for less nectar. The bee families cannot nourish well and will have a weaker capacity to survive.

In the wetter periods, the bees cannot fly and bring nectar in the hive, therefore, they cannot store enough food to reproduce.

The wet and cold winters could increase mortality during hibernation.

To prevent the damages and losses, beekeepers have to set up their own strategy adapted to the local conditions. The beehive boxes have to be reinforced, the beehives have to be reallocated, food has to be supplemented with new diets, and pests and diseases have to be managed. Beekeepers have to be informed every moment about the climate evolution (temperatures, rains, winds etc), to take the corresponding measures to protect the bee families in order to maintain their health and power to survive, reproduce and produce bee products [30].

Rajagopalan et al (2024) quantified the effect of warmer autumns and winters on honey bee foraging activity, age structure overwinter, spring colony losses, and evaluated indoor cold storage to diminish the negative effect of climate change. They proposed to store in a cold place the bee colony during winter for reducing honey bee colony losses [57].

Important intervention actions provided by the CAP Strategic Plan in the EU

The EU Common Agricultural Policy regarding the development of beekeeping is permanently adapted to the new conditions by issuing intervention measures, among which the most important ones are the following:

-providing consultancy services for apiculturists: technical assistance, training, updated information, facilitating networking;

-sustaining the investments in tangible and non-tangible assets;

-preventing and combating bee diseases and pests attack;

-mitigating the effects of climate change;

-promoting best management practices;

-enhancing the bee breeding to enlarge the colonies using best and selected bee queens and buying packaged bees;

-sustaining the bees transhumance in a rational manner to diminish the related costs;

-promoting the collaboration and cooperation among beekeepers to exchange ideas, to form associative forms, to organize bee honey and other products fairs;

-stimulating the delivery of valuable information to consumers to develop their awareness about the quality of bee products;

- suggesting actions to improve honey quality; in this respect, the EU sustains the laboratories for honey analysis of honey and other bee products to detect toxic substances for bees;

-to continue to control the quality of imported honey in order to protect the EU beekeepers of an unfair competition;

- to diversify marketing solution in valorizing honey, in bottled manner in cans labeled to show the geographical origin;

-to increase value added to get a higher price per sold product and increase beekeeper's income;

-to extend research programmes in beekeeping and apicultural products;

-to develop research networking actions and create bridges between researchers for exchanging ideas and solving problems;

- to intensify the monitoring of marketing actions, emphasizing on communication and promotion;

-helping consumers to become more aware of the nutritive and energetic value of honey and other bee products for increasing consumption;

- sustaining beekeeping by providing financial support for the period 2023-2027 [63].

CONCLUSIONS

The statistics proved a continuous increase in the number of beehives and also regarding honey production. Both the bee hives and production of honey are concentrated in Asia and Europe, followed by Americas.

If in the year 2000, at the global level there were 58.8 million beehives, after 23 years, that is in the year 2022, their number reached 102 million, meaning a surplus of +76.3%.

The distribution of the beehives by continent is: Asia 44.6%, Europe 24.7%, Africa 17.7%, Americas 11.4% and Oceania 1.4%.

India, China Mainland, Turkey, Iran (Islamic Rep.), Ethiopia, Russian Federation, Argentina, Tanzania (U. Rep.), USA and Mexico are the top 10 countries with the highest number of bee hives at the world level.

In 2022, the EU had 20.27 million beehives, a level by 19.44% higher than in the year 2016.

Spain, Romania, Greece, Poland, Italy, France, Hungary, Germany, Bulgaria and Czechia are the top 10 countries with the highest number of beehives.

The global honey production reached 1.83 million tons in 2022, being by +45.8% higher than 1.25 million tons in the year 2000.

A correlation coefficient, $r = 0.949$ reflects that between honey production and the number of bee hives it is a positive and very strong connection.

The regression equation: $y = 0.0148\ x + 0.4064$ showed that an increase by one million beehives will determine a growth by 0.0148 million tons of honey at the global level.

From the peak of 22.5 kg honey per bee hives in the year 2005, in 2022, it was registered 17.9 kg at the global level.

Honey production by continent was distributed as follows in 2022: Asia 48.2%, Europe 22.8%, Americas 18.5%, Africa 8.5% and Oceania 2%.

The top 10 honey producing countries at the global level in the year 2022 were: China, EU-27, Turkey, Iran (Islamic Rep.), India, Argentina, Russian Federation, Mexico, Ukraine and Brazil, all together representing 73.6% of the world honey production.

In the year 2022, Europe produced 418.3 thousand tons honey, representing 22.8% of the global production, for which it is situated on the 2nd position after China.

Europe is also the largest honey importer, due to the high demand for consumption and the main suppliers of honey are the developing countries.

In 2022, the EU produced 286 thousand tons honey, by 21.7% more compared to 235 thousand tons in the year 2014.

Germany, France, Romania, Spain, Hungary, Italy, Poland, Greece, Bulgaria and Portugal are the top honey producing countries in the EU in 2022.

The average honey yield per bee hive in the EU is 21 kg, but Finland, Germany, Belgium, Denmark, Estonia, Austria, Italy, Lithuania, Latvia and France produce much more honey.

The EU pays a special attention to honey quality and traceability from beekeeper or importer to consumer, attested by labeling which offers information about honey geographical origin.

The main problems honey bees between are facing at present are: the crisis of biodiversity, pollution and climate change.

The increased number of managed honey bees has affected the number of wild bees and other pollinators disturbing the balance of the eco-systems and diminishing biodiversity regarding both the structure of pollinators species and flora mainly in Europe (especially in the Southern part in the Mediterranean countries) and in Asia.

Also, as a result of the high number of honey bees in some regions of the world, the density ratio between wild bees and honey bees has decreased. Normally, the wild bees must have a few times higher number than honey bees.

Special recommendations have been specified to be taken into consideration for avoiding this unpleasant aspect in the future.

Also, special suggestion have been made for the presence of honey bees in the cities, so that their number not affect the abundance of wild bees and other pollinators and not to disturb the residents and tourists.

To prevent the appearance of diseases and pests attack, it was suggested as apiculturists to keep a severe cleaning and hygiene in the apiary and to avoid imports of bee queens and package bees. Treatments are compulsory to save the bee hives if it is possible and using medicines based on organic substances.

The use of pesticides from the Neonicotinoids category must be stopped for avoiding the loss of bee colonies.

To diminish the negative effects of climate change on beekeeping, apiculturists must adapt the applied technology to the local conditions, taking measures for assuring flowering sources, reproduction of the bee family, strengthening its power to pass easier over the winter season making food storage.

The EU strategy is focused to enhance beekeepers knowledge and skills by an intensified consultancy service and to offer support for investments in modern beehives, high genetic value bee queens, bee colony breeding, a more balanced transhumance, an increased production and honey quality and to intensify the marketing actions for making consumers more aware of the high nutritive and energetic quality of honey and the bee products.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

MEAT PRODUCTION, TRADE, CONSUMPTION AND SELF-SUFFICIENCY RATE IN ROMANIA IN THE PERIOD 2014-2022

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Abstract

The goal of the study is to analyze the dynamics of meat production, import, export, availability for human consumption and self-sufficiency rate (SSR) in Romania in the period 2014-2022 based on the data provided by National Institute of Statistics. The empirical data were processed using the growth rate, trend regression equations, determination coefficient, illustrative graphical representations and tabled results for the indicators taken into consideration. The results highlighted that in the studied period, total meat production (in fresh meat equivalent), decreased by 22.5%, from 1,291.9 thousand tons in 2014 to 1,001.6 thousand tons in 2022. But, by meat sort, the situation is different as follows: bovine meat production declined by 8.9% and pork production by - 16.4%, while sheep and goat meat increased by 27.2% and poultry meat by 43.8%. The imported quantities of meat registered an ascending trend from 383.9 thousand tons in 2024 to 628.5% in 2022 (+63.7%). By meat sort, the imported amounts increased by 12.4% for beef, by 200% for pork, by 400% for sheep and goat meat and by 8.1% in case of poultry meat. In 2022, Romania exported 166.8 thousand tons meat meaning by 31.61% more than in 2014. By meat type, the exported amounts increased by 200% for bovine meat, by 86 % in case of sheep and goat meat, by 45.2% in case of poultry meat, but in case of pork declined by 36%. The meat availability for consumption increased by 22.4% from 1,150.6 thousand tons in 2014 to 1,463.3 thousand tons in 2022. For total meat, self-sufficiency rate (SSR) declined from 83.3% in 2014 to 68.4% in 2022. By meat sort, SSR went up for bovine meat accounting for 87.1% in 2022 versus 82.1% in 2014, for pork SSR went down to 45.4% in 2022 versus 70.2% in 2014, SSR for sheep and goat meat was 100% in 2022 versus 106% in 2014 and for poultry meat, SSR increased from 87.5% to 95.2% in the studied period. In 2022, a Romanian consumed in average 74 kg meat, of which 38 kg pork, 27.9 kg poultry meat, 5 kg beef and veal and 2.6 kg sheep and goat meat, much more than in 2014, except bovine meat. As a conclusion, imports sustain pork domestic market as production is not enough to cover the demand, but also in smaller amounts for the other meat types. Romania is also an exporting country of meat, as long as the availability of meat on the internal market is raising.

Key words**:** *meat, production, import, export, consumption availability, self-sufficiency, Romania*

INTRODUCTION

The increase of the world population requires more and more food, but production is constrained by the limited natural resources especially land and water, and in addition by the negative impact of climate change [4].
Meat is an important component of human nutrition as it is a source of high value protein. That is why at the global level, meat production registered a higher and higher level trying to meet the demand.
In 2022, 362.6 Million metric tons of meat were produced and in 2032 it is expected to reach 382 Million tons, but the growth rate will differ by species so that in 2032, pig meat will be by 11% higher, poultry meat by 15%, beef and veal by 10% and sheep meat by 15%. It

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

was also estimated that, in 2032, 41% of total animal protein will be provided by poultry meat [25].

Taking into account only the main species producing meat: swine, poultry, bovines and sheep and goats, the world meat production reached 350.5 Million Metric tons in the year 2023, being by 61.4% higher than in 2016, but by 3.6% smaller than in 2022.

The share of each meat type in the world meat output in 2023 was 39.8% poultry, 34.8% pork, 20.5% beef and veal and 4.9% sheep and goat meat [51].

The main producing countries of pork at the global level are: China EU, USA and Brazil [37, 54]. The top leaders in beef production are: USA, Brazil and China with a share of 50% in the global production, followed by EU, India and Argentina [55]. The largest poultry meat producing countries are USA, Brazil, China, Russia, which accounts for about 54% of the global output [19]. The top producing countries of sheep and goat meat are China, India, Australia, Nigeria, Iran, Turkey [18].

The EU contributes by about 12% to the global meat production. In 2022, the EU meat production attained 42.2 Million tons (pork, poultry, bovine and sheep and goat meat), being by 12.5% less than in the year 2007. In 2022, the contribution of the meat type to the EU meat production was: 50% pork, 30.8% poultry meat, 15.6% beef and veal, and 3.6% sheep and goat meat [13].

However, meat production in the EU is expected to decline by 2035. The situation is different by meat.

Beef production is expected to decrease, the main causes being: low productivity, high production cost related to the environment sustainability and climate change regulation, but it will continue to remain important for human health.

Pork production is also expected to decrease due to sustainability, health concerns, the uncontrolled African Swine Fever outbreaks, and high production costs.

Poultry meat will be the only meat type which is expected to reach a higher output, grace to its special qualities: healthy food, high protein content, lean meat, tasty and easy to cook, and a smaller price than beef and pork.

Sheep and goat meat is also expected to decline due to the reduction in livestock, but consumption will remain stable [12].

At the global level the average meat consumption per capita is 28.1 kg, but it is much higher in North America (78.6 kg), Oceania (55 kg), Europe (52.1 kg) and South America (49 kg). Meat consumption is smaller than the global mean in Asia (22.3 kg) and Africa (9.6 kg) [52].

According to FAO, the average food consumption requirement per day and capita must be over 2,700 Kcal and minimum 55 g protein, of which 50% should be of animal origin [16].

All the countries make efforts to assure a corresponding average daily diet to their inhabitants, but in the world there are still huge discrepancies among the developed and developing countries.

In general, the developed countries are able to produce more meat and other products of animal origin to cover the internal market needs and also to make export.

According to FAO, Self Sufficiency is defined as "the percentage of food consumed from the amount produced domestically".

Therefore, it shows the capacity of a country to cover the consumption requirements of its population from internal food production.

However, not all the countries are able to produce enough food and are obliged to make imports. Also, there are countries which are able to produce more, and in this case the surplus is exported. Thirdly, there are countries which produce enough food, but also apply for imports and make exports.

Therefore, the availability of food comes from production plus imports and minus exports, the expression being synthesized in Self Sufficiency rate (SSR) whose formula is:

SSR = Production x 100 /(Production +Imports -Exports) [17].

SSR could be measured in various ways:

Quantitatively, SSR could be quantified in the volume of food production and by type of commodity (wheat, maize etc, meat, eggs, milk etc) reflecting the capacity of a country to cover its own population's needs for food products.

Qualitatively, SSR could be expressed in:

- Dietary energy production (DEP) of over 2,700 kcal per capita per day for a balanced diet reflecting the capacity of a country to assure the energy requirements.
- Protein, carbohydrates, fats per inhabitant per day, reflecting the capacity of a country to produce the need in high value nutrients in diet. In case of protein is 55 g per capita and day, of which 50% must be of animal origin.
-*Monetary value*, taking into account the value of its components, which allows comparisons regarding SSR among different countries and establishing their hierarchy in the world, continent, region, by group of countries depending on their development level.

SSR cannot be isolated from the country contribution to international trade and depending on Export/Import ratio, there are net exporting countries (E/I > 1) and net importing countries (E/I < 1).

In general, the majority of net exporting countries have a SSR over 100 and also a DEP higher than 2,700 kcal/capita.

However, self sufficiency is still a controversial topic among experts because a part of them sustains that SSR assures a stable food supply, while other experts deny and affirm that it could led to instability.

This aspect makes distinction between food self sufficiency and food security which are different notions, but they are connected to each other and interact in various ways [17].

Food Self sufficiency was studied by various researchers as literature has proved.

Porkka et al.(2013) affirmed that a higher dietary energy production per capita over 2,700 kcal is adequate for a balance diet [45].

Fader et al (2013) discussed about the countries where land and water resources are not enough to assure domestic food production and are obliged to make imports to cover the country needs [14].

O'Hagan (1975) approached the topic the national food self sufficiency [27].

Clapp (2017) discussed about the self sufficiency and food security and sustained that a country must be a part of international trade to assure the economic efficiency besides being focused on self sufficiency [10].

Fathelrahman et al. (2021) also sustained that food security could be assured only by an openess to trade in order to increase availability of a higher food supply in India, Egypt, Pakistan, Saudi Arabia and United Arab Emirates [15].

Baeer (2019) referred to food security and food self sufficiency in various countries emphasizing the differences determined by agriculture peculiarities regarding natural, social and economic resources. Wealthy countries situated in favorable regions for agriculture (North America, Australia, New Zealand, Kazakhstan) have the capacity to assure food sufficiency and security. The EU, despite the small arable land area per capita, is able to carry out a high food production. In the Middle East, North Africa and South America, the countries depend on food imports. Sub-Saharan African and Central Asian countries continue to have a critical food situation [3].

Szainer (2024) assessed food production and self sufficiency in Ukraine compared to the EU and Poland and affirmed that Ukraine possible accession will have an important impact on the EU supply and demand [53].

Amhamed et al. (2023) analyzed food security strategy in Qatar destined to increase domestic food production and external exports [2].

Beltran-Pena et al (2020) were focused on sustainable food systems affirming that the major challenge of mankind is the higher global food demand and the limited resources of the Earth [4]. Silva et al (2024) discussed food sovereignty, food security and international trade in Chile [46].

According to Statista (2016), in 2015, the SSR for meat by type in the EU-28 accounted for 110% for pork, 107% for poultry, 99% for beef and veal and 83% for sheep and goat meat [50]. According to FAO (2020), in 2018, the EU SRR for meat accounted for pork 119%, for poultry 106%, for beef and veal 104% and for sheep and goat meat for 91%. Brankov et al. (2021) analyzed food self sufficiency and the influence of various factors on its level in the South Eastern European Countries [5].

Kołodziejczak (2019) analyzed SSR for meat in the EU in 2016 and found the in the EU-28 SSR was 106%, in the EU-15 107% and in the EU 13- 101%. The calculated forecast expectations by 2080 are: 103%, 99% and, respectively, 127%. Therefore, in the EU-13 it is expected an increase in meat production which could cover consumption must better. The author specified that the main EU countries with the highest SSR for meat are, in the decreasing order: Denmark, Austria, Ireland, Belgium, Netherlands, Poland and Hungary [22].

Mateos et al. (2024) studied pig meat production in the EU-27 and found that in 2022, the EU produced 23 Million tons pork, representing 21% of the global production. Pork sector is facing the following main problems: high pork consumption which affects human health, African Swine Fever outbreaks, high production costs related to higher price for farm inputs, and also to the new regulations regarding farm management, environment sustainability and animal welfare [25]. Kubala (2018) found that the leaders in beef self sufficiency are Poland, Lithuania and Estonia, while the leaders in pork self sufficiency are Hungary and Estonia. The lowest self sufficiency is in Bulgaria and Slovakia for beef and in Slovenia for pork [23].

Kubala (2021) found that the highest SSR of poultry meat production is in Poland, Slovenia, Lithuania and Hungary, while the lowest SSR is in Bulgaria, Czechia, Estonia, Slovakia and Latvia [24].

Slaboch (2016), making a comparison among the Visegrad countries regarding self sufficiency for beef, pork and poultry meat affirmed that in Czechia and Slovakia SSR declined for pork and poultry meat, while in Poland production is able to cover consumption with a higher SSR for beef and poultry. Also, Hungary is able to cover domestic consumption by production [47].

In Romania, Grodea (2017) discussed about self sufficiency and food security for meat and found that it has a lower level than in other EU countries, but there are incentives to sustain internal production [21].

Popescu (2022) affirmed how important is production and import for assuring food availability for the population of Romania. In Romania, meat consumption increased and reached 74 kg per capita, the most preferred meat being pork which is traditional in the country, followed by poultry meat, then comes beef and veal and, finally, sheep and goat meat [38]. Consumers like poultry meat for it is cheaper than pork, tasty, and healthier and easy to cook [6]. Beef consumption is about 5 kg per capita and year, as the price high, but it is healthier than pork. Production declined due to the reduction of livestock [30].

In Romania, pig herds went down, but consumption remained at a relative constant level of about 38 kg/capita/year and a similar trend was noticed in other EU countries [28, 29, 36].

Romania is a net importer of pork to cover internal market requirements, even thou pork price increased due to the high demand and lower production, even thou the farm inputs prices went up and increased production costs, reflecting a real crisis [35, 40].

Sheep and goat meat is preferred especially by breeders who are accustomed with its smell and taste, but also Romanians eat lamb which is the traditional meat at Easter [7, 8].

Sheep and goats are also raised in other EU countries like Greece, Italy and Spain [43].

In Romania, livestock declined in the last decade leading to the reduction of the number of slaughtered animals and their live weight affecting meat production [41, 44].

Also, the structure of meat production is deeply linked to the structure of animal farms [39].

Sheep and goats livestock followed an upward trend which lead to a slight production growth and consumption [31].

Romania sustains agro-food trade, exporting especially cereals and oil plants seeds, but also sheep and goats and poultry meat, the main beneficiaries being the EU countries and Arabian countries. Imports are supplied by the main EU partners and represented by processed meat and dairy products, and also by vegetables and fruits [32, 33, 42].

Food consumption has an important share in the Romanians' daily basket expenditures in close connection to the salary level, which is one of the smallest in the EU. For this reason, in GDP, a major contribution is given by consumption and not by export [34].

However, Romanians purchase much more than they consume, especially on the religious fests, which favour food loss and waste. For this reason, important measures and solutions

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

were taken and proposed to diminish food loss and waste along the food supply chain [49].

More than this, as long as, more and more consumers are interested of a healthier diet, a part of producers have become to be focused on organic agriculture not only in the vegetal sector, but also in the animal production to offer high quality products to the market [9].

In this context, the goal of this study is to quantify meat production, import, export, availability for human consumption, self-sufficiency rate (SSR) and average gross annual consumption of meat per inhabitant in Romania in the period 2014-2022.

MATERIALS AND METHODS

For this study, the empirical data were collected from the National Institute of Statistics for the period 2014-2022 for which the information were available in the year 2024 in Food Balances.

The key indicators approached in this research have been:

(i)Total meat production

(ii)The imported amount of meat

(iii)The exported quantities of meat

(iv)The available amount of meat for human consumption

(v)Self-Sufficiency Rate (SSR), calculated according to the formula:

SSR = P x 100/(P + I - E)................(1)

where:

P = production, I= Import, E = Export

(v)Average gross annual meat consumption per inhabitant.

(vi)SSR in terms the average daily protein assured in Romania per inhabitant compared to the requirement of animal origin per capita of 27.5 g according to FAO.

(vii) SSR in terms of meat Export/Import ratio.

All these indicators from (i) to (vii) were also analyzed by meat type: bovine meat, pork, sheep and goat meat and poultry meat.

From a methodological point of view, the empirical data were processed using:

-The growth rate in the whole studied interval based on the fixed basis index, dividing the level of the indicator in the final year 2022 by its level in the first year, 2014, multiplying the result by 100.

-Regression equations were used for showing the evolution trend of each indicator according to the data spread in the graph;

-The coefficient of determination, R square, was calculated for quantifying in what measure the variations of the indicators were determined by the variation in time;

-The graphical representation of the data was necessary for helping the readers to better understand the dynamics of each studied indicator throughout the selected period.

- A part of the results were displayed in tables. The results were accompanied by suitable comments and, finally, the conclusions resulting from this research were drawn.

RESULTS AND DISCUSSIONS

Meat production (in equivalent fresh meat)

In Romania, meat production registered a decreasing trend from 1,291.9 thousand tons in the year 2014 to 1,001.6 thousand tons in 2022, meaning a reduction by 22.5%.

This was determined by various causes, among which the most important is the decline in livestock of bovines by 11.27% and pigs by 23.98%, which a deep influence on the number of slaughtered a animals. However, an important growth was achieved in case of sheep + 7.66%, goats + 4.65% and poultry livestock +3.67% (Table 1).

Table 1. Livestock by species in Romania in 2022 versus 2014 (Thousand heads)

	2014	2022	2022/2014 %
Bovines	2,068.8	1,833.7	88.63
Pigs	5,041.7	3,328.7	66.02
Sheep	9,518.2	10,247.3	107.66
Goats	1,417.1	1,483.1	104.65
Poultry	75,446.7	78,220.7	103.67

Source: Own calculations based on the data from NIS [26].

The occurrence of various diseases has affected the livestock in Romania, the identified infected and ill animals being slaughtered. It is about The African Swine Fever (ASF), which affected Romania starting from 2017, the country registering the highest number of outbreaks in the EU [1]. In 2017, Romania produced just 55.6% of pork requirements due to ASF [48].

After the first cases of Avian Influenza (Bird Flu) registered in 2006, 2007, 2010, in the year 2022, the disease reappeared in a poultry farm in Oinacu town, at the border with Bulgaria [11, 56].

To stop these diseases important measures of biosecurity, retains of animals from movement and transportation, sale and acquisition, hygiene and disinfection have been taken in households, sheds, and farms.

Another cause of the reduction in livestock was the negative impact of climate change in terms of high temperatures and long and severe droughts on forage production in arable land, pastures and hayfields [20].

In this context, to cover the population needs in meat, the imported quantities increased from 383.9 thousand tons in 2014 to 628.5 thousand tons in 2022, meaning + 63.7%.

The exported amounts of meat recorded an ascending trend from 126.7 thousand tons in 2014 to 170.5 thousand tons in 2018, but then, they registered a decline to 153.2 thousand tons in 2020, and had a slight recover to 166.8 thousand tons in 2022 (Fig. 1).

Only 65% of production change was cause by time variation and the difference by other factors.

Import varied definitely in a high proportion 93.4% throughout the analyzed period, while export changes were determined 55.3% by other factors in the studied period.

Taking into account production, import and export, the meat availability for human consumption increased by 22.4% from 1,150.6 thousand tons in 2014 to 1,463.3 thousand tons in 2022. However, the small R square of only 0.32 reflects that the variations across the time have had a low impact compared to other factors of influence (Fig. 2).

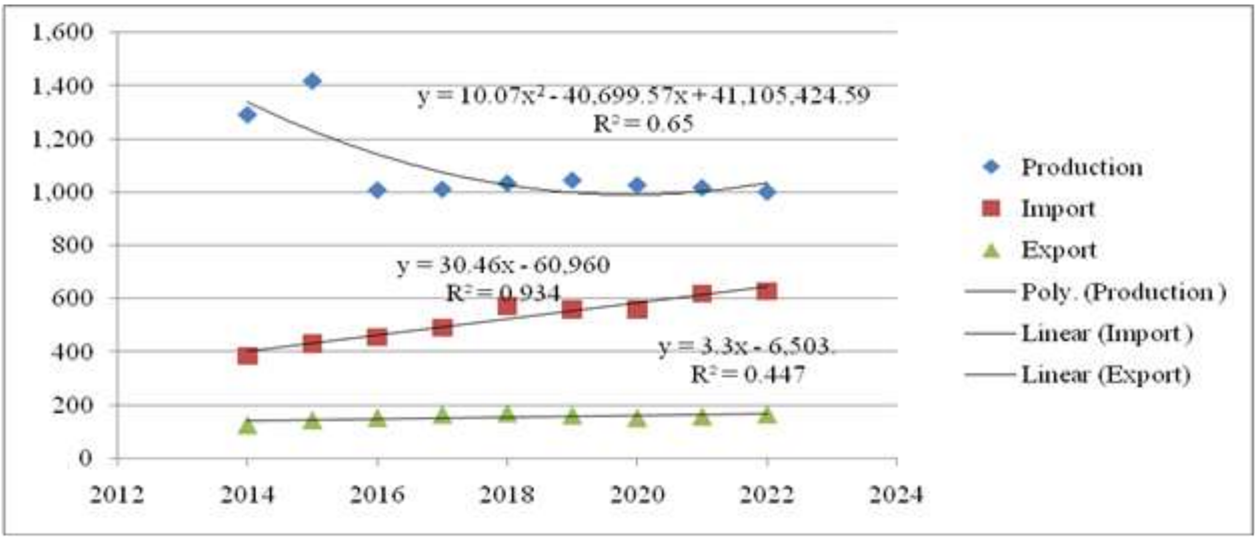


Fig.1. Dynamics of meat production, import and export in Romania in the period 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

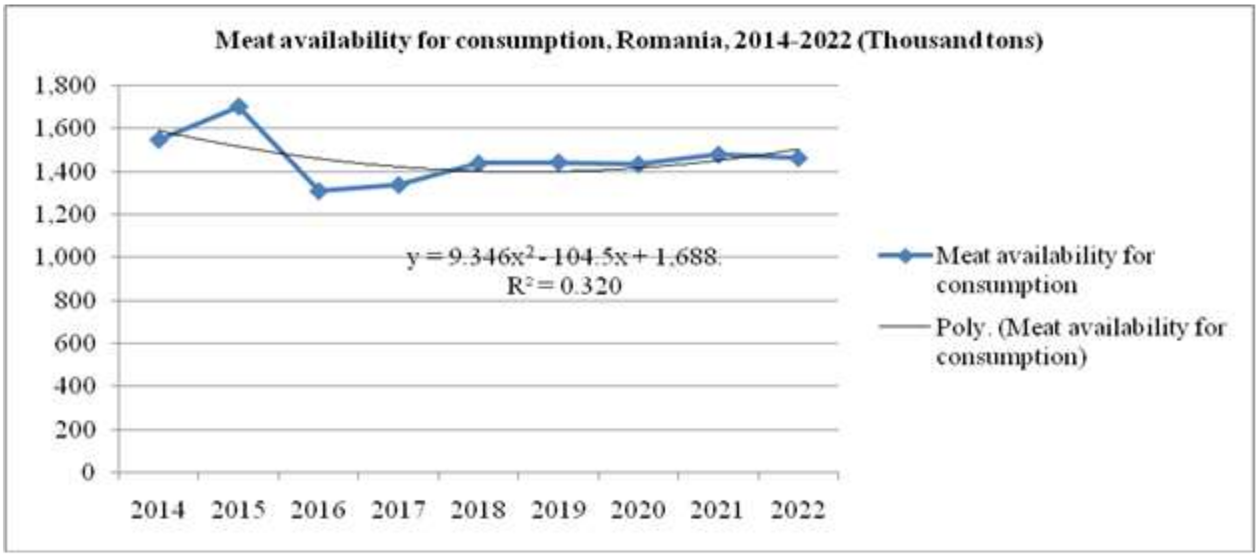


Fig. 2. Dynamics of meat availability for human consumption in Romania, 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

Bovine meat (in equivalent fresh meat)

Bovine meat production registered a decline by 8.9% from 90.6 thousand tons in 2014 to 82.6 thousand tons in 2022 for the reasons related to the diminished forage production and low acquisition price offered by slaughterhouses. In addition, the low consumption of beef meat compared to the Western European countries did not encouraged farmers to fatten too many bovines (young steers). In addition, Romanians prefer pork which is the traditional meat in the country gastronomy.

However, imports increased from 24.1 thousand tons in 2014 to 27.1 thousand tons in 2022 (+12.4%).

Because of the low consumption of about 5 kg/capita per year at present, twice times lower than the EU average, exports were encouraged especially to the EU market where the request of this sort of meat is much higher. In 2022, the amount of the exported bovine meat accounted for 14.9 thousand tons being 3.33 times higher than 4.47 thousand tons in 2014 (Fig. 3).

As a results, the bovine meat availability for human consumption in the domestic market decreased from 110.4 thousand tons in 2014 to 94.4 thousand tons in 2022, meaning by 14.5% less (Fig. 4).

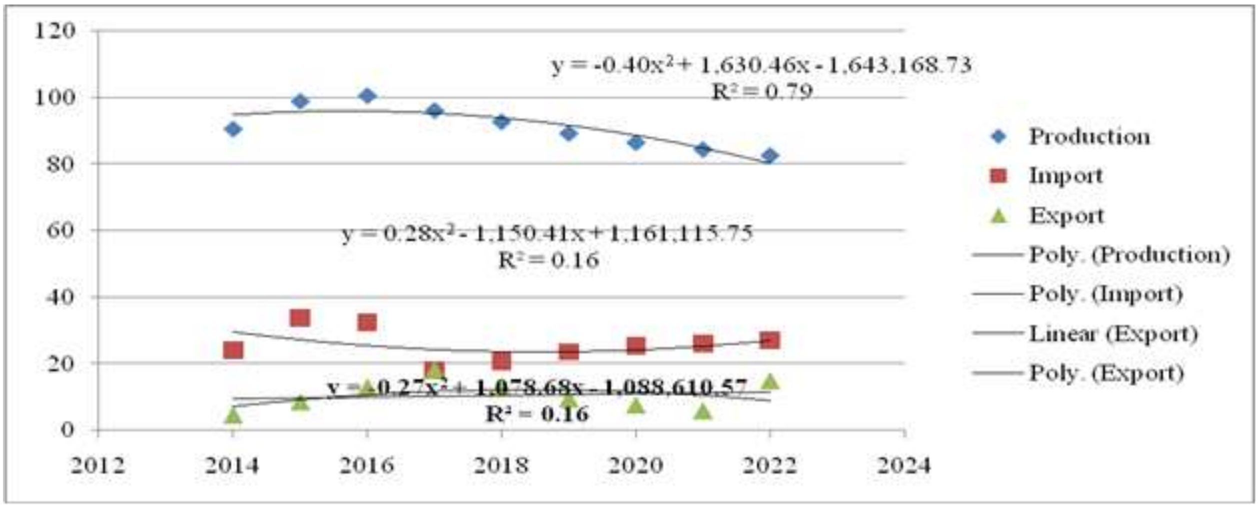


Fig. 3. Dynamics of bovine meat production, import and export, Romania, 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

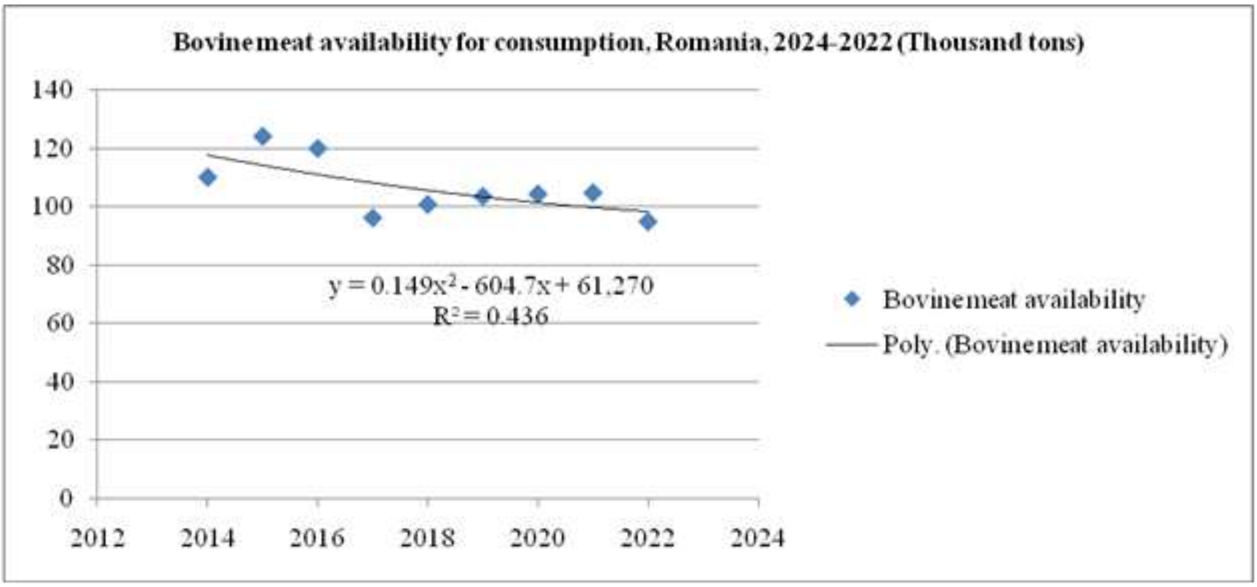


Fig. 4. Dynamics of bovine meat availability for human consumption, 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

Pork meat (in equivalent fresh meat)
Pork meat suffered a deep decline from 412.3 thousand tons in 2014 to 344.9 thousand tons in 2022, meaning a reduction by 16.4%.
The causes are well known regarding the impact of African Swine Fever (ASF), the smaller forage production as the result of the climate change, the lack of piglets for fattening, the small acquisition price offer by slaughterhouses to pig growers.
Being the most preferred meat by consumers, important amounts of pork were imported to cover the internal market demand. In 2022, there were imported 436.9 thousand tons pork by more than double than in 2014 (208.4 thousand tons).
Under these conditions, the exported quantities declined from 33.9 thousand tons in 2014 to 21.7 thousand tons in 2022 (-36%) (Fig. 5).
The imported amounts of pork added to the internal production saved the pork availability for consumption, whose level increased by 25.2% from 577.9 thousand tons in 2024 to 723.9 thousand tons in 2022 (Fig. 6).

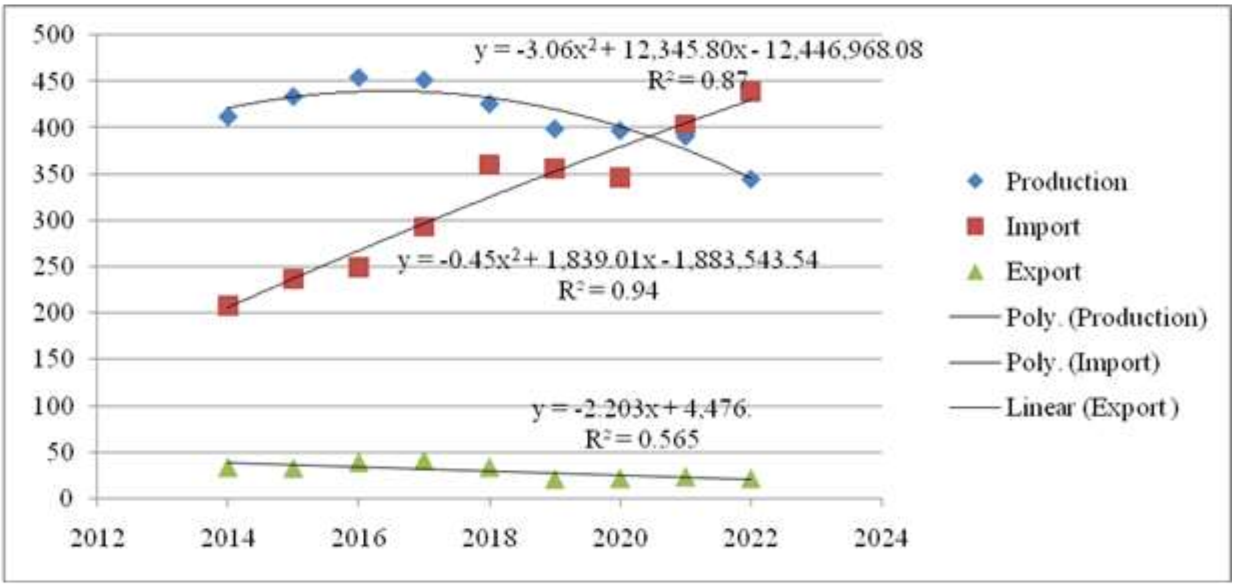


Fig. 5. Dynamics of pork meat production, import and export, Romania, 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

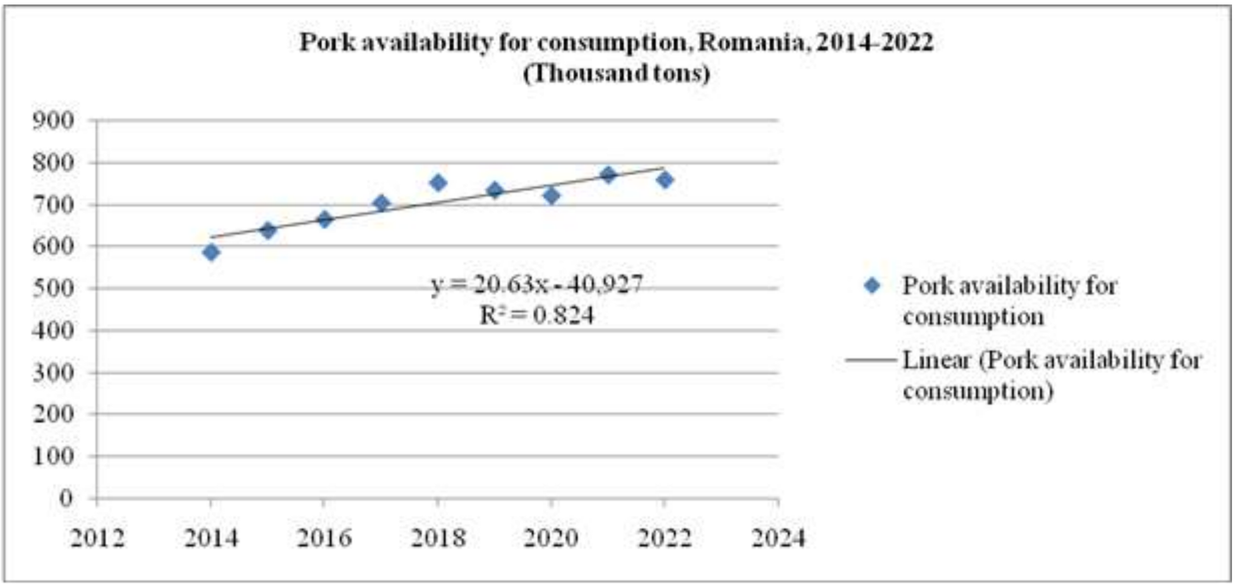


Fig. 6. Dynamics of pork meat availability for human consumption, 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

Sheep and goat meat (in equivalent fresh meat)

The number of sheep and goats had an ascending trend during the last decade, so that it could sustain not only milk production, but also meat production and export.

In 2022, sheep and goat meat output reached 62.2 thousand tons being by 27.2 % higher than in 2014 when it accounted for 48.9 thousand tons. This aspect stimulated consumption and also export.

Romania also imported sheep and goat meat whose amount accounted for 2.49 thousand tons in 2022, being 4.8 times higher than in 2014.

The exported quantities of sheep and goat meat increased from 3.6 thousand tons in 2014 to 10.3 thousand tons in 2019 (+86%), but since the year 2020, Romania exported only 2,4 thousand tons of this sort of meat (Fig. 7).

The available sheep and goat meat for consumption increased by 9.3% from 45.8 thousand tons in 2014 to 50.1 thousand tons in 2022 (Fig. 8).

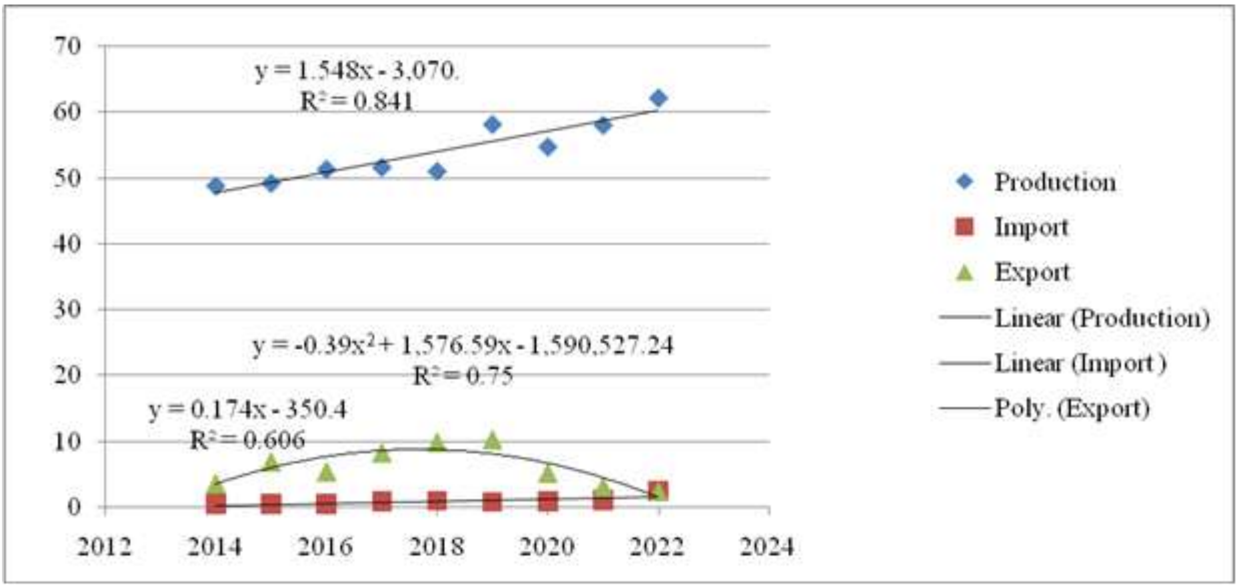


Fig. 7. Dynamics of sheep and goat meat production, import and export, Romania, 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

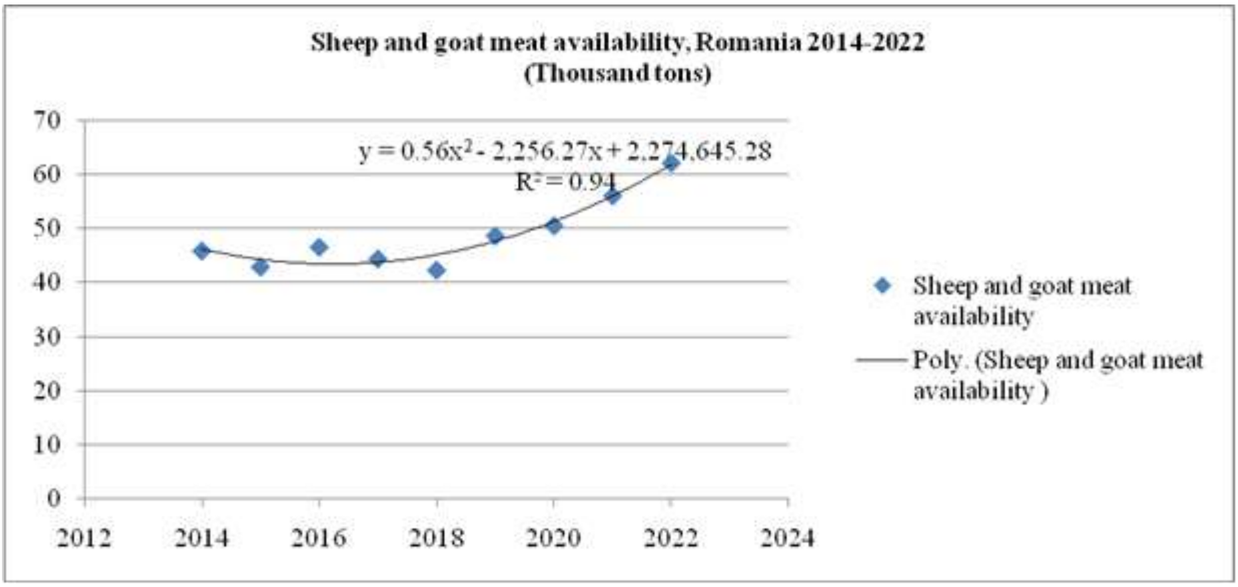


Fig. 8. Dynamics of sheep and goat meat availability for human consumption, 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

Poultry meat (in equivalent fresh meat)

After pork, poultry meat comes on the 2nd position in the preferences of the Romanian consumers. Poultry growing is an economic sector of agriculture with a high economic efficiency as broilers chickens have a short fattening period, relatively lower production costs and meat is better marketed.

Poultry meat production increased by 43.8% from 355.5 thousand tons in 2014 to 511.4 thousand tons in 2022.

Also, imports went up by 8.1% from 130.7 thousand tons in 2014 to 141.4 thousand tons in the same interval to diversify the offer.

Romania's export of poultry meat also had an ascending tendency, in 2022, the exported amounts accounted for 115.9 thousand tons being by 45.2% higher than in 2014 when they were only 79.8 thousand tons (Fig. 9).

The availability of poultry meat for internal consumption increased by 32.4% from 400.7 thousand tons in 2014 to 530.9 thousand tons in 2022 (Fig.10).

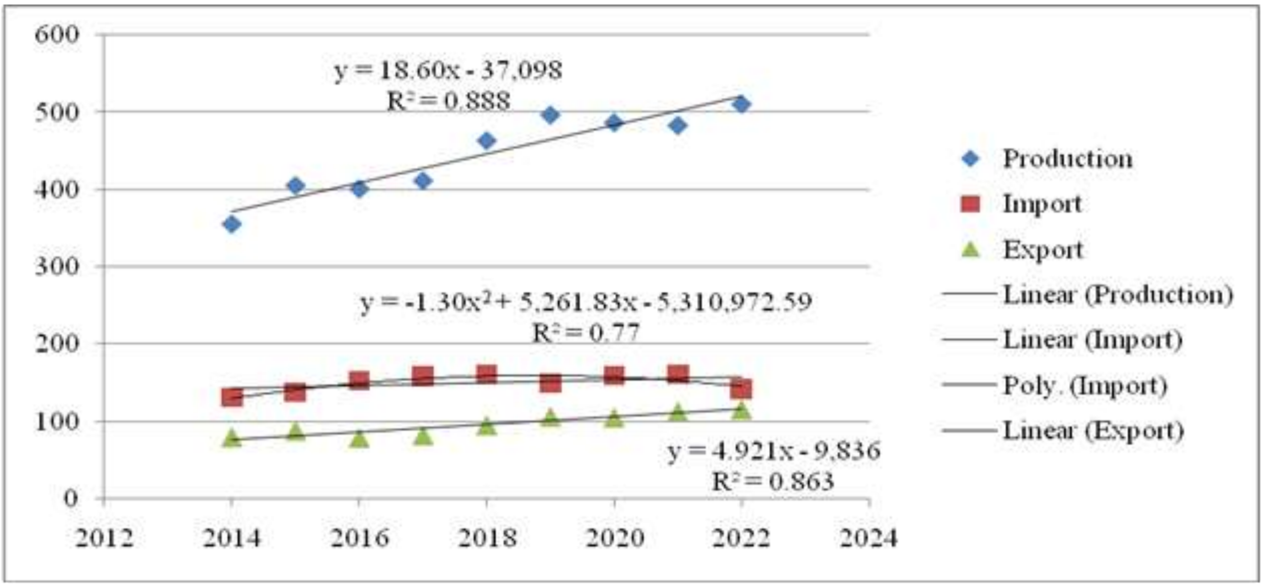


Fig. 9. Dynamics of poultry meat production, import and export, Romania, 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

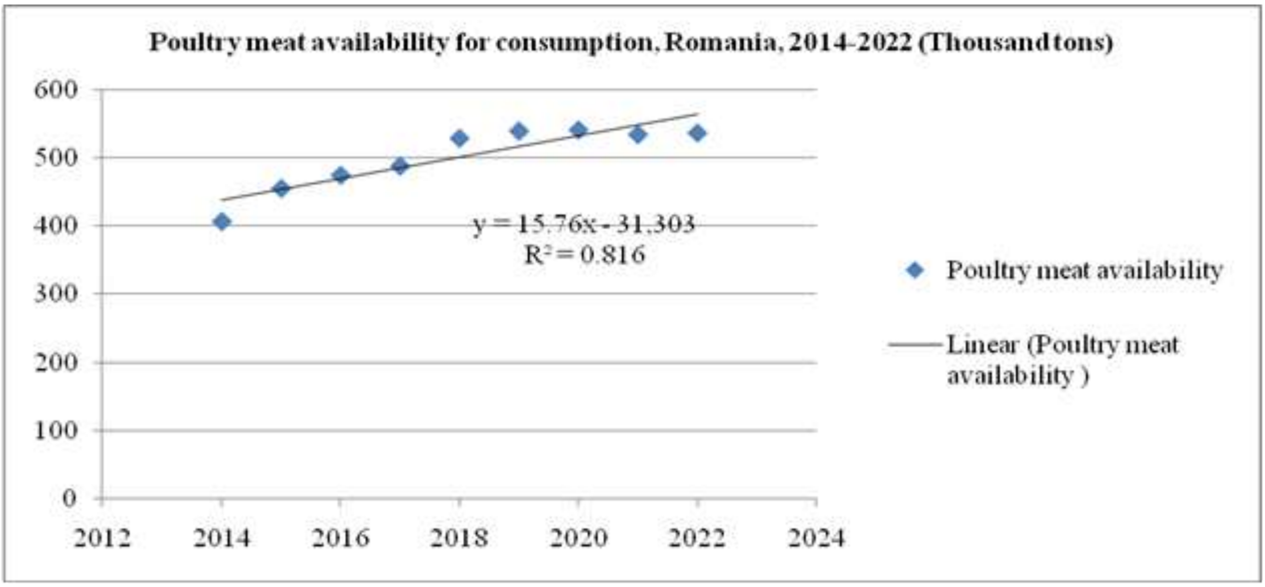


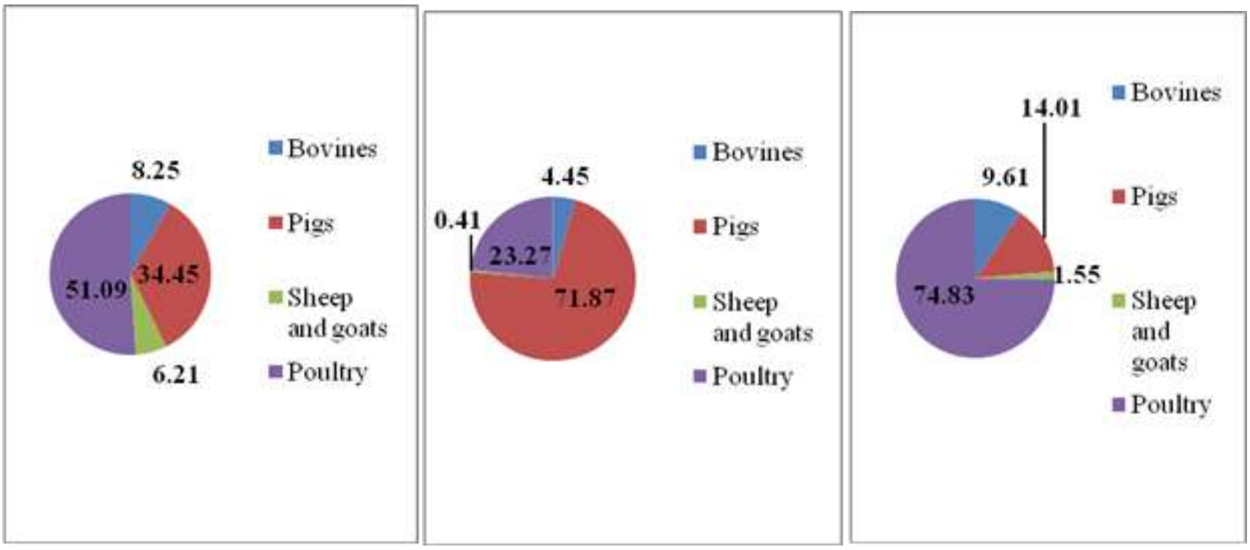
Fig. 10. Dynamics of poultry meat availability for human consumption, 2014-2022 (Thousand tons)
Source: Own design based on the data from NIS [26].

The contribution of each species to meat production, import and export in Romania

The highest contribution to meat production is given by poultry whose share accounts for 51.09%, being followed by pigs with 34.45%, bovines with 8.25% and finally sheep and goats with only 6.21%

The highest share in the amount of imported meat belongs to pork, 71.87%, followed by poultry meat, 23.27. Bovine meat has a much smaller share, 4.45% and finally, sheep and goat meat have the smallest level, only 0.41%.

The top contributor to the exported amounts of meat are poultry which accounts for 74.83%. On the second position is pork whose share in meat exports is 14.01%. Bovine meat keeps only 9.61% of the meat exports and finally sheep and goat meat only 1.55% (Fig. 11 a, b and c).



(a)-Contribution to meat production (%) b- Contribution to meat import (%) (c) Contribution to meat export (%)
Fig. 11. The contribution of each species to meat production (a). import (b) and export (c) in Romania in 2022 (%)
Source: Own design and calculations

Taking into account meat production, import and export, the self-sufficiency rate had a different level and evolution in the analyzed interval, depending on the meat sort.

In case of total meat, SSR reflected a decline from 83.35 in 2024 to 68.4% in 2022.

SSR for bovine meat showed an increase from 82.1% in 2014 to 100% in 2017, but then, it decreased to 80.5% in 2021 and increased again in 2022 attaining 87.1%.

In case of pork, SSR registered a deep decline from 79.2% in 2014 to 45.4% in 2022, which is an alarm bell in connection to the internal market needs which call for imports to be covered and satisfy the population requirements.

In case of sheep and goats meat, SSR is ensured as the values of this indicator are over 100 in each year of the studied period.

SSR for poultry meat increased from 87.5% in 2014 to 95.2% in 2022 which reflects a satisfactory situation that internal production and also imports sustain the domestic market and consumption, at the same time the country being an important exporter of this type of meat (Table 2).

Table 2. Meat Self-Sufficiency Rate (SSR) dynamics by meat type, Romania, 2014-2022 (%)

	Total meat	Bovine meat	Pork meat	Sheep and goats meat	Poultry meat
2014	83.3	82.1	70.2	106.7	87.5
2015	83.2	79.4	67.9	115.2	89.1
2016	77.1	83.8	68.3	110.5	84.4
2017	75.6	100.0	64.1	116.7	84.4
2018	71.9	92.1	56.5	121.1	87.6
2019	72.4	86.2	54.2	119.7	92.2
2020	71.6	82.8	54.9	106.5	90.0
2021	68.9	80.5	50.6	103.5	90.5
2022	68.4	87.1	45.4	100.0	95.2

Source: Own calculations.

Similar results were found by Stanciu, A. (2022) who affirmed that in the year 2020, sheep meat had a SSR higher than 100, poultry meat was assured 90.4%, and bovine meat 82.9% [48].

Average annual gross meat consumption per inhabitant

As a result of production and imports, meat availability registered an increasing trend as shown before.

In consequence, the mean of meat consumption per inhabitant per year increased from 57.8 kg in 2014 to 74 kg in 2022, meaning a surplus of 28% (Fig. 12).

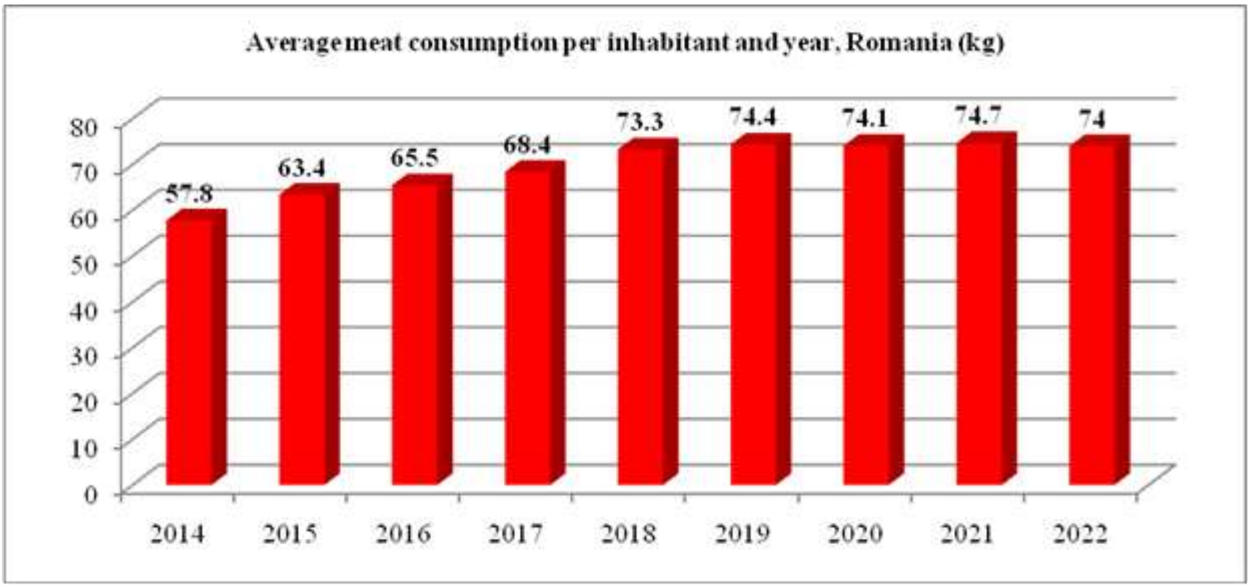


Fig.12. Average annual gross meat consumption per capita, Romania, 2014-2022
Source: Own design based on the data from NIS [26].

Bovine meat consumption is the only case which shows a slight decline from 5.6 kg/capita in 2014 to 5 kg/capita in 2022 (-10.8%).

Pork consumption increased by 31% from 29 kg/capita in 2014 to 38 kg/capita in 2022.

Sheep and goats meat consumption registered an increase by 13% from 2.3 kg/inhabitant in 2014 to 2.6 kg in 2022.

Poultry meat consumption went up per capita by 38.8% from 20.1 kg in 2014 to 27.9 kg in 2022 (Fig. 13).

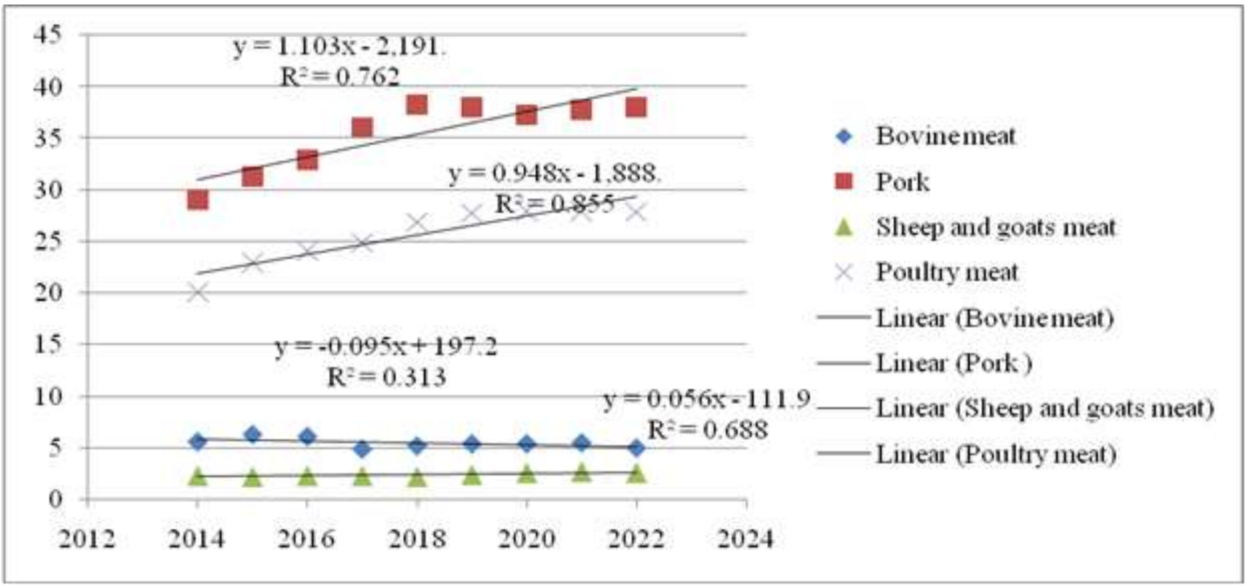


Fig. 13. Dynamics of average annual gross meat consumption by meat sort, Romania, 2014-2022 (kg/inhabitant)
Source: Own design based on the data from NIS [26].

SSR expressed in a qualitative manner answering to the question: In what measure does meat cover the requirement of average protein consumption per capita and day?

According to FAO, the need of average protein consumption per capita an day is 55 g, of which 50% that is 27.5 g must be of animal origin coming from meat, egg, milk etc.

This is a qualitative expression of SSR in relation to the food quality reflected by high biological nutrients.

The data from Table 3 reflects that in Romania, in the period 2014-2016, meat consumption of animal protein per day and capita was below 27.5 g, while starting from 2017 it exceeded the requirement level reaching 29.30 g in 2022 after recording a peak of 29.54 g in 2021.

Therefore, from this point of view, Romania is able to assure a corresponding protein level of animal origin in the daily average meat consumption per inhabitant.

Table 3. Contribution of meat consumption by type to the average daily protein requirement of animal origin per capita of 27.5 g

	Total meat and meat products	Bovine meat	Pork	Sheep and Goat meat	Poultry meat
2014	22.78	1.96	10.94	0.85	8.69
2015	24.99	2.20	11.78	0.81	9.93
2016	25.81	2.14	12.40	0.83	10.40
2017	27.03	1.71	13.62	0.85	10.74
2018	28.97	1.80	14.45	0.82	11.62
2019	29.45	1.90	14.33	0.88	12.00
2020	29.36	1.90	14.07	0.95	12.10
2021	29.54	1.92	14.24	0.99	12.10
2022	29.30	1.75	14.33	0.95	12.06

Source: NIS, Meat and meat products balance [26].

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Is Romania a meat net importing or exporting country?

To answer this question, SSR could be expressed by Export/Import ratio. In case that the result is < 1, the country is a net importer of meat and, if E/I ratio is > 1, the country is a net exporter of this product.

The results presented in Table 4 reflects that Romania is a net importing country of meat, as regards total meat, pork, bovine and poultry meat. But, it is also a net exporting country of sheep and goat meat as E/I level is higher than 1 in almost the whole studied period, except the year 2022.

In case of poultry meat, an increasing trend for E/I ratio was noticed, the maximum level 0.82 being recorded in the year 2022.

Table 4. SSR in terms of meat Export/Import ratio, Romania, 2014-2022

	Total meat and meat products	Bovine meat	Pork	Sheep and Goat meat	Poultry meat
2014	0.33	0.18	0.16	7.05	0.61
2015	0.33	0.25	0.14	14.37	0.64
2016	0.34	0.40	0.16	9.47	0.52
2017	0.34	1.00	0.14	9.22	0.52
2018	0.30	0.60	0.09	10.00	0.59
2019	0.29	0.40	0.06	13.20	0.72
2020	0.27	0.29	0.06	5.84	0.66
2021	0.26	0.22	0.06	2.69	0.70
2022	0.26	0.55	0.05	0.96	0.82

Source: Own calculations.

In case of bovine meat, in 2017, the E/I ratio was an exception accounting for 1 reflecting self-sufficiency.

But in the other years, it was far away of such a status, despite that in the year 2022, the E/I ratio attained 0.55.

In case of sheep and goats the E/I ratio has high values, the maximum being 14.27 recorded in the year 2015 and also other high levels were noticed in 2019 accounting for 13.20 and in 2018 for 10.

In case of poultry meat, the highest E/I ratio 0.82 was registered in the year 2022, but in 2019 was recorded 0.72 and also in 2021 was attained 0.70 (Table 3).

CONCLUSIONS

The study analyzed meat production, import, export, consumption availability and self sufficiency rate in Romania aiming to identify the dynamics of these indicators in the interval 2014-2022.

Self sufficiency is an important specific indicator which provides information about the country capacity to carry out a corresponding production to cover the population needs. In other words, consumption to be assured from domestic output.

In case of meat, the results showed that Romania's production is not self sufficient for meat as a whole, and by meat type, the only sufficient meat production is sheep and goats meat. Regarding the other meat sorts, the self sufficiency rate was below 100%. If in case of poultry meat, the situation is very good, in case of bovine meat and especially in case of pork we cannot talk about self sufficiency.

These results were proved by the decline in total meat production by 22.5% in the analyzed period, in pork production by 16.4% and in bovine meat production by 8.9 %. Compared to 2014 level, poultry meat production increased by 43.8% and in case of sheep and goat meat by 27.2%.

The contribution of these four species to Romania's meat output is poultry 51.09%, pigs 34.45%, bovines 8.25% and sheep and goats 6.21%.

Therefore, to cover the consumption requirements, Romania was obliged to import more pork and beef. However, it also purchased poultry meat and sheep and goat meat from other countries in smaller amounts to diversify the offer.

Taking into account the imports and exports made by Romania, the ratio Export/Import is unbalanced, with a level below 1 in case of pork and bovine meat and also in a smaller proportion in case of poultry meat. Only in case of sheep and goat meat, this ratio reflected that exports exceed imports. As a result Romania proved to be a net importing country of meat.

In the year 2022, the SSR accounted for 68.4 for the whole meat, 87% for bovine meat, 45.4% for pork, 100% for sheep and goat meat and 95.2% for poultry meat.

In 2022, a Romanian consumed 74 kg meat, by 28% more than in 2014. Bovine meat consumption per capita was about 5kg per year and inhabitant by 10.8% lower than in 2014.

Pork consumption increased by 31% from 29 kg/capita in 2014 to 38 kg/capita in 2022.

Sheep and goats meat consumption registered an increase from 2.3 kg/inhabitant to 2.6 kg in 2022, meaning a surplus of 13%, while poultry meat attained 27.9 kg in 2022 versus 20.1 kg in 2024 (+38.8%).

The average protein consumption per capita coming from animals in Romania was below 27.5 g/capita/day in the interval 2014-2016, but since 2017, Romania succeeded to exceed the world average so that in 2022 it accounted for 29.3 g.

In 2022, Romania's SSR in terms of meat Export/Import ratio was: 0.26 for total meat, 0.96 for sheep and goat meat, 0.82 for poultry meat, 0.55 for bovine meat and 0.05 for pork, which reflects the status of net importing country.

These results oblige us to propose measures which could be taken for improving the situation of meat sector as follows:

-Implementation of modern technologies in farm animals based on the progress in genetics, nutrition, reproduction research;

-Investments in new raising systems which could assure a higher productivity in terms of daily gain, superior live weight at slaughter, a better carcass quality and a higher food conversion in meat.

As long as the livestock has no chance to recover due to the causes mentioned in the study, breeders must pay more attention to solutions which could grow the performance per animal in terms of a higher live weight, a shorter period of fattening and higher meat quality.

This means a better and sufficient amount of forages, the use of the heterosis effect by crossing the local breeds with other breeds specialized in meat production, more attention for maintaining the animal health and welfare. Also, farmers have to look for solutions to diminish production costs to assure a high economic efficiency in their business. Studying the market and looking for new suppliers which offer farm inputs at a more convenient price and also for beneficiaries which could offer a higher price per live weight will have a beneficial effect from a financial point of view.

More meat production will diminish the imports and will lead to a higher capacity of Romania to better cover consumption needs and increase self sufficiency rate.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

SOYBEAN PRODUCTION TRENDS IN THE WORLD, EUROPEAN UNION AND ROMANIA

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Abstract

The study aimed to investigate the trends in soybean crop cultivated area, yields and production at the global level and in the EU (2015-2023) and Romania (2007-2023) using the data from USDA, European Commission, National Institute of Statistics. The processing was based on growth rate, trend line regressions, R square, food balance, self sufficiency rate (SSR), comparisons etc. Soybean is an important protein-based and energy crop, called to produce healthier foods and animal meals, to sustain renewable energy production, to reduce pollution by capturing Nitrogen, diminishing the amounts of fertilizers, protecting environment and conserving biodiversity. In *2023, at the global level, 139.74 Million ha were cultivated with soya, production reached 419.5 Million tons seeds, (+32% vs. 2015), and yield attained 2.82 tons/ha (+0.06 vs. 2022).This was due to high consumption of 406.1 Million (+27.3% vs. 2015). Brazil, USA, Argentina and Paraguay produce 91.7% of the global soy seed output. In 2023, the EU-27 cultivated 11.94 Million ha with oilseeds crops, of which: rape 52.2%, sunflower 39.2% and soybean 0.98 Million ha (8.2%). For the next year, the forecast is +0.1 Million ha for soybean, +0.21 Million ha for sunflower and a decline by -0.46 Million ha for rape. In 2023, the EU produced 32.55 Million tons oil seeds of which soybean (9.2%), sunflower (30.1%) and 60.7% rape. Soybean SSR was 17.59% vs. SSR 63.91% for rape + sunflower + soybean, 84.98% for rape+ sunflower. Italy, France, Romania, Croatia and Austria contributes by 83% to the EU output. Romania accounts for 14% in the EU soya market. In 2023, 141.7 thousand ha were cultivated with soya (+ 6.38% vs. 2007). Production reached 303.2 thousand (2.2 times higher vs. 2007). The top output was 465.6 thousand tons in 2018, and yield raised to 2,140 kg/ha (2.09 times vs. 2007). As a conclusion, soybean is called to have a greater role in human food, animal meals, energy production, environment protection and biodiversity preservation. This means an extend in cultivated area, higher yield and production globally. However, the EU will continue not to cultivate GM soybean, but to import for covering the market requirement.*

Key words**:** *soybean, importance, cultivated area, production, yield, trends, world, EU, Romania*

INTRODUCTION

Soybean (*Glycine max* (L) Merrill) is a wonderful plant among the oil seeds crops cultivated in the world, grace to its large range of utilizations for assuring livestock feed, for producing various foods and other commodities, a reason to be nick-named "the plant useful to carry out more than 1,000 products" [21].

In the year 2021, at the global level, after maize, rice and wheat whose production was 1,200, 600, 595 million tons, soybean came on the 4th position with 372 million tons [12].

Compared to the global situation of soybean one decade before, nowadays, both the cultivated area and obtained production are higher [24].

In 2023/2024, it is cultivated on over 137.10 million ha worldwide, the largest surfaces being in Brazil, 45.8 million ha, from which 153 million tons seeds have been harvested, meaning an yield of 3.3 ton/ha [43].

On the 2nd position comes USA, where soybean is grown on 33.3 million ha, obtaining 113.27 million tons seeds and, respectively, 3.4 tons/ha [44].

In the EU, soybean is grown on 1.1 million ha and the harvest accounted for 2.98 million tons, by about 30% more than in 2022/2023 as the climate was favorable in 2023-2024 [45]. In the year 2023, soybean was situated on the 6th position after wheat, maize, barley, rapeseeds and sunflowers seeds [30, 45].

The EU countries growing soya are France, Italy, Serbia, Romania and Austria. Netherlands, Germany, France, Poland, Belgium, Denmark, and Ireland do not produce too much soybean output.

In Europe, soybean production was 11.5 million tons, and taking into consideration the EU needs of 30-35 tons, this means that the offer from own output could cover about 30% of demand. This is a good sign to diminish imports from overseas countries [23].

Romania cultivates soybean on an important surface, but its yield is not so high mainly in the last decade when climate change had a negative impact. Soybean has a smaller share in the cultivated surface and production of oil seeds crop after sunflower and rape [25, 27, 28, 36]. However, the general trend in the last decades reflects and increased surface and production, showing a higher interest in the cultivation of this crop.

Grace to its high protein and fat content, it is expected that soybean to contribute to the diversification of plant-based foods and sources of renewable energy, but taking into consideration the large variety of climates, farmers must select and cultivate the varieties which are suitable to the growing season [9].

As long as the global population is continuously raising and food requirements are higher and higher, soybean is consider a potential source of protein which could diversify protein production destined to nourish both the livestock and the humans, and this means a new challenge and opportunity for farmers [19, 40].

Nutritional and energetic value

The chemical composition reflects that the dried soybean seeds have: 36% protein and 20% oil, 30% carbohydrates, 9 % water and 5% ash and 100 g has an energetic value of 446 kcal and 1,870 kJ. Soybean is also rich in micro-elements such as: Calcium 277 mg, Iron 15.7 mg, Magnesium 280 mg, Potassium 704 mg, Sodium 2 mg, Zinc 4.89 mg, Copper 1.66 mg, Manganese 2.52 mg and Selenium 17.8 μg [41, 16, 38].

A part of the soya foods are healthy because of the high quality protein and fat which contains important fatty acids [15].

Because of the soybean chemical composition, soybean has become the standard to which other vegetable food ingredients are compared [21].

The digestibility corrected amino acid score of soy protein is equivalent to that of meat, eggs and casein as mentioned by [33].

Agronomical and environmental advantages

Soybean growth is influenced by genetics, soil quality and climate conditions. Its roots depths could vary between 75 and 150 cm, an advantage which make the plant to be resistant to drought.

Due to the presence of symbiotic bacteria from the Rhizobia group, soybean can fix atmospheric nitrogen like other legumes [8].

In this way, its cultivation contributes to the fight against soil, water and air pollution, preserving environment quality. More than this, farmers are advantaged using less quantities of fertilizers and diminishing production costs per surface unit.

In addition, soybean could also contribute to lower gas emissions in the green houses as it releases 24.5 times lower gas than beef. Also, its Carbon footprint accounts for 6.44 kg CO_2e per kg [21, 7].

Soybeans have also a high impact on the preservation of biodiversity and conservation of agro-ecosystems [18].

Economical advantages

Soybean production is much higher than the output of all pulses.

Grace to the results in the scientific research, modern soybean varieties have a shorter growing period from sowing to harvesting, which advantage the farmers [49].

Soybean produces the highest protein production per surface unit, and that is why many researchers consider that it could become the most important crop in assuring protein production to nourish the mankind and animals [47, 48].

Soybean is useful in crop rotation because it fixes Nitrogen and sustains yield of other crops [1].

The extend of soybean cultivation and higher yields could reduce production costs compared to other crops and increase farmers' income and profit [39].

A higher production could stimulate exports, enhancing the trade and improving the payment balances in the producing and exporting countries [40, 17].

Social advantages

The implementation of modern technologies for cultivating soybean could help the farmers to get a good income and high profit and this will assure the well-being of their families.

Increasing soybean production could led to a higher protein and energy production which will be available for nourishing the globe population and fighting against hunger.

The large range of uses could contribute to the diversification of food production and improvement of the human diet [13].

Soybean uses

Approximately 85% of the world's soybean crop is processed into soybean meal destined to complete animal feed and soybean oil, the remainder processed in other ways or eaten whole.

Full-fat soybean is successfully used as an ingredient in poultry rations [29] and also it may be included in the diets for pigs to increase the energy density.

During the industrial processing, a large variety of byproducts could be introduced in the soybean meal to optimize diet for pigs and poultry [14].

For ruminant livestock, soybean meal is defatted containing hulls, which are readily digestible and could be used as an ingredient in ration [2].

Soybeans has multiple uses in food industry, where there are produced: soy flour, tofu, soymilk, soy-based yogurt, meat analogs, soy nuts, miso, tempeh, nato, souces, edamame, curls, chocolate, bread, biscuits and other bakery products, okara, soybean oil, soy concentrates, etc.

Soybean oil is used in various ways, but usually it is utilized for frying or sautéing a variety of
dishes or is used as such, being a support for heart, bones and skin health.

By industrial processing, soybean is a raw material for producing "biodiesel for any diesel engine and also for hydraulic oil, grease, solvent, ink, plastics and other products" [37].

Health advantages

Because of its high quality protein and fat compared to animal protein from meat, dairy products and eggs, soybean could have a larger application in producing healthier food of a great variety of diets both in traditional and modern cuisine. This will be in accordance with the modern consumers' preferences which more oriented to healthier diets including plant-based protein and hybrid diets with a lower share or missing animal protein.

Therefore, soybean could be utilized as an ingredient in diverse recipes of meals and cuisines, based on soy protein like: soybean meat and dairy food alternatives.

Soybean ingredients could satisfy both the ill people who needs healthy diets without animal protein and fats, and also modern consumers who belong to various categories of diet preferences like: vegetarians, who do not consume meat and fish, flexitarians, who consume less than 50g/day (less than 350g/week) meat and meat products, omnivorous who consume more meat and meat products ≥ 170 g/day (more than 1,190 g/week), and vegans who do not consume foods of animal origin [6].

In this way, the development of a new vision in human nutrition and gastronomy based on plant diets including soybean ingredient could contribute to a lower environmental footprint.

The consumption of soybean foods could prevent heart diseases and cancer, diminish depression and kidneys and skin problems.

Therefore, soybean is a plant which have future as a source of high protein and energy, with multiple uses, under the condition of implementing modern environmentally friendly technologies and meeting the SDGs (Sustainable Development Goals) as established by FAO [16].

Soybean disadvantages

The consumption of foods having GM soybean ingredients could led to allergies and cancer compared to non GM plants whose products are healthy.

The GM soybean is mainly used for producing tofu, soy flour, chocolate, biscuits, potato chips, dairy products, margarine, mayonnaise, sauces. The most sensitive people to soybean protein are babies and children [5].

However, the EU has recently authorized the use of GM soybean intended to be used for human and animal consumption, under the condition *"not to be cultivated in the EU and to be used only for food and feed, and to follow a complete and rigorous procedure, which guarantees a high level of protection of human and animal health, as well as for the environment"* [35].

The import constrains for GM soybean has led to a disturbance in soy feed market and also had a negative effect of price evolution [4].

The cultivated area is projected to raise as demand for GM-free soybean in the market is higher due to the human consumption requirements. In consequence, soybean out will grow to better cover the needs and diminish imports [34]. In this context, the goal of this study is to analyze the dynamics of cultivated area, production, yield at the global level, pointing out the updated performance in the main producing countries, also at the EU level and in Romania, and finally to identify the main trends.

MATERIALS AND METHODS

To perform this research work, a large range of published articles have been studied and also the statistical data were collected from various official information sources like USDA, FAOSTAT, European Commission, and National Institute of Statistics. For processing the data, there were used different procedures and methods including: dynamic analysis on various periods depending on the data availability, the growth rate in the analyzed interval for soybean cultivated area, yield and production, market share of various countries in total soybean seeds production, making comparisons, regression equations for reflecting the trend line, R square for showing the determinants of the changes across the time, food balance, self sufficiency rate where it was the case to show the capacity for meeting the market needs from internal production and from import.

Graphical representations were utilized for a better understanding of the evolution of the indicators and tables synthesized the data and results, being accompanied by corresponding comments.

RESULTS AND DISCUSSIONS

Soybean - World cultivated area, yield and production

In 2022/2023, soybean was cultivated on 137.10 million ha, from which there were produced 378.7 million metric tons seeds, reflecting an average yield of 2.76 Metric tons/ha. The estimates for 2023/2024 and 2024/2025 are presented in Table 1.

Table 1. Soybean cultivated area, yield and production in the world

	MU	2022/2023	Prel. 2023/2024	Proj. 2024/2025 In October
Cultivated area	Million ha	137.10	139.74	145.81
Yield	Metric tons/ha	2.76	2.82	2.94
Production	Million Metric tons	378.7	394.7	428.92

Source: [42].

The global soybean seeds output has recorded an ascending tendency from 317.8 Million tons in 2015 to 419.5 Million tons in 2024, an estimated level which reflects a growth by 32% in the last decade. The regression equation reflects that in the year 2025, soybean seeds output is expected to be 427.1 Million tons. The value of R square = 0.906 shows that soybean production has definitely grown almost year by year (Fig. 1).

This trend was sustained by the increased consumption which is estimated to reach 406.1 Million tons in 2024, by 27.3% higher than 319 Million tons in 2015. The requirements of soybean seeds have increased year by year taking into consideration its multiple uses both for animal feed and also for human foods. The regression equation reflects that in the year 2025, it is expected as soybean seeds consumption to reach 414.3 Million tons. The R square = 0.764 tells us that only 76.4% of the variation in consumption depended on time, and that the difference of 23.6% was influenced by other factors (Fig. 1).

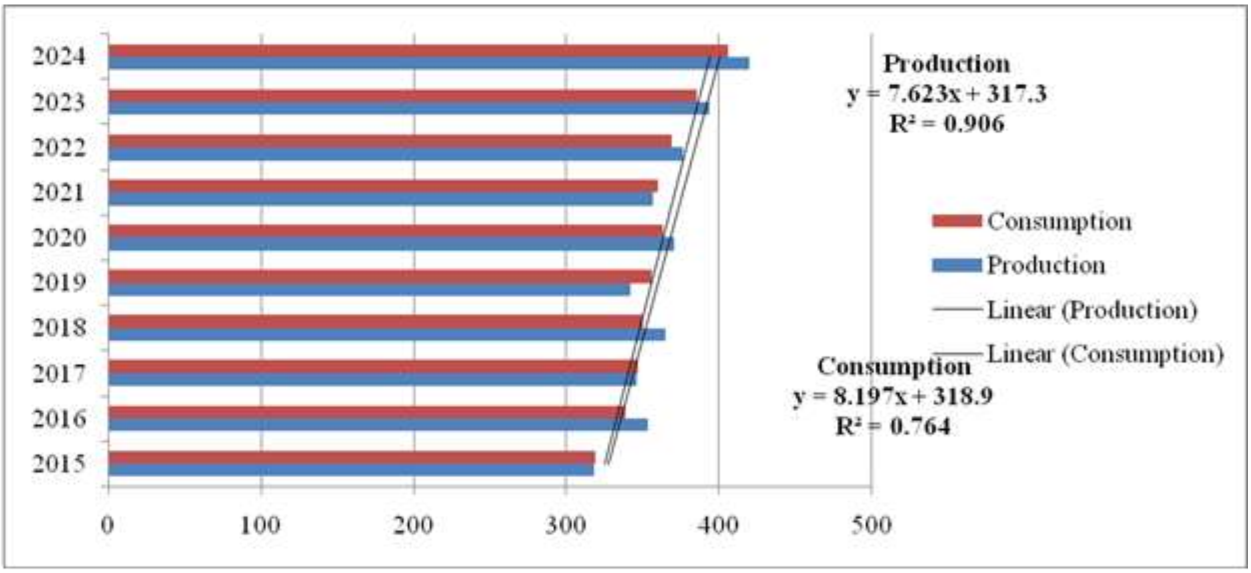


Fig. 1. Dynamics of soybean production and consumption worldwide, 2015-2024 (Million tons).
Source: Own design based on [10].

However, FAO estimated a little bit different figure than us, with about 2 Million tons more, so that in the 2024/2025 projection for the world oil seeds production is 687 Million MT, of which: 429 (62.4%) soybean seeds, 88 Million MT (12.8%) rapeseeds and 51 Million MT (7.42%) sunflower seeds and the remaining representing 119 Million MT (17.38%) belonging to other oil seeds crops. Using the FAO of United Nations (2023), concerning the changes in the cultivated area with soya, yield and production in the year 2022 versus 1961 level, as term of reference, the harvested surface was by +461.71% larger, seeds yield was by 131.02% higher and output increased by +1,197.94 [22].

Table 2. The top 10 main producing countries of soybean seeds and their share in world production in 2023/2024 (Estimates)

	Area (Million ha)	Yield (Metric tons/ha)	Production (Million Metric tons)	Market share (%)
1.Brazil	45.8	3.34	153	38.7
2.USA	33.29	3.4	113.27	28.6
3.Argentina	16.30	2.95	48.10	12.2
4.Paraguay	3.75	2.93	48.10	12.2
5.China	10.47	1.99	20.84	5.2
6.India	13.20	0.90	11.88	3.0
7.Canada	2.26	3.09	6.98	1.7
8.Russia	3.50	1.94	6.8	1.7
9.Ukraine	2.00	2.60	5.2	1.3
10.EU-27	1.03	2.90	2.99	0.75

Source: Own calculations based on the data from [42].

The top 10 main producing countries of soybean seeds and their share in the world production, in the decreasing order, are: Brazil, USA, Paraguay, Argentina, China, India, Canada, Russia, Ukraine and the EU (Table 2).

Four countries Brazil, USA, Argentina and Paraguay produce 91.7% of the global soybean seeds output (Table 2).

According to USDA, it is expected that in 2024/2025, soybean seed production to grow in the major producing countries to: 162 Million MT in Brazil, 124.9 Million MT in USA, 51.5 Million MT in Argentina, 7.2 Million MT in Canada, 7.2 Million MT in Russia, 5 Million MT in Ukraine.

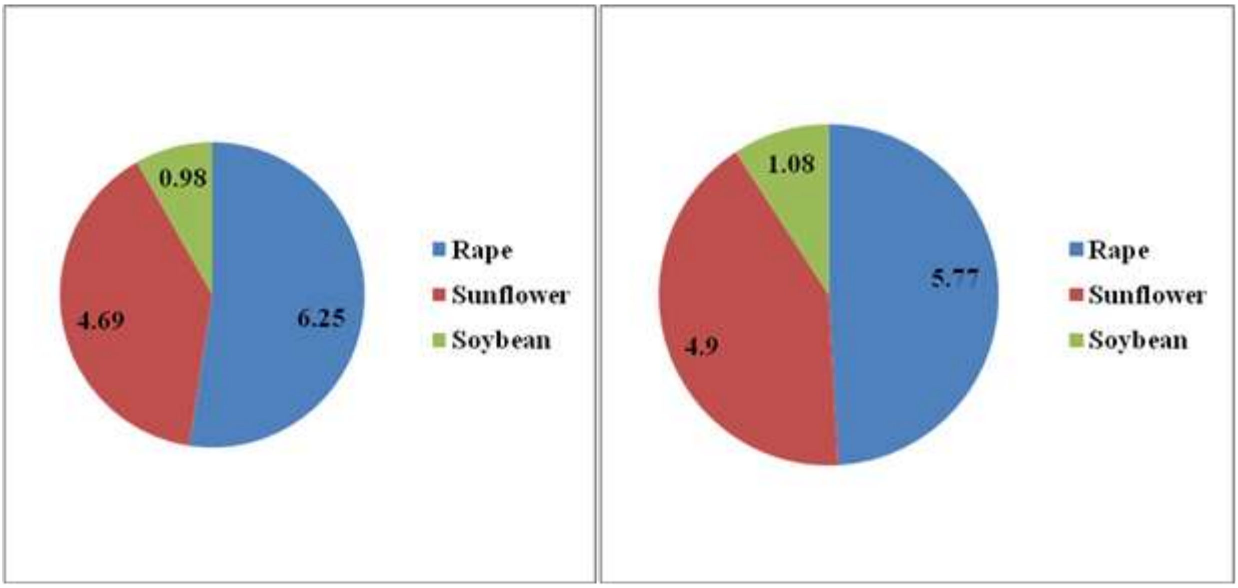
However, in the EU-27, it is expected a relatively constant level of about 2.9 Million MT [46].

Soybean area, yield and seeds production in the EU-27

In the 2023/2024, in the EU-27, the cultivated area with the major oil seeds crops accounted for 11.94 Million ha, of which: rape 6.23 Million ha (52.2%), sunflower 4.69 Million ha (39.2%), and soybean 0.98 Million ha (8.2%).

Compared to the EU cultivated area with oil crops in the year 2018, we may notice a slight increase by +0.14 Million ha. In case of each oil crop, in the year 2023-2024 versus 2018, it was found a decline in cultivated surface by -0.7 Million ha for rape, -0.67 Million ha for sunflower and by - 0.03 Million ha for soybean. The comparison was made with the results found in 2018 by [30].

For September 2024/2025, it is projected a growth to 1.08 Million ha soybean (+0.1 Million ha), to 4.9 Million ha for sunflower (+0.21 Million ha) and to 5.77 Million ha (-0.46 Million ha) for rape (Fig. 2) [11].



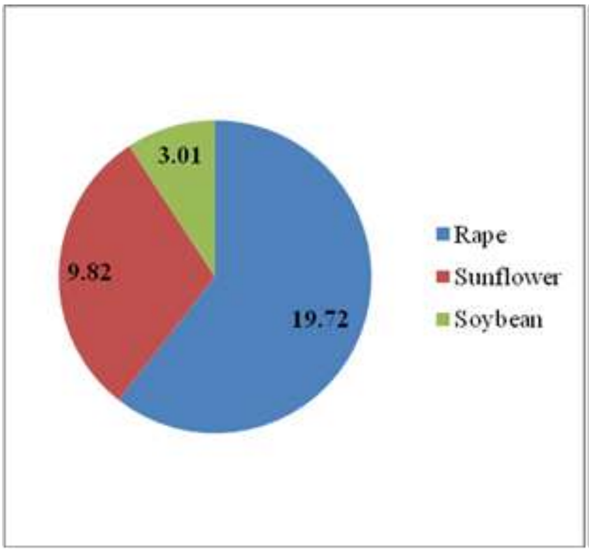
2023/2024 2024-2025

Fig. 2. Soybean cultivated area in the EU-27 in 20232024 and projected for September 2024-2025 compared to rape and sunflower surface (Million ha).
Source: Own design based on the data from [11].

If we compare with the results found in 2017 by [30], when the EU produced 35.09 Million tons oil seeds, of which rape seeds 21.91 Million tons, sunflower seeds 10.44 Million tons and soybean seeds 2.74 Million tons, with the data provided by [11] for 2023-2024, we may notice that in 2023-2024, the EU oilseeds output will be by 2.54 Million tons smaller than in 2018, the rape seeds production will decline by -2.19 Million tons, the sunflower seeds output will decrease by -0.62 Million tons, and, in case of soybean seeds production it is expected an increase by +0.27 Million tons (Fig. 3).

Regarding oil seeds production, for 2024-2025, it is projected that the EU-27 to carry out 29.51 Million tons oil seeds, of which: 17.21 Million tons rapeseeds (58.3%), 9.52 Million tons sunflower seeds (32.2%) and 2.78 Million tons soybean seeds (9.5%).

Therefore, it is expected that soybean output to grow (Fig. 3).



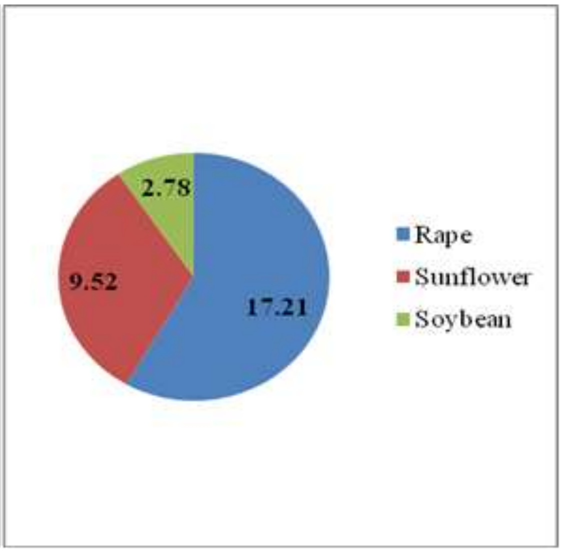


Fig. 3. Soybean seeds production in the EU-27 in 20232024 and projected for September 2024-2025 compared to rape and sunflower output (Million tons).
Source: Own design based on the data from [11].

The EU-27 yields for oil seed crops for the year 2023-2024 and 2024-2025 are presented in Table 3 comparatively in with the records mentioned by [30] in the year 2017. From this table, we may notice a decline of production performance per surface unit for each oil crop. In case of soybean, yield is expected to decrease from 2.85 tons per ha in 2017 to 2.10 tons in 2023-2024 (-0.01) and to 1.94 tons in 2024-2025 (-0.07).

Table 3. Oil seed yields by main oil seed crops in the EU in 2023-2024 and 2024-2025 versus 2014 (Tons/ha)

Crop	2017	2023-2024		2024-2025	
	(Tons/ha)	(Tons/ha)	Diff, versus 2017 (Tons/ha)	(Tons per ha)	Diff, versus 2017 (Tons/ha)
Soybean	2.85	2.84	-0.01	2.78	-0.07
Sunflower	2.45	2.10	-0.32	1.94	-048
Rape	3.25	3.14	-0.11	2.98	-0.27

Source: Own calculations based on the data from [11] and [30].

Table 4. Soybean balance in the EU-27 in 2023-2024 and forecast for 2024-2025 and its share in total oil crops balance (rape + sunflower and soybean) (Million tons)

	2023-2024			2024-2025		
	Soybean	Total oil seeds	Soybean share (%)	Soybean	Total oil seeds	Soybean share (%)
Beginning stocks	1,200	2,567	46.7	1,300	3,100	41.9
Usable production	2,782	32,324	8.6	3, 007	29,741	10.11
Imports from the 3rd countries	13,250	19,477	68.02	13,436	19,970	67.28
Total supply	17,232	54,368	31.69	17,743	52,722	33.65
Domestic use	15,709	50,127	31.33	16, 209	48,402	33.48
Of which crushing	13,861	46,483	29.81	14,339	44,876	31.95
Exports to the 3rd countries	223	1,230	18.13	234	1,309	17.87
Total use	15,932	51,357	31.02	16,443	49.711	33.07
Ending stocks	1,300	3,011	43.17	1,300	3,011	43.17

Source: Own calculations based on the data from [11].

The soybean balance Sheet in the EU-27

The figures presented in Table 4 regard the soybean balance in 2023-2024 and forecast for 2024-2025 and its share in total oil seeds balance (rape + sunflower and soybean).

They reflect an increase in usable production (+225), seed import (+186), total supply

(+511), domestic use (+500), of which crushing (+478), seed export (+11) and total use (+511).

These increases are also showed by the higher share of soybean in total oil seed balance sheet in 2024-2025 as presented in the last column. The figures indicate that imports of soybean will continue to increase to complete the supply in the common market.

Taking into consideration that imports of soybean meals for animal feed is very costing, the EU should have another orientation in its policy encouraging internal production. Imports increased costs with farm inputs for animal feed and not only will affect farmers' business efficiency.

Self Sufficiency Rate (SSR) for soybean seeds in comparison with the other oils seeds in the EU-27

Taking into account production, import and export, it was determined the Self Sufficiency Rate (SSR) separately for soybean, oils seeds (rape + sunflower + soybean) and rape + sunflower.

The results showed that soybean has the lowest SRR, accounting for 17.59% in 2023-2024 and in 2024-2025, this rate is expected to be by -3.72 percentage points lower.

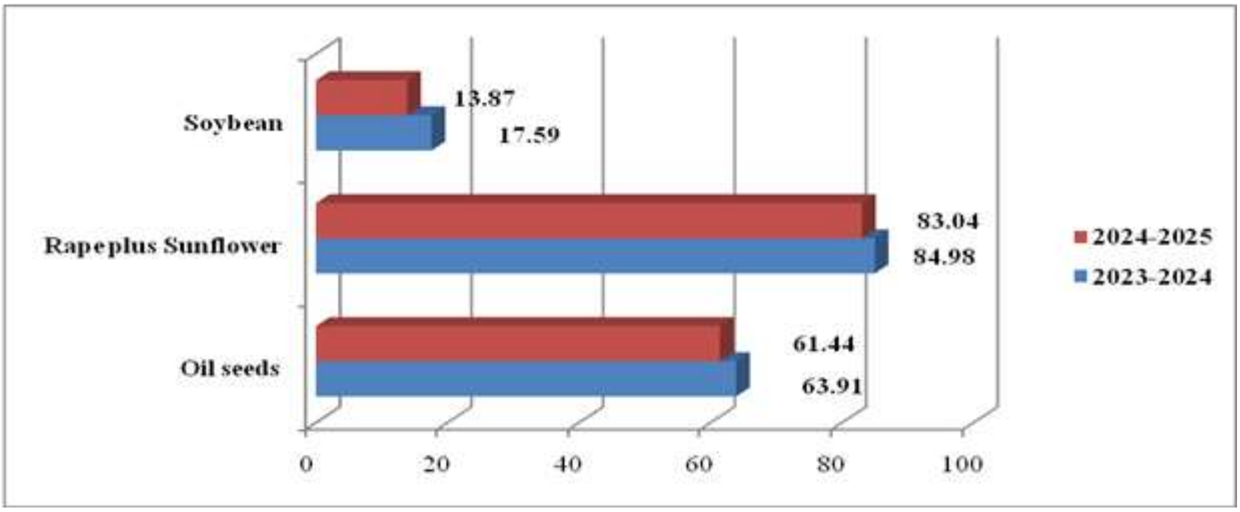


Fig. 4. The EU Self Sufficiency Rate for Soybean, Oil Seeds and Rape plus Sunflower in 2023-2024 and 2024-2025 (%)
Source: Own calculations.

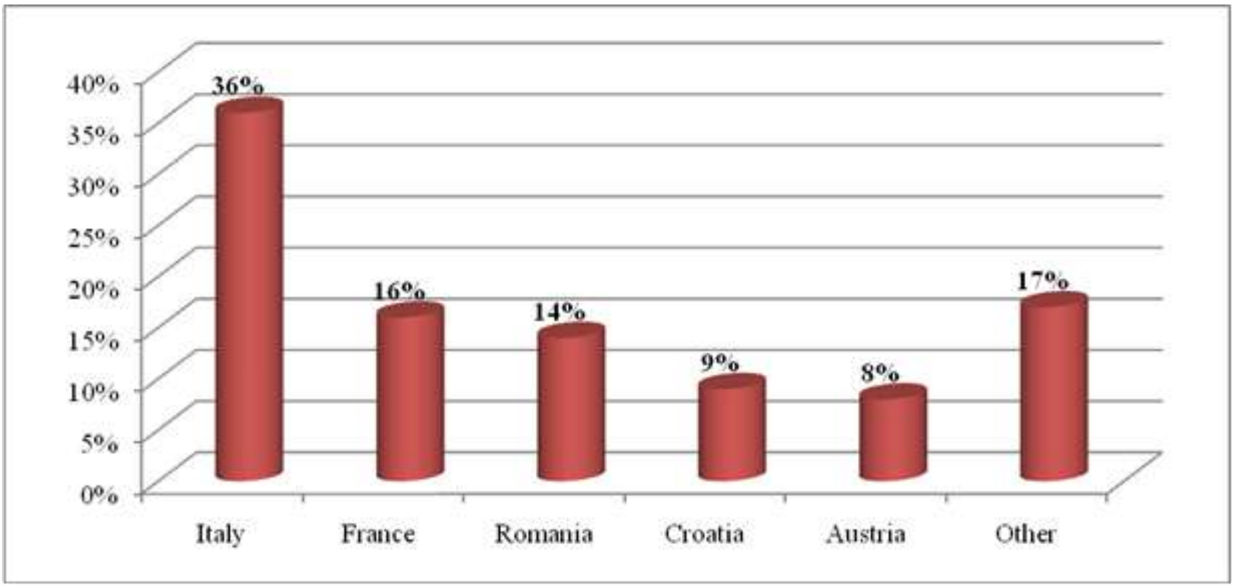


Fig. 5. The main EU member states producing soybean by October 2024 (% of total EU soybean production)
Source: Own calculation based on [46].

In case the all three oilseeds (rape + sunflower + soybean), SSR was 63.91% in 2023-2024, but in 2024-2025 is expected to be by -2.47 percentage points smaller. Taking into account only rape and sunflower, SSR has the highest level, accounting for 84.98% in 2023-2024. However, for the next 2024-2025, it is expected a SSR of 83.04%, meaning a decrease of -1.94 percentage points (Fig. 4). Till October 2024, the EU-27 produced 2.9 Million Metric tons soybeans, representing 1% of the global output. The main EU countries producing soybean are: Italy (36%), France (16%), Romania (14%), Croatia (9%) and Austria (8%), all these 5 countries together summing 83% of the EU soybean output. The remaining of 17% is carried out in other countries: Netherlands, Poland, Belgium, Denmark and Ireland (Fig. 5) [46].

Soybean area, yield and production in Romania

Romania comes on the 3rd position in the EU with 14% market share in the EU-27 output.

In Romania oleaginous seeds crops were studied regarding their cultivated and production performance by various researchers as shown by literature in the field. [1] studied the trends in trade with oleaginous seeds, [26] analyzed sunflower production, import and export , [31] approached the rape production concentration, [21], referred to the impact of climate change on sunflower yield and [39] emphasized soybean profitability.

The cultivated area with soybean increased starting from 2007 when the country joined the EU.

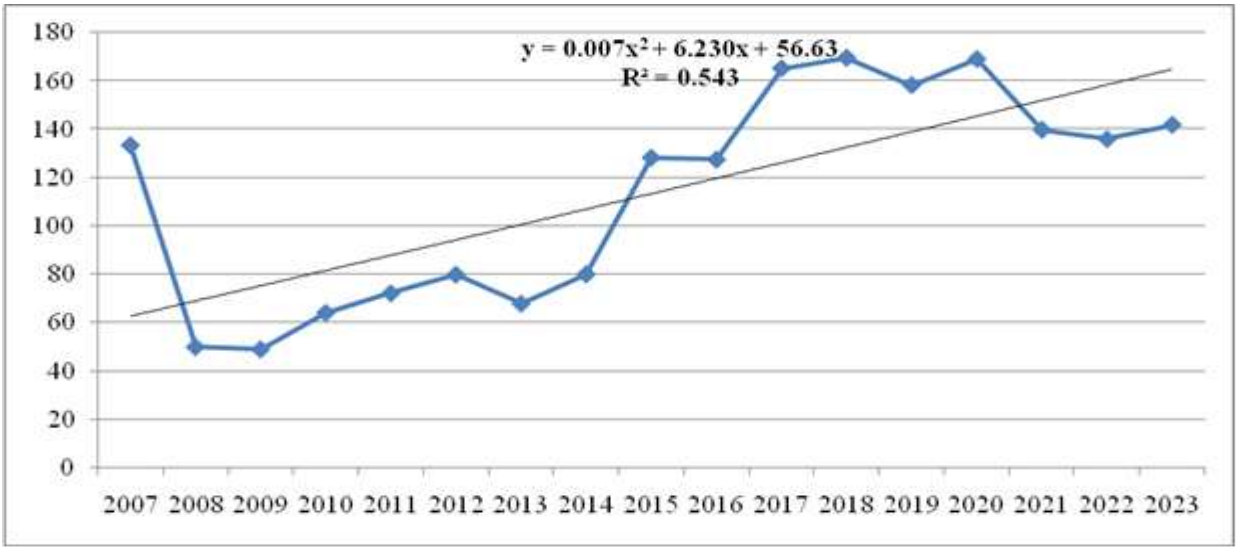
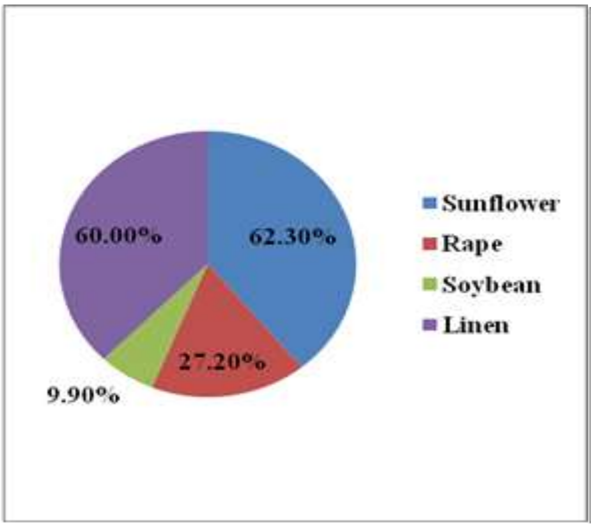


Fig. 6. Dynamics of soybean area in Romania, 2007-2024 (Thousand ha)
Source: Own design based on the data from [20].

In 2007, the cultivated area with soybean was 133.2 thousand ha, but in 2008 dropped to 49.8 thousand ha and then in 2009 went down again to 48.8 thousand ha, the minimum level registered in the interval 2007-2023. Year by year, the surface increased, the maximum level being 169.4 thousand ha in the year 2018, the best year for this crop in term of production as well. In 2023, the area with soybean accounted 141.7 thousand ha, meaning by 6.38% larger than in 2007 and by 16.4% smaller than in 2018 (Fig. 6). The regression equation reflects that for the year 2025 it is expected that the area cultivated with soya to be 147.9 thousand ha.

The R square value = 0.543 reflects that the variation of cultivated area in Romania depended 45.7% of other factors (cultivars used, technology applied, climate change, farm inputs price: seeds, diesel etc, farm gate delivery price etc) than time. In 2007, the share of cultivated area with soybean represented 9.94% of the surface with oilseeds crops, including sunflower, rape and linen for oil. In 2023, the soybean area accounted for 7.59%, being by 2.35 percentage points smaller than in 2007. In 2018, when soybean was cultivated on the largest surface, its share in total oils seeds area was 9.33% (Fig. 7).



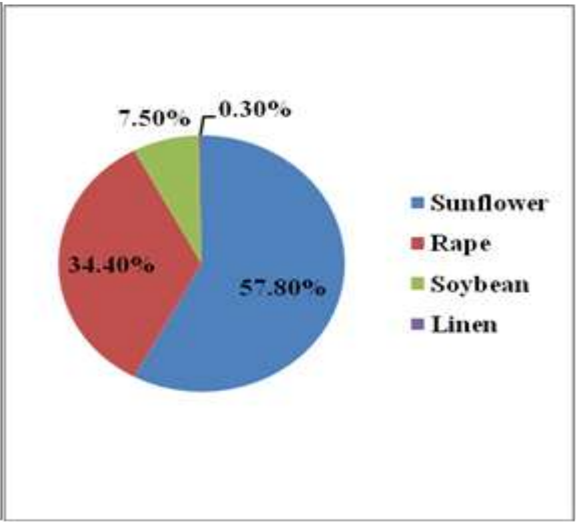


Fig. 7. The share of soybean cultivated area in total surface with oil crops, Romania, 2023 versus 2007 (%).
Source: Own design based on the data from NIS, 2024 [20].

The reduction in the cropped area with sunflower, soybean and linen was made in favor of rape which had to give a higher contribution as a raw material for producing renewable energy.

Taking into account the importance of soybean as a source of protein destined to cover the reduction in meat production, it is expected as in the future, soybean to have a greater role being cultivated on larger areas.

The soybean seeds production increased 2.2 times in 2023, attaining 303.2 thousand tons compared to 136.1 thousand tons in 2007. In the studied interval, the greatest output was achieved in 2018, 465.6 thousand tons, while the minimum production was registered in 2008 (90.6 thousand tons) (Fig. 8).

It followed a sinuous trend which depended on the evolution of cultivated area and also of the production performance per surface unit.

This was determined on the technologies applied by farmers and their adaptation to climate change which had a deep impact in agriculture of Romania during the last decade.

High temperatures and long and severe droughts affected many regions including the ones which are favourable for soybean crop.

This is proved by the fact that after 2018 when soybean attained the peak of production, in the next years the output was much smaller.

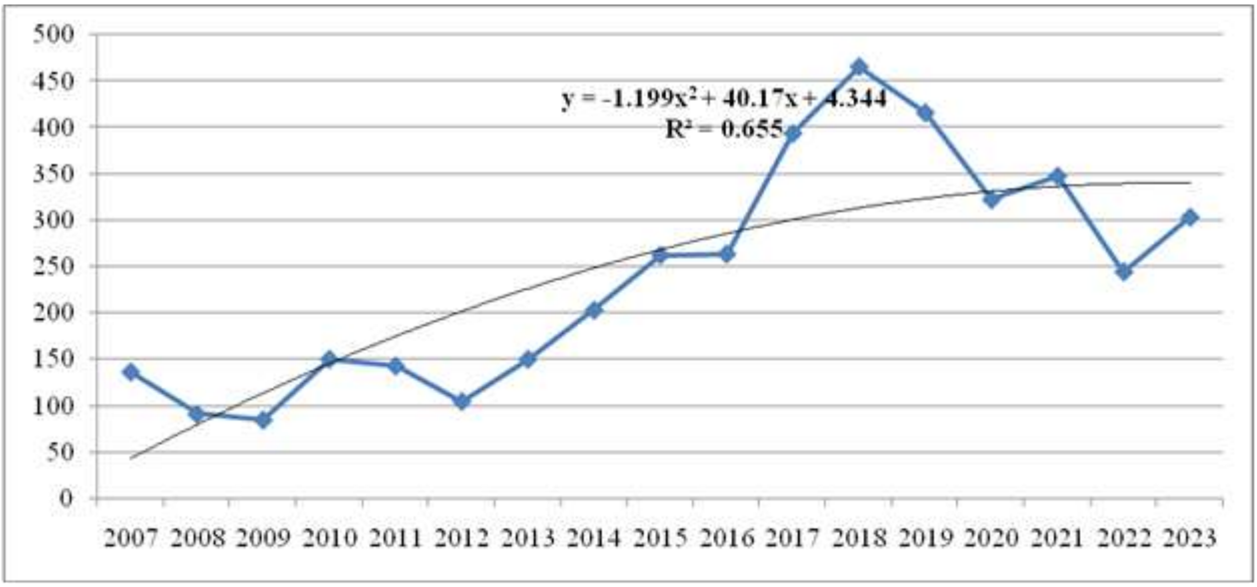
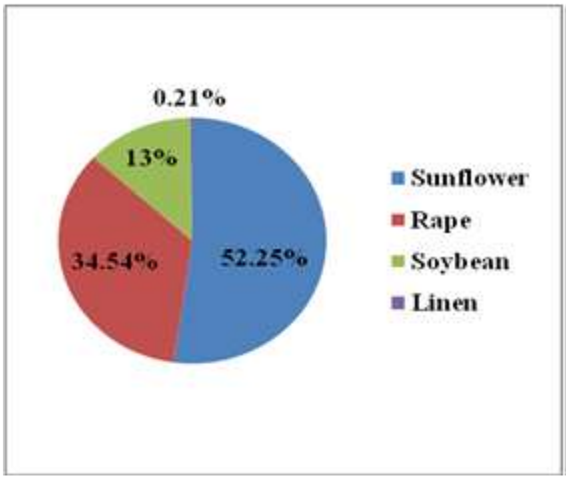


Fig. 8. Soybean production, Romania, 2007-2023 (Thousand tons)
Source: Own design based on the data from NIS, 2024 [20].

In 2007, soybean output had a share of 13% in total oil seeds production, and was ranked the 3rd after sunflower (52.25%) and rape (34.53%). In 2023, the share of soybean decreased to 7.36%, remaining on the 3rd position after sunflower (48.98%) and rape (43.49%) (Fig. 9).

Figure 9 shows a decline in sunflower contribution to oil seeds output by 3.27 percentage points, an increase of 8.95 pp in case of rape and a decline in soybean by -0.04 pp. This reflect farmers' orientation to rape crop for which they received subsidies to sustain biodiesel production.



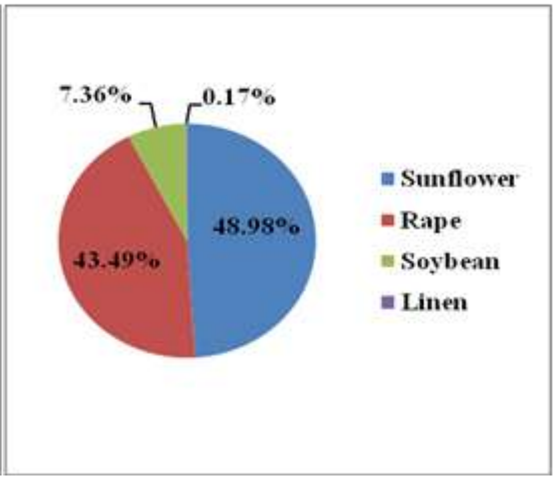


Fig. 9. The contribution of soybean and other oil seeds crops to production in 2023 versus 2007 (%)
Source: Own design based on the data from NIS, 2024 [20].

Soybean yield increased in Romania to 2,140 kg/ha in 2023 being 2.09 times higher than in 2007, when it was recorded the lowest level.
However, in the most favorable year, 2018, it was carried out the highest yield accounting for 2,748 kg per surface unit (Fig. 10).
Also, in the year 2018 versus the performance registered in the year 1961, soybean seeds production was +10,610.43% higher, cultivated area was +1,594.2 % larger and yield was by +532.17% greater [22].
In fact, since 2013, soybean seeds yield started to exceed 2,000 kg/ha, except the years 2020 and 2022 when the performance was below this figure because of the unfavorable climate conditions with high temperatures and long and severe droughts.

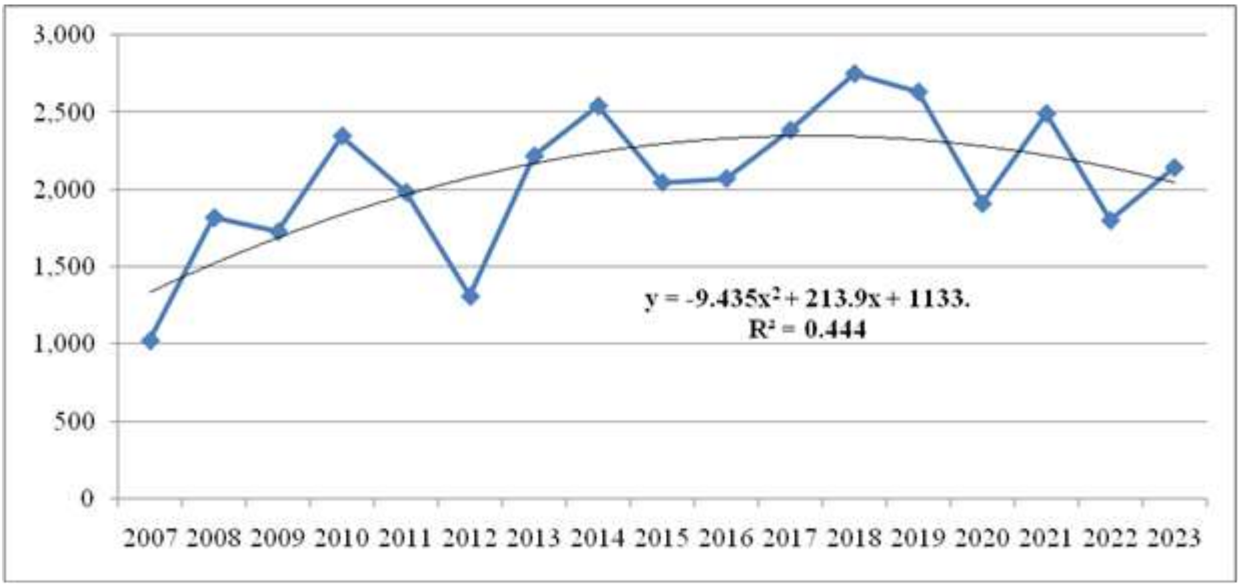


Fig. 10. Dynamics of soybean yield in Romania, 2007-2023 (tons/ha).
Source: Own design based on the data from NIS, 2024 [20].

Yields could be sustained by farmers if they will test various varieties in the their local soil and climate conditions and select the ones with the highest performance.

In addition, they have to look for the most appropriate moment for sowing in connection to temperature and soil moisture and to apply the agricultural works at the right moment and of high quality.

CONCLUSIONS

The study investigated the trends in soybean crop cultivated area, yields and production at the global level, in the EU and Romania.

Soybean is consider an important protein and energy source which could enhance the plant position among the protein-based crops called to compensate the decline in meat production and healthier food products and animal meals, to sustain renewable energy production, to reduce pollution by capturing Nitrogen, diminishing the amounts of fertilizers, protecting environment and conserving biodiversity.

In 2023, at the global level, the cultivated area was 139.74 Million ha, production reached 419.5 Million tons, being by 32% higher than in 2015, and average yield accounted for 2.82 tons/ha compared to 2.76 in 2022.

The increased production was stimulated by the higher consumption which in 2024 attained 406.1 Million, by 27.3% more than in 2015.

The main producing are Brazil, USA, Argentina and Paraguay which all together produce 91.7% of the global soy seed output.

In the EU-27, in the year 2023, 11.94 Million ha were covered by oilseeds crops, of which: rape 52.2%, sunflower 39.2% and soybean 0.98 Million ha (8.2%). For the next year, it is provided an increase by +0.1 Million ha for soybean, +0.21 Million ha for sunflower and a reduction by -0.46 Million ha for rape.

In 2023, the EU produced 32.55 Million tons oil seeds including rape, sunflower and soybean, of which 3.01 Million tons soybean seeds (9.2%), 9.82 Million tons sunflower seeds (30.1%) and 19.72 Million tons rape seeds (60.7%).

The soybean balance 2024-2025 versus 2023-2024 reflected an increase in usable production (+225), seed import (+186), total supply (+511), domestic use (+500), of which crushing (+478), seed export (+11) and total use (+511).

The Self Sufficiency Rate for soybean was 17.59% in 2023, very small, compared to SSR 63.91% for rape + sunflower + soybean together and 84.98% for rape+ sunflower. For the next year, forecast estimates a lower SSR for soybean, reflected that the EU do not cover the needs of soybean from internal production and imports are called to meet the higher demand.

The EU-27 soybean production of 2.9 Million Metric accounts for 1% of the global output. The main EU producing countries are: Italy (36%), France (16%), Romania (14%), Croatia (9%) and Austria (8%), all these 5 countries together summing 83% of the EU output.

Romania comes on the 3rd position in the EU (14% market share). In 2023, the country cultivated 141.7 thousand ha with soya, by 6.38% more than in 2007, but 16.4% less than in 2018.

Soybean seeds output increased 2.2 times in 2023, attaining 303.2 thousand tons compared to 2007. The top production of 465.6 thousand tons was achieved in 2018.

Soybean yield raised to 2,140 kg/ha in 2023 being 2.09 times higher than in 2007 (the lowest level).

As a conclusion, taking into account the importance of soybean as a source of protein destined to cover the reduction in meat production, it is expected as in the future, soybean to have a greater role being cultivated on larger areas and sustain yield.

In the EU imports of soybean will continue to grow to cover the market requirements, but the recent approval of two GM soybean will led to a disturbance in soy feed and food market and will have a negative effect on price evolution.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

SUSTAINABILITY OF THE WORKFORCE ON A FARM IN THE NORTH-EAST REGION OF ROMANIA

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Abstract

Sustainability in the labour field on a farm in the Nord-East Region of Romania is a valuable subject having a significant impact on the performance and long-term development of the agricultural enterprise. The efficiency of using the available resources is known as productivity or effectiveness. The efficiency measurement can be attained through several methods, however two of them are most frequently utilised for performance evaluation. The first method, the physical productivity computed by measuring the natural performance of production indicators and is expressed in natural or conventional units; the second method, the performance is measured in terms of value, allowing to evaluate efficiency in terms of financial-monetary terms and is utilised in the modern management of enterprises. In this paper, the main objectives include identifying the optimization directions of workforce performance for S.C. Treter S.R.L., evaluation level and labour productivity evaluations, available resources analysis for improving labour productivity and review of economic consequences of the changes traced in the workforce productivity field. In the period 2019-2023, S.C. Treter S.R.L. increased the number of employees from 12 to 17, this expansion was the result of the company's development policy, oriented towards the acquisition of additional land and expansion of operational capacities, and the evaluation of work efficiency shows an increase in annual return from 218,526 lei/employee in 2019 to 229,363 lei/employee in 2023. In terms of commercial labour efficiency, it peaked in 2022 at 233,199 lei/employee and the analysis of daily and hourly efficiency showed fluctuations, with the highest productivity level in 2022 and the lowest in 2021, thus highlighting the variable impact of agricultural production and number of employees on the company's performance. The study showed that S.C. Treter S.R.L. had a steady increase in the number of employees and improved efficiency in the use of human resources, indicating a well-founded expansion strategy, thus the positive developments in work efficiency underline the importance of continued investment in technological progress and employee skills development. These measures are essential for maintaining and improving productivity and adapting to fluctuating economic conditions, and increasing work efficiency has a direct impact on the volume of output and the time taken to produce it, thus highlighting the essential role of effective human resource management in organisational success.

Key words: *human resources, sustainability, performance, efficiency*

INTRODUCTION

Labour is a fundamental component from economical perspective, being considered an essential production indicator in the manufacturing and services sectors.

Within economic theories, labour is described as one of the three main resources, together with capital and land, that assist to generate income and value in an economy [14].

From a social perspective, workforce is not only an economic activity, but it represents a more vital component of society.

Through labour, individuals ensure the means of living, develop and value abilities and are an integral part of the community wellbeing, as well as labour is a significant component of social identity and status of an individual in society [9].

Therefore, labour is the intersection between economic and social dimension, having a major impact on the economic operating system, as well as social structure and cohesion, as a central component in the process of society progress and development, influencing both tangible and cultural and moral essential elements of the individual and collective life [6].

From economical perspective, labour implies expenses, representing a production cost determined by the number and quality of individuals involved and hourly fee [11]. Labour is distinct from the other production indicators, land and capital, as it is triggered by individuals that have different reasons to efficiently fulfil the tasks [2].

Workforce in agriculture is influenced by difficult and inconsistent conditions, often times unfavourable, accompanied by diversity and seasonality, which require adaptability of the plants and animal's needs, being correlated to natural cycles and specific requirements of living organisms [14].

From social and economic, agriculture labour is defined often times by its familiar nature, not being compensated directly, less specialised and adapted to the technical requirements of productions, even more the quality of agricultural labour is difficult to be evaluated due to high dependencies on climatic conditions and the difficulties to control it [9].

In the context of workforce in the agricultural field, the labour offer is greatly influenced of the salary levels, although this relation is sometimes offset by indicators like time to rest, that can sometimes lead to replace resting time with work times and the effect of income, which can lead to a reduction of working hours in case of an increase in hourly fee [8].

Labour is an investment in production, being quantified in terms of labour productivity, representing an essential indicator of economic efficiency analysis [6].

The main methods used to compute labour productivity are: the method of physical units (utilised for cases where it is produced a single type of item or a specific task and it is based on the report between total production or volume of tasks and total time spent); the method of conventional units (is used to compute labour productivity for a group of products, that can be converted in conventional units, like nutritional or calories, using specific corelation coefficients) and the method of value units (which implies evaluations of production as valuative, expressed monetary.

This can compress main production and secondary or undetermined and is calculated by assessing the final production and gross margin to total time of labour consumed) [17].

Indicators of labour productivity reflect efficiency of production labour, being influenced by both quantity and quality of work and utilised capital [16].

An increase of labour productivity can have an impact on the valoric structure of the product at macroeconomic level and can alter the report between living labour and labour at macroeconomic level, leading to a reduction of unitary cost [12].

The analysis of workforce productivity relies on a set of indicators that express the quantity of products obtained in report to the labour expense, as well as the labour expense necessary to obtain units of product.

Considering the computing methodology of production and labour expenses, we can identify the following indicators to measure labour productivity [4].

a) measuring the volume of production:

- methods in natural units: they apply in companies with a homogeneous production or with a small number of products, where is computed labour productivity in physical and quantitative terms [5].
- conventional methods: utilised in similar situations, but converted production in conventional units, like kilograms or tones [12].
- methods of working hour shifts: utilised in companies with homogeneous production, establishing standard times for each operation and the labour productivity is measured according to the completion of this standardizations [1].
- valoric method: is applied in companies with a diverse production or heterogenic, where computing labour productivity is in terms of value [14].

The analysis and relevance of valoric indicators of labour productivity are essential to express total volume of activity in dynamics over time and space. At macroeconomic level, the labour productivity calculation through valoric method utilises indicators like net production, global production, goods production and added value [7].

b) measurement through labour consumption:

- total number of employees: this indicator measures annual productivity of workers, quarterly or monthly, based on number of employees [10].
- total individual-working days: utilised to compute average daily productivity, representing average daily productivity achieved by a worker [3].
- total individual-working hours: this indicator measures the average hourly productivity, being used to evaluate the average productivity achieved by a worker in a working hour [13].

The purpose of this research is to investigate the sustainability of the workforce in a farm, located in the North-East Region of Romania, with a dedicated perspective on the enterprise S.C. Treter S.R.L. The study is focused on the evaluation of utilizing the indicators of production with the intend of obtaining optimal efficiency by using the available resources.

The approach to productivity can be achieved through various modalities, each one having specific methods to measure results. This includes physical productivity, which evaluates efficiency in natura of the production indicators and it is expressed in physical units, as well as the productivity express valoric, which is allowing efficiency assessment in terms of financial-monetary terms and is utilised extensively in modern enterprises management.

The main objectives of this study reflect:

1. determining the ways to increase economic efficiency of the labour performance for S.C. Treter S.R.L.: this stage implies to evaluate the existing research on identifying the methods and practices that can improve workforce efficiency within the analysed enterprise.
2. determining the labour efficiency level and dynamics within S.C. Treter S.R.L.: the purpose is to analyse the level of current farm labour productivity and how it evolves over time.
3. analysis of resources for increasing labour efficiency: this stage implies identification and evaluation of factors that can positively influence the increase of labour efficiency, like qualified human resources or management processes.
4. analysis of economic effect of changes in labour productivity: the objective is to evaluate the economic impact of changes in labour productivity on the financial and profitability performances of the enterprise S.C. Treter S.R.L.

MATERIALS AND METHODS

The study is focused on the sustainability analyses of workforce in S.C. Treter S.R.L. The company is a private capital enterprise with a mix of Romanian-French stakeholders, specialized in the cultivation of cereals, leguminous plants and oilseed crops. The farm has in usage 1,300 hectares of personal propriety of arable, out of which 150 hectares are personal propriety and the rest is leased land. The main type of cultures in the company's portfolio are cereals (wheat, barley, triticale, corn), oilseed crops (sunflower and rapeseed) and aromatics (coriander).

To increase efficiency and maximise the crops outputs, the farm has implemented a simplified working system, which means diversity in the steps for preparation of the soils, sown and based on the needs of the crops.

In terms of labour force, the company has currently 17 employees, with a majority number of qualified workers in the agricultural sector. The growth of the company and of the land field create the need to expand the workforce, with approximately 80% of qualified workers for dedicated job roles.

The study intends to evaluate sustainability in the workforce in the specific context of a farm from the North-East Region of Romania, taking into consideration aspects like qualified workers, need of workforce and operational efficiency.

In order to measure the labour efficiency, we utilised a diverse set of indicators, as following:

- method of natural physical units, of labour (number of hours per shift) and valoric, based on production volume and the costs of the achieved labour.
- labour efficiency express in valoric units which allow a comparison between time and

space, offering a holistic perspective of efficiency. This method took into account the changes in sorting structure of production and prices.

- valoric indicators of labour efficiency, like net production, global production and value added have provided a more in-depth evaluation of the labour efficiency and has contributed to the global results of the farm.

RESULTS AND DISCUSSIONS

In the current analysis of the labour force of the company S.C. Treter S.R.L., we will focus on evaluating the available human resources and their degree of efficiency in usage, we will examine the aspects concerning the structure of personnel and the modalities of managing and utilization of the personnel to fulfil the company's objectives. Therefore, the evolution of the number of company employees with the purpose to obtain an overview of the trends and changes in the labour force dimension over time is presented in Fig. 1.

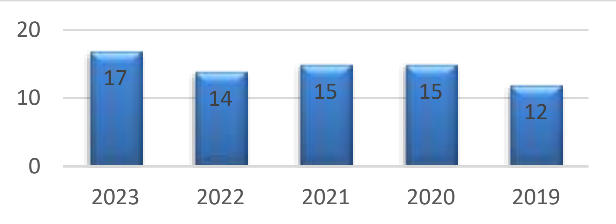

Fig. 1. Evolution of number of employees during the period 2019-2023
Source: own calculations based on the company's accounting data.

We observe that the company has a relatively small number of employees, that registered an increase year over year, since 2019 when the company had 12 employees to 2023 having a total of 17 employees. This increase in number of employees was determined by the extend in land field, as well as the company strategy which has as objective growth and development through acquisition or lend of additional lands.

The personnel structure within the company is in average as follows: 1 accountant, 1 agriculture engineer, 8 agriculture mechanics, 2 not qualified workers and 3 guardians. Analysing the structure, we can observe that the majority of employees are from the agriculture production sector, represented by agriculture mechanics and engineer (Fig. 2).

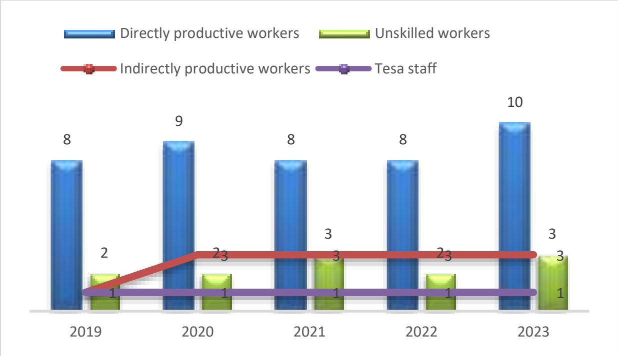

Fig. 2. Structure of personnel between 2019-2023
Source: own calculations based on the company's accounting data.

Regarding the other classes of employees, they are grouped as indirect productive workers, this includes guardians that ensure protection and security of the land and offices, as well as the non-qualified workers that handle a series of tasks for preparation of machines, loading and unloading of raw material, and the last group is represented by the accountant who is part of the Technical, Economic, Socio-Administrative category.

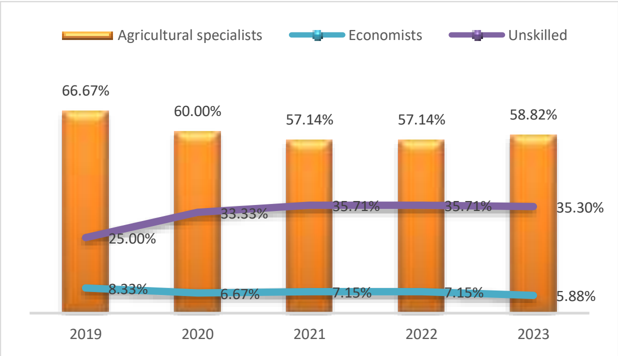

Fig. 3. Structure of personnel by job roles between 2019-2023
Source: own calculations based on the company's accounting data.

In Fig. 3 is illustrated the structure of the company personnel by job role, so we can observe that on the entire period of time we analysed the set of data, the agriculture employees represent over half of the entire number of personnel, followed by the non-qualified workers and the accountant of the company that has an Economic degree.

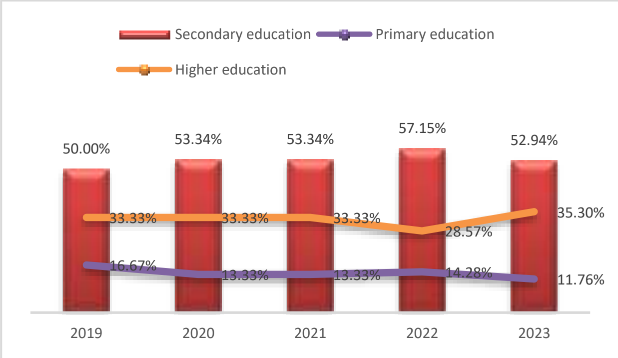

Fig. 4. Structure of personnel by level of qualifications
Source: own calculations based on the company's accounting data.

From Fig. 4, we can observe that the company includes personnel from the three levels of education, over 50% have secondary education, while over 28% have higher education from the total number of employees, the company has as well employees with primary education. During the analyses period, the structure of the personnel by level of experience is classified in five categories: 0-10 years, 11-20 years, 21-30 years, 31-40 years and over 40 years of experience (Fig. 5).
Examining the structure of personnel by level of experience, we observe that the majority are the young employees, the ones in the first range 0-10 years of experience (over 40% from the total of personnel between 2019-2023), followed by the range 11-20 years of experience with 25% in the year 2019, this registered a slight decrease in 2020. The smallest proportion of the personnel by experience levels can be observed in the range 31-40 years and over 40 years. This indicates that the company intends on utilizing a new personnel strategy, focused on youth that bring a fresh vision and reenergize the workforce.

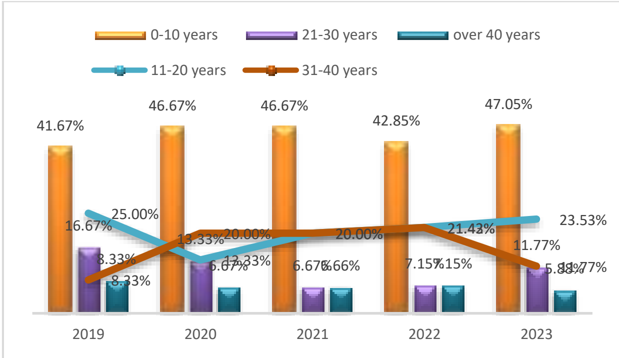

Fig. 5. Structure of personnel by experience
Source: own calculations based on the company's accounting data.

The tools for increasing labour efficiency with the company are diverse and focus on quantitative and qualitative components of the labour force. In this matter, evaluation emphasises the dimension, structure, mobility and stability of the workforce, as well as the degree of qualification and level of salaries (Table 1).

Table 1. Analysis of annual labour efficiency

Name/Symbol	Formula	Years				
		2019	2020	2021	2022	2023
Efficiency of labour annually (value) (Wav) - lei	VT/Ns	218,526	244,786.3	91,086.93	271,123.8	229,363.1
Efficiency of labour annually (commercial) (Wac) - lei	CA/Ns	187,368.8	230,389.1	98,402.8	233,198.8	224,773.1

Source: own calculations based on the company's accounting data.

Analysing the evolution of labour productivity over the years, a significant influence of the obtained production, the turnover and the total revenues registered by the company, related to the number of employees, is observed, thus the annual labour efficiency experienced an increase from 218,526 lei/employee in 2019 to 229,363 lei/employee in 2023, flagging an increase in efficiency of resource utilization within the company in the period of time 2019-2023.
Regarding the labour productivity expressed commercial which indicates the report between the business turnover and number of employees, the highest was registered in 2022, reaching the peek value of 233,199 lei/employee, this increase in labour efficiency

is due to expansion of sold products and increase in personnel.

In regard to the value of labour efficiency, it indicates the revenue by employee, as follows: 2019 registered 218,526 lei/employees, in 2020 it was 244,786 lei/employees, in 2021 the sum 98,402 lei/employee, in 2022 total of 271,123 lei/employee and in 2023 it reached 229,363 lei/employee.

This evolution of labour efficiency shows the fluctuations and trends in the financial performance of the company, emphasising the importance of labour efficiency in the context of company management.

Table 2.Analysis of daily labour efficiency

Name/Symbol	Formula	Years				
		2019	2020	2021	2022	2023
No. of days/worker/year/company (Z)	-	3.048	3.855	3.825	3.528	4.335
Efficiency of daily labour (valoric) (Wzv)	VT/Z	860.34	952.48	357.20	1075.89	899.46
Efficiency of daily labour (commercial) (Wzc)	CA/Z	737.67	896.46	385.89	925.39	881.46

Source: own calculations based on the company's accounting data.

Glancing at sustainability in the workforce, from the daily efficiency perspective within the company, it is shown the influence of number of days per worker over a year time and on the company, as well as of the indicators resulting (Table 2). The analysis of the daily efficiency expressed commercially indicates the lowest point in year 2021, when it reached 357.2 lei/no of days/worker/year/company, while the highest level of productivity was registered in 2022, with a value of 925.39 lei/no of days worker/year/company. This difference between 2021 and 2022 is based on the level of agriculture productions and number of company employees.

In regard to the daily labour efficiency expressed valoric, this is constant over the five years timeframe we researched, 860 lei/no of days/worker/year/company, except year 2020, when there was a value of 385.89 lei/no of days/worker/year/company. These observations emphasize the importance of efficient management of human resources and of adaptability to labour strategies under fluctuating market and economic conditions.

Table 3. Analysis of labour efficiency hourly

Name/symbol	Formula	Years				
		2019	2020	2021	2022	2023
No. of hours/worker/company. (O)	-	24,384	30,840	30,600	28,224	34,680
Labour efficiency hourly (valoric) (Wov)	VT/O	107.54	119.05	44.65	134.48	112.43
Labour efficiency hourly (commercial) (Woc)	CA/O	92.20	112.05	48.23	115.67	110.18

Source: own calculations based on the company's accounting data.

Regarding the sustainability of labour force from the hourly efficiency perspective in connection to the production, this is maintained at a constant level over the five years we analysed. This steady level of labour efficiency is directly connected to the stable environment of agriculture production and of the company’s employees’ influences. We can observe that, according to the data from Table 3, the highest level of efficiency from the commercial perspective was registered in the year 2022, while the lowest level was registered in 2021. In the other timeframe analysed, 2019 and 2020, the efficiency indicators kept a constant level, similar with the 2022-2023. This stabilization of hourly labour efficiency is reflecting the constant maintenance of agriculture labour efficiency, except for the year 2021. So, we can determine that there are a multitude of opportunities to increase labour efficiency within the economic units influenced by the technical and technological progress, the organisational and management method of the production and labour, as well as the management indicators.

The level and dynamics of labour efficiency are influenced by a large number of factors: natural, biological, technical-organisational, social-politics and psychosocial. Considering the economic transition, updating and re-technologization are essential, stimulated by the private propriety relations and the economic law on the market, facilitating integration with the developed European countries.

The main growth opportunities of labour efficiency include technical progress, improvement of qualified labour force, integration of modern management methods and optimization of financial employee stimulants. In order to establish the correct growth of labour efficiency is necessary to consider all elements that influence the level and dynamic, as are the productions particularities on each branch of the company.

The introduction of the technical progress represents the most important route to labour efficiency growth, leading to saving materials and work resources on each company.

The growth in labour efficiency generates direct effects on the volume of production and the number of employees, leading to an increase in the output per unit of time and a reduction in the time required for production. Direct effects include increasing production and saving labour resources.

CONCLUSIONS

The sustainability analysis of the labour force on a farm in the North-East Region of Romania emphasises the main evolution and attributes of human resources and labour efficiency between 2019-2023.

The personnel structure reflects the importance of specialized employees (agriculture), representing over half of the total number of company employees, followed by non-qualified workers and the accountant.

The labour efficiency analysis indicates a constant increase in the evaluated timeframe, annual labour efficiency increased from 218,526 lei/employee in 2019 to 229,363 lei/employee in 2023; at the same time, labour efficiency expressed valoric has fluctuated, but had an upward trend, varying between 98,402 lei/employee in 2021 and 271,123 lei/employee in 2022.

Regarding the daily labour efficiency, this was influenced by agriculture production obtained and the number of company employees, and the labour efficiency expressed commercial has fluctuated between 357.2 lei/no of days/worker/year/company in 2021 and 935.39 lei/no of days/worker/year/company in 2022, while the labour efficiency expressed valoric maintained a steady level over 860 lei/no of days/worker/year/company in 2021 and 935.39 lei/no of days/worker/year/company, except the year 2021, when it registered a decrease to 385.89 lei/no of days/worker/year/company.

ACKNOWLEDGEMENTS

The authors acknowledge the support offered by the manager of SC Treter SRL, Rediu, Galati County, Romania for providing the accounting data to set up this paper.

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***SC Treter SRL, Ltd Company Accounting.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ECONOMIC AND ENERGY EFFICIENCY OF PRIMARY TILLAGE AND FERTILISATION SYSTEMS IN FIVE-FIELD CROP ROTATION OF THE RIGHT-BANK FORESTSTEPPE OF UKRAINE

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Abstract

According to the greening index, the zero level of fertilization in crop rotation corresponds to biological agriculture, the first level to ecological agriculture, and the second and third levels to its biologisation. According to the ecological classification of cropping systems, the first and second levels of fertilization ensure an increasing, and the third intensive level of greening of the agricultural sector. The yield of crops in the crop rotation is significantly reduced in the case of chisel disc and disking tillage. Differentiated tillage slightly reduces this indicator in peas, corn, white mustard in the link with legumes and slightly increases in winter wheat and buckwheat. At the same time, the yield of white mustard increases in the link with buckwheat, but only in fertilized areas. In terms of crop rotation productivity, the mouldboard and differentiated tillage are equivalent, while the chisel disc and disking tillage are significantly inferior to the control. The highest indicators of economic and energy efficiency were obtained with differentiated tillage with the application of 6 tons of manure + $N_{98}P_{66}K_{92}$ *per hectare of crop rotation. It is recommended that in a five-field grain crop rotation, ploughing (mouldboard) should be carried out only for corn (to a depth of 25-27 cm), differentiated tillage for peas (to a depth of 18-20 cm), and disking tillage should be used for other crops (to a depth of 6-12 cm) with the application of 6 tons of manure +* $N_{98}P_{66}K_{92}$ *per hectare of arable land and the use of non-marketable products as organic fertilizer*

Key words: *crop rotation, tillage, fertilization, crops, yield*, marketable products, non-marketable products, *economic efficiency, energy efficiency*

INTRODUCTION

Today, there are many requirements for mechanical tillage: it must be soil-protective, moisture-saving, anti-erosion, soil-forming, resource-saving, and must provide for the preservation of soil ecological functions, in particular, bio-ecological, bioenergy, hydrological, hydrogeological, biogeochemical, gas-atmospheric and biogeocenotic functions [33]. Scientists point out that the ecological functions of the soil related to the regulation of gas exchange, moisture exchange and heat transfer by mechanical tillage and fertilizer application ensure the maintenance of biodiversity and ultimately life on the planet [14, 15].

Until the early 20th century, the depth of main tillage in Ukraine increased and then differentiated depending on the biological characteristics of agricultural plants and soil and climatic conditions. In the middle of the first half of the 20th century, the optimal ploughing depth for chernozems was 18-22 cm, and in some cases 25-27 cm [11, 16].

From the 1930s to the 1950s, the main tillage method in Ukrainian agriculture was ploughing with ploughs with skimmers to a depth of at least 20-22 cm. The main purpose of tillage during this period was to create a strong, structured, cultivated topsoil to a depth of at least 20 cm, in the lower part of which the most favourable conditions for moisture and structure formation were created [17].

In 1952, for the first time in the Soviet Union, Taras Maltsev abandoned ploughing. He made a moldboardless plough, which he used in a four-field crop rotation to deeply cultivate only the fallow fields, and to disc the rest by 7-8 cm [18].

Today, most scientists suggest ploughing once every 3-5 years, mainly for row crops, and for other crops, conducting moldboardless cultivation with flat cutters, disking, peeling to different depths [19].

Scientists recommend cultural ploughing when the coefficient of structure of the upper (0-10 cm) soil layer is below 0.67 (according to the Savvinov method)[9]. The principle is the mutual movement of two layers of soil (upper and lower) by ploughing [9].

The plough without skimmers can be used to incorporate lime and manure into the soil [10]. In other cases, cultivated ploughing with skimmers is effective, even on weed-free fields, as it creates a heterogeneous tilts layer. A plough without skimmers only mixes the top (de-structured) and bottom (insufficiently structured) layers of soil to form a homogeneous cultivated layer [1].

Most scientists propose to use a differentiated system of basic tillage in crop rotations, which involves a scientifically based combination of methods and measures of mechanical impact on different soil depths, taking into account the biological characteristics of agricultural plants, soil differences, climatic conditions, fertilization systems[14, 16, 1, 10].

Main cultivation should primarily ensure increased labour productivity, environmentally sound land use, soil protection from degradation processes, efficient use of water resources and improvement of recreational properties of landscapes, as its impact on the productivity of agrophytocenoses is almost the same, and the soil nutrient regime and phytosanitary condition are optimized by the use of fertilizers and pesticides, respectively [26]. However, our recent research indicates the opposite: agrophytocenosis yields and crop rotation productivity can significantly depend on the main tillage systems [20, 21, 22, 23].

The results of research by other domestic scientists also convincingly prove this conclusion. On the typical deep black soil of "Agrofirma Kolos" of Kyiv region (Ukraine) in a stationary field grain crop rotation of ten plots, the highest efficiency was provided by the system of shelfless tillage, in which deep ploughing was carried out for sunflower and sugar beet, shallow shelfless loosening for winter wheat after corn for silage and soybeans and chiselling for other crops [3].

The most effective system of shelfless tillage in the conditions of the Right-Bank Steppe of Ukraine was the one that provides for a combination of ploughing for row crops with "zero" tillage for agrophytocenoses of the usual row seeding method in the crop rotation. Research by the Kirovograd Institute of Agricultural Production (Ukraine) has given grounds to recommend winter wheat production: after black fallow, no-till cultivation by 18-22 cm, corn for silage – disking or "zero" cultivation (for ploughing under the predecessor); for sugar beet – ploughing by 28-30 cm (for flat-cutting by 18-22 cm for the winter wheat predecessor); for spring barley - 20-22 cm flat-cutting (with 28-30 cm ploughing under the sugar beet predecessor); for corn – 25-27 cm ploughing; for peas – 18-22 cm ploughing or zero tillage (with 25-27 cm ploughing under the corn predecessor; for sunflower – 22-25 cm ploughing in dry years and minimal tillage in wet years [4].

Also, in the Forest-Steppe of Ukraine, a differentiated system of primary tillage is proposed, which provides for periodic (every 3-4 years) deep ploughing (25-27 cm) for row crops, primarily sugar beet; deep and medium moldboardless tillage for legumes, sunflower and spring grain crops; shallow or surface tillage with combined and disc tools for winter cereals; periodic direct sowing for cereals under the condition of chemical weeding, low weediness of fields and late harvesting of predecessors [27].

In the five-field stationary crop rotation of the Institute of Agriculture of the Steppe Zone (Ukraine), shelf, differentiated and shallow (mulching) systems of cultivation of ordinary heavy loamy chernozem are equivalent in terms of arable land productivity, and the latter has an advantage in terms of economic and energy efficiency [31].

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

The highest agrotechnical, economic and energy efficiency in field grain-tilled crop rotation of the Right-Bank Forest-Steppe of Ukraine under industrial, ecological and biological farming systems was provided by the shelfless main tillage of typical chernozem. Scientists recommend ploughing with a tiered plough every 4-5 years of crop rotation and using disc and flat-cut tillage between ploughing [29].

The Odesa State Agricultural Research Station (Ukraine) recommends a differentiated system of basic tillage of southern black soil in short rotation crop rotations in the Southern Steppe of Ukraine [7].

In the stationary experiments of the Cherkasy State Agricultural Experimental Station (Ukraine) during 1975-2015, the highest grain yields were obtained with systematic ploughing - 6.45 and 8.19 t/ha in crop rotations with perennial grasses and peas, respectively; with no-till cultivation, the decrease in this indicator is insignificant, and with surface cultivation - significant. The highest yield of winter wheat (4.89-4.95 t/ha) was obtained in a crop rotation with perennial grasses under shallow tillage, and under moldboardless tillage it was lower than under ploughing [5].

In a typical five-field rotation (20% each of perennial and annual grasses and row crops, the remaining 40% of cereals), the highest efficiency indicators were achieved with differentiated tillage, with deep ploughing once per rotation and shallow (10-12 cm) chernozem tillage in the other years, using a typical stubble cultivator and disc harrow [12].

It is important to study the systems of basic cultivation and fertilisation, and their agrotechnical, economic and energy evaluation are priority areas in modern approaches to agricultural production.

The aim of the study was to determine the optimal combination of tillage and fertilization systems for typical chernozem, which would ensure the best indicators of its structural and phytosanitary condition, crop rotation productivity at the level of 10 t/ha of dry matter, 8 t/ha of fodder units and 5.5 t/ha of digestible protein of the marketable and non-marketable products of agrophytocenoses.

MATERIALS AND METHODS

The studies were performed on a typical deep low-humus medium loam black soil of experimental field of Bila Tserkva National Agrarian University during 2020-2022 in a stationary a five-field grain crop rotation, where four systems of basic tillage (Table 1).

Table 1. Systems of basic tillage in crop rotation

№ field	**Crop**	**Tillage***			
		mouldboard (control)	chisel disc	differentiated (mouldboard, chisel & mouldboardless)	disking (continuous shallow)
		Depth (cm) and cultivation			
1	Peas	18-20 (p.)	18-20 (*d.r.*)	18-20 (*d.r.*)	10-12 (d.h.)
2	Winter wheat	8-10 (d.h.)	8-10 (d.h.)	8-10 (d.h.)	8-10 (d.h.)
	White mustard on green manure	10-12 (d.h.)	10-12 (d.h.)	10-12 (d.h.)	10-12 (d.h.)
3	Corn	25-27 (p.)	25-27 (*d.r.*)	25-27 (p.)	10-12 (d.h.)
4	Buckwheat	10-12 (d.h.)	10-12 (*d.r.*)	10-12 (*d.r.*)	10-12 (d.h.)
5	Winter wheat	6-8(d.h.)	6-8 (d.h.)	6-8 (d.h.)	6-8 (d.h.)
	White mustard for green manure	10-12 (d.h.)	10-12 (d.h.)	10-12 (d.h.)	10-12 (d.h.)

**Note: p. – plowing, d.h. – disc harrow, d.r.* – deep ripper.
Source: Authors' own results.

Four fertilization systems were also studied : 0 – without fertilizers, 1 –6 t/ha of manure $+N_{64}P_{54}K_{58}$, 2 – 6 t/ha of manure + $N_{98}P_{66}K_{92}$, 3 – 6 t/ha of manure + $N_{126}P_{82}K_{116}$ (Table 2).

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 2. Fertilization systems for crop rotation

№ field	Crop	Fertilizer level	Manure, t/ha	Mineral fertilizer's, kg/ha (active ingredient)									
				Total			Basic fertilizer		For pre-sowing cultivation	Row fertilization			Fertilizing with nitrogen
				N	P	K	P	K	N	N	P	K	N
1	Peas	0											
		1		30					30				
		2		30	30	30	30	30	30				
		3		30	30	50	30	50	30				
2	Winter wheat	0											
		1		60	60	60	60	60					60
		2		90	60	90	60	90					90
		3		120	60	90	60	90					120
	White mustard on green manure	0											
		1		30	30	30	30	30	30				
		2		60	30	60	30	60	60				
		3		80	60	80	60	80	80				
3	Corn	0											
		1	30	60	60	60	50	50	50	10	10	10	
		2	30	90	90	90	75	75	75	15	15	15	
		3	30	110	110	110	90	90	90	20	20	20	
4	Buckwheat	0											
		1		30	30	30	30	30	30				
		2		50	30	50	30	50	50				
		3		70	30	70	30	70	70				
5	Winter wheat	0											
		1		80	60	80	60	80					80
		2		110	60	80	60	80					110
		3		140	60	100	60	100					140
	White mustard on green manure	0											
		1		30	30	30	30	30	30				
		2		60	30	60	30	60	60				
		3		80	60	80	60	80	80				

Source: Authors own results.

In the experiment, threefold repetition was placed completely on the area, plots of the first order (tillage system) – sequentially in one tier, the second (fertilizer rates) – sequentially in four tiers. The sown area is 684 (9×76) and 171 (9×19) m², respectively, and the recorded area is 448 (7×64) and 112 (7×16) m². The area of one field without protective strips is 7835.6 m² (76×103.1), and the total area under the experiment is 3.7 hectares. The number of elementary plots in the experiment was 240. As organic fertilizers, we used by-products of agrophytocenoses, green mass of post-harvest white mustard and semi-rotted cattle manure, and as mineral fertilizers– ammonium nitrate, simple granular superphosphate and potassium salt. The soil structure was determined by the method of Igor Baksheev [30], accounting for pests and diseases according to the methods [2], weediness of crops by the quantitative weight method [24], humus balance by the method proposed Igor Pokotylo et al [13].

RESULTS AND DISCUSSIONS

In general, in the crop rotation during the vegetation of agricultural plants, the content of agronomically valuable water-resistant aggregates in the soil layers 0-10, 10-20, 20-30 and 0-30 cm was for mouldboard 65.3; 65.8, 66.2 and 65.8%, for chisel disc tillage - 61.0, 66.9, 68.4 and 65.5, 65.4; differentiated tillage - 66.2, 67.1 and 66.2; disc tillage - 60.2, 66.5, 68.4 and 65.1%, respectively. Thus, under chisel-disc and disc tillage there is a slight deterioration in the structural state of the arable layer (0-30 cm) of typical chernozem. Under the second and fourth tillage options, the structure of the upper (0-10 cm) soil layer was significantly lower by 4.3 and 5.1%, the middle (10-20 cm) layer was lower by 1.1 and 0.7%, and the lower (20-30 cm) layer was lower by 2.2% than under the control. In the soil layers of 0-10, 10-20, 20-30 and 0-30 cm, this indicator is 0.1, 0.4, 0.9 and 0.4% higher, respectively, for differentiated than for mouldboard tillage (Table 3).

Table 3. Crop yields in five-field crop rotation, t/ha

Tillage	Fertilizer level	Crop					White mustard as a green fertilizer in a link with	
		peas	winter wheat	corn	buckwheat	winter wheat	peas	buckwheat
mouldboard (control)	0	2.16	2.66	3.18	1.23	2.24	10.45	9.78
	1	2.94	4.84	5.77	1.97	4.26	15.16	15.61
	2	3.41	6.25	7.64	2.45	5.66	17.78	18.36
	3	3.69	6.87	8.39	2.70	6.29	18.89	19.61
chisel disc	0	1.92	2.33	2.64	0.98	1.83	9.92	10.21
	1	2.66	4.45	5.09	1.69	3.76	14.55	16.18
	2	3.11	5.80	6.85	2.14	5.11	17.04	18.93
	3	3.36	6.37	7.54	2.35	5.71	18.07	20.36
differentiated (mouldboard, chisel & mouldboardless)	0	2.05	2.87	2.90	1.31	2.36	10.10	10.42
	1	2.81	5.01	5.55	2.09	4.41	14.72	16.49
	2	3.26	6.40	7.46	2.60	5.84	17.22	19.32
	3	3.53	6.98	8.23	2.87	6.49	18.30	20.72
disking (continuous shallow)	0	1.85	2.21	2.13	0.85	1.71	9.47	8.89
	1	2.59	4.36	4.89	1.62	3.65	14.07	14.57
	2	3.01	5.69	6.89	2.15	4.98	16.58	17.20
	3	3.26	6.24	7.74	2.42	5.54	17.62	18.38
SD_{05}		0,21	0.31	0.44	0.24	0.36	0.91	0.82

Source: Authors own results.

The level of greening of the agricultural sector is assessed by two indicators: the rate of organic fertilizer application and the greening index [29, 32]. The latter is calculated by dividing the total amount of active ingredient of fertilizer (kg NPK) by the mass of organic matter (t) entering the soil, which was 10, 22, 25 and 27 t under zero, first, second and third fertilization systems, respectively, and the index of greening of agriculture was 0, 8, 10 and 12. According to this indicator the zero fertilization system corresponds to biological fertilization and the first one to ecological farming, the second and third to its biologisation [28]. According to the ecological classification of cropping systems [8, 25, 6] the first and second fertilizer systems ensure an increasing and intensive level of greening in the industry.

In winter wheat, corn and buckwheat, the highest ratio of marketable to non-marketable products was observed in disking tillage, slightly lower in chisel-disc tillage, and the lowest in the control. In peas, this indicator is the lowest for ploughing and the highest for differentiated cultivation. For mouldboard, chisel-disc, differentiated and disking tillage, it was 1.296; 1.248 for winter wheat after peas; 1,311 and 1.288, peas – 1.240; 1.278; 1.255 and 1.290, corn – 1.465; 1.555; 1.492 and 1.583, buckwheat – 2.516; 2.661; 2.563 and 2.760, in winter wheat after buckwheat – 1.271; 1.292; 1.284 and 1.309.

With an increase in the fertilizer rate, the ratio of marketable to non-marketable products increases in all tillage options.

Thus, under the zero, first, second and third fertilization systems of differentiated cultivation plots, this indicator was 1.184, 1.288, 1.331 and 1.332 for peas; 1.331 and 1.442, winter wheat after peas – 1.222; 1.247; 1.267 and 1.285, corn – 1.409; 1.477; 1.501

and 1.580, buckwheat – 2.402; 2.498; 2.605 and 2.748 in winter wheat after buckwheat – 1.267; 1.278; 1.290 and 1.299. The yields of the main crops of the crop rotation are significantly reduced under moldboard and disc tillage. Under differentiated cultivation, this indicator is slightly reduced in peas, corn, white mustard and slightly increased in winter wheat and buckwheat (Table 3). The yields of peas were 3.05, 2.76, 2.91 and 2.68 t/ha under the mouldboard, chisel disc, differentiated and disking, 5.16, 4.74, 5.32 and 4.63 t/ha of winter wheat after peas, 6.25; 5.53, 6.04 and 5.41 t/ha, buckwheat – 2.09, 1.79, 2.22 and 1.76 t/ha, winter wheat after buckwheat – 4.61, 4.10, 4.78 and 3.97 t/ha, white mustard in a link with peas – 15.57, 14.90, 15.09 and 14.44 t/ha, white mustard in a link with buckwheat – 15.84, 16.42, 16.74 and 14.76 t/ha. Under moldboard tillage, the yield of green manure decreases in the link with peas and increases in the link with buckwheat, but these deviations from the control did not reach statistically significant values. The difference in yields between the control and the rest of the experimental treatments with increasing fertilizer rates increased in white mustard (in the link with peas), peas and winter wheat after buckwheat; in winter wheat after peas, this was observed only in the second and fourth treatments.

Under the zero, first, second and third fertilization systems, the decrease in maize grain yield was 0.54, 0.68, 0.79 and 0.85 t/ha under the chisel disc, 0.28, 0.22, 0.18 and 0.16 under the differentiated cultivation, 1.05, 0.88, 0.75 and 0.65 t/ha under the disking; legumes – 0.24; 0.28, 0.30 and 0.33 in the second variant of cultivation, 0.11, 0.13, 0.15 and 0.16 in the third, 0.31, 0.35, 0.40 and 0.43 in the fourth; mustard in the link with peas – 0.53, 0.61, 0.74 and 0.82 in the second variant, 0.35, 0.44, 0.56 and 0.59 in the third, 0.98, 1.09, 1.20 and 1.27 t/ha in the fourth variant of soil tillage. White mustard in the link with buckwheat under zero, first, second and third fertilization systems increased the yield by 0.43, 0.57, 0.68 and 0.75 t/ha under chisel disc, 0.64, 0.88, 0.96 and 1.10 under differentiated tillage and decreased it by 0.89, 1.04, 1.16 and 1.23 t/ha under disking tillage. The yield of buckwheat decreased by 0.25, 0.28, 0.31 and 0.35 t/ha under the second and by 0.38, 0.35, 0.30 and 0.28 t/ha under the fourth cultivation options, respectively, and increased by 0.08, 0.12, 0.15 and 0.17 t/ha under the third cultivation option.

Table 4. Non-marketable yield and crop rotation productivity under different tillage and fertilization systems, t/ha

Tillage	Fertilizer level	Crop					Crop rotation productivity, dry matter	
		peas	winter wheat	corn	buckwheat	winter wheat	marketable products	marketable and non-marketable products
mouldboard (control)	0	2.53	3.22	4.39	2.92	2.81	1.98	4.48
	1	3.74	5.93	8.35	4.82	5.39	3.42	7.84
	2	4.49	7.82	11.39	6.29	7.23	4.40	10.22
	3	5.25	8.74	12.90	7.21	8.10	4.83	11.43
chisel disc	0	2.17	2.91	3.93	2.43	2.34	1.68	3.84
	1	3.28	5.64	7.84	4.27	4.84	3.05	7.10
	2	3.95	7.47	10.81	5.88	6.64	3.98	9.41
	3	4.57	8.33	12.13	6.79	7.46	4.38	10.52
differentiated (mouldboard, chisel & mouldboardless)	0	2.43	3.51	4.09	3.15	2.99	1.98	4.54
	1	3.62	6.25	8.20	5.22	5.64	3.44	7.99
	2	4.34	8.11	11.20	6.77	7.53	4.42	10.37
	3	5.09	8.96	13.00	7.89	8.43	4.86	11.65
disking (continuous shallow)	0	2.16	2.79	3.23	2.18	2.21	1.51	3.50
	1	3.20	5.59	7.68	4.27	4.77	2.96	6.95
	2	3.96	7.37	11.03	6.14	6.53	3.93	9.39
	3	4.67	8.22	12.72	7.23	7.31	4.36	10.62
SD_{05}		0.25	0.29	0.40	0.35	0.36	0.27	0.44

Source: Authors own results.

Table 5. Efficiency of the studied systems of basic tillage and fertilization of typical chernozem

Tillage	Fertilizer level	Economic efficiency					Energy efficiency				
		Expenses, thousand UAH /ha	Cost of production, thousand UAH/ ha	Cost per ton of feed units, UAH thousand.	net profit, thousand UAH/ha	Profitability, %.	energy consumption, GJ/ha	Energy yield with harvest, GJ/ha		Energy efficiency ratio	
								marketable products	marketable and non-marketable products	marketable products	marketable and non-marketable products
mould board (control)	0	12.35	14.81	3.43	2.46	19.9	33.8	48.3	102.7	1.4	3.0
	1	20.32	29.19	3.23	8.87	43.6	44.8	88.3	202.2	2.0	4.5
	2	25.65	40.90	3.14	15.25	59.4	55.5	160.5	318.7	2.9	5.7
	3	29.32	44.34	3.24	15.02	51.2	69.5	166.9	353.8	2.4	5.1
chisel disc	0	11.86	13.70	3.85	1.84	15.5	31.8	40.0	89.0	1.3	2.8
	1	21.04	27.77	3.71	6.73	32.0	37.7	67.1	154.9	1.8	4.1
	2	25.32	38.13	3.39	12.81	50.6	41.1	108.5	217.9	2.6	5.3
	3	29.36	41.19	3.55	11.83	40.3	57.2	134.4	282.0	2.4	4.9
differentiated	0	11.81	15.14	3.28	3.33	28.2	32.1	49.4	105.8	1.5	3.3
	1	19.75	29.90	3.12	10.15	51.4	43.2	89.9	208.7	2.1	4.8
	2	25.24	42.48	3.07	17.14	67.9	54.2	161.6	317.7	3.0	5.9
	3	29.22	45.70	3.20	16.48	56.4	67.0	168.1	346.8	2.5	5.2
disking (continuous shallow)	0	9.86	11.50	3.64	1.64	16.6	30.1	36.8	80.7	1.2	2.7
	1	18.70	25.23	3.39	6.53	34.9	36.5	62.8	146.4	1.7	4.0
	2	23.71	36.41	3.20	12.70	53.6	40.9	106.4	215.6	2.6	5.3
	3	27.89	39.60	3.36	11.71	42.0	56.9	132.5	278.1	2.3	4.9

Source: Authors own results.

The yield of pea and winter wheat (after both predecessors) is significantly lower in chisel disc and disking tillage than in the control. Under differentiated tillage, there is a slight decrease in this indicator in legumes and an increase in winter wheat after buckwheat; in winter wheat after peas, this indicator increased slightly (by 0.22 t/ha) only in areas with the highest fertilizer rate (table 4).

The yield of non-marketable products of corn and buckwheat is significantly lower on the second than on the first variant of tillage.

The yield of buckwheat straw only on fertilized plots was significantly higher under differentiated than under chisel disc tillage and the growth was insignificant on unfertilized plots.

Under disc cultivation, at zero and first fertilization levels, this figure was 0.74 and 0.55 t/ha lower than in the control, while at the second and third fertilization levels this difference was insignificant.

The output of non- marketable products per hectare of arable land in crop rotation under mouldboard tillage was 2.50, 4.42, 5.82 and 6.60 t/ha, chisel disc tillage – 2.16, 4.05, 5.43 and 6.14 t/ha; differentiated tillage – 2.56, 4.55, 5.95 and 6.79 t/ha; disking tillage – 1.99, 3.99, 5.46 and 6.26 t/ha at zero, first, second and third fertilization levels, respectively.

Thus, both on unfertilized and fertilized plots of moldboard and disking tillage, this indicator is significantly reduced, while in differentiated tillage it increases slightly.

According to the yield of marketable and non-marketable products of agrophytocenoses, the mouldboard and differentiated tillage in crop rotation are equivalent and the chisel disc and disking tillage are significantly inferior to the control.

Under the zero, first, second and third fertilisation systems, grain yields were 2.29, 3.96, 5.08 and 5.59 t/ha in the first tillage variant, 1.92, 3.51, 4.62 and 5.05 in the second, 2.31, 3.96, 5.10 and 5.61 in the third, 1.73, 3.41, 4.51 and 5.03 t in the fourth, and feed units of marketable and non- marketable products were 3.60, 6.29, 8.17 and 9.05 t/ha; 3.08, 5.67, 7.47 and 8.27 t/ha; 3.60, 6.33, 8.22 and 9.13 t/ha and 2.71, 5.52, 7.41 and 8.30 t/ha respectively.

For all tillage options, the lowest cost per ton of feed units and the highest net profit and profitability were obtained by applying a crop rotation of 6 tons of manure + $N_{98}P_{66}K_{92}$per hectare of arable land.

For mouldboard, these indicators were 3.26 thousand UAH/t, 10.40 thousand UAH/ha and 43.6%, for chisel disc – 3.63; 8.30 and 34.6, for differentiated – 3.17; 11.78 and 51.0, for disking – 3.40 thousand UAH/t; 8.15 thousand UAH/ha and 36.8%, respectively (Table 5).

The energy yield and energy efficiency coefficients of marketable and non-marketable products were 116.0 and 244.4 GJ/ha; 2.2 and 4.6 in the first tillage variant, 87.5 and 186.0; 2.0 and 4.3 in the second, 117.2 and 244.8; 2.3 and 4.8 in the third, and 84.6 and 180.2 GJ/ha; 2.0 and 4.2 in the fourth, respectively.

The highest energy efficiency coefficients were recorded for the second fertilization system, which involves the application of 6 tons of manure + $N_{98}P_{66}K_{92}$ per hectare of crop rotation.

Further increase in fertilizer is inefficient, as it increases the energy yield with the crop, but reduces the level of profitability and energy efficiency.

CONCLUSIONS

According to the greening index, the zero level of fertilization in crop rotation corresponds to biological agriculture, the first level to ecological agriculture, and the second and third levels to its biologisation. According to the ecological classification, the third fertilisation system indicates an intensive level of greening of agricultural production, while the first and second systems indicate an increasing level.

The yield of the main crop in the rotation is significantly reduced under chisel disc and disking tillage. Under differentiated tillage, this indicator decreases slightly for peas, maize and white mustard in the link with peas, and increases slightly for winter wheat and buckwheat. The yield of white mustard in the link with buckwheat also increases under this tillage.

In terms of crop rotation productivity, the mouldboard and differentiated tillage are equivalent, while the chisel disc and disking tillage are significantly inferior to the control.

The highest indicators of economic and energy efficiency were obtained with differentiated tillage with the application of 6 tons of manure + $N_{98}P_{66}K_{92}$ per hectare of crop rotation.

It is recommended that in a five-field grain crop rotation, ploughing (mouldboard) should be carried out only for corn (to a depth of 25-27 cm), differentiated tillage for peas (to a depth of 18-20 cm), and disking tillage should be used for other crops (to a depth of 6-12 cm) with the application of 6 tons of manure + $N_{98}P_{66}K_{92}$per hectare of arable land and the use of non-marketable products as organic fertilizer.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

THE EVOLUTION ANALYSIS OF THE EXPENDITURES WITH THE AGRICULTURAL LAND FERTILIZATION, BY ECONOMIC SIZE CLASSES IN THE EU27 AND IN ROMANIA, DURING THE PERIOD 2007-2022

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Abstract

Agricultural land fertilization expenditure has evolved significantly in the European Union (EU27) and in Romania, reflecting economic, technological and regulatory changes in the agricultural sector. Differences in fertilization expenditures, depending on the economic size of farms, are particularly relevant in the analysis of expenditures and profitability in agriculture. The methods and indicators used allow a comprehensive assessment of the performance of agriculture in Romania in relation to the EU27 average. By using these methods, not only general trends can be identified, but also specific aspects that require improvement, such as economic efficiency, agricultural productivity and resource use. The indicators provided are relevant for both short-term and long-term analysis, thus facilitating better strategic planning for the development of the agricultural sector. The analysis of the evolution of expenditure on the fertilization of agricultural land by classes of economic size in the EU27 and in Romania highlights a trend of increasing expenditure, influenced by multiple variables, including the economic size of farms, access to technology, and agricultural policies. To ensure the sustainability and competitiveness of agriculture, it is essential to adopt measures to support small and medium-sized farms in accessing the resources and technologies needed to optimize fertilization expenditure.

Key words*: *EU27, Romania, evolution, fertilization, expenditures chain, vegetable

INTRODUCTION

The use of chemical fertilizers is a basic requirement of current agricultural technologies. When they are applied correctly, in relation to the characteristics of the soil, the requirements of the plants, correlated with the phase of vegetation and climatic conditions, they contribute to the continuous increase of productions until the genetic potential of the varieties and hybrids is reached. As natural resources are running out, it is up to a smart agriculture to ensure food security for all of humanity [5].

The economic dimension of fertilizers expenditures is an area that concern very much the farmers, the policymakers and the researchers, the expenditures are not just a matter of purchasing inputs, they are influenced by many factors such as raw material prices, government policies, market dynamics, environmental considerations. Understanding the economic implications of fertilizers expenditures are very important in developing strategies that contribute to agriculture profitability and sustainability [7].

Researchers have explored in various directions the evolution and the impact of the fertilizer’s expenditures.

While fertilizers are necessary for achieving high productions, their associated expenditures can impose economic burdens that can be significant over time, especially if are not managed sustainably [11].

In Africa, a study on smallholder farms highlighted the challenges posed by high prices and the importance of the subsidies in affording fertilizers, and also underscores the significant role that government intervention play in mitigating the economic burden of fertilizers on farmers [10].

A cost-benefit analysis of fertilizers' use across different agricultural systems made by Morris et al. [6] illustrate that regional variation in fertilizers expenditures lead to disparities in the agricultural productivity and economic outcome, their analysis being very important for farmers to understand the decision-making processes regarding the use of fertilizers and the economic implications.

Heffer and Prud'homme (2018) analyze the global fertilizers' market with focus on how the price volatility impacts the agricultural costs and economic stability, emphasizing the farmers vulnerability to market fluctuations and the necessity for policies that stabilize the fertilizers 'prices in order to maintain the economic viability in agriculture [4].

In the context of EU27, large farms benefited from economies of scale, which allowed them to purchase fertilizers at more competitive prices and to optimize their use through advanced farming techniques. These farms are often better equipped with precision technologies, which help to reduce expenditures in the long term, even if the initial investments are higher [4]. In contrast, small and medium-sized farms had to allocate a larger proportion of their budget to the purchase of fertilizers, with limited access to such technologies and little financial support [6].

In Romania, the situation is similar, but with specific peculiarities. Small farms predominate and their access to resources and modern technologies is often limited. As a result, fertilization expenditures are a major challenge for smallholder farmers, who often have limited financial resources and limited access to credit and subsidies. In addition, regional variations and traditional farming practices play an important role in determining fertilization expenditure, with significant differences between agricultural regions of the country.

The evolution of these expenditures is also influenced by the EU's common agricultural policies, which have promoted the sustainable use of fertilizers and the reduction of their impact on the environment. These policies have stimulated the transition to greener agricultural practices, but have also created new economic challenges for farmers, especially those on small farms [2].

In the mandatory rules of 2023 from our country regarding the fertilization of lands and subsidized crops from the Payments and Intervention Agency for Agriculture – APIA it is specified that farmers submitting the single application for area payments must comply with several mandatory conditions involving both the use of a fertilizer application calendar, with periods of prohibitions, and fertilization with a limited amount of nitrogen [1].

In a previous scientific paper, Rădoi et.al [8] analyzed the evolution of expenditure with agricultural land fertilization by economic size classes in Romania during the period 2007-2021 and the conclusion that emerged from the analysis was that there are many variation among the years analyzed, a more homogeneous period was 2014-2021 for the higher expenditures class, meanwhile the inferior economic classes have increased expenditures per ha.

MATERIALS AND METHODS

In order to analyze the performance and the evolution of the agricultural sector in Romania in comparison with the UE27 average, many methods and key indicators were used, each of them having a specific role in evaluating different aspects of agriculture.

The analysis begun with the agricultural surfaces and the value of agricultural production by economic dimension classes, offering an image of the structure of agricultural land and its efficiency.

The Output/Input ratio reflects the economic efficiency of agricultural holdings, being calculated as a ratio between the revenues obtained (outputs) and production costs (inputs). A higher ratio indicates better economic efficiency.

Other indicators used: the NPK chemical fertilizers kg of active substance; expenditures with fertilizers per hectare (Euro/ha); the chemical fertilizer expenditures share in the inputs' total of in the agricultural holding; chemical fertilizers 'expenditures for 100 Euro vegetable production.

To find out the indicators' degree of dispersion over the analyzed period, we used the coefficient of variation:

Cvar(%) =(Standard deviation/Average)*100 ....(1)

The annual growth rate was used to determine the trend of the analyzed indicators, and it was calculated using the formula:

Growth rate (%)= ((geomean(analyzed period)-1)*100...(2)

The significance of the difference between the calculated averages is given by the t-test which is used to determine whether the observed differences between Romania and the EU27 are large enough to be considered statistically significant, not just random. Its interpretation was for probabilities of 95%, 99% and 99.9% (t cal>t theoretical) [9].

By using these methods, not only general trends can be identified, but also specific aspects that require improvement, such as economic efficiency, agricultural productivity and resource use. The indicators provided are relevant for both short-term and long-term analysis, thus facilitating better strategic planning for the development of the agricultural sector.

All the indicators were calculated being structured on economic size classes, as follows:

First Class - (1) 2,000 - < 8,000 Euro
Second Class - (2) 8,000 - < 25,000 Euro
Third Class - (3) 25,000 - < 50,000 Euro
Fourth Class - (4) 50,000 - < 100,000 Euro
Fifth Class - (5) 100,000 - < 500,000 Euro
Sixth Class - (6) >= 500,000 Euro.

RESULTS AND DISCUSSIONS

1.Comparative analysis of the main technical-economic indicators of agricultural holdings, by economic size classes, at EU27 and Romania's level for the period 2007-2021

(a)*Comparative analysis of the physical size of agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021*

Table 1. The evolution of surfaces in agricultural holdings, in the EU27, by economic size classes for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	ha	ha	ha	ha	ha		ha	%	%
(1)	5.7	5.2	6.0	5.6	Mt	Mt	0.6	11.0	0.4
(2)	15.7	15.3	13.9	14.7	9.2	***	0.9	5.8	-0.9
(3)	35.8	29.4	27.2	30.2	15.4	***	3.3	10.8	-1.9
(4)	60.2	49.8	48.2	52.2	22.0	***	5.1	9.8	-1.6
(5)	105.3	97.6	98.0	99.6	47.4	***	3.8	3.9	-0.5
(6)	316.8	294.7	253.0	283.9	184.3	***	26.1	9.2	-1.6

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE025) Total Utilised Agricultural Area (ha) [3].

From Table 1, it is observed a slight increase in the agricultural areas related to small holdings (2,000 - <8,000 EURO), while the areas related to large holdings (>=500,000 EURO) decreased considerably. This suggests a trend towards land fragmentation or a decrease in land held by large holdings in the EU27.

Table 2. The evolution of agricultural areas in agricultural holdings, in Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	ha	ha	ha	ha	ha		ha	%	%
(1)	4.09	3.46	4.5	4.1	Mt	Mt	0.5	11.4	0.7
(2)	12.95	10.62	12.4	11.1	7.1	***	1.6	14.3	-0.3
(3)	48.2	39.89	33.8	39.6	35.5	***	8.2	20.8	-2.5
(4)	122.91	97.72	77.7	99.8	95.7	***	23.0	23.1	-3.2
(5)	444.64	328.06	285.3	350.5	346.4	***	70.8	20.2	-3.1
(6)	1,554.1	1241.1	1,139.5	1,302.8	1,298.7	***	147.2	11.3	-2.2

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE025) Total Utilised Agricultural Area (ha) [3].

These trends reflect internal restructuring, changes that occur in each country as an effect of the land governance and policies that favour or penalize different types of holdings.

The situation in Romania (Table 2) shows a significant reduction of agricultural areas in the large categories (>=100,000 Euro), indicating a possible restructuring of the agricultural sector, with a greater concentration of land in smaller holdings. This could reflect a deconcentrating in ownership of agricultural land and a loss of competitiveness of large holdings.

Table 3. The significance of the deviations of agricultural holdings areas, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	ha/expl	ha/expl	(+/-)ha/expl	%	
(1)	6	4	2	137.3	***
(2)	15	11	4	132.4	***
(3)	30	40	-9	76.2	***
(4)	52	100	-48	52.3	***
(5)	100	350	-251	28.4	***
(6)	284	1,303	-1,019	21.8	***

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE025) Total Utilised Agricultural Area (ha) [3].

In Table 3, the differences are analysed statistically, highlighting significant differences between the agricultural areas in the EU27 and Romania, especially in the categories of large holdings (>=100,000 Euro), in the EU-27 in class (5) is registered an average of 100 ha/ holding, meanwhile in Romania is an average of 350 ha/holding. For the class (6) the difference is even bigger, 284 ha/holding in the EU-27 compared to 1,303 ha/holding in Romania. These deviations indicate major structural differences between agriculture in Romania and that of the rest of the EU27, where Romania has larger areas in these classes, suggesting a deficit in the economic efficiency. This structure may be the result of different agronomic and economic histories as well as national policies.

(b)*Comparative analysis of vegetable agricultural productions in agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021*

Table 4. The evolution of plant agricultural productions value, in the EU27, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/ha	€/ha	€/ha	O/I	O/I		O/I	%	%
(1)	1,056	846	1,095	875	Mt	Mt	97.7	11.2	0.3
(2)	1,046	948.8	1,225	979	104	N	86.9	8.9	1.1
(3)	858	876.8	1,134	902	-77	N	98.3	10.9	2.0
(4)	830	913.11	1,192	924	21	N	115.4	12.5	2.6
(5)	1,117	1,193.55	1,408	1175	251	*	98.3	8.4	1.7
(6)	1,588	1,738.98	2,331	1795	620	**	214.6	12.0	2.8

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE136) Total crops output (€/ha) [3].

A constant increase in value of plant agricultural productions is observed (Table 4), after year 2014, especially in the high economic size classes (>=500,000 Euro), at the end of year 2021 the value for this class was 2,331 euro/ha. This indicates high efficiency and continuous optimization of agricultural production in large farms, thanks to advanced technologies and effective support policies. In contrast, Romania presents a much lower average for all classes and a more volatile agricultural vegetable production’s value, even if the year 2021 presents a higher amount for all classes (Table 5). For example, the highest value is for class (1) with 1,134 euro/ha indicating lower efficiency and greater sensitivity to external factors (such as weather conditions or international markets). Volatility also indicates possible deficiencies in agricultural risk management.

Table 5. Evolution of value of plant agricultural productions, in Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/ha	€/ha	€/ha	€/ha	€/ha		€/ha	%	%
(1)	717	778	1,134	813	Mt		119.6	14.7	3.3
(2)	768	746	862	793	-20.3	***	68.0	8.6	0.8
(3)	566	651	868	679	-134.1	***	81.7	12.0	3.1
(4)	438	632	902	642	-171.0	***	112.3	17.5	5.3
(5)	467	692	1,025	688	-124.8	***	146.0	21.2	5.8
(6)	409	798	1,083	758	-55.2	***	159.9	21.1	7.2

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE136) Total crops output (€/ha) [3].

Table 6. The significance of the deviations of the value of agricultural production per hectare, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	€/ha	€/ha	€/ha	%	
(1)	875	813	62	107.6	N
(2)	979	793	187	123.5	***
(3)	902	679	223	132.9	***
(4)	924	642	281	143.8	***
(5)	1,175	688	486	170.7	***
(6)	1,795	758	1037	236.8	***

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE136) Total crops output (€/ha) [3].

Table 6 highlights the significant differences in productivity between the EU-27 and Romania, with the EU-27 having a clear advantage in all economic size classes. These deviations reflect a more efficient use of resources and a greater capacity to generate value per hectare in the EU-27. The differences could be explained by different access to technology, agricultural knowledge, soil quality and agricultural infrastructure.

(c)*The comparative analysis of the Outputs/Inputs (O/I) ratio, in agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021*

Table 7. Evolution of the Outputs/Inputs (O/I) ratio in agricultural holdings, in the EU27, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	O/I	O/I	O/I	O/I	O/I		O/I	%	%
(1)	1.45	1.27	1.17	1.221	Mt	Mt	0.105	8.561	-1.521
(2)	1.35	1.22	1.35	1.257	0.036	N	0.047	3.716	0.000
(3)	1.24	1.13	1.25	1.165	-0.091	N	0.042	3.610	0.057
(4)	1.19	1.14	1.26	1.157	-0.009	N	0.046	4.011	0.409
(5)	1.16	1.11	1.2	1.129	-0.028	*	0.036	3.157	0.242
(6)	1.07	1.05	1.12	1.076	-0.053	**	0.038	3.492	0.327

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE132) Total output / Total input (ratio)[3].

At the level of the EU-27, the O/I ratio is relatively stable in the years' evolution and for classes with low variations (c%< 10%), indicating a consistent profitability and efficiency of agricultural holdings, especially in large holdings. The stability of this ratio suggests that EU27 farms are able to maintain a healthy balance between investments (Table 8). In Romania, the O/I ratio shows higher fluctuations (c% > 10%) and lower values, indicating reduced efficiency and variable profitability. However, there is an increase in this ratio in the medium and large categories, which could signal recent improvements in resource management and adaptation to agricultural markets. Table 8 shows significant differences between the economic efficiency of agricultural holdings in the EU27 and Romania, with Romania lagging behind the EU27. This gap is for sure an indicator of the need for investments in technology, agricultural management and other resources to increase the economic efficiency of farms in Romania.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 8. Evolution of the Outputs/Inputs (O/I) ratio in agricultural holdings, in Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	O/I	O/I	O/I	O/I	O/I		O/I	%	%
(1)	1.32	1.52	1.16	1.35	Mt	Mt	0.12	8.80	-0.92
(2)	0.97	1.72	1.31	1.478	0.128	N	0.21	13.94	2.17
(3)	1.02	1.6	1.37	1.430667	-0.04733	N	0.16	11.03	2.13
(4)	0.9	1.49	1.45	1.328	-0.10267	N	0.17	12.61	3.47
(5)	0.93	1.31	1.59	1.245333	-0.08267	N	0.17	13.81	3.91
(6)	0.89	1.28	1.52	1.306667	0.061333	N	0.31	23.80	3.90

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE132) Total output / Total input (ratio) [3].

Table 9. The significance of deviations in the Outputs/Inputs (O/I) ratio, by economic size class, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	O/I	O/I	O/I	%	
(1)	1.350	1.221	0.13	110.6	**
(2)	1.478	1.257	0.22	117.6	***
(3)	1.431	1.165	0.27	122.8	***
(4)	1.328	1.157	0.17	114.8	***
(5)	1.245	1.129	0.12	110.3	*
(6)	1.307	1.076	0.23	121.4	**

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu); (SE132) Total output / Total input (ratio) [3].

2.The comparative analysis of the main technical-economic indicators of the use of chemical fertilizers in agricultural farming, by economic size classes, at EU-27 and Romania's level for the period 2007-2021

(a)The comparative analysis of the quantities of chemical fertilizers used per hectare of agricultural land at the level of the EU27 and Romania for the period 2007-2021

In Romania, the doses of chemical fertilizers per hectare increased significantly between 2007 and 2021, from 42.4 kg s.a./ha in 2007 to 120.4 kg s.a./ha in 2021, with an average of years of 60.5 kg s.a./ha being much below the EU27 average of 118.6 kg s.a./ha (Table 10).

Table 10. Quantitative evolution of chemical fertilizer doses in the EU27 and Romania for the period 2007-2021

Area/MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	Kg sa/ha	Kg sa/ha	Kg sa/ha	Kg sa/ha	Kg sa/ha		Kg sa/ha	%	%
UE27	134.1	120.5	120.4	118.6	Mt	Mt	9.5	8.0	-0.8
Romania	42.4	49.1	102.6	60.5	-58.1	θθθ	17.8	29.3	6.5

Source: Own calculation based on data from FAOSTAT, 2023 [4].

It reflects an intensification of agriculture in Romania, although the use of fertilizers is still at a lower level, which is a result of financial accessibility or more traditional agricultural practices.

(b)The comparative analysis of expenditures per hectare of agricultural land with chemical fertilizers in agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021

The analysis continues with tables regarding the chemical fertilizers expenditures evolution in agriculture, both at the level of the European Union (EU27) and in Romania, over a period of 14 years (2007-2021).

Table 11 shows that at the level of EU27 an overall increase in expenditure per hectare is observed from 2007 to 2021, with annual growth rates varying by economic size classes. Larger farms (>500,000 Euro) have significantly higher expenses in 2021 compared to small farms (2,000-8,000 euro).

Table 11. Evolution of expenditures per hectare of agricultural land with chemical fertilizers, at EU27 level, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Abat	Signf.	StDev.	C%	Rhythm
	€/ha	€/ha	€/ha	€/ha	€/ha		€/ha	%	%
(1)	64.7	78.2	99.3	77.5	Mt	Mt	8.5	10.9	3.1
(2)	72.3	91.8	98.3	86.3	8.8	*	7.2	8.4	2.2
(3)	75.6	101.9	111.9	95.5	18.0	**	9.8	10.3	2.8
(4)	84.6	111.7	116.6	103.3	25.7	***	9.3	9.0	2.3
(5)	102.6	145.5	141.8	132.4	54.8	***	13.2	10.0	2.3
(6)	111.9	162.3	172.4	151.4	73.9	***	16.8	11.1	3.1

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

For example, from 2007 when the expenditures/ha were 64.7 euro/ha increased until 2021 at 99.3 euro/ha for class 1, ad for higher classes sums 141.8 euro/ha (class 5) and 172.4 euro/ha (class 6).

Expenditures per hectare have increased in Romania in all categories, but the values are lower than the EU27 average (Table 12).

Table 12. Evolution of expenditures per hectare of agricultural land with chemical fertilizers, at the level of Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/ha	€/ha	€/ha	€/ha	€/ha		€/ha	%	%
(1)	43.52	64.74	98.90	67.2	Mt	Mt	15.1	22.5	6.03
(2)	42.63	64.88	90.53	66.1	-1.2	N	12.9	19.6	5.52
(3)	41.08	63.60	82.30	62.6	-4.6	N	11.2	18.0	5.08
(4)	64.53	70.61	84.36	69.0	1.7	N	10.6	15.4	1.93
(5)	50.57	83.62	103.41	81.2	13.9	N	15.0	18.5	5.24
(6)	49.89	100.43	108.01	90.6	23.4	*	16.1	17.7	5.67

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

For example, farms with small economic sizes in Romania had expenses of €90.5/ha in 2021, compared to €98.3/ha at the EU level, but the real difference is observed at higher economic classes, for class 5 in Romania the expenditures were 103,4 euro/ha, in EU27, 141.8 euro/ha, at class 6 108 euro/ha for Romania and 172.4 euro/ha for EU27.

Table 13. The significance of the deviations of chemical fertilizer expenditures per hectare of agricultural land, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	€/ha	€/ha	€/ha	%	
(1)	77.5	67.2	10.3	115.3	*
(2)	86.3	66.1	20.2	130.6	***
(3)	95.5	62.6	32.9	152.5	***
(4)	103.3	69.0	34.3	149.7	***
(5)	132.4	81.2	51.2	163.0	***
(6)	151.4	90.6	60.8	167.1	***

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

For small and medium farms (2,000 - 50,000 euro) the deviations are relatively small, which suggests that small farms in Romania have relatively similar costs to those in the EU27, probably due to a more homogeneous level of available resources and technologies.

For the higher economic dimension classes , the biggest deviations are observed here, indicating that large farms in Romania invest significantly less in fertilizers per hectare compared to those in the EU27, with a difference of up to 167.1% for class 6(>€500,000). This can be explained by differences in technology, access to financial resources, the excellent soil conditions, and perhaps a more efficient use of limited resources.

(c)Comparative analysis of the costs of chemical fertilization to obtain 100 Euro of plant production in agricultural holdings by classes of economic size at the level of the EU27 and Romania for the period 2007-2021

In EU27, expenditures ranged from an average of 8.93 euro /100 euro for small farms to 8.49 euro/100 euro for very large farms, with some significant variation over time (Table 14).

Table 14. Evolution of expenses with chemical fertilizers to obtain 100 Euro of plant production, at EU27 level, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/100€	€/100€	€/100€	€/100€	€/100€		€/100€	%	%
(1)	6.10	9.24	9.07	8.93	Mt	Mt	1.15	12.92	2.88
(2)	6.93	9.68	8.02	8.85	-0.08	N	0.80	9.08	1.05
(3)	8.82	11.62	9.86	10.62	1.69	**	0.85	8.00	0.80
(4)	10.18	12.23	9.79	11.27	2.33	**	1.11	9.82	-0.28
(5)	9.19	12.19	10.07	11.31	2.38	**	1.22	10.83	0.66
(6)	7.04	9.33	7.40	8.49	-0.45	N	0.92	10.85	0.35

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

It is interesting to see that the classes that range between 25,000 euro and 500,000 euro have an average between 10.62 euro/100 euro and 11.31 euro/100 euro production, so the smallest farms and the biggest one have the less investments/ more efficiency to produce the plant productions.

Table 15. Evolution of expenses with chemical fertilizers to obtain 100 Euro of plant production, in Romania, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	€/100€	€/100€	€/100€	€/100€	€/100€		€/100€	%	%
(1)	6.04	8.31	8.72	8.3	Mt	Mt	1.2	15.0	2.66
(2)	5.60	8.66	8.98	8.2	0.0	N	1.4	16.6	3.43
(3)	7.25	9.76	9.48	9.2	1.0	N	1.3	14.3	1.93
(4)	14.74	11.18	9.35	10.8	2.6	**	1.5	13.8	-3.19
(5)	11.07	12.07	10.09	11.9	3.7	***	1.2	9.9	-0.66
(6)	12.52	12.58	9.98	12.2	3.9	***	1.6	12.8	-1.61

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

From Table 15, it can be seen that expenditures were generally lower than in the EU27 but with a similar upward trend.
So, the smallest amount can be observed at the classes 1 and 2, the highest at the larger farms, economic classes 5 and 6.
Averages range between 8.2 euro/100 euro plant production to 12.2 euro/100 euro plant production.
The year 2021 for classes 3 to 6 show a decrease in the expenditures compared to previous years.

Table 16. The significance of the deviations of the expenses with chemical fertilizers to obtain 100 Euro of vegetable production, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	€/100€	€/100€	€/ha	%	
(1)	8.9	8.3	0.7	108.2	N
(2)	8.9	8.2	0.6	107.6	N
(3)	10.6	9.2	1.4	115.2	**
(4)	11.3	10.8	0.4	104.2	N
(5)	11.3	11.9	-0.6	94.7	N
(6)	8.5	12.2	-3.7	69.7	ѲѲѲ

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

Comparing the expenditures/ 100 euro plant production, the deviations are moderate for small farms, but increase significantly for large farms, indicating a more efficient cost in Romania at this level (Table 16).
Small farms: Moderate deviations indicate slightly higher efficiency in Romania in achieving plant production with the same fertilizer expenditures, suggesting that these farms manage to maximize production even with more limited resources.
Large farms: The deviations increase significantly for large farms, which shows that Romania has a higher efficiency in using fertilizers to generate production. This may indicate better management of resources and adaptation to specific conditions that allow comparable or superior returns to be obtained with lower investment.
(d)Comparative analysis of the share of expenditures with chemical fertilization in the total inputs in agricultural holdings by classes

of economic size in the EU27 and Romania for the period 2007-2021

The share of expenditure at the level of EU27 increased slightly across all categories, with larger variations in small and medium-sized farms (Table 17).

Table 17. The evolution of the share of chemical fertilizer expenditures in the total inputs at the farm level, in the EU27, by classes of economic size, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	%	%	%	%	%		%	%	%
(1)	5.94	7.54	8.22	7.32	Mt	Mt	0.63	8.67	2.35
(2)	6.63	8.69	8.80	8.31	1.00	**	0.64	7.75	2.05
(3)	6.63	8.69	8.80	8.31	1.00	**	0.64	7.75	2.05
(4)	6.78	7.87	8.30	7.77	0.45	N	0.43	5.56	1.46
(5)	5.40	6.81	6.62	6.58	-0.73	*	0.51	7.76	1.46
(6)	3.70	4.58	3.87	4.22	-3.09	**	0.41	9.65	0.32

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

At first economic class the share increased from 5.94% in 2007 to 8.22% in 2021, the next 2 classes have a share of 8.8% in the same year and the smallest share has the upper economic dimension class, 3.87% in year 2021.

Table 18. Evolution of the share of chemical fertilizer expenditures in the total inputs at the farm level, in Romania, by economic size classes, for the period 2007-2021

Classes/ MU	2007	2014	2021	Average	Deviation	Signf.	StDev.	C%	Rhythm
	%	%	%	%	%		%	%	%
(1)	3.65	5.98	6.36	5.7	Mt	Mt	0.9	16.2	4.06
(2)	1.82	7.15	7.34	6.3	0.6	N	1.3	20.7	10.47
(3)	1.55	9.26	7.52	7.4	1.7	*	1.9	25.5	11.97
(4)	5.02	11.95	9.44	10.0	4.3	***	2.0	19.7	4.62
(5)	5.83	14.21	14.35	12.8	7.0	***	2.5	19.3	6.64
(6)	4.57	12.59	12.48	9.8	4.0	**	2.9	29.8	7.45

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

In Romania significant increases in the share of chemical fertilizer expenditure are observed, especially on medium and large farms (Table 18).

If for the lower economic classes, the shares in year 2021 are between 6.36% and 7.52%, for the medium size classes are at 9.44%, increases for class 5 at 14.35% and 12.48% for class 6.

The deviations are high for small and medium farms, indicating a difference in cost structure and fertilizer use between the EU27 and Romania (Table 19).

Small farms: The large deviations for small and medium farms suggest that, in Romania, fertilizers have a lower share of total inputs compared to the EU27.

This could reflect a lower reliance on or access to fertilizers compared to other inputs (eg manual labor or other technologies).

Large farms: For large farms, deviations indicate a significantly lower share of fertilizer expenditure in Romania compared to the EU27.

Table 19. The significance of the deviations of the chemical fertilizer expenditures shares in the total farm inputs, by classes of economic size, between the EU27 and Romania, for the period 2007-2021

Classes/ MU	UE27	Ro	Deviation (UE vs R0)		Signf.
	%	%	%	%	
(1)	7.32	5.73	1.58	127.58	***
(2)	8.31	6.30	2.01	131.91	***
(3)	8.31	7.39	0.92	112.48	N
(4)	7.77	9.99	-2.22	77.80	ӨӨӨ
(5)	6.58	12.75	-6.17	51.62	ӨӨӨ
(6)	4.22	9.77	-5.55	43.21	ӨӨӨ

Source: Own calculation based on data from FADN PUBLIC DATABASE SO (Europa.eu) [3].

This may suggest that large farms in Romania are able to use other inputs or technologies that offset the need for intensive fertilizer use, or that access to fertilizers is more limited and therefore resort to alternative strategies.

CONCLUSIONS

Agriculture in Romania and the EU27 experienced an increase in costs related to chemical fertilizers, reflecting changes in the agricultural sector and the impact of market factors. However, the relatively higher efficiency of Romanian farms in the use of these inputs suggests a capacity to adapt and optimize resources, even in the context of lower costs per hectare. The structural differences between Romania and the EU27 indicate opportunities to improve the economic performance of Romanian farms, especially regarding the adoption of technologies and practices that allow a more efficient use of fertilizers.

(1) Regarding the evolution of agricultural areas it is found that during the period 2007-2021, in the EU27 and Romania are different trends. In the EU27, small holdings have seen a slight increase, while large ones have decreased, suggesting a potential fragmentation of farmland. In Romania, this decrease is more pronounced for large holdings, indicating either a redistribution of land to smaller holdings, or a loss of competitiveness of the large ones. The agricultural structure in Romania is different, with a greater concentration of land in larger holdings. This may be the result of a tradition of extensive agriculture and national policies that favoured the formation of large holdings.

(2) Analysing the agricultural productivity showed that the value of agricultural crop production in Romania is significantly lower than in the EU27, with large deviations against Romania. This suggests that Romanian agriculture does not exploit the available resources as efficiently and produces a lower economic value per hectare. The differences can be attributed to limited access to modern technology, inefficient resource management and lack of investment in agricultural infrastructure.

Also, in Romania, agricultural production is more volatile, which indicates an increased sensitivity to external factors, such as climatic conditions and international markets. Volatility can also be a sign of less sophisticated farming practices and insufficient risk management.

(3) In terms of economic efficiency the Output/Input ratio (O/I) in Romania is lower and more fluctuating compared to the EU27, indicating a reduced economic efficiency of Romanian agricultural holdings. This suggests that Romanian farmers obtain less profit for each unit of resource invested, which is the result of inefficient practices, insufficient use of technology and high input costs.

Although the O/I ratio remains below the EU27 average, there is an upward trend in the medium and large economic size categories in Romania, which indicates possible improvements in resource management and adaptation to market conditions. This positive trend could be a signal of a gradual maturation of the Romanian agricultural sector.

(4) In the use of chemical fertilizers, Romania recorded a significant increase per hectare between 2007 and 2021, which suggests an intensification of agricultural practices. However, utilization remains below the EU27 average, which may indicate a historical underutilization of these resources or financial constraints preventing Romanian farmers from widely adopting modern agricultural technologies.

Although the expenditures on chemical fertilizers are lower in Romania than in the EU27, they have increased significantly, suggesting a gradual convergence towards European standards. This may reflect a gradual adaptation of Romanian farmers to the demands of the European market, but may also indicate additional financial pressures on them.

(5) The idea of convergence with the EU27 finds persistent differences. The significant differences between Romania and the EU27 in terms of agricultural areas, productivity, economic efficiency and resource use indicate that Romania is still in the process of aligning itself with European standards. These persistent differences underline the need for national policies to support the modernization of agriculture, increase competitiveness and improve rural infrastructure.

In order to reduce the gaps with the EU27 average, Romania must continue to invest in agricultural technology, professional training for farmers and rural infrastructure. Investments should also focus on developing sustainable agricultural practices that maximize productivity without compromising natural resources in the long term.

(6) In the period 2007-2021, the expenditures per hectare with chemical fertilizers increased both at the EU27 level and in Romania. This trend reflects rising prices of agricultural inputs, as well as possible increased use of fertilizers to achieve higher yields. Expenditures per hectare in Romania are generally lower than the EU27 average. However, the percentage deviations show that the larger farms in Romania have a different cost structure compared to those in the EU27, with significantly lower expenditures per hectare.

(8) Expenditures for obtaining 100 Euro of crop production are lower in Romania than in the EU27, suggesting that, despite lower expenditure per hectare, Romanian farms may be more efficient in using fertilizers to achieve agricultural production.

(9) The share of expenditure on chemical fertilizers in total agricultural inputs has increased both in the EU27 and in Romania, indicating a growing dependence on these inputs for agricultural production. This may reflect both an intensification of agriculture and an adaptation to market conditions.

(10) The deviations between the EU27 and Romania in terms of the share of expenditure and costs per hectare suggest that there are structural differences in agriculture between the two regions. These are influenced by factors such as access to technologies, average farm size, and agricultural policies.

(11) The evolution of expenditures and their efficiency varies significantly depending on the economic size of the farms. Large farms, both in the EU27 and in Romania, generally have higher costs per hectare, but manage to maintain a relatively high level of efficiency in relation to the production obtained.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

COMMON AGRICULTURAL POLICY TOOLS FOR RISK MANAGEMENT IN AGRICULTURE: A CASE STUDY ON 24 UNITS EXPLOITING TOGETHER OVER 12,000 HA IN THE NORTH EAST OF ROMANIA

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Abstract

The paper emphasizes the influence that the Common Agricultural Policy programmes and subsidies on the agricultural production in Romania from the risk management point of view. Agricultural production is deeply dependent on climatic factors. In the perspective of climate changes with increasingly pronounced effects, the European Union, through specific institutions and mechanisms, has introduced financial facilities for agricultural units that apply for insurance premiums for agricultural crops or animals. This approach is likely to increase the share of cultivated areas that are insured, following the model of the west states in the European Union. The present paper centralizes the technical-economic details of some studied agricultural units benefiting from non-refundable financing as a result of applying some insurance policies. Extensive research was made for this article in the North-East Region of Romania, managing to obtain primary sources data from 24 agricultural units and 53 insurance policies applied by these units. The units studied range in size from 148 ha to 1,910 ha. However, most of the units are of the medium-large category, their average exploited area being 521 ha. Moreover, the cumulative area of the studied units is 12,503 ha. It was found that for the 24 agricultural units studied, 80.75% of their cumulative area benefits from insurance against natural disasters. The total amount for the policies paid by the 24 farmers was over 400,000 Euro, while the total value of the settlements by AFIR was 230,141 Euro. The results of the empirical study indicate the increasing interest of large agricultural units in accessing non-reimbursable grants intended for agricultural insurance for cereal crops. The authors have identified the efforts that responsible entities support to maintain this interest, even if the way of organizing reporting and ensuring visibility needs improvement.

Key words**:** *crops risk management, crop insurance, insurance grants*

INTRODUCTION

Agricultural production has always been determined by climatic factors. This imposed the need to regulate and develop some financial compensation or compensation schemes for farmers, given the strategic nature of the products obtained. These schemes have always aimed at compensating at least partially the losses resulting from climatic phenomena to allow farmers to resume production activity [12]. The literature introduced relatively recently the concept of "critical moments" with reference to the risks to which agriculture is exposed in certain periods, as a result of climate change and considering the very high vulnerability of the sector to environmental conditions, along with the almost total dependence of agriculture on climate and natural factors. CM (critical moments) is defined as periods of risk during the year when livelihoods are vulnerable to specific climate hazards. The World Bank (2015) reports raise the same risks issue of which agriculture is subjected. "Agriculture and associated land use change account for up to one quarter of greenhouse gas (GHG) emissions globally and at the same time, agriculture has the potential to become part of the solution." [11]

The Common Agricultural Policy represents the main instrument for regulating markets in the production, processing and distribution of agri-food products at the European level [2]. For Romania, an important challenge is to obtain an equivalent on technical and economic terms with the rest of Europe. This

can become possible through numerous approaches of varying complexity. Since joining the European Union, Romania has gone through two complete multi-annual financial exercises and is currently in the third. The first such financial exercise took place between 2007 - 2013, in continuation of the pre-accession exercise, which took place between 2000 and 2006. The period 2007 - 2013 represented an important improvement in those sectors of agriculture that had the greatest deficiencies [15]. Later, in 2014 - 2020, the PAC levers contributed to the further improvement of an already stable and relatively resilient Romanian agricultural framework [16]. The financial incentives were directed where, from a statistical point of view, there were still gaps compared to the averages of the European Union countries. Such a deficiency was identified as the low incidence of cultivated and insured areas against various climatic risks [4]. From this point of view, the western states of the E.U. had, since 2014, a much larger share of insured arable areas. In the absence of optional insurance policies applied by farmers with private insurance companies, the Romanian government had to compensate them from the state budget, with substantial amounts, as a result of calamities recorded almost annually [14]. As a result, in the period 2002 - 2014, compensation or compensation systems for farmers were developed that contributed to the partial reduction of production losses suffered by [7].
Hail, storms and torrential rains are the meteorological phenomena that generated the most compensations paid for agricultural crops in 2019 and 2018 (96.3%)", according to the data provided by UNIRC, the National Union of Insurance and Reinsurance Companies in Romania, by member companies [13].
In the European Union, the grants for encouraging the insurance appliance emerged in 2007 by the Common Agricultural Policy developed by European Union [3]. At first, the harvest compensation was made available just for the fruits and vegetables sectors and the wine producers. Later, Article 68 of 73/2009/EC has extended the way of compensation to all agricultural sectors from 2008, but it has been launched only in specific Member States like Italy France, Netherlands and Hungary [9]. Crop insurance premium have an influence on crops in two ways. The first is by rising the expected income to the insured crop areas, keeping the share amount of insured crop revenue (the effect of direct profit). The second is by encouraging agricultural units to apply for insurances for more of their crop revenue, thus increasing the amount received and reducing the risk degree of the crop to which an insurance premium has been submitted, which in turn stimulates more areas dedicated of those crops (the effect of indirect coverage) [17]. In Romania, the first specific mechanism for financial stimulation for applying insurance policies appeared in 2020. This was implemented through SM 17.1 of AFRI – Agency for Financing Rural Investments [6]. In August 2020, the first call of insurance policies files for vegetable crops and livestock was established. From that moment, every year, the financing institution AFRI launches one such call during which farmers can submit files by which they are granted 70% of the eligible amount of the policies actually paid to the insurance company [1].
The purpose of the article is to highlight, on the one hand, to what extent the farmers who choose to apply for insurance premiums on their agricultural crops, consider certain crops more efficient in insuring and which are these. On the other hand, it was determined what are the actual costs of securing the surfaces and what is the support from European funding in this regard.
The theoretical framework is developed in two directions: European grants and risk management. If for the second topic, the literature, as a theoretical framework, is very well developed, regarding the effects of European grants, the literature is rather of the type of reports of specialized institutes, such as the Ministry of Agriculture, the Ministry of European Funds, NSI (National Statistics Institute), the Agricultural Directorates, PIAA (Payments and Intervention Agency for Agriculture) or Eurostat.
In the Romanian agricultural sector, a practice of agricultural and livestock insurance has not yet been formed, the main reason being

associated with the economy from the communist period, the mentality being difficult to change. Thus, the idea of association in agricultural cooperatives, as well as the idea of insurance against imminent risks of crops and animals, hardly makes their way. Through the Common Agricultural Policy, major efforts are being made to change the mentality in this regard, which is why this special grant branch was allocated to finance insurance against natural risks in agriculture (17.1). In addition, given that specific grant funds for risk management in agriculture are an absolute novelty for national agricultural practice, the authors believe that the specialized literature, in a pragmatic approach, can be improved by bringing such topics to the fore. In this way, transparency of information can be ensured and the idea that supports the relevance and importance of agricultural risk management can be conveyed through the use of insurance grants. In fact, the idea of non-refundable insurance financing as a component of agricultural risk management is new to practice and specialized literature. We believe that the specific literature reporting on the progress of Romanian agriculture, achieved as a result of accessing non-reimbursable funds since 2000, starting with the Special Accession Program for Agriculture and Rural Development (SAPARD) grants, can be completed with this new idea [7]. For international approaches regarding the functionality of agricultural systems in developed countries, this topic may seem exhausted or a normality, but for the specifics of national agriculture, the idea practically promoted by the EU and supported by the present empirical research, may prove useful and important, as well as with high degree of novelty. Basically, a main reason why we support this approach is to ensure the transparency of information, to increase the visibility of the favorable results obtained as a result of the change in mentality regarding insurance in agriculture and in this way to make a minimal contribution to highlight the Romanian agricultural potential. A direct consequence of this approach, thought of as an assumption in the way of approaching the work, from the perspective of the theme novelty degree, is that the way of using the non-reimbursable funds intended exclusively for agricultural insurance is a support for attracting other grants and, especially, to improve losses in the Romanian agricultural sector. When constructing this assumption, we took into account the degree of absorption of grants and the efficiency of their use. Thus, we noticed from the analysis of the progress reports regarding the access to the grants intended for Romanian agriculture that, although the first SAPARD funds had a very low degree of absorption (a little over 50%), the following multi-annual financial exercises were accessed and used much more efficiently, currently reaching a high level of competition. Therefore, applying to the funds for insurance policies, especially non-refundable, in the context of considering risk management, is not a habit or a generality for the Romanian agricultural sector, especially among small and medium-sized farms. Moreover, there was and still is some aversion to this farm insurance expense. In this way, the authors have the opinion that the results of the work could indicate the importance and relevance of these expenses for financial protection against imminent risks and, gradually, the change in the attitude of farmers towards the way of managing agricultural insurance, together with a better understanding of the way of operation of risk management. The improvement of the level of knowledge in the field can be realized mainly in the side of practical approaches, so necessary for Romanian literature and not only.

MATERIALS AND METHODS

The design of the methodological structure for the development of this article included the analysis of a number of 24 agricultural units in Romania, respectively from the counties of Iași and Galați. All the 24 agricultural units studied are active in the vegetable production sector. They were also selected based on the fact that in the 2022-2023 agricultural year they opted for an optional insurance policy for at least one crop in their crop structure. In addition to the crop structure of each of the 24 units, the authors also had access to all the details of the insurance policies applied with the insurance companies. Although the research is based on a small sample, the quality of the results is ensured by the relevant structure of the subjects included in this sample.

Therefore, the output elements of this paper are based on data from primary sources. In this regard, the authors collected and processed both PIAA – Payments and Intervention Agency for Agriculture area files and insurance policies, annexes and all their accompanying documents. A series of correlations will be centralized in this paper between the total areas exploited by the 24 units and the insured areas, in relation to the types of crops, the amounts paid to the insurance companies and the non-refundable amounts from the E.U. In order to design the tables, figures and ideas in the work, it was gathered, centralized analyzed and interpreted a data set consisting of 400 entries.

It was also considered reviewing the crop structure of each individual unit, for highlighting the share of the insured / uninsured areas of the units. Also, all this database and details were used to formulate the ideas and the tables and graphs presented in the following.

Taking into account only 24 agricultural units in the present empirical research was a decision taken and accepted with difficulty, but we argue this aspect as follows: obtaining complete data in accordance with the proposed work variables was very difficult, given that for now the reports on the non-reimbursable funds allocated to specific 17.1 grants branch are not centralized, they are not completely organized; moreover, on the page dedicated to these Payments and Intervention Agency for Agriculture (PIAA) reports, numerous errors are recorded in each monthly report; for this reason, to which are added others that it will be mentioned as follows, we selected the information that presented a maximum degree of certainty and accuracy [10]. Then, considering the specificity of the paper theme, which is of the utmost novelty, it was difficult to find data from several reporting sources, so as to ensure a larger number of farms considered for analysis. Another justification is the following: the monthly average number of accepted financing requests is 600 economic units throughout the country, which means for the year 2023 an average of 170 economic units per county. It was chosen to work with the 2 counties, Iasi and Galati, because for them it was gained access to complete sources of information. In addition, given that small farms are not yet part of the category of those very interested in agricultural insurance even from grants, the study was conducted on large farms, so from this point of view the area of investigation has narrowed. Considering these limits, it was assumed the context of developing a work that can generate extended results in future works, this being a pilot approach. Thus, it was proposed that in future works, thinking that the reports will be richer in information, and will allow to expand the area of representation of the units. Generalization is an extremely relevant aspect for a complex methodological framework, but through this article, considered as a pilot study, its aim is to highlight the results on the two counties, so that the research can be continued on a larger number of counties and, moreover, to ensure the visibility of the results in the form of an impulse for an extended approach to such a subject. Therefore, given the limit of generalization of the results, the decision of the research approach is argued with the fact that for the 2 reference counties there are few agricultural units that have accessed non-reimbursable funds through branch 17.1. in 2022.

The choice of the two reference counties is given by the access to complete data and the consideration of the physical-geographic characteristics for the suitability of cereal crops. Thus, on the banks of the Prut River, in exposure from North to South, there are 4 counties with identical or very similar pedo-climatic conditions favorable to cereal crops: Botosani, Iasi, Vaslui, Galați. Of these, 2 are the poorest in the North-East Development Region, and on some indicators also in Romania (Vaslui and Botosani), although the agricultural and natural potential is high. For the county of Iasi, it was relatively easy to identify the data for analysis, respectively for Galați, compared to the counties of Vaslui and Botosani. Moreover, the motivation for choosing this specific investigation area, is also given by the fact that during the repeated documentation regarding the results of attracting non-refundable funds for Romanian agriculture, it was noticed that even starting with SAPARD financing (2000-2006) these produced favorable results, but at a very slow pace, especially in the Northeast Development Region. Even if Romanian agriculture, in each region, has a very high development potential, there are a number of limiting factors, and the lack of sufficient support funds is one of the major factors acting against the development of national agriculture, especially in the North-East Region.

RESULTS AND DISCUSSIONS

As previously mentioned, the main selection criteria of the agricultural units taken over for the study was the size expressed in exploited area and the option of the farmer to apply for a risk insurance premium for at least one of the agricultural crops in their farm. The size structure of the selected agricultural companies selected is presented below in Table 1.

Generally accepted and used tie-breaking thresholds were taken into account in the classification of agricultural units according to the exploited area.

It can be seen that the distribution based on cultivated areas is eloquent. This is evidenced by the average size of each farm in the category in which it was nominated. Also, the average of the dimensions reveals a uniform distribution of the economic units in the three categories.

Table 1. The size structure of the studied agricultural holdings

Farm size (ha)	Number of farms	%	Total area (ha)	Average size (ha)
<250	5	20.8	1,009.55	201.91
250 – 500	10	41.6	3,152.81	315.28
>500	9	37.5	8,340.73	926.75
TOTAL	**24**	**100**	**12,503.09**	**520.96**

Source: own analysis of primary data from sample of farmers.

As stated before, a database was formed by the primary sources information gathered from the 24 agricultural units. The authors centralized and analyzed this 400-entry database. This is rendered, explained and interpreted in the Table 2 below.

The centralizing table highlights most of the data used for this paper. The areas of all the 24 studied units are centralized, the percentage of the total area of each individual unit, insured and uninsured, the insured areas, in bold and the uninsured areas. The insured and uninsured areas are highlighted at the unit level, at the culture level and at the total general level.

The presentation of the results shown in Figure 1 below is relevant as the basis for the following figures and tables. As can be seen in this figure the distribution of crops within the areas exploited by the 24 agricultural units studied, generally respects the general average percentage allocation of the areas at the national level. Specifically, maize, wheat and sunflower crops have the most generous area usage. An aspect that emerges from the model of the distribution of crops at the national level is the presence, within the total areas of the 24 units studied, of an important share in terms of seed lot crops.

It can be seen that the seed plots (maize and sunflower) are cultivated on an area of 1,551 ha out of the total of 12,503 ha exploited by the units, respectively 12%.

This relatively large area and significant percentage is due to the fact that the units selected by the authors for the study are from the medium-large category and have performant economic indicators and an advanced technical capacity.

Due to these aspects, these units have been selected by multinational seed multiplication companies for seed production. As is well known, these multinational seed producing companies only contract agricultural units that have the technical and financial capacity necessary for the precision of obtaining the seed.

Within the following Figure 2, the share of insured areas is presented at the level of the same agricultural crops or crop categories.

As can be seen, the shares of areas insured for each individual crop, out of the total areas allocated to the respective crop or group of crops, are between 0% and 100%. However, most of the categories shown in the Figure 2 present shares worthy of analysis and debate.

Thus, as regards the maize crop, it is cultivated by all 24 producers, the total area allocated for this crop being 3,846 ha. Of this area, the largest part, in percentage of 78.3%, is insured against climatic risks. A very close share is also found in the case of wheat cultivation, where 79.72% of the total allocated area of 2,309 ha is insured against climatic risks. As for the wheat crop, it is in the crop structure of 20 of the 24 analyzed producers. The total area allocated is, according to Figure 2, 2.397 ha and 94% of this area is insured.

Table 2. The area exploited (ha) by the 24 agricultural units analyzed, and the share of insured and uninsured crops

															Insured		Uninsured	
Area share	Unit	Maize	Wheat	Sunflower	Rape	Soybean	Seed lot	Sorghum	Lucern	Feed crops	Meadows	Barley & Oa	Sugar Beet	TOTAL	Area	Percent	Area	Percent
1.2	1st	86.7	22.8	13.0	7.2			9.6	0.8		8.6	0.0		148.7	129.7	87.2	19.0	12.8
1.3	2nd	62.4	17.6	35.4	14.9				13.3	6.5	16.0	0.0		166.1	130.3	78.5	35.7	21.5
1.7	3rd	43.7	0.9	40.5	28.6			3.5	18.6		48.6	22.9		207.3	154.3	74.4	53.0	25.6
1.9	4th	131.5	65.1	34.5					7.4			0.0		238.5	231.2	96.9	7.4	3.1
2.0	5th	19.7		3.3			225.9					0.0		248.9	248.9	100.0	0.0	0.0
2.0	6th	24.6	59.3	106.3	20.3	18.7			13.7	3.1	5.7	0.0		251.6	229.2	91.1	22.4	8.9
2.0	7th	66.4	75.7	45.3	67.0							0.0		254.4	254.4	100.0	0.0	0.0
1.9	8th	123.6		30.9		21.7			3.7		6.3	46.6		232.9	222.9	95.7	10.0	4.3
2.3	9th	100.1	97.4	23.1	30.1	31.1			11.4			0.0		293.2	293.2	100.0	0.0	0.0
2.5	10th	48.4	41.2	76.0					106.9		1.1	0.0	41.6	315.2	131.2	41.6	184.0	58.4
2.6	11th	115.8	153.2	30.7		20.0			1.0			0.0		320.7	320.7	100.0	0.0	0.0
2.7	12th	137.9	106.6	54.0		37.1			0.5			0.0		336.1	336.1	100.0	0.0	0.0
2.5	13th	179.0	14.5	30.8	66.4		3.6		20.9			3.4		318.6	315.0	98.9	3.6	1.1
3.1	14th	70.0	151.1	54.3	43.9				8.8			44.2	13.3	385.7	322.5	83.6	63.1	16.4
3.6	15th	303.5	27.8	57.4	52.6				2.0	1.2		0.0		444.5	110.0	24.8	334.4	75.2
4.7	16th	104.2	308.0	170.7								0.0		583.0	583.0	100.0	0.0	0.0
5.0	17th	107.6	115.0	329.3	65.5					3.7		0.0		621.2	394.9	63.6	226.4	36.4
5.5	18th	68.8					623.3					0.0		692.1	692.1	100.0	0.0	0.0
5.6	19th	194.8	250.0	134.5								0.0	127.1	706.3	571.8	81.0	134.5	19.0
5.9	20th	238.4		26.1			471.0					0.0		735.5	735.5	100.0	0.0	0.0
7.8	21st	462.0	183.8	284.1	40.1				2.5			0.0		972.5	929.9	95.6	42.6	4.4
8.4	22nd	433.9	280.8	298.5							31.4	0.0		1,044.6	579.3	55.5	465.3	44.5
8.9	23rd	130.7	119.9	92.8	136.0	20.6	227.4	11.5	69.8		162.9	103.6	32.1	1,107.1	900.6	81.4	206.5	18.6
15.0	24th	592.3	306.8	338.3	245.7	123.8			96.5	8.7		0.0	166.3	1,878.4	1,144.8	60.9	733.6	39.1
	TOTAL	3,846.1	2,397.5	2,309.8	818.2	273.0	1,551.1	24.5	377.7	23.2	280.7	220.7	380.4	12,503.1	9,961.5	79.7	2,541.6	20.3
	Insured area	3,001.1	2,253.8	1,841.3	778.2	149.2	1,547.5	0.0	122.2	0.0	0.0	220.7	214.1	10,128.2				
	Insured percent	78.0	94.0	79.7	95.1	54.7	99.8	0.0	32.3	0.0	0.0		56.3	81.0				
	Uninsured percent	22.0	6.0	20.3	4.9	45.3	0.2	100.0	67.7	100.0	100.0		43.7	19.0				

Source: own analysis and centralization of primary data from the sample of farmers.

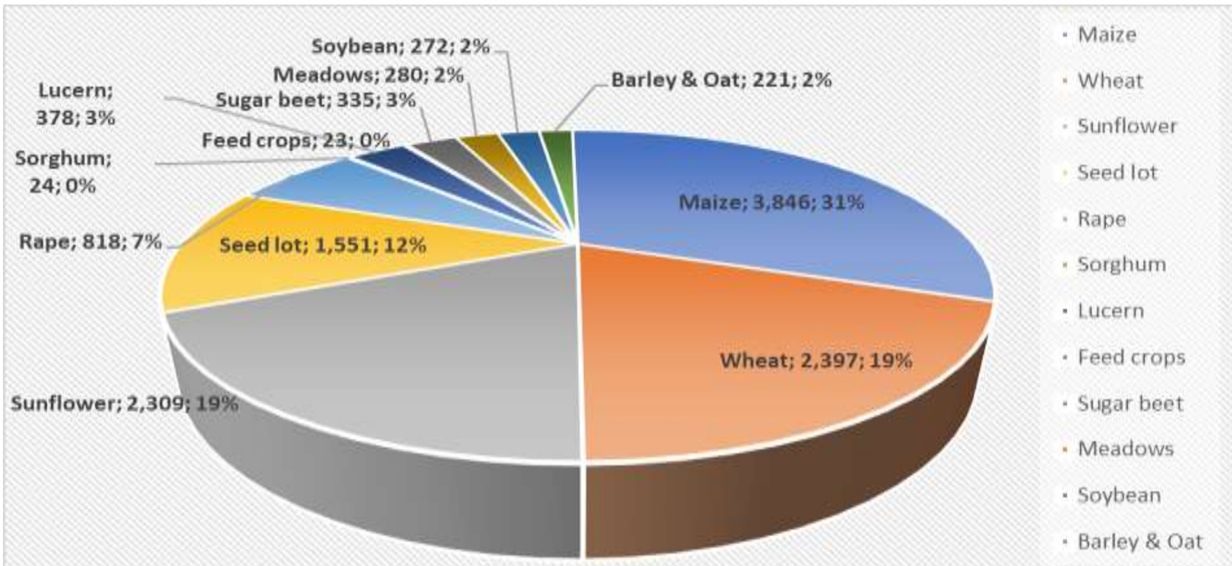

Fig. 1. The structure of crop area in all the 24 studied farms (ha; %)
Source: own analysis and centralization of primary data from the sample of farmers.

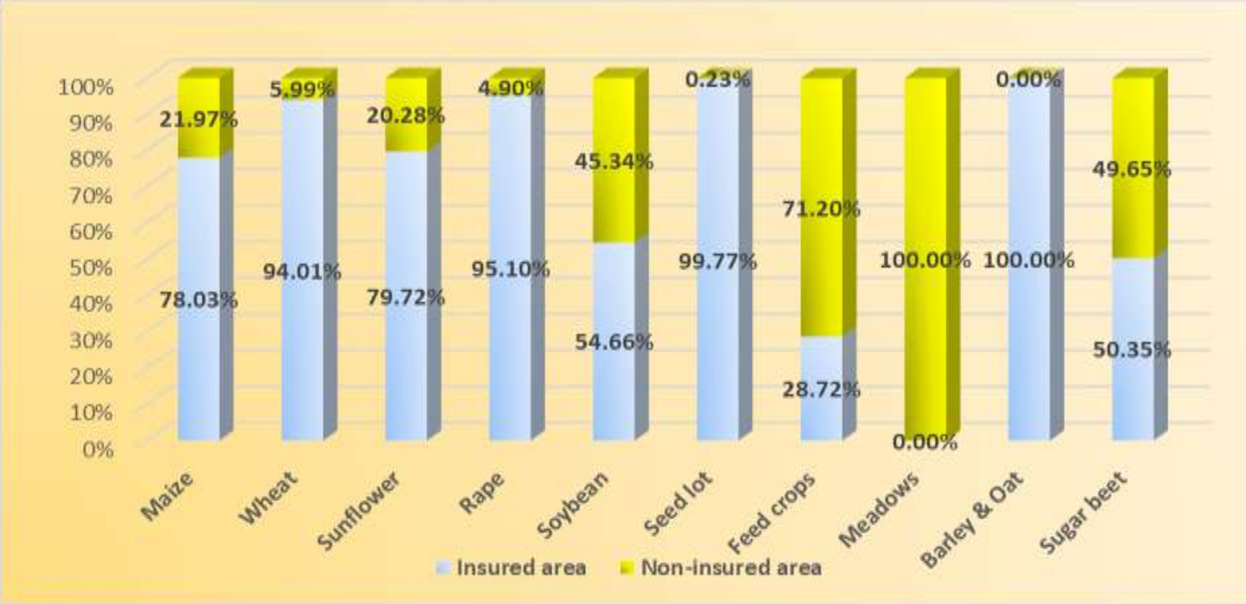

Fig. 2. The share of the area for which insurance premiums were applied
Source: own analysis and centralization of primary data from the sample of farmers.

Worthy of debate are at least two categories of crops, namely seed lots and barley & oat, which have the largest shares of the insured areas. The explanations are different for the two categories. Thus, as far as seed lots are concerned, farmers are obliged by seed multiplication contracts to make insurance premiums for seed lot crops [5]. Thus, over 99% of the analyzed areas benefited from this facility. On the other hand, we can see a 100% insured area in the case of Barley & Oat crops. This time, the share of 100% is due to the fact that farmers allocate relatively small areas to these two crops, in the present analysis, concretely, 221 ha, respectively 2% of the 12,503 ha. The reason why statistically the areas of these two crops are insured in 100% share is given by the fact that all the cultivator farmers (5 out of 24) also have other cereal crops on significant, insured areas. Thus, when concluding the policies and insuring the main cereal crops, these two crops are also added to the insurance package, even if they benefit from smaller areas. As for the sugar beet crop, it is exploited by a number of 3 of the 24 analyzed farms, and the total area allocated is 335 ha or 3%. It can be seen that 50% of this area is insured against harmful climatic phenomena. Finally, the situation of the meadows is also worthy of interpretation. This is 0% insured, not being an arable area. It was however taken into account in the present study because for the 24 analyzed units all data and area were collected and processed to show, among other things, the share of non-arable land in relation to arable land. At the level of all the units studied and the entire area of land exploited cumulatively, 80.75% of the areas are insured, respectively 10,096.03 ha out of a total of 12,503 ha.

As will be shown in the following, the share of medium-large agricultural units in Romania that opt for applying of an optional insurance for climate risks is constantly increasing and is expected to increase further given the popularization among farmers, of the financing instrument that settles 70% of the eligible value of these policies.

In the Table 3, the cumulative values of the policies applied by the 24 analyzed companies were reported in relation to the total area exploited cumulative by them. The exchange rate is the average exchange rate of the whole 2023 published by the Romanian National Bank.

Table 3. AFRI Insurance Cost Reporting and Grant Funding for the combined exploited area of the 24 agricultural units studied, 12,503 ha

Nr. crt	Criteria name	Euro	Lei [8]
1	Total cumulative value of the insurance premiums for all 24 units	400,485.05	1,974,992.00
2	Total value per arable ha	32.77	161.59

3	Eligible cumulative value of the insurance premiums for all 24 units	328,773.40	1,621,346
4	Eligible cumulative value per arable ha	26.90	132.66
5	Total settled value from grants for all 24 units	230,141.34	1,134,942
6	Settled value from grants per arable ha	18.83	92.86

Source: own analysis and centralization of primary data from the financial documents of the sample of units.

Numerous interpretations can be derived from Table 3 shown previously. Thus, the cumulative eligible and non-eligible value for the financier settlement of the policies applied by the 24 companies studied was 400,485.05 Euro (1,974,992 lei). The total insurance value per arable ha was thus 32.77 Euro (161.59 lei). All the funds granted to the 24 agricultural units analyzed came from the 2014-2020 financial year. Starting with 2023, the financing institution will continue granting these incentives from the new financial allocation, namely from the National Strategic Plan 2023-2027.

There are several considerations that need to be made regarding the previously rendered results. As can be seen, the authors selected for the present study a number of 24 economic operators from the agricultural sector based on certain criteria. Size was one of the criteria, namely the selected units are part of the medium-large category, over a third having more than 500 ha exploited and more than 40% having between 250 and 500 ha exploited. On the other hand, according to Table 3, a relatively low cost can be found with optional insurance concluded for adverse weather events. Thus, it is found that, on a general level, one hectare of insured arable land costs 32 Euro (161 lei), of which Almost 19 Euro (92 lei) is the amount settled later by the financier. Thus, the farmer remains with an effective cost of 14 Euro (69 lei) per insured arable ha. It should be emphasized, in this sense, that the financing institution settles 70% of the eligible value of the insurance policy regardless of the occurrence or not of unfavorable weather conditions or the compensation or not to the farmer. Thus, the farmer can have unfavorable conditions registered and benefit from compensation through the policy even if this is also settled with the financier. The reason why an insurance policy does not present the total value as being eligible for settlement from AFRI is given by the fact that, in addition to the standard features of the premium and the insured risks, farmers also choose a series of optional features by their own choice. These optional features, although they have modest costs compared to the total value of the policy, are not settled by the financier. A calculation of the intensity of the non-refundable support relative to the total value of the policy reveals that 57% of the total values were settled by the financier. In other words, processing the settled value to the total value, with options included, the intensity of the non-reimbursable support is 57%, which we consider to be a significant aid.

The authors intend to continue the study by analyzing the total values and amounts, eligible, settled, etc. for each crop individually, among the 10 crops or groups of crops found in the structure of the 24 units. The number of units taken for study is likely to increase during a subsequent study. Therefore, a series of subsequent results will be based on a larger number of units, and the research will thus be more extensive. The authors have decided that in this work they will refer to the global, general analysis of the characteristics of the insurance policies, the analysis of the data at the level of individual crop, rendering it in a future work.

As it appears from the data analysis carried out, in 6 of the 10 basic agricultural crops, namely maize, wheat, sunflower, rapeseed, seed lot, barley and oat, the areas are insured in a proportion of over 75%, among which 2 with 100% and 99.77%. This is a hint that the possibility of accessing these funds has stimulated the interest of farmers to insure their crops and to consider the mechanisms for managing agricultural risks given by natural hazards. To this finding is added the promotion in various ways, such as the mass media, articles in publications with easy access to the public, interviews, the involvement of officials, etc. of the advantages of accessing these funds and, thus, encouraging a change in mentality. Another very favorable factor is the simplification of the documentation that allows access to the submission of financing requests and the provision of free consultancy for this purpose. Thus, the implications at the agricultural policy level have a positive impact, in the sense that the directions proposed by the PAC are followed, which leads to the chance of attracting other funds and encouraging local producers to continue investing in agricultural crops, especially as in the past for about 15 years they felt helpless and discouraged.

CONCLUSIONS

The authors studied, processed and centralized the technical-financial data of 24 agricultural units from the counties of Iași and Galați, România. The total cumulative area of the 24 farms is 12,503 ha. It was found that thanks to the financial incentives for settling 70% of the eligible value of the policies, more than 80% of the areas of the 24 units benefit from insurance, the percentage varying depending on the crop or group of agricultural crops. It was also found that for farmers the average cost of crop insurance is 14 Euro (69 lei) /ha. Receiving financial aid from AFRI is not conditioned by the incidence of unfavorable climatic elements or the activation of the insurance policy. The studied units benefited from a total cumulative amount of 230,141 Euro (1,134,942 lei) from the financing institution AFRI. The authors will continue the research by studying all the technical-economic characteristics of the areas provided by each agricultural culture individually. In 2024 and the following years, farmers will continue to benefit from the settlement of policies in the same way, also with 70% non-refundable, the source of financing being the National Strategic Plan 2023 – 2027 currently in force.

In terms of considering managerial risks in agricultural farms, including from the PAC perspective, it is mentioned that major difficulties may arise in accessing non-reimbursable funds, especially in conditions where the policy is not assumed. Accessing the funds is a major opportunity for farmers in Romania, regardless of the size of the farm they manage, which is why it is imperative to know and understand the role of the PAC by farmers who undertake the organization of the complete activity for agricultural farms. This is a sure way of increasing the level of performance, of superior positioning in relation to the requirements of international agricultural market policies and a way of guaranteeing market success.

The limits of this paper consist in the limitation of the reference region for the proposed analysis, respectively in the consideration of a minimal set of risks, which is why it is not possible to generalize the results. However, given the specificity of agricultural areas and management systems in Romanian agriculture, we believe that in other future works we will be able to extend the reference area to other geographical areas and other size categories of agricultural farms. Certainly, the paper indicates a practical prevalence that can be useful including in taking measures to reduce the effects of the analyzed risks and to adopt a more efficient management system.

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POTENTIAL OF AGRICULTURAL BIOMASS VALORIZATION FOR CIRCULAR BIOECONOMY

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Abstract

This paper assesses the role that cereal crop byproducts could play in a circular economy context in Romania. The study focuses on the quantification of biomass availability using Residue-to-Product Ratio (RPR) and estimating the bioenergy potentials by means of Lower Heating Value (LHV) calculations for a variety of byproducts of vegetal crops. Results show that cereal crop side products an important source of biomass and hence offer opportunities for bioenergy and circular agricultural systems. However, in an effort to balance the approach of biomass utilization, sustainability issues related to soil health and food security are also discussed. This work emphasizes the importance of considering environmental and economic advantages in contributing to a circular bioeconomy.

Key words: *bioeconomy, biomass availability, bioenergy, circular agriculture, Romania*

INTRODUCTION

Integration of agricultural biomass into the bioeconomy sector is a key step toward achieving sustainability and renewable resources [6, 27]. Biomass that can be resulted from agriculture sector is being increasingly regarded as one of the significant feed stocks in the transition process from a fossil-based economy to a bio-based one [24].
The EU has been at the forefront in this transition; agricultural biomass contributes about 68% of the total biomass supply in the region [4]. It is coupled with the EU Bioeconomy Strategy that focuses on mobilization of biomass resources for economic growth, sustainable development, and societal progress [18,8]. This takes the form of cascading biomass use, where agricultural by-products are converted into high-value products like biofuels, bioplastics, and bio-based chemicals [8]. The cascading concept ensures, the highest level of efficiency in the use of resources before its final recycling or return to the soil in organic form, as far as possible. By prioritizing uses of biomass that would create most economic and environmental value, could reduce material waste, while adding value to the sustainability of agricultural systems by creating new sources of income for farmers, efficient use of resources, and reduction in the carbon footprint of agricultural production [5, 6, 7].
Agricultural biomass that is including dedicated crops, crop residues (straw, stoovers, husks), manure, pruning, processing waste such as fruits and vegetable waste, bagasse and chaffs (Figure 1). The dedicated crops are those grown for the sole intention of producing biofuels and energy. These include classical sources of biofuel such as corn and sugarcane, rapeseed, oil palm, jatropha, sorghum, and cassava and energy grasses like miscanthus and switchgrass [19,14]. The remainder needed energy sector is filled by short rotation forests and more dedicated crops. Besides the primary products, a number of postharvest by-products and leftovers are utilized for bioenergy. Herbaceous by-products come from straw derived from cereals, rice, and corn [23, 22]. Also from bagasse and empty fruit bunches from oil palm; and from pruning derived from stover and empty cobs of corn.
Wood biomass comes from the regeneration of orchard wood, vineyards, olive, and oil palm plantations. Other processing residues include kernels, sunflower shells, rice husks. These represent a different variety of source material

able to be converted into energy in support of sustainability efforts .

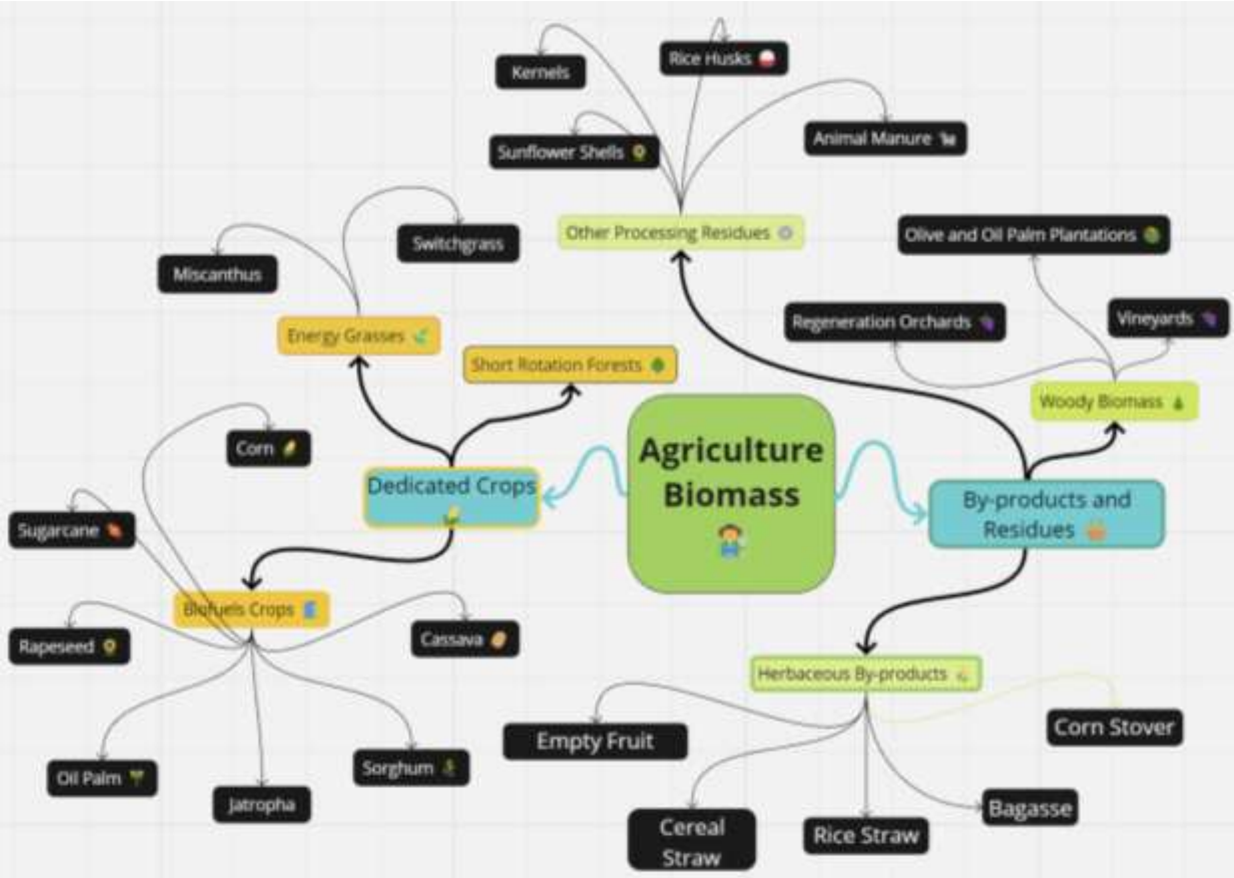

Fig. 1. Sources of biomass from agriculture [2, 11, 28]
Source: Author's own elaboration.

In this context, the aim of this paper is to explore the opportunity and challenges of agricultural biomass inclusion into the bioeconomy by means of its utilization in the circular agriculture system. For this, three objectives were set, as follows:

(i)quantification of biomass availability from major cereal crops in Romania, such as wheat, maize, barley, oats, rice, and sorghum

(ii)estimation of bioenergy potential of the selected cereal crops. For this, the energy output was obtained by applying LHV values.

(iii)highlight the sustainability implications by further discuss the wider implications of diverting agricultural harvest by-products for the purpose of bioenergy production on soil health, food security, and circular agricultural practices.

MATERIALS AND METHODS

The study design incorporates a quantitative approach, utilizing statistical data and mathematical calculations to derive insights into the role of biomass in circular agriculture. The statistical data were extracted from open data of National institute of Statistics Romania. To determine the amount of crop Harvest by-products produced relative to the primary production this study utilized the Residue-to-Product Ratio (RPR) as a primary index metric. The equation for calculating the biomass available from agricultural residues using primary production and the Residue-to-Product Ratio (RPR**)** was:

Biomass Available = Production×RPR (1)

where:

-Biomass Available is the amount of agricultural residue biomass available.

-Production refers to the total yield or production of a primary crop (tons).

-RPR (Residue-to-Product Ratio) is the ratio of crop residue generated per unit of primary crop (e.g., straw per ton of wheat).

Potential energy was calculated by using the following equation:

Potential Energy (GJ) = Biomass Available (tons) × Lower Heating Value (LHV) (GJ/ton) (2)

where:

-Potential Energy (GJ) is the total energy that can be produced from the biomass.

-Biomass Available (tons) is the amount of biomass derived from agricultural residues (calculated using the production and RPR).

-Lower Heating Value (LHV) (GJ/ton) is the energy content of the biomass, usually given in gigajoules per ton (GJ/ton), and varies by biomass type (e.g., wheat straw, corn stover).

RESULTS AND DISCUSSIONS

Agriculture biomass as a raw source for circular economy

According to Eurostat, biomass is an essential source of renewable energy, especially for heating, electricity, and transport.

Biomass energy accounted for about 59% of all renewable energy consumption in the EU in 2021, making it the centerpiece of energy production across the region [9].

In circular agriculture, biomass can be effectively recycled and utilized to produce biofuels, fertilizers, and animal feed [16].

Within vegetal production, cereal crop Harvest by-products are foreseen to contribute significantly in a circular economy. The residue can be used in the production of bioenergy through various methods, such as direct combustion, gasification, and anaerobic digestion of post harvest by-products like wheat straw and rice husk. This, therefore, reduces over-dependence on fossil fuel.

Besides, these post harvest by-products play a critical role as soil amendments. Mulching or composting improves the structure of the soil and increases the water retention and fertility.

Besides energy and agriculture, cereal crop post harvest by-products are also being employed in industries for the production of various biocomposites like paper.

These uses of crop post harvest by-products prove to be indicative of the potentials in economic and environmental sustainability within a circular economy (Table 1).

Table 1. Potential Uses of Cereal Crop Residues

Harvest by-products	**Primary Use**	**Secondary Use**	**Examples**
Wheat Straw	Bioenergy (Combustion)	Mulch, Animal Bedding	Power generation, soil cover
Rice Husk	Biogas, Biochar	Industrial Raw Material	Fertilizer, packing material
Maize Stover	Bioenergy (Ethanol)	Compost, Animal Feed	Ethanol production, soil cover
Barley Straw	Soil Amendment	Animal Bedding, Bioenergy	Livestock feed, combustion
Sorghum Stalk	Bioenergy (Ethanol)	Animal Feed, Mulch	Fuel, livestock feed

Source: Authors' own elaboration based on [2, 4, 10, 16, 23, 27].

Production of corn and wheat in Romania is shown in Fig. 2, while in Fig.3 it is presented total production for selected crops: barley, oats, sorghum and rice.

Biomass production in Romania

Romania occupies a top position in the EU production of grain and oil seed, accounting for 10% of EU production [20].

This insight is very relevant in terms of the development of biomass production in circular agriculture, since an increase in Romanian cereals and oilseed production can make a positive contribution to the assured supply of agricultural post harvest by-products in the frame of bioenergy, while the transition of the feedstock supply chain may result in circular agriculture.

Analyzing the detailed data on primary production of the last decade, from 2012 to 2021, there were significant fluctuations in cereal production within Romania (Figures 2 and 3).

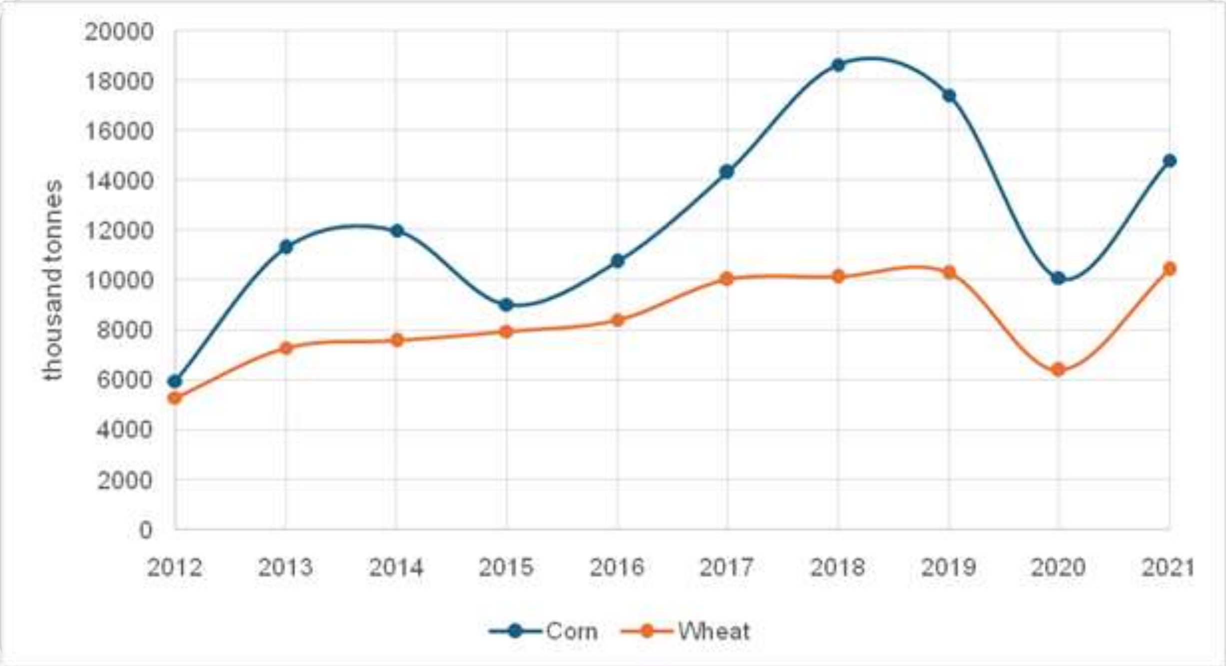

Fig. 2. Production of corn and wheat, Romania
Source: Author's representation based on NIS data [17].

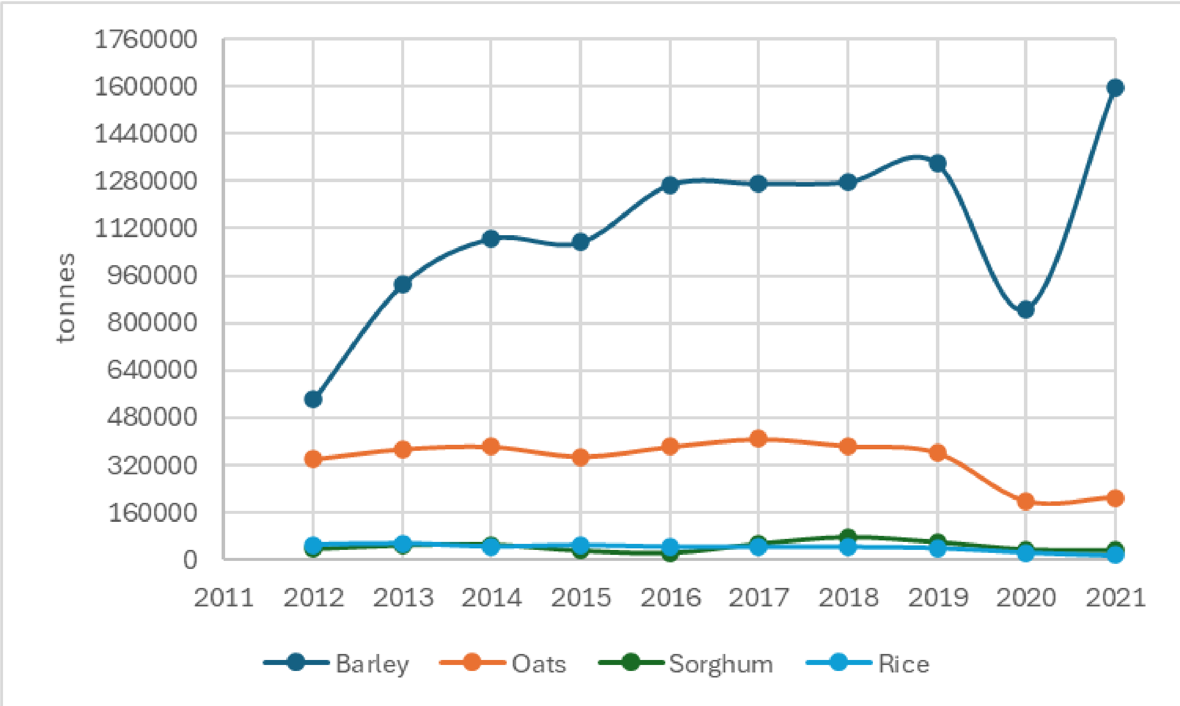

Fig. 3. Total production for selected crops In Romania
Source: Author's representation based on NIS data [17].

Analyzing the detailed data on primary production of the last decade, from 2012 to 2021, there were significant fluctuations in cereal production within Romania (Figures 2 and 3).

The production of corn began an upward trend from about 5.95 million tons in 2012 to a peak in 2018 with 18.66 million tons, reflecting an increase in agricultural output. At the same time, wheat production also increased gradually from 5.29 million tons in 2012 to more than 10 million tons by 2019. However, both crops show a sharp decline in the year 2020, probably due to external factors like bad weather conditions or economic disruptions, but their recovery could be seen by 2021.

Overall, barley and oats were observed to be important crops as well, with substantial fluctuations, especially in 2020. Sorghum and rice remain smaller contributors to Romania's agricultural output, with rice experiencing a continual decline. These trends may have implications for future crop management strategies, especially regarding the integration of these crops into Romania's bioenergy or food security plans.

Analyzing the cereal production trends data, it becomes evident the potential for utilizing agricultural post harvest by-products as biomass for bioenergy. Biomass post harvest by-products are directly related to agricultural production because higher crop yields translate into an equivalent amount of post harvest by-products since post harvest by-products are a set percentage of the crop.

Biomass residues are organic materials produced after a crop has been harvested. Examples include those emanating from cutting or pruning, like stems, straw, stalks, leaves, and branches. In most cases, if these parameters are known, it is possible to estimate the energy potential of biomass.

Furthermore, by applying the Residue-to-Product Ratio (RPR) we have calculated the potential biomass available resources. The RPR values was considered after a brief literature review as described in Table 2.

Table 2. Residue-to-Product Ratios (RPR) for Major Cereal Crops

Cereal Crop	Average RPR	Range of RPR	Primary Post harvest by-products Types
Wheat	1.3	1.0 - 1.6	Straw, Chaff
Rice	1.5	1.2 - 1.8	Straw, Husk
Maize (Corn)	1.5	1.0 - 1.6	Stover (stalk, leaves, husks)
Barley	1.4	1.1 - 1.6	Straw, Chaff
Sorghum	1.2	1.0 - 1.4	Stalk, Leaves
Oats	1.5	1.3 - 1.7	Straw, Chaff

Source: Author's own findings after [10, 21, 11].

RPR quantifies the amount of crop residue that is produced for each unit of the primary product produced, such as grain.

This is one of the most important measures when accounting for biomass availability for various uses such as bioenergy, enrichment of soil and biobased products [25].

The actual ratios may vary depending on local conditions and specific crop varieties.

Corn typically has an RPR of around 1.5, meaning for every ton of corn produced, 1.5 tons of post harvest by-products (stalks, leaves, cobs) are available.

With corn production peaking at 18.66 million tons in 2018, Romania could potentially generate around 28 million tons of corn biomass.

Similarly, wheat straw, with an RPR of approximately 1.3, can add significant biomass resources to the circular economy. These agricultural post harvest by-products, which might otherwise be wasted, can be repurposed into bioenergy or organic fertilizers (Figure 4).

The analysis has further advanced by calculating the energy potential by using Lower Heating Value (LHV) (Table 3).

LHV is defined as the quantity of useable energy that releases the combustion of a unit of fuel with the exclusion of the latent heat of vaporization of water [1].

In other words, this value is regarded as fundamental to any bioenergy assessment, as it offers an estimation for the energy potentials contained in varied types of biomass, including agricultural residues. Indeed, cereal crop post harvest by-products like wheat straw, maize stover, and rice husks have been generally observed with LHV values of about 12 to 17 GJ per ton [1, 3].

Of course, these values vary due to a set of factors that relate to moisture content and the specific biomass type.

In applications related to bioenergy systems, LHV has been estimated to account for the amount of energy producible from available biomass in Romania.

For the developed model, it was used a median value for each selected crop, based on literature review.

Among the selected vegetal species, corn and wheat are the dominant contributors to Romania's bioenergy potential, providing the most significant quantity of agricultural post harvest by-products that could be diverted into bioenergy.

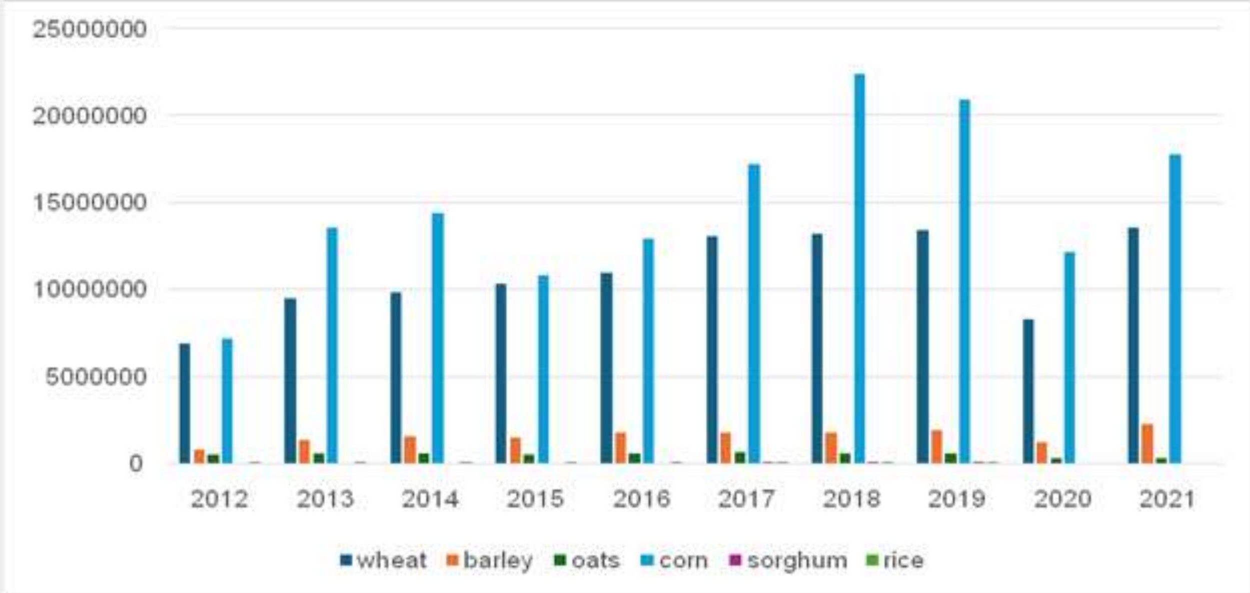

Fig. 4. Yearly biomass available for the selected crops
Source: Author's calculations

Table 3. LHV Values For Cereal Crop Residues (JRC, FAO, IRRI), Biomass Energy Resource Center

Cereal Crop	LHV (GJ/ton)
Wheat Straw	13-15 GJ/ton
Maize (Corn) Stover	15-17 GJ/ton
Barley Straw	13-15 GJ/ton
Rice Husk	12-14 GJ/ton
Rice Straw	12-14 GJ/ton
Oat Straw	13-15 GJ/ton
Barley	13-15 GJ/ton
Sorghum	14-16 GJ/ton

Source: Author's own elaboration.

Poor growth conditions may have contributed to a potential decline in both corn and wheat in 2020, but both rebounded in 2021 (Figure 5).
The other relevant contributions come from barley and oats even if their values are lower. This bioenergy carrier has been regularly raised from 10,602 thousand GJ in the year 2012 up to 31,239 thousand GJ in 2021 (Figure 6).

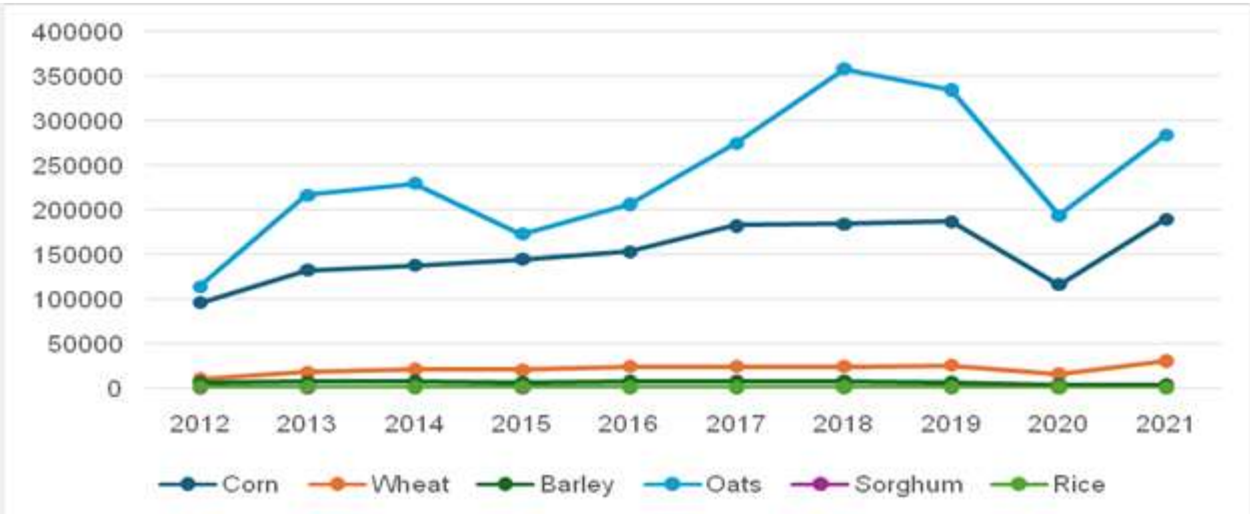

Fig. 5. Dynamics of the potential energy value for the selected crops (GJ)
Source: Author's calculations.

Oats have represented quite stable values, with some ups and downs in their oscillations.

Sorghum and rice are minor biomass feedstocks, although sweet sorghum has a huge potential for biofuels. The availability of such feedstocks is particularly relevant with a view to bioenergy production for diversifying energy sources within circular agriculture.

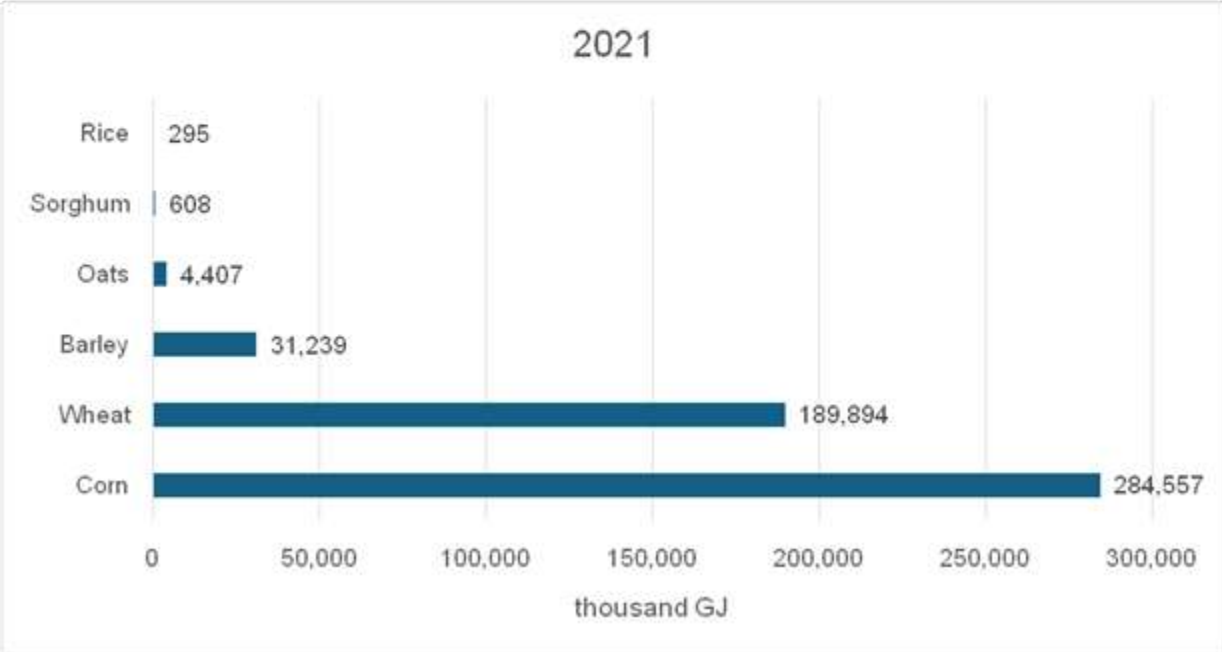

Fig. 6. Potential Energy for the selected crops for the year 2021 (GJ)
Source: Author's calculations.

It is important to take into consideration that in the same time with the increasing demand for biomass in the bioeconomy, there is concern for its supply in a sustainable manner. In this light, [15] says that a balance needs to be maintained with much care. Other strategies that have been put forth to help address these challenges and ensure that growth in the bioeconomy does not come at the expense of other important agricultural functions include the sustainable intensification of agriculture and utilization of marginal lands.

However, we highlight that the calculated potential for bioenergy in an absolute maximum since all agricultural post harvest by-products were considered to be used exclusively for the production of bioenergy. In reality, these vegetal wastes already have a number of other important uses in practical agricultural systems that are critical for sustainable farming and environmental conservation.

The most critical uses of crop post harvest by-products involve soil conservation. Leaving a portion of the biomass in the field after harvest is necessary for the replenishment of organic matter in the soil. Organic matter in the soil is important for maintaining appropriate soil structure and fertility. Crops leftovers incorporated in the soil will add to the water retention of the soil, reduces erosion, and enhances microbial activities-all critical factors for the long-term maintenance of soil health. Also, integrating post harvest by-products within the soil contributes to the sequestration of carbon, therefore reducing greenhouse gas emissions [26,12,13].

Vegetal waste also contributes much in animal husbandry, by providing the bedding material. Straw and other crop post harvest by-products contribute to clean and absorbent beddings for animals, thus contributing to animal welfare for comfortable and hygienic living. This bedding can later be composted and returned to the fields, creating a nutrient loop that supplies organic fertilizer toward soil fertility without total dependence on chemical inputs.

These valorizations of vegetal waste are essential in maintaining a balanced and circular agricultural system.

Excessive shifting of this post harvest by-products for bioenergy purposes, without these functions, may lead to a loss of soil quality and increased dependence on synthetic fertilizers, therefore acting against the goals of sustainability that bioenergy is supposed to promote.

Thus, as promising this bioenergy potential might be, it calls for a reasonable approach in which enough post harvest by-products are left behind for the maintenance of soil health and bedding of livestock, so as to strike a balance in ensuring overall sustainability in agricultural practices.

Another issue that needs to be addressed is the technological challenges. For example, due to inefficient conversion of biomass ethanol and methane during fermentation present limitations. More technological inventions are required to make the energy sources derived from biomass more competitive with those from fossil fuels [16].

Last, but not least, there are the financial challenges that need to be taken into account. While biomass is generally procured at low costs, the energy production from biomass remains relatively expensive due to the logistical issues of transportation costs and seasonal feedstock availability.

CONCLUSIONS

Biomass utilization for bioenergy, fertilizers and bio-based products is considered a green alternative for transition to circular bioeconomy.

However, it may cause a disruption in natural ecosystems by the appropriation of net primary production. Cascade use of biomass, a concept in which biomass is used sequentially for different uses before finally getting combusted for energy-can reduce environmental impacts and increase resource efficiency.

ACKNOWLEDGEMENTS

This paper was funded by Ministry of Agriculture and Rural Development, through sectorial program, contract ADER 22.1.4

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

AGROTECHNOLOGICAL AND ECONOMIC IMPORTANCE OF THE HEAT SUPPLY FORECASTING FOR THE POST-HARVEST PERIOD IN THE DRY STEPPE ZONE OF UKRAINE

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Abstract

The purpose of the study is to assess available agroclimatic resources and forecast heat supply in the post-harvest period in the Dry Steppe zone of Ukraine. Dynamic analysis of agrometeorological indices was performed by comparing the average long-term values. The correlation analysis of the agroclimatic conditions of the growing season revealed a significantly strong dependence of individual meteorological indices on the availability of heat resources in the post-harvest period. It was established that the sum of effective and active temperatures for the post-harvest period has a weak and moderate correlation with the mean monthly air temperature and atmospheric aridity index in April and May, while in June the coefficient increases. The highest correlation of the specified meteorological parameters was recorded for the period 1992–2021. Linear regression models of the dependence of the sum of active and effective temperatures during the post-harvest period with high adequacy (R^2=0.69–0.70) were developed. The models allow forecasting the temperature conditions for placing the fore crops for winter wheat. Besides, they are useful for better selection of varieties and hybrids for the post-harvest crops of sunflower and millet. As a result, 28.31% higher yields of millet, and 15.77% higher yields of sunflower in 2022-2023, comparing to 2021, were collected owing to better choice of suitable crops' genotypes. The economic effect of the methodology reached additional 220 EUR/ha for millet, and 80 EUR/ha for sunflower, respectively. The implementation of this method contributes to a more productive use of natural resources and an increase in crop productivity and profitability.

Key words *post-harvest period, hydrothermal conditions, statistical analysis, linear model, agricultural resources forecasting*

INTRODUCTION

While the technical level of agriculture improves, the importance of agrometeorological forecasts increases, and the scope of their application expands. The latter is especially true for intermediate post-harvest crops, grown under irrigated conditions [20]. Currently, Ukrainian farmers have practical experience in postharvest and cultivation of forage crops, green manure crops, and vegetables. However, the full cycle of cultivation of cereals and oil crops is of greater interest, and this question has not been adequately studied. Under such conditions, the time factor acts as an additional limiting factor, as a category that limits hydrothermal and insolation resources, and determines the possible selection of crops, their varietal and hybrid composition, and cultivation technology. Thus, the prediction of the supply of heat resources acquires high significance.

In general, the methodology for the evaluation and forecasting of agroclimatic resources is complicated due to its dynamism and uncertainty. It is also impossible to ignore current climate change [2, 4]. There are quite a lot of special studies on the assessment of agroclimatic resources from the point of view of optimising the placement and cultivation in different zones of field crops, vegetables, and fruits [14, 15, 16]. However, insufficient attention was paid to the residual post-harvest period in the Dry Steppe zone of Ukraine in these studies [1].

Forecasting the heat resources of the potential production period will contribute to the most rational use of climatic and weather conditions to ensure the highest possible probability of guaranteed achievement of the expected crop productivity. The development and mastering of forecasting methods is the basis for both adaptive cultivation technologies and rational use of agro-climatic resources [12].

There are common methods of forecasting the heat supply during the growing season, which are based on the revealed correlations between the dates of the beginning of spring and the total heat income [21, 22]. The intricacy of the computations and the need for specialized meteorological data, which is not generally available, are their main drawbacks. In our opinion, methods based on the dynamics of the temperature regime and rainfall, which determine the possibility of second crop cultivation, will have greater practical importance. The most important is the active vegetation period, which is the part of the season between dates with an air temperature of more than +10°C. The start and finish of the growing season are therefore recorded in Davitai's writings between the dates of the air temperature shift through +10°C. The study has established that there is a connection between the date of the air temperature transition through +10°C and the total amount of heat income ($\Sigma t > 10°C$) there is a connection, which in most geographical areas is reflected in high values of correlation coefficients [3]. The study's scientific validation of the relationship between the length of the growing season and the timing of spring's arrival is crucial. This allows us to predict the sum of temperatures above +10°C for the growing season or its certain intervals, as well as the duration of the growing season.

Such empirical models have good reliability because they take into account the most important factors that determine not only the current growing conditions, but also the patterns of ontogenetic changes in plants [10].

Therefore, this approach could be used to predict the heat supply and the economic value of the postharvest period, since it is known that heat and moisture resources undergo significant annual fluctuations, while insolation resources are sufficient for plant photosynthesis in most areas. Thus, agrometeorological variables such cycle start and termination dates, sums of active and effective temperatures, and hydrothermal indices are more susceptible to study and model participation when assessing the heat supply of the post-harvest period. However, if the termination of the growing season in the post-harvest period is due to the transition of temperatures below the biological minimum, then the beginning relates to the harvesting of the previous crop. However, practical experience shows that it also depends on the current environmental conditions. Numerous studies have established that the speed of plant development is often determined by the course of the thermal regime, although the influence of moisture availability is also important. Thus, according to the results of the analysis of agrometeorological conditions during the cultivation of oil crops (sunflower, oil flax, safflower), the duration of interphase periods depended on the factors of the external environment, such as heat and moisture, while during the period of formation of generative organs, the greatest influence was found to be due to the hydrothermal coefficient [13].

The aim of the study is to assess the agroclimatic resources and forecast the heat supply of the post-harvest period of the Dry Steppe Zone of Ukraine to manage the cultivation of various groups of crops at the post-harvest sowing.

MATERIALS AND METHODS

The study was performed based on a scientific approach using monographic, analytical, comparative, and statistical methods. The source of the initial information is the results of observations of Kherson Hydrometeorological Centre. The analysis was carried out by comparing the average long-term characteristics of the agrometeorological parameters. The meteorological values for the period 1961–1990 and the current average values were determined as the base values recommended by the World Meteorological Organisation as a climatic norm.

To assess temperature conditions and thermal resources, the limits of temperature conditions under which plant life processes are possible are traditionally used – the temperature of the beginning of growth (biological minimum) and the maximum temperature. For promising post-harvest crops such as millet, sunflower, and soybean, the biological minimum is +10°C, which is the basis for the subsequent calculations.

Consequently, research on variations in the total active air temperature is useful for the implementation of post-harvest technology.

They compute the average monthly air temperature for the time by multiplying it by the number of days in a given month, and they compute the total monthly temperature for a portion of the month by multiplying the average monthly temperature by the number of days in this period.

Considering the high dependence of the growing season duration on climatic conditions, it is also important to assess growing conditions according to multi-year complex indicators, which reflect the influence of weather conditions on the production processes.

Thus, a wide range of coefficients are used to assess the aridity of a season or a certain period.

According to the studies, Ped proposed to use the general aridity index (Si), which is calculated as the difference between temperature anomalies, precipitation, and soil moisture storages [8, 9].

Arid conditions are reflected by positive values of Si, while humid conditions are characterized by negative values of the index. Since atmospheric aridity (Sa) plays the main role in the irrigated conditions, this part of the water balance is of decisive importance, which allows to be considered separately as the difference between temperature and precipitation anomalies (Eq. 1):

$$S_a = \frac{\Delta T}{\sigma_T} - \frac{\Delta R}{\sigma_R}, \qquad \text{(Eq. 1)}$$

where:

$\Delta T;\ \Delta R$ – deviation of average monthly values, respectively, of air temperature (°C) and precipitation amounts (mm); $\sigma_T;\ \sigma_R -$ root mean square deviation of mean monthly values, respectively, of air temperature (° C) and precipitation amounts (mm) [7].

Correlation and linear regression analysis were performed using common statistical methodology within the framework of MS Excel software environment [5].

RESULTS AND DISCUSSIONS

Analytical grouping of the indicators, statistical indices do not provide a complete quantitative description of the influence of individual factors on the changes in the level of heat supply during the period, which necessitated the use of the correlation-regression method (Table 1).

The correlational analysis of the degree and nature of the relationship between individual agrometeorological indicators demonstrates the presence of some peculiar characteristics. During 1945–2021, the sum of effective and active temperatures for July–October, as a potential post-harvest period, had a weak to moderate correlation with mean monthly air temperature for April and May, while an increase to a significant level was observed for June.

The interconnection for the July–September period is strong.

Higher values of the correlation coefficient in June and July–September were also recorded for 1961–1990 and 1992–2021 periods.

In our opinion, this is related to cyclical thermodynamic processes in the atmosphere and could be used in forecasting the availability of thermal resources in the post-harvest period.

Table 1. Correlation Connections Between the Mean Monthly Air Temperature and Thermal Conditions of the Post-harvest Period

Sum of the temperatures in the post-harvest period	Mean monthly air temperature, (° C)					
	IV	V	VI	VII	VIII	IX
	1945–2021					
$\sum T_{effective}$ (VII–X)	0.29	0.22	0.53	0.74	0.74	0.77
$\sum T_{active}$ (VII–X)	0.32	0.27	0.56	0.77	0.81	0.76

$\sum T_{effective}$ (assessed)	0.50	0.47	0.68	0.70	0.76	0.69
$\sum T_{active}$ (assessed)	0.45	0.41	0.58	0.60	0.65	0.62
	1961–1990					
$\sum T_{effective}$ (VII–X)	0.24	0.35	0.42	0.62	0.70	0.63
$\sum T_{active}$ (VII–X)	0.32	0.45	0.51	0.66	0.76	0.63
$\sum T_{effective}$ (assessed)	0.56	0.61	0.54	0.53	0.73	0.61
$\sum T_{active}$ (assessed)	0.46	0.45	0.40	0.43	0.60	0.59
	1992–2021					
$\sum T_{effective}$ (VII–X)	0.44	0.13	0.47	0.72	0.64	0.82
$\sum T_{active}$ (VII–X)	0.41	0.11	0.42	0.77	0.70	0.82
$\sum T_{effective}$ (assessed)	0.55	0.39	0.66	0.68	0.65	0.70
$\sum T_{active}$ (assessed)	0.47	0.35	0.60	0.60	0.51	0.59

Source: Own study.

Considering that the actual beginning of the post-harvest period is determined by the harvesting dates of the fore crop, which significantly depends on the hydrothermal conditions of June – the ripening period of winter wheat, the dates of its ripening were simulated using proven methods and the estimated sums of active and effective temperatures of the remaining period were determined accordingly [11].

The correlation coefficients were shown to have an increase in value for the months of April, May, and June and a minor reduction for the July–October period.

The correlation between the mean monthly air temperature in June and the sum of active and effective temperatures for the estimated post-harvest period in the analysed periods was R=0.40–0.60 and R=0.54–0.68, respectively.

In agrometeorology, complex indices are used to monitor conditions, assess the level of manifestation of individual processes, and forecasting.

The advantage is a more accurate and unbiased simulation of the change and impact of meteorological phenomena, leading to their wide practical application [6, 17, 19].

An analysis of the degree and nature of the relationship between the atmospheric aridity index and air temperatures indicates the presence of similar characteristics.

During the calendar period, a weak and moderate degree of correlation between the studied indices is recorded for April and May and moderate and significant for June. The greatest dependence of the formation of thermal resources on the conditions of July–September is observed (Table 2).

Table 2. Correlation Between Mean Monthly Values of Atmospheric Aridity and Thermal Conditions of the Post-harvest Period

Sum of the temperatures in the post-harvest period	Atmospheric aridity index (Sa)					
	IV	V	VI	VII	VIII	IX
	1945–2021					
$\sum T_{effective}$ (VII–X)	0.30	0.22	0.53	0.73	0.74	0.76
$\sum T_{active}$ (VII–X)	0.33	0.26	0.56	0.77	0.80	0.75
$\sum T_{effective}$ (assessed)	0.51	0.46	0.68	0.70	0.75	0.68
$\sum T_{active}$ (assessed)	0.47	0.40	0.58	0.60	0.64	0.61
	1961–1990					
$\sum T_{effective}$ (VII–X)	0.28	0.36	0.43	0.62	0.70	0.62
$\sum T_{active}$ (VII–X)	0.35	0.45	0.51	0.66	0.76	0.62
$\sum T_{effective}$ (assessed)	0.59	0.61	0.54	0.54	0.73	0.60
$\sum T_{active}$ (assessed)	0.47	0.45	0.41	0.44	0.59	0.58
	1992–2021					
$\sum T_{effective}$ (VII–X)	0.44	0.13	0.48	0.72	0.64	0.82
$\sum T_{active}$ (VII–X)	0.41	0.10	0.43	0.77	0.70	0.81
$\sum T_{effective}$ (assessed)	0.56	0.39	0.68	0.68	0.64	0.69
$\sum T_{active}$ (assessed)	0.48	0.35	0.62	0.60	0.51	0.59

Source: Own study.

As the index of atmospheric aridity (Sa) reflects the conditions of the spring-summer growing season of winter wheat, the grain ripening processes and, accordingly, the harvest period, the correlation coefficients with respect to the sum of temperatures for the period determined by the calculation method are significantly higher. However, even in this case, during the growing season of the fore crop, the values for June (R=0.41–0.68) were higher, compared to April (R=0.47–0.59) and May (R=0.39–0.61).

Such a regularity makes it possible to use the indicated June agrometeorological indices for forecasting heat supply in the post-harvest period. At the same time, in the reference period 1992–2021, a slightly closer relationship is observed. Considering the mentioned above, it was decided to choose this period as the base array.

Corresponding linear regression models were developed based on the obtained values of the parameters' vectors and the intercept terms (Table 3).

Table 3. Linear Regression Models for the Dependence of the Sum of the Air Temperatures in the Post-harvest Period on Mean Monthly Air Temperature and Atmospheric Aridity Index

Sum of the temperatures	Equation of the model	R^2	F_{act}	F_{theor}
$\sum T_{effective\ (VII–X)}$	$8{,}558+937.2a_1-353.0a_2$	0.532	5.32	0.0113
$\sum T_{active\ (VII–X)}$	$6{,}161+545.9a_1-199.1a_2$	0.454	3.50	0.0446
$\sum T_{effective\ (assessed)}$	$10{,}127+1{,}204a_1-424.8a_2$	0.700	13.0	0.0001
$\sum T_{active\ (assessed)}$	$23{,}346+2{,}611a_1-993a_2$	0.686	12.0	0.0002

Notes: a_1 – atmospheric aridity index (Sa); a_2 – mean monthly air temperature of June, ºC.
Source: Own study.

The mean monthly air temperature and the index of atmospheric aridity in June were established to be strongly related to heat supply in the post-harvest period of winter wheat. The linear regression equations are statistically significant, as F_{actual} is greater than $F_{theoretical}$ in all the models. Higher quality is a defining characteristic of the models that characterize the heat supply of the calculated post-harvest period, which also more accurately represents the conditions of the remaining growing season. Therefore, it is possible to recommend the use of such models for the forecast of heat supply in the post-harvest period to make a reasonable selection of crops and varieties for cultivation in such conditions.

The aridity index of the base array 1992–2021 was used to convert this mathematical model in accordance with the actual current values of meteorological indices, since the sum of active temperatures is primarily used to estimate thermal resources and conditions for plant growth and development. Therefore, by simplifying the equation using the following formula, the total active temperatures for the post-harvest period might be anticipated using the current air temperature and the amount of precipitation in June (Eq. 2):

$$Y = 496.458 + 93.589 \times T_{June} - 3.539 \times O_{June} \quad \text{(Eq. 2)}$$

where:
Y – sum of the active temperatures of the post-harvest period, ºC; T_{June} – mean monthly temperature in June, ºC; O_{June} – precipitation amount in June, mm.

The advantages of the latter model are its simplicity and easy access of the data required for calculations, as well as significant statistical accuracy of the obtained forecasts. Among the drawbacks, it should be noted that in some years winter wheat harvesting takes place later, which makes it somewhat difficult to determine the current mean monthly values of air temperature and precipitation.

The economic effect of the implementation of the model for forecasting the sum of active temperatures for Millet and Sunflower crops

We used the generated models to predict the total active temperatures for Odesa Agricultural Research Station conditions in 2022 and 2023. The forecasted values were just 3.8-4.3% different from the actual ones, which were further recorded in the field conditions in the intercourse of agrometeorological observations.

Based on the forecast of the sum of the active temperatures, millet varieties Vitrylo (early-ripening), Polto and Sonechko slobidske (middle-ripening), Myronivske 51 and Denvikske (moderately-late-ripening) were chosen for sowing in 2022-2023. As a result, average yield of millet was 2.81 t/ha, that is significantly better than average yield, harvested in 2021 – 2.19 t/ha (28.31% higher). Cultivation technology peculiarities in 2022-2023 remained unchanged compared to the reference year 2021, therefore, pure economic effect from millet cultivation reached additional 220 EUR/ha (in prices for millet in Ukrainian grain market dated January, 2024).

The same is true for sunflower, cultivated in 2022-2023 in the post-harvest crops. Using the developed models for meteorological forecasts, it was determined that considering the prognostic features of the season, the hybrid Kosmos and the variety Prometei should be selected for sowing, as they would fit best for the predicted temperature regime. As a result, sunflower yield averaged to 1.52 t/ha for Kosmos, and 1.49 t/ha for Prometei in the season 2022-2023, that is 16.92% and 14.62% higher than in the year 2021, respectively, under the same agrotechnological conditions [18]. The pure economic effect in this case reached additional 80 EUR/ha (in prices for sunflower seeds in Ukrainian grain market dated January, 2024) (Table 4).

Table 4. The economic effect of the application of the models to forecast the sum of the active temperatures in 2022 and 2023 for the conditions of Odesa agricultural research station- Case study Millet and Sunflower varieties

Varieties	**2022-2023**		**2021**		**Difference between 2022-2023 and 2021**		**Market price Euro/t**	**Income surplus Euro/ha**
	Sum of active temp. ºC	Yield t/ha	Sum of active temp. ºC	Yield t/ha	Sum of active temp. ºC	Yield t/ha		
Millet								
Vitrylo	2,364	2.32	1,986	1.85	378	0.47	355	166.9
Polto	2,364	2.80	1,986	2.16	378	0.64	355	227.2
Sonechko	2,364	2.54	1,986	2.10	378	0.44	355	156.2
Myronivske 51	2,364	3.10	1,986	2.29	378	0.81	355	287.6
Denvikske	2,364	3.29	1,986	2.55	378	0.74	355	262.7
Sunflower								
Kosmos	2,364	1.52	1,986	1.30	378	0.22	390	85.8
Prometei	2,364	1.49	1,986	1.30	378	0.19	390	74.1

Source: Own results.

Therefore, the developed agrometeorological models have practical value, are effective, reliable and useful tool to assist in right selection of hybrids and varieties for the post-harvest crops cultivation in the conditions of the South of Ukraine.

CONCLUSIONS

Predicting the amount of heat that will be available during the post-harvest phase is crucial for crop productivity planning and varietal composition selection. An evaluation of the agroclimatic conditions in June shows that the post-harvest phase is significantly and strongly dependent on meteorological indices and heat supply. The proposed models for the evaluation of the sum of active and effective temperatures are accurate enough to reflect the thermal conditions of the post-harvest crop growing season, cultivated after winter wheat harvesting. The implementation of this method contributes to the optimization of management decisions regarding the placement of crops and the development of the most productive ways of using natural resources under the irrigated conditions.

The application of the models allowed right choice of millet and sunflower varieties and hybrids for the post-harvest cultivation, that resulted in 15-30% yield output increase. More research should be conducted to improve the accuracy of forecasting models.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

DEVELOPMENT OF DRY-SCALE CLEANER CUM GRADER FOR STORED ONION BULBS (*ALLIUM CEPA L.*)

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Abstract

Uncleaned and ungraded onions stored in sacks command low prices, a significant share of farmers' income. Manual cleaning and grading of stored onions are labor intensive, tedious, and provide inconsistent results. This study sought to develop a dry-scale cleaner cum grader for stored onion bulbs to simplify operations, reduce labor costs, minimize operation losses, and generate more income for the onion farmers. The design of the machine parts was computed based on the onions' average physical (shape, size, surface area, density, colour, and weight) and mechanical (hardness, compressive strength, impact, and shear resistance) properties. The study used locally available materials to fabricate the machine and conducted a preliminary performance test to ensure functionality and optimum machine speed settings. Based on the results, machine cleaning and grading speed of 71 rpm and 17 rpm can remove dry scales and grade them according to standard sizes at a rate of 493 kg/hr at 73 % efficiency. The machine reduced manual labor utilization from 3 man-day/100kg to 0.08 man-machine-day/100kg. Mechanical damage (2%), including slight bruises in the bulbs, and the noise level (82 dB) were lower than the maximum threshold of 3% and 92 db. The machine costs ₱125,000 with an operating cost of ₱40/100kg and power consumption of 14.41W-hr. It can break even after cleaning and grading 33,263 kg of stored onion bulbs at a custom rate of ₱1/kg per year. The study successfully developed the onion cleaning cum grading machine suggesting group ownership for utilization.

Key words: *cleaning, grading, machine, stored onion bulbs, performance*

INTRODUCTION

Onion (*Allium cepa* L.), locally known as "sibuyas" in the Philippines, is a beneficial and widespread vegetable crop grown primarily for its pungent bulbs and flavorful leaves. It is among the 15 most commonly grown vegetables worldwide [11]. Primarily, its application is to spice up meat, salads, and vegetable dishes and address various health concerns such as poor appetite, atherosclerosis prevention, and the treatment of cough, obesity, insomnia, hemorrhoids, and constipation.

In the Philippines, onion was among the top five vegetables and the most significant contributor to domestic vegetable earnings of Php5.5 B in 2017. There are two major types of onion locally grown, "Red Creole" and "Yellow Granex." It has a total production of 184.43 thousand metric tons, which was higher by 50.4% than its total production in 2016. Its increase is due to the expansion in area by 5,271.07 hectares from 2016 to 2017. Central Luzon leads among the onion-producing areas, followed by Ilocos and MIMAROPA region [18]. Onion farming has been one of the major sources of livelihood and income among Filipino farmers, especially in Luzon. However, due to the lack of local supply, farmers have difficulty competing with imported onions [5]. It resulted in fluctuation in the supply and its prices in the market. In addition, onion is only a one-season crop and must be available year-round [8]. As a conventional practice, farmers and traders stored their harvest to prolong its shelf-life.

Curing is significant if onions are to be stored [4]. It involves some polymerization of substance present in the scales to allow natural dormancy to develop, resulting in the development of the darker color, dry shrunken neck, and dry outer scales of the onion skin [7]. Before farmers sell onions in the market, excess scales due to curing are removed or cleaned to increase their marketability. This process is tedious in which farmers manually clean the onion bulbs individually.

Grading especially based on size and quality, is another tedious job. It is an essential primary processing operation to market fruits and vegetables successfully. However, farmers in Nueva Ecija sell their produce by sacks and are not graded due to the timeliness and inconsistency of the operation [6]. This practice takes away a significant share of their income.

Hence, there is a need to develop an onion cleaner with a size grader that can simplify and hasten the onion postharvest operation. Cleaning and grading onion bulbs mechanically can also help improve the quality, add value, and reduce the operation cost, thus, generating better livelihood opportunities for onion farmers.

MATERIALS AND METHODS

This section involves the machine components' conceptualization, analysis, and calculations. The mechanical and physical properties of onion bulbs from literature, standards, and specifications were used to serve as bases in choosing the materials and their sizes. Computer-Aided Design (CAD) software provided an output for technical drawing and 3D simulation of the designed frame.

Design considerations

The onion dry-scale cleaning cum grading machine was designed based on the following considerations: (a) should be electric motor-driven and made from locally available materials; (b) the hopper should have a maximum loading capacity of 25kg; (c) should be able to clean the onion bulb by removing and separating only the cracked and partially sloughed dry scales from the onion bulb and maintaining a least one layer of intact dry scale; (d) the machine should grade red onion bulbs into small (15 to 30 mm), medium (31 to 50 mm), and large (51 to 80 mm); (e) the machine should obtain a minimum machine capacity and efficiency of 300kg/hr and 70%, respectively; (f) the machine should only exhibit a maximum mechanical damage (e.g., scratched, sliced, or bruised) of 3%; (g) the machine should not produce noise of more than 92db; (h) can be lifted and moved by a maximum of three (3) physically fit laborers; (i) the machine can be operated by a maximum of three (3) laborers (e.g., one person assigned for loading and the others for bagging); and, (j) the break-even weight of the machine should be less than the capacity per year of the storage facility to ensure ownership.

Design of machine's major parts and principle of operation

The conceptualized machine comprised five (5) major components: hopper, cleaning unit, grading unit, frame, and transmission assembly. It has an overall dimension of 1.78m x 0.8m x 1.25m (L x W x H) (Fig. 1).

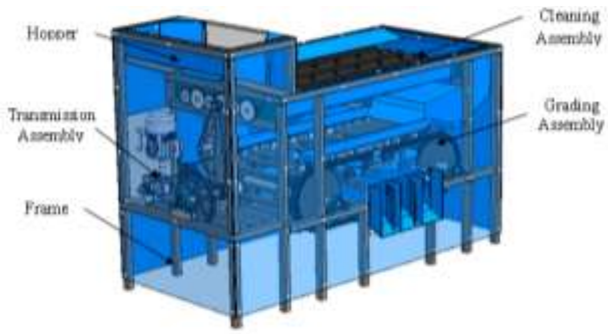

Fig. 1. Conceptualized design of the machine
Source: Own conception.

The onion cleaning cum grading machine was designed to be operated by three persons. The operator would first turn on the electric motor's push button switch to operate the machine. The electric motor's power requirement was calculated based on the weight, diameter and speed for cleaning and grading as in the equation below [12]:

$P = F \times D/2 \times 2\pi N/60$.................................(1)

where:
P = power, W
F = weight, N
D = diameter, m
N = speed, rpm

The loading of the uncleaned and ungraded onion bulbs take place in the hopper positioned at the upper part of the cleaning unit. It also holds and regulates the feeding to the cleaning assembly (Fig. 2). The cross-sectional shape of the hopper was rectangular. It was made from 1.5mm galvanized iron sheet metal. It was attached to the frame using rivets. The side slope was based on the angle of repose of the unclean onion bulb. The total holding capacity of the hopper was computed using:

$H_C = \gamma_O \times V_H$..(2)

where:
H_C = holding capacity of the hopper, kg
γ_O = bulk density of onion bulb (kg/m^3)
V_H = volume of the hopper, m^3

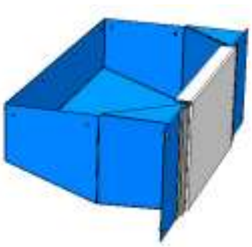

Fig. 2. Conceptualized hopper of the machine
Source: Original.

The cleaning assembly was composed of six (6) rollers. Three (3) were coated with rubber and were screwed with V-belts. They were arranged alternately with the other three (3) plain rollers made from Polyvinyl Chloride (PVC) pipes. Each end was attached to a fabricated housing for bearings with a center-to-center distance of 85 mm. The conveying capacity (kg/hr) was determined using the following formula: [1]

$$C_C = \frac{\pi}{4}(D^2 - d^2) \times p \times (N \times \epsilon_v \times 3600/60) \times \rho_b$$ ....(3)

where:
D = screw diameter, m
d = plane rubber diameter, m
p = pitch of the screw, m
ϵ_v = volumetric efficiency, decimal
A belt and pulley were used to transmit the power from the source to the middle right shaft of the cleaning assembly.
To meet the intended peripheral speed of the rotating components, the pulley diameter was calculated using [20].

$n_S D_S = n_L D_L$..(4)

where:
n_S = speed of small pulley, rpm
D_S = diameter of small pulley, inch
n_L = speed of large pulley, rpm
D_L = diameter of large pulley, inch
The length of belt and the speed ratio of the drive were calculated using:

$$L = 2c + \pi/2\,(D_2 + D_1) + (D_2 - D_1)^2/4C$$ ......
....(5)

where:
L = length of the belt, inch
C = distance between centre of pulleys, inch
Speed ratio= n_S/n_L
Spur gear transmission was used to incorporate counter rotations of the roller. The desired center distance given the module and speed ratio was computed using:

$C = M\,(t_1 + t_2)/2$...(6)

where:

C = centre distance, mm
M = module
t_1 = teeth of the driver gear
t_2 = teeth of the driven gear
The bulbs were cleaned by the counter-revolution of the plain and screwed rollers, and the slough-off dry scales were separated and fell straight to the scale outlet. The cleaning operation also permits manual inspection and selection of rotten onions. On the other hand, the cleaned bulb traveled straight to roller length with the help of the screwed rollers (Fig. 3).
The bulbs were pushed to the end and entered the grading assembly.

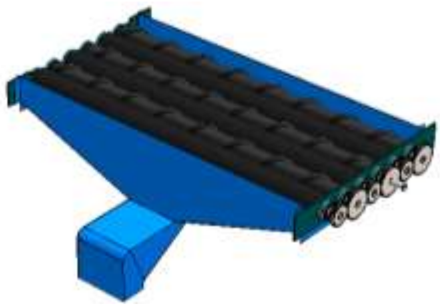

Fig. 3. Cleaning assembly of the machine
Source: Original.

The grading assembly comprised forty (40)

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Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

rollers connected at a high-pitched continuous chain link (Fig. 4). The length of the chain was computed using:

$L_P = 2(C/P) + (N + n)/2 + (N\text{-}n/2\pi)^2 \times (P/C)$ ....(7)

where:
L_P = length of chain, pitches, mm
N = number of teeth of teeth of the large sprocket
n = number of teeth of the small sprocket
C = centre to centre distance, mm
P = pitch of the chain, mm
To suit the length of the chain, the centre distance for a given length was determined by using:

$C = \frac{P}{8} = \left[2L_P - N - n + \sqrt{(2L_P - N - n)^2 - 0.810(N - n)^2}\right]$ ....(8)

where:
C = center to center distance, mm
P = pitch of the chain, mm
Twenty (20) roller shafts, arranged alternately, were attached and rotated along with the chains. The other twenty were provided with slot mechanisms to permit a downward movement. The formula for the law of cosine and trigonometric functions was used to calculate the height of the downward movement. Both ends of the roller shafts were incorporated with small-sized wheels.
Large-sized sprockets were utilized to drive the grading rollers with a shaft driven by a belt and pulley. All shaft diameter was selected on the basis of strength and subjected to fluctuating combined twisting and bending moments and computed using equivalent twisting moment [12]. The material for shafting was AISI 1020 -Cold rolled steel [17]. Sizes were computed using the following formulas:

$T_e = \sqrt{(K_M M)^2 + (K_T T)^2}$............................(9)
$T_e = \pi/16\ \tau d^3$...(10)

where:
T_e = equivalent twisting moment, N-mm
M = maximum bending moment, N-mm
T = maximum twisting moment, N-mm
K_M = combined shock and fatigue factor for bending
K_T = combine shock and fatigue factor for torsion
τ = maximum permissible shear stress, MPa
d = diameter of the shaft, mm

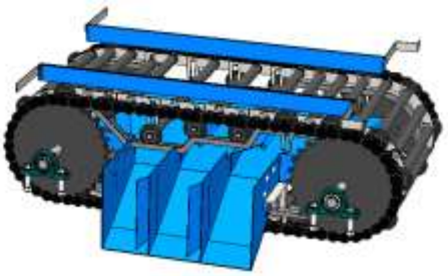

Fig. 4. Machine's grading assembly design
Source: Original.

Roller shafts was designed to follow a downward path to allow expansion of the gaps between rollers. The height of the downward movement of the roller corresponded to the hypotenuse gaps between the rollers following the onion grades. The grading length was divided into three sections of onion grades (small: 15 to 30mm; medium: 31 to 50mm, and large: 51 to 80mm) and was provided with a separate outlet. The belt and pulley were used to transmit the power from the driver to the grading assembly, and the bevel gear was used to change the power source's rotation orientation. The pitch angle of the driver bevel gear (γ) was computed using:

$\gamma = \tan^{-1}(t_1/t_2)$......................................(11)

The frame is the primary holder of the entire load during the working condition. It was made of a 40 mm square tube. It was designed to withstand the stresses and working loads during the operation.

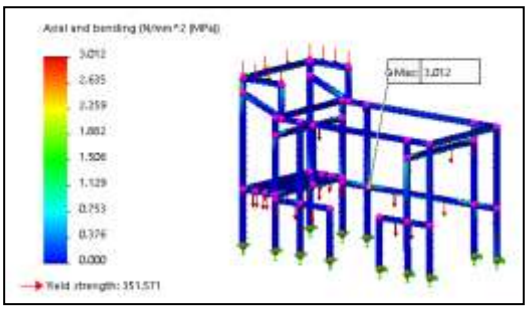

Fig. 5. Results of the frame equivalent stress analysis
Source: Original.

The stress analysis on the machine's frame, in Fig. 5, reveals a maximum stress of 3.01MPa upon applying the forces. This result is lesser than the yield strength of the material, which is 351.57MPa. This result clarifies that the frame can withstand all the loads applied during the operation. On the other hand, the simulation analysis for resultant displacement in Fig. 6 shows a maximum value of 0.035mm. This result proves that applying the forces can cause negligible change or deformation in the frame's shape.

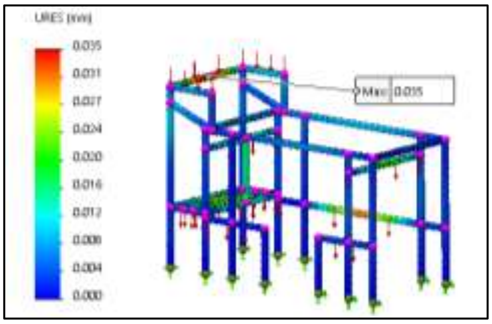

Fig. 6. Results of the resultant displacement analysis
Source: Original.

Fabrication

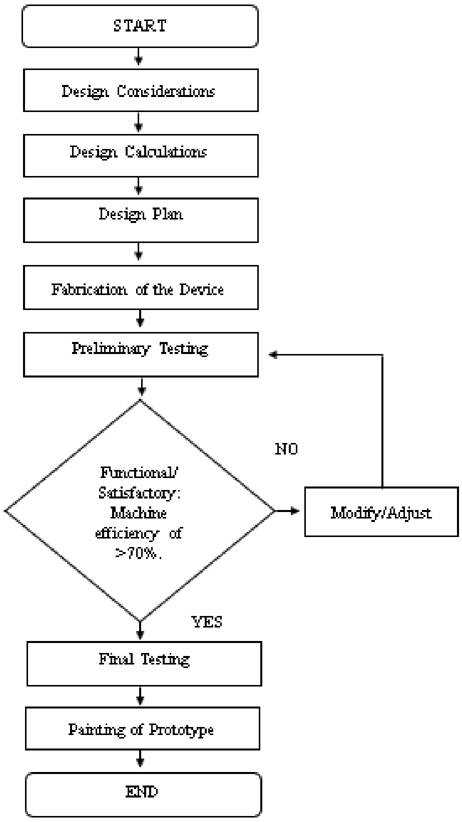

Fig. 7. Flow chart of activities for the development process
Source: Original.

The machine was fabricated from April to August 2020 at San Rafael Village, Navotas City, Philippines at the midst of the COVID19 pandemic. The process flow chart in Fig. 7 presents the different processes done during machine fabrication. The machine undergoes preliminary testing and modifications or adjustments on different components until machine efficiency reaches ≥70%. Finally, the machine was tested to evaluate its performance.

Performance evaluation

The machine was tested to determine its performance based on the parameters such as capacity, efficiency, mechanically damaged bulbs, noise level, and power consumption. Machine performance was evaluated based on three levels of speed combination as treatment in the cleaning and grading assembly and was replicated three (3) times. The performance evaluation was set up according to the Completely Randomized Design (CRD). Samples used were uncleaned and ungraded onion bulbs with visible loose dry scales due to curing and storing. The sample for each replication comprised ten kilograms (10kg) and was randomly assigned among treatments considering that no rotten bulbs were included. Raw data were collected during each trial, such as initial weight, operating time, impurities left and removed, weight in each outlet chute, correct and correctly graded weight, the weight of mechanical damage, power consumption, and noise emitted. Lastly, statistical tests using the Analysis of Variance (ANOVA) and Post-Hoc test using Tukey's Honestly Significant Difference (HSD) were used to indicate statistical significance among treatments and to determine which speed combination is the best.

Capacity: It is the weight of the cleaned and graded onion bulbs received at the outlet per unit time of executing each operation. It is expressed in kilograms per hour (kg/hr). The capacity was calculated using the following formula [16]:

$$\text{Capacity} = \frac{\text{initial weight (kg)}}{\text{total duration of test (sec)}} \quad .....(12)$$

Efficiency: Machine efficiency is the product between cleaning and grading efficiencies [13]. Cleaning efficiency is the ratio of the weight of the impurities left in the bulb (e.g., dry scales, roots, etc.) during cleaning to the sum of the weight of the scales left and the weight of scales removed by the machine expressed in Percent (%). The weight of impurities removed by the machine is the difference between the initial and the weight after cleaning the test material. It was calculated using the following formula [3]:

$$\text{Cleaning Efficiency} = \frac{\text{weight of impurities left in the bulb}}{\text{weight removed+weight left}} \times 100 \quad \text{.........(13)}$$

Grading efficiency, on the other hand, refers to the ratio of the weight of a product of a particular grade to the total weight of the graded material expressed in percent. During the test, a one-kilogram sample was collected randomly on each chute, and each size was evaluated using a veneer caliper. Grading efficiency was calculated using the following formula:

$$\text{Grading efficiency} = (\text{eff}_s \text{ x } \text{eff}_m \text{x } \text{eff}_l) \text{ x } 100 \quad \text{.........(14)}$$

$$\text{eff}_n = \frac{\text{weight of correctly grade bulb (kg)}}{\text{total weight of sample (kg)}} \quad \text{.........(15)}$$

where: eff_n = eff_s or eff_m or eff_l
eff_s = efficiency for small grade, decimal
eff_m= efficiency for medium grade, decimal
eff_l= efficiency for large grade, decimal

Percent mechanical damage **:** It is the ratio of the damaged material to the total material after the operation expressed in percent [16]. Mechanically damaged onion bulb refers to the scratched, sliced, or bruised bulbs after the operation. Acceptable maximum mechanical damage is 3.5% [15]. It was calculated using:

$$\%\text{ mechanical damage} = \frac{\text{weight of damage bulbs}}{\text{weight of the sample}} \times 100 \quad \text{.........(16)}$$

Power consumption**:** It is the amount of power that the electric motor consumes during every test trial, expressed in watts-hour (W-hr). It was determined using a digital power meter.

Noise level**:** The noise emitted by the machine was measured using a digital noise level meter at the location of the feeder, and bagger express in decibels. The noise was taken approximately 50 mm away from the ear level of the operators [16]. Acceptable maximum noise level of a machine is of 92db [15].

Cost analysis**:** The economic performance of the machine was calculated based on annual cost, fixed costs, variable costs, unit cost of operation, break-even cost, and payback period. Fixed costs include depreciation, interest on investment, property tax, insurance, and shelter/housing. Variable costs are the cost of labor, repair, and maintenance per hundred (100) hours of use. On the other hand, the break-even and payback period determines when the total benefit compensates for the total costs.

RESULTS AND DISCUSSIONS

Machine Description

The machine comprised five major components: a hopper, cleaning unit, grading unit, frame, and transmission assembly powered by a 0.5hp electric motor. The loading of the uncleaned and ungraded onion bulbs takes place in the hopper. The cleaning unit, composed of six rollers, removes excess dry scales and remains one to two dry scales. Each roller rotates in the opposite direction using spur gears. After cleaning, onions are conveyed to the roller-type grading assembly for size grading.

Photo 1. Dry-scale cleaner cum grader for stored onions
Source: Original.

Performance of the Machine

Statistically, the machine performance was affected significantly by speed in terms of cleaning capacity, grading capacity, overall capacity, and power consumption at a 1% confidence level. Results show that in terms of cleaning capacity, grading capacity, and

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

overall capacity, speed in T3 was significantly higher among T1 and T2. In contrast, T1 and T2 were not significantly different. On the other hand, power consumption reveals that T3 was significantly lower than T1 and T2. The mean power consumption when using a speed combination of T1 and T2 was not significantly different. This provides sufficient evidence that speed variation has a significant effect on the performance of the machine. This further means that there is a significant increase in the machine's cleaning capacity, grading capacity, and overall capacity if the speed is increased [9, 2, 19], and power consumption if otherwise. Similarly, the means of the percent mechanical damage as influenced by different speed variations showed a significant difference at a 5% confidence level. Results show that the speed combination of T1 was significantly lower than T3. On the other hand, the means between T1 and T2 and between T2 and T3 were not significantly different. These results provide sufficient evidence that the increase in speed is directly proportional to mechanically damaged bulbs [10, 14].

Furthermore, regarding cleaning efficiency, grading efficiency, overall efficiency, and noise level, no significant difference was observed in the speed variations in the machine's performance. These results clarify that speed variation does not significantly affect the performance of the machine in terms of efficiency and noise level [9,10].

Overall test results revealed that satisfactory machine performance was expected when the speed combination was 71rpm and 17rpm (Table 1). It is based on the machine considerations and the Philippine Agricultural Engineering Standard (PAES).

Table 1. Machine performance as influenced by different speed variations

Machine Parameters	T1, rpm 53 & 13	T2, rpm 61 & 15	T3, rpm 71 &17
Cleaning capacity, kg/hr	427.52 b	458.83 b	535.28 a
Grading capacity, kg/hr	458.86 b	489.16 b	556.53 a
Overall capacity, kg/hr	401.72 b	430.08 b	493.30 a
Cleaning efficiency, %	80.84	87.16	88.50
Grading efficiency, %	87.46	85.79	82.20
Overall efficiency, %	70.70	74.77	72.75
Mechanical damage, %	1.23 b	1.60 ab	2.09 a
Noise level, dB	78.87	80.96	82.51
Power consumption, W-hr	17.17 a	16.2 a	14.41 b

Means with the same letter are not significantly different
Source: Original.

The total cost of fabricating the machine was ₱125, 000.00. The machine's unit cost was ₱196.22/hr or ₱40/100kg (Fig. 8).

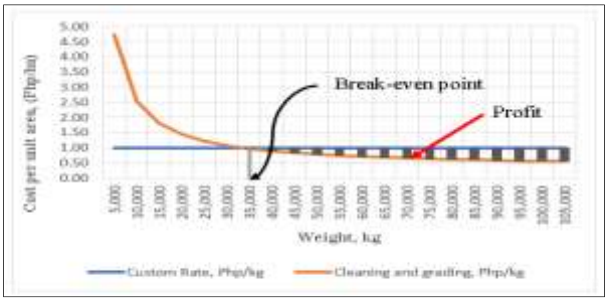

Fig. 8. Cost curve of using the machine
Source: Original.

As shown in Fig. 8, the machine needs to clean and grade 33,263kg to break even all the costs in 1 year at a custom rate of ₱1/kg to consider ownership; otherwise, it is expensive to use. Furthermore, using the machine requires 3 persons as operators, which lessens the utilization of manual labor from 3 man-day/100kg to 0.08 man-machine-day/100kg.

CONCLUSIONS

The results of the study led to the following conclusions:

- A dry-scale cleaner cum grader for stored red onion bulbs was successfully developed based on the considerations and was fabricated using locally available materials;
- The machine showed satisfactory performance in cleaning capacity, grading capacity, overall capacity, cleaning efficiency, grading efficiency, overall efficiency, percent mechanical damage, power consumption, and noise level when set up to 71rpm in cleaning and 17rpm in grading; and,
- The machine should be owned by a group of farmers or farmer's cooperatives. Although individual ownership may also be considered, it should be subjected to custom service.

ACKNOWLEDGEMENTS

The researcher wants to express his sincere gratitude to his adviser Emmanuel V. Sicat, Ph. D, for his support and guidance that leads to the completion of this study. Also, to the Department of Science and Technology-Engineering Research and Development for

Technology, Philippines for the scholarship granted to the researcher.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

IMPLEMENTATION OF SUBPROGRAMS OF THE FEDERAL SCIENTIFIC AND TECHNICAL PROGRAM FOR THE 2030 DEVELOPMENT OF AGRICULTURAL ECONOMY IN RUSSIA

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Abstract

Increasing the efficiency of agricultural production and the need to ensure the technological sovereignty of the country in the current geopolitical conditions is of particular relevance. The purpose of the work is to study the impact of the implementation of subprograms of the Federal Scientific and Technical Program for the Development of Agriculture for 2017–2030 on technological changes in agricultural production of individual subsectors. As a result of the analysis of the effectiveness of the implementation of the subprograms of the Federal Scientific and Technical Progress of Russia for 2018-2022, trends in significant positive scientific and technological achievements in the production of sugar beets, potatoes, beef cattle breeding and feed production were identified. expansion of the domestic research base in the field of genetics, biotechnology, selection and breeding. Promising directions for the development of agricultural sectors for the long term have been developed, taking into account the implementation of the FNTP for the development of Russian agriculture. Various business models have been substantiated and mechanisms for stimulating the introduction of technologies have been created, taking into account the specific features of innovation processes in various industries.

Key words: *state support, FNTP, agriculture, neo-industrial development, indicators, subprograms, industry regulation, efficiency*

INTRODUCTION

Scientific and technological development of the Russian agro-industrial complex using innovative solutions and developments of domestic science are the most important conditions for achieving technological independence [24, 25]. In Russian agricultural production, digital technologies, artificial intelligence and big data processing systems are widely used, and innovative projects are being implemented in the field of precision farming and smart agriculture. In the mechanical engineering industry for the food and processing industries, the share of domestic machinery and equipment increased from 12% in 2014 to 49% in 2021. Exports of mechanical engineering products for the food industry in 2018-2021 increase annually by an average of 10%. New models of tractors and combines have built-in systems for monitoring and forecasting the condition of farmland. Innovative technologies for cultivating potatoes, beets, and flax are being actively introduced [20].

The Federal Scientific and Technical Program for the Development of Agriculture (FSTP) is the leading instrument of state support for Russian agriculture. With the help of this program, the Doctrine of Food Security is being implemented. Combining the financial resources of the state and business based on co-financing of specific projects with active interaction with scientific organizations will make it possible to successfully solve the problems of the Federal Scientific and Technical Commission and significantly increase the innovation and investment potential of agricultural production. An effective mechanism for stimulating the creation or modernization of new industrial production is a special investment contract [5, 34].

The developed FSTP subprograms for specific areas of agricultural activity include activities for personnel training and scientific support. A special role in the development of agricultural production based on the introduction of effective innovative solutions is assigned to domestic science.

Research and production cooperation has a significant role to play as an effective form of innovative entrepreneurship, aimed at creating high-tech products, introducing and disseminating the results of scientific and intellectual activity and innovative products [33].

Theoretical and methodological approaches to the development of agriculture in the conditions of neo-industrialization are associated with the convergence of information resources, biotechnologies, nanotechnologies, as well as modern transport and logistics systems [27].

So, T.C. Devezas substantiated the evolutionary theory of technological change, the followers of which are scientists from the world scientific community. The issue of recognizing universal Darwinism as a theoretical basis for the analysis and evolutionary programming of technological transformations of socio-economic systems continues to remain controversial. In particular, the diffusion of technologies is proposed to be considered as a natural law, reflecting the constant transformation of innovative technologies, products and markets. The proposed scientific paradigm of biosocioeconomics is based on the convergence of various scientific fields, for example, information and molecular technologies [6].

A significant number of foreign publications are focused on the problem of studying the conditions for the introduction of digital technologies and innovations in agribusiness [2, 15].

Technological innovations of agricultural enterprises are considered as the most important prerequisite for the dynamic development of China's agricultural sector [36], and the industrialization process has a multiplying effect in the development and implementation of fundamentally new technologies [18, 23].

The theory of endogenous growth identifies technological innovation as the most important factor in the formation of competitive advantages [38,39].

The positive role of state support in enhancing innovation activity and creating a favorable innovation and investment image of agricultural enterprises to attract new stakeholders has been reflected in a number of studies by Chinese scientists [40, 41, 42].

In development of this topic, Li, L., Gao, Y., & Wang made relevant conclusions based on the results of a study of the totality of agricultural enterprises in China in 2007-2021. The impact of government support for technological innovation is greater for state-owned agricultural enterprises than for private businesses [35]. The multiplier effect of subsidies is more typical for agricultural business organizations than for manufacturing enterprises. The authors' recommendations for Chinese agriculture boil down to adhering to the principle of targeting and supporting specific projects or individual enterprises; flexibility of economic policy in order to strengthen the innovative susceptibility of agricultural enterprises [16].

Taking into account the above, the assessment of technological transformations of agricultural production in Russia is characterized by high practical significance, since the scientific and technological support activities for the declared projects implemented within the framework of the Federal Scientific and Technical Commission characterize the qualitative level of economic policy and can be changed in accordance with the objectives of innovative development.

The purpose of the work is to study the impact of the implementation of subprograms of the Federal Scientific and Technical Program for the Development of Agriculture for 2017–2030 on technological changes in agricultural production of individual subsectors.

MATERIALS AND METHODS

The methodological basis of the study is regulatory documents, acts and resolutions in the field of agricultural development, as well as documents in the field of development of innovations and investments at the federal and regional levels, information from the Ministry of Agriculture of the Russian Federation and Rosstat on the results of production activities of agricultural sectors.

Based on the use of information data from such subprograms as the production of sugar beets, potatoes, beef cattle breeding and feed production, an analysis of the effectiveness of these subprograms was carried out, directions and mechanisms for stimulating the introduction of innovations in the agricultural sector were determined.

RESULTS AND DISCUSSIONS

Federal scientific and technical program for the development of agriculture for 2017-2030based on fundamental technological transformations and wider use of new domestic technologies. In addition to the program in 2018-2021. subprograms have been developed for specific types of activities with the aim of achieving technological sovereignty and strengthening food security, the validity of which has also been extended until 2030 [22].

In 2018, the subprogram “Development of selection and seed production of sugar beets in the Russian Federation” and the subprogram “Development of selection and seed production of potatoes in the Russian Federation” were adopted.

Table 1 presents the main indicators of the FSTP subprogram for sugar beets. According to the analysis, a paradox was revealed, despite the leading values in terms of sugar beet production in Russia, its yield indicators remain insufficiently high compared to other countries.

Table 1. Indicators of FSTP subprograms for potatoes and sugar beets (2025)

Name ofindicators	Potato	Sugarbeet
Level of innovative activity of breeding and seed production organizations, %	50	25
Investments in selection and seed production, billion rubles.	8.1	2.4
Level of provision of breeding and seed production organizations with innovative infrastructure facilities, %	25	40
Number of new domestic hybrids (varieties) used in production	12	8
The share of seeds produced within the framework of domestic breeding subprograms,%	25	20

Source: Own calculations based on the data from [28,30].

The results of the implementation of the subprogram “Development of selection and seed production of sugar beets in the Russian Federation” show the positive effect of the contribution of the development of scientific support to the results of production activities.

13 new technologies were developed for selection, seed production, storage and processing of sugar beets, and over 30 new sugar beet hybrids were created. Import substitution of selection achievements was actively carried out: the share of produced seeds of domestically selected hybrids in the total volume of domestic consumption exceeded 8%; the share of organizations using domestically selected sugar beet hybrid seeds was 17 % [30].

The sugar beet subprogram is being implemented in the Voronezh and Oryol regions, as well as the Krasnodar Territory. In 2023, the gross harvest of sugar beets in Russia increased by 8.6% compared to 2022; in Voronezh - by 10.5%; Orlovskaya - by 18.4percent. The increase in production volumes was achieved both due to the expansion of sown areas and as a result of increased yields through the creation of new sugar beet hybrids. According to the Ministry of Agriculture, the area sown with sugar beets in 2023 increased by 1.6% compared to the previous year and reached over 1,063 thousand hectares. In 2022-2023 the yield in Russia as a whole increased by 3.7% and amounted to 504.7 c/ha [3].

In the Progress agricultural company in the Krasnodar Territory, which uses domestic breeding achievements, the sugar beet yield is 780-800 c/ha [19].

According to experts, increasing the yield of the final product to 10-12 tons of sugar per hectare will require increasing the yield of sugar beets to 800-1,000 centners per hectare, which will allow reaching the level of Germany and France [11].

Fig. 1 reflects production and yield of sugar beet in Russia compared to other producing countries.

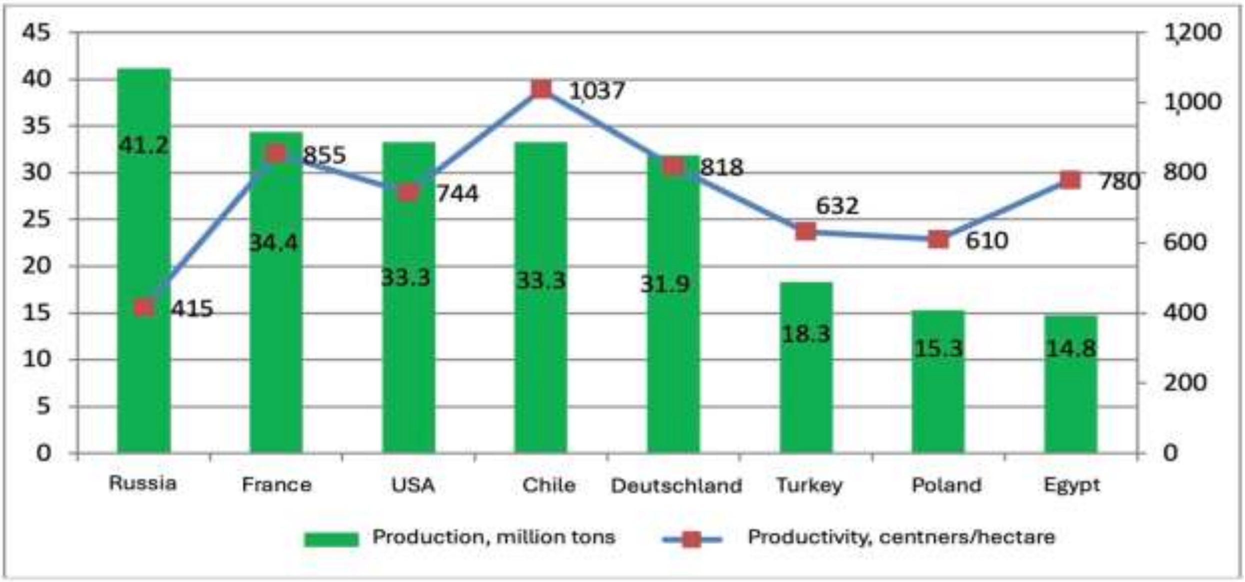

Fig. 1. Cross-country comparisons of sugar beet production and yield (2021)
Source: Own calculations based on data from [26].

The imposed sanctions restrictions have significantly complicated the import of necessary resources and the export of granulated beet pulp to the markets of European countries. It is necessary to build new terminals for the transportation of raw sugar and by-products of sugar beet processing.

Solving the problem of achieving technological sovereignty in the production of sugar from our own raw materials actualizes the task of further developments in the field of sugar beet breeding, since the supply of domestic seeds, according to experts, ranges from 1.8% to 3%. Positive results have already been achieved in the regions participating in the implementation of the subprogram. For example, in the Krasnodar Territory in 2024 it is planned to sow almost half of the sown areas with domestic seeds; in Voronezhskaya - about 16 percent of the allocated area.

Russian breeders receive government support in the form of financing and preferential lending. In 2024, the share of state subsidies for investments in the construction of selection and seed production centers will increase from 20% to 50%.

In order to stimulate demand for seeds produced during the implementation of the Federal Scientific and Technical Program, it is expected to reimburse from 50 to 70% of the costs of their purchase.

According to the expert opinion of agricultural scientists, to stimulate the introduction of innovation, grant support is needed for the creation of new varieties, placing a state order for the production of seeds, as well as subsidizing funds for the development of the material and technical base of agriculture, improving the institutional framework for protecting the rights of domestic breeders, state support at the stage of refinement, promotion, logistics and storage of seeds[12].

The Potatoes subprogram of the FNTP is aimed at increasing production volumes and creating new competitive varieties. Currently, comprehensive scientific and technical programs are being implemented in 19 Russian regions on the basis of scientific organizations at the regional and industry level, as well as selection and seed production centers.

As a result of the implementation of the subprogram, about 40 new potato varieties were created and over 36 thousand tons of elite seeds were obtained. As a result, the share of produced elite seed potatoes amounted to 18% of total domestic consumption [28].

In terms of production volumes, Russia is among the top five largest countries, although crop yields are 2-3 times lower compared to countries such as Belgium, Germany, Denmark, Spain, the Netherlands, and Norway. One of the objectives of the subprogram is to reduce the volume of imports of both food and seed potatoes. In 2018-2022 Imports of ware potatoes ranged from 300 thousand tons to 570 thousand tons [17].

In 2023, the gross potato harvest in farms of all categories was equal to 20.1 million tons, an increase of 6.6% compared to 2022. In certain regions of the FNTP subprogram, the growth rates of both production volumes and yields were significantly higher than all-Russian indicators (Fig. 2).

Important priorities for ensuring the country's food security are the creation of a domestic system for growing seed potatoes and technological re-equipment of the production process. In 2022, imports of seed potatoes decreased by 24.4% compared to 2018 [32].

The introduction of new competitive potato varieties will improve its taste and increase processing volumes. As a result of the subprogram, 5% of new varieties are dietary, and about 10% of the total number of created varieties is intended for processing [37].

There is positive experience in expanding the potato product chain based on the formation of mutually beneficial contractual relationships between production and processing. For example, the Tambov Farms company grows industrial potatoes intended for the production of chips. In 2023, investment projects for potato processing were implemented in the Lipetsk, Novosibirsk, and Oryol regions. Further development of processing will be determined by the availability of effective measures to support investors [17].

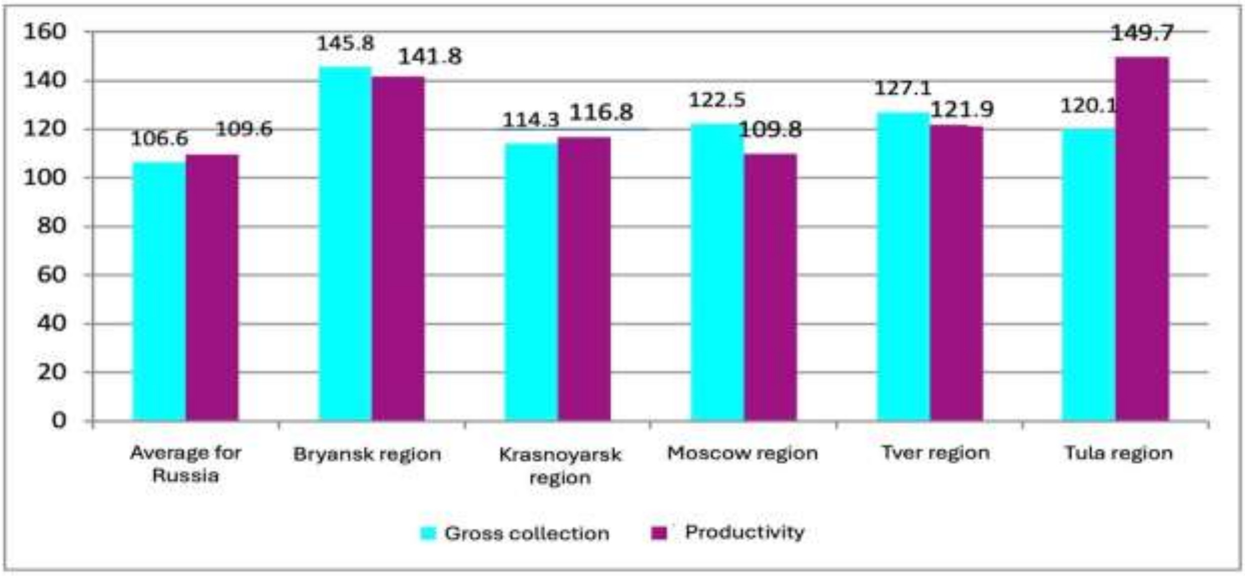

Fig. 2. Indices of physical volume of gross value added by economic sectors, %
Source: Own calculations based on the data from [3].

Foreign experience of European countries confirms the effectiveness of interfarmer cooperation in the production of seed and food potatoes [1].

The development of livestock farming is largely determined by the action of the subprograms of the Federal Scientific and Technical Commission for the development of meat and dairy cattle breeding, broiler poultry farming and feed production. According to official statistics for 2018-2022. the share of livestock breeding organizations carrying out technological innovations increased from 4.7% to 10.8%; the volume of newly introduced or technologically improved innovative goods, works, and services has increased more than 4 times. Figure 3 shows the dynamics of newly introduced innovative products per head of various types of livestock.

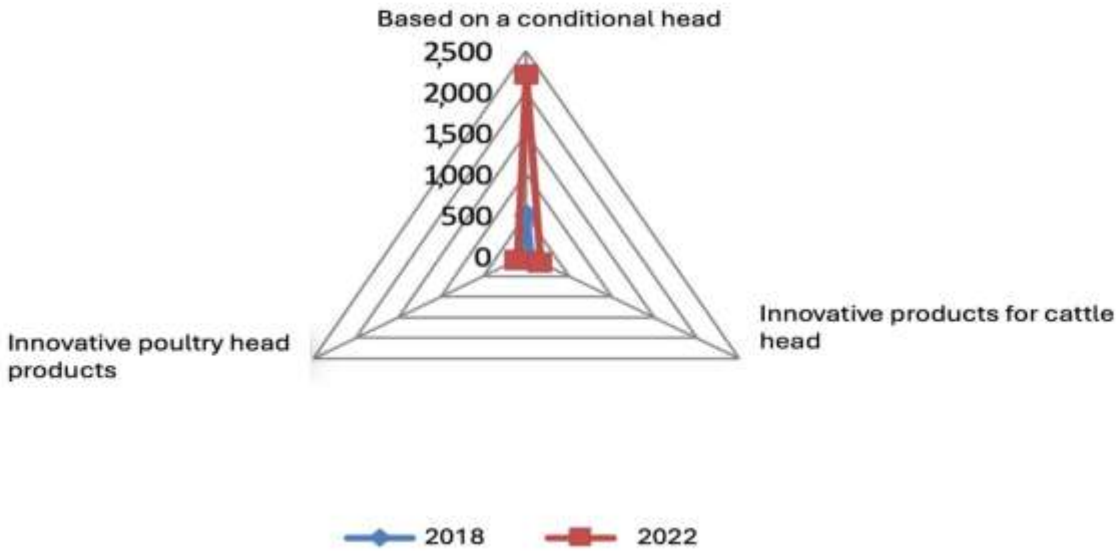

Fig. 3. Dynamics of newly introduced innovative products per head of various types of livestock, rub.
Source: Own calculations based on the data from [9].

In the livestock industry, the cost of introduced innovative products per head of livestock has increased more than 4 times over the past 5 years and amounted to 2,200 rubles, per head of cattle - 166 rubles, showing an increase of up to three times the size, per head of poultry the cost of production amounted to 103 rubles, there was an increase of about 20 percent.

The subprogram "Increasing the genetic potential of beef cattle" was included in the FNTP in 2021, within the framework of which 10 technologies will be created in the field of genetics, biotechnology, selection and breeding work for the development of the domestic breeding base of beef cattle.. The main financing tools are infrastructure development, subsidies, funding of scientific research. These measures are aimed at improving the structure of the livestock population and increasing the production and economic indicators of beef cattle breeding [31].

In the world market, more than half of the total beef production is provided by beef cattle. In terms of the share of beef cattle, countries such as Australia (more than 90%), Canada (over 80%), and the USA (about 80%) dominate. According to experts, the share of beef cattle in Russia is 15%, and the number of beef cows is estimated at 1.2 million heads. About 30% of beef is produced in the country's beef cattle industry, and over 400 thousand tons of beef are imported annually. To achieve self-sufficiency in beef, the cattle population for meat production must increase 2.5-3 times [13].

An important reserve for the development of beef cattle breeding in Russia is the presence of unused agricultural land. According to the National Meat Association, in 2020-2022. gross production of specialized meat and crossbred cattle for slaughter increased by 8% and reached almost 600 thousand tons in live weight. In the total production volume, the share of specialized meat and crossbred cattle for slaughter is more than 20%.The largest number of beef cattle is concentrated in the Bryansk and Oryol regions, the Republic of Kalmykia, the Republic of Buryatia, and the Trans-Baikal Territory. In 2022, the above-mentioned regions produced more than 40% of beef and crossbred cattle for slaughter. During the analyzed period, 78 facilities were built, reconstructed and modernized for almost 100 thousand cattle places and an additional 7.6 thousand tons of meat were produced [21].

The FSTP subprogram to improve the genetic potential of beef cattle is being implemented in the Bryansk, Oryol, Tula, Moscow, Kaliningrad, Kaluga, and Smolensk regions.

State support includes such measures as reimbursement of part of the costs of beef cattle breeding, including breeding; preferential short-term and investment lending with an interest rate of up to 5%; reimbursement of part of the costs of producing cattle up to 2 years old, shipped to processing organizations. Promising forms of support include subsidizing farmers participating in the technological chain of forming breeding stock and raising young animals; The expansion of the forage base for beef cattle breeding predetermines the need for state subsidies for the costs of creating cultivated pastures, as well as the costs of purchasing forage harvesting machines. In Russia, the distribution of beef cattle throughout the country is characterized by its high concentration in large farms and dispersion in the small-scale sector. The main livestock of beef cattle is raised in the regions of the Southern, Central and Volga Federal Districts. More than 40% of beef cows are concentrated in the Miratorg agricultural holding; less than 200 enterprises raise from 500 to 1,000 heads; the rest of the livestock is kept in households and private farms. The Miratorg agricultural holding unites more than 100 farms, 3 feedlots and a slaughter and processing complex [8,13].

A study of models for organizing beef cattle breeding in Russia and a number of foreign countries showed significant differences both in growing technology and in business processes within the chain of creating the final product [4, 7, 10].

In North America, participants in the meat product chain include calf farms, industrial feedlots, livestock markets and auctions, and large meat processing plants. In Russia, on the contrary, the small-scale nature of production and processing predominates, the development zone is the industrial fattening system, and in some cases it is necessary to improve the specialized infrastructure. According to experts from the National Meat Association, the optimal business model is based on the formation of a farming cluster around a fattening enterprise with the mandatory inclusion of an integrator company that provides consulting assistance to farmers in obtaining grants and loans, as well as provides accounting and veterinary services. Similar clusters are organized in the Vladimir, Tomsk and Leningrad regions; A large project is currently being implemented in the Republic of Buryatia with the participation of 30 farms, a feedlot and a service center.

The functions of the created service center are to manage and control the activities of farmers supplying livestock for further fattening.

A similar model of cooperation with farms and other small agricultural business organizations can be implemented in the Miratorg agricultural holding [21].

The subprogram for the development of production of feed and feed additives for animals is aimed at strengthening the country’s feed base and reducing import dependence by stimulating Russian developments and technologies.

According to the Ministry of Agriculture, the share of imported amino acids for feed production is 80%, enzyme preparations - over 70%; 70-90%, protein feed of animal origin - about 30%, microelements – 90% [14].

The first direction of the subprogram is focused on the development of feed production technologies, as well as the development of selection and seed production of feed crops.

The second direction is related to the development and implementation of technologies for the production of balanced feeds and their components, including microbial protein.

It is expected that feed digestibility will increase by at least 10%.

The third direction of the subprogram is related to the organization of production of enzymes, probiotics, and feed antibiotics necessary for increasing livestock productivity.

Certain projects can only be implemented by large enterprises-agricultural holdings, which should be taken into account when justifying their financial support.

By 2025 it is expected to increase the innovative activity of feed production organizations by 25%; develop 10 new improved competitive technologies for the production of feed and feed additives and 3 new technologies for balanced feed.

The implementation of the subprogramme's activities will increase the share of high-quality domestic roughage and succulent feed by 18 percentage points [29]. According to Rosstat, in 2022 the volume of feed production in Russia amounted to 34.2 million tons, an increase of more than 6% compared to 2021.
The production volume of premixes for cattle increased by 6.1%. Innovative transformations in the industry in 2018-2022 were empirically studied (Table 2). Thus, significant results of the implementation of the FSTP subprograms for agricultural development are presented. Increasing the efficiency and competitiveness of the domestic agricultural sector of the economy in modern geopolitical conditions is inextricably linked with the development of innovation and investment processes, digital support of agricultural production, harmonization of federal and regional scientific and technical policies and popularization of the results of the Federal Scientific and Technical Commission.

Table 2. Dynamics of indicators of innovative development of feed production

Innovation Profile Indicators	2018	2022	2022 to 2018
Share of innovative goods, works, services in the total volume of shipped goods, works, services, %			
Production of prepared feed for farmed animals	3.9	7.6	1.9
Production of feed microbiological protein, premixes, feed vitamins, antibiotics, amino acids and enzymes	7.2	31.0	4.3
Innovative goods, works, services, newly introduced or subjected to significant technological changes over the past three years, billion rubles.			
Production of prepared feed for farmed animals	12.6	26.7	2.1
Production of feed microbiological protein, premixes, feed vitamins, antibiotics, amino acids and enzymes	7.2	16.0	2.2
Innovative goods, works, services, newly introduced or subjected to significant technological changes over the past three years, per conventional head of livestock, rub.			
Innovativeready-madefeeds	366.7	917.5	2.5
Innovativefeedprotein	209.9	549.8	2.6

Source: Own calculations based on the data from [9].

CONCLUSIONS

The study analyzed the implementation of FSTP subprograms of Russian agriculture for 2018-2022 made it possible to state noticeable technological changes in the production of sugar beets, potatoes, beef cattle breeding and feed production. The scientific support of FSTP, supported by appropriate financial support from the state, resulted in the expansion of the domestic research base in the field of genetics, biotechnology, selection and breeding. This made it possible to significantly increase the production and economic indicators of the analyzed types of activities, strengthen the breeding base and improve the innovative profile of agricultural enterprises, which indicates an increase in the country's food security. A compilation of the theory and practice of technological shifts in agricultural production in foreign countries has confirmed the possibility of using various business models and mechanisms for stimulating the introduction of technologies. The work proposes to use a model of interfarmer cooperation to develop contractual relations between production and processing in the production of food and seed potatoes. Taking into account the predominantly small-scale nature of beef cattle breeding, a farming cluster with a fattening enterprise and an integrator company providing consulting and financial support, as well as veterinary services, was recognized as the optimal business model.
Improving mechanisms for stimulating the development and implementation of new technologies should develop in the direction of strengthening grant support for the development of individual varieties; placing government orders for seed production; subsidizing the costs of developing the material and technical base; improving the institutional framework for protecting the rights of domestic breeders.
The study proposes improving mechanisms for stimulating the development and implementation of new technologies based on the development of grant support for the

development of certain varieties, placing government orders for seed production, as well as the development of subsidiary support and the regulatory framework for the protection of intellectual property rights of Russian breeders. Global trends justify the need for government funding of interdisciplinary agricultural production projects based on the synthesis of information technologies, biotechnologies and (or) nanotechnologies to predict technological changes.

ACKNOWLEDGEMENTS

The reported study was funded by the Russian Science Foundation, project №23-18-00236 «Structural transformation of accumulation and consumption in order to neo-industrialize the agricultural sector of the Russian economy in modern geopolitical conditions».

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APPLICATION OF FUZZY COGNITIVE MODELS TO ASSESS THE BALANCE OF ELEMENTS OF THE SYSTEM OF SCIENTIFIC SUPPORT AND COMMERCIALIZATION OF INNOVATIONS IN THE AGRO-INDUSTRIAL COMPLEX

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Abstract
Achieving technological independence from imported technologies and innovative products for the agricultural sector of the Russian economy is becoming especially relevant. The purpose of this study is to assess the balance of institutional elements of the system of scientific support and commercialization of innovations in the agricultural sector of economics and science, government, agribusiness, marketing and informatization using fuzzy cognitive models. Based on the application of cognitive modeling methods, relationships were identified between these elements for 16 different indicators included in the subsystems: educational potential, digitalization potential, human resources, science financing; research performance. Analysis and assessment of the influence of factors on each other and on the system as a whole was carried out on the basis of regression analysis using the example of 84 regions of Russia using data for 2021-2022. The greatest impact on the volume of shipped innovative goods, considered as the main concept, was exerted by the determinants "The share of organizations implementing technological innovations" and "The ratio of the salaries of scientific workers to the average salary in the region", other concepts are characterized by weak or negative dependencies. The results of cognitive modeling of the system of scientific support and commercialization of innovations in agriculture in Russia show the need to develop mechanisms for harmonizing federal and regional policies in the field of innovation implementation. The practical value of the research results lies in the possibility of applying the results in developing regional programs to accelerate the implementation of innovations in various industries and their replication.

Key words*: *system of scientific support and commercialization of innovations, agriculture, development institutions, cognitive modeling, factor analysis, regions, differentiation, directions of balance, development

INTRODUCTION

In modern conditions, innovative development in all spheres of the economy is associated with accelerated intellectualization, computerization of production, and rapid rates of creation of new technologies [21]. The author's concept of the formation of regional systems of scientific support and commercialization of innovations in the agro-industrial complex is based on the concept of National Innovation Systems (NIS) and diffusion of innovations [7,11]. At the same time, increasing the efficiency of application of the results of scientific activity is associated with the creation, implementation, dissemination and commercialization of innovations taking into account the needs of the regions and the peculiarities of agricultural production in them [4, 6].

Early studies proposed a five-tier model of innovation, including science, agribusiness, government, society, information support, and representing a set of institutions and mechanisms operating on the principles of planning and coordination to search for, create, disseminate and replicate innovations and advanced production technologies [5].

The state program “Development of Science and Technology” aimed to form a competitive research sector that would ensure breakthrough rates of economic modernization [20]. However, the process of commercialization of innovation is not developing fast enough. Insufficient level of funding of scientific research is one of the main reasons for the disunity of science and production, therefore one of the prerequisites for the integration of production, science and education is a long-term investment public-private partnership [22,23].

Global trends indicate a steady growth of knowledge and production intensity, i.e. the transformation of existing knowledge into a technological process [17,18]. As a result of the development of these processes, the task of improving human resources in the context of digital transformation and its integration into the chain of interaction between science and production when introducing innovations in agriculture is becoming more relevant [12,13]. Modern theory of decision support and adoption develops the direction of cognitive modeling based on identifying the relationships and mutual influence of statistical and evaluation indicators, as well as in modeling systems with specific cause-and-effect relationships between elements [15,16].

The global scientific community widely uses fuzzy cognitive maps for evaluation in modeling various socio-economic processes, noting as their advantage the possibility of using expert assessments and accumulated knowledge [19].

The research project presents software products for constructing cognitive maps and provides their detailed characteristics. Issues of developing methodological approaches to the use of cognitive models in various areas of the economy are presented in the works of foreign and domestic researchers [8,14,24].

Cognitive modeling takes into account the characteristics of such weakly structured systems as agriculture and rural areas, which is confirmed by the results of studies. In particular, M.E. Anokhina used cognitive strategies to develop scenarios for achieving stable economic growth in the agro-food complex of Russia [1].

Russian researchers Chernov and Shelkov applied a scenario approach to studying the possibilities of innovative development of agriculture[2].

Foreign scientists have used a cognitive approach in developing mechanisms for improving agricultural management in Scotland based on environmental regulation of agricultural production, taking into account expert assessments from farmers and the non-agricultural population [3,9].

The purpose of this study is to assess the balance of institutional elements of the system of scientific support and commercialization of innovations in the agricultural sector of economics and science, government, agribusiness, marketing and informatization using fuzzy cognitive models.

MATERIALS AND METHODS

The study is based on the study and generalization of a group of indicators and corresponding statistical data on the institutional elements of the system. During the research, such empirical methods as measurement, generalization, comparison, analysis were used. The identification or absence of relationships between institutional elements and subsystems of educational and personnel potential, as well as the potential for digitalization, financing and effectiveness of scientific research was carried out using cognitive modeling methods,using the Software For Fuzzy Cognitive Modeling software product.

RESULTS AND DISCUSSIONS

The paper develops methodological approaches to assessing the balance of elements of the system of scientific support and commercialization of innovations in Russian agriculture using the author's methodology for assessing and calculating indicators not reflected in official statistics. Despite the expansion of the database on scientific and innovative activities in agriculture, the developed author's assessment and forecasting tools predetermined the need to use additional indicators based on the adjustment of existing statistical indicators in relation to agriculture. Subsystems of educational and personnel potential, as well as potentials for digitalization, financing and effectiveness of scientific research will be identified empirically. The study puts forward a hypothesis about the possibility of identifying cause-and-effect relationships between institutional elements for the purpose of further harmonization and achieving balance in the system as a whole.Technological transformations of the Russian agro-industrial complex are largely determined by the efficiency of the system of scientific support and commercialization of innovations. In a number of foreign countries, innovative development is modeled by strategies of scientific and technological leadership of large companies and corporations, ensuring the implementation of domestic scientific achievements in agriculture. There are various approaches to managing interregional differentiation of innovative development. One of them is smoothing out on the basis of the flow of knowledge from leading regions in scientific support to outsider regions. Other researchers propose the use of a program-targeted approach and the active involvement of outsiders in the creation of joint scientific innovative platforms [10]. To assess the balance of the institutional elements of the system, the authors developed an assessment and forecasting toolkit in their early works, including indicators from the following subsystems: educational potential, digitalization potential, human resources potential, science funding; research performance. The assessment of the mutual influence of factors was carried out on the basis of regression analysis performed on the basis of 84 regions of Russia using data for 2021-2022.

For the analysis and subsequent construction of a cognitive map, 16 indicators were selected with a preliminary construction of a matrix of paired coefficients. The following were included in these indicators:

C1 - Agricultural output, million rubles;

C2 - Share of employed population with higher education, %;

C3 - Number of students, per 10,000 people;

C4 - Share of organizations with broadband Internet access, in the total number of organizations, %;

C5 - Share of organizations using personal computers, %;

C6 - The share of active Internet users among the adult population, %;

C7 - Internal expenditure on scientific research and development, thousand rubles;

C8 - Ratio of average monthly salary of scientific workers to average monthly salary in the region, %;

C9 - Share of those engaged in research and development in the average annual number of those employed in the regional economy, %;

C10 – Inventive activity coefficient (number of domestic patent applications for inventions filed in Russia per 100 thousand people), units;

C11 – Share of organizations implementing technological innovations, %;

C12 – Share of budget funds in internal research and development, %;

C13 – Share of products of high-tech and knowledge-intensive industries in the gross regional product, %

C14 – Number of researchers in the field of agricultural sciences, people;

C15 – Number of labor force aged 15 years and older in the constituent entities of the Russian Federation, thousand people;

C16 – Volume of shipped innovative goods, million rubles. To determine the weights of the relationships, a fairly common method of paired comparisons was used. The strength of the relationship between concepts was calculated by adjusting the regression coefficients based on the normalization of each factor with an assessment of significance by the p-value of the regression model.

Positive and negative values of concepts characterize, respectively, direct and inverse dependence; zero values reflect the absence of mutual influence of factors.

Based on the processing of table data by the Software For Fuzzy Cognitive Modeling 1 program, the parameterization of the system of scientific support and commercialization of innovations in Russian agriculture was carried out in the format of a fuzzy cognitive map (Fig. 1).

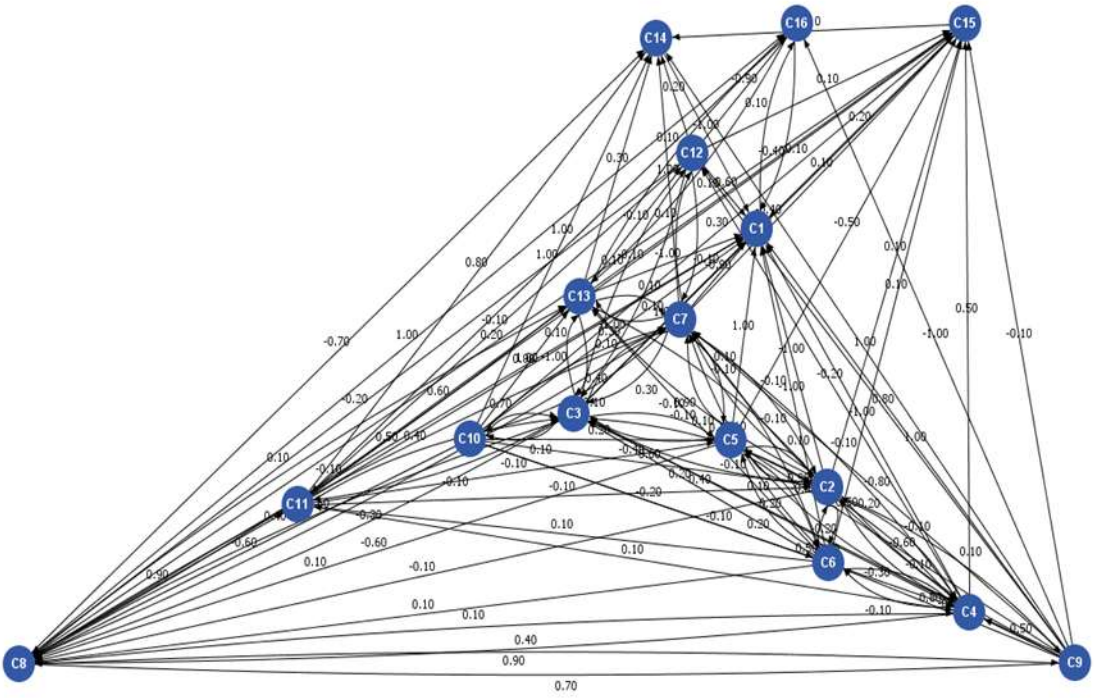

Fig. 1. Fuzzy cognitive map of the system of scientific support and commercialization of innovations in the agro-industrial complex
Source: Own calculations based on Software For Fuzzy Cognitive Modeling data.

The most important indicator of the effectiveness of the system of scientific support and commercialization of innovations in the agro-industrial complex is the volume of shipped innovative goods, defined as one of the target concepts. The greatest influence on this concept was exerted by the determinants "The share of organizations implementing technological innovations" and "The ratio of salaries of scientific workers to the average salary in the region".

The analysis showed that the above concepts are supported by the system, since their estimates are significantly higher than the estimates of the reverse effect. However, the subsystem "Efficiency of scientific research" did not reveal any impact on the production of innovative products. For example, the coefficient of inventive activity is characterized by a low value, which may indicate an insufficient level of commercialization. This fact indicates the need to develop measures to stimulate the marketing potential when introducing innovations into agricultural production. Extremely low impact of the concept "The share of products of high-tech and knowledge-intensive industries in the gross regional product", which indicates insufficient distribution of the digitalization process in agriculture. In the research financing block, a negative impact of the concept "Share of budget funds in internal research and development" on the target determinant "Internal expenditure on research and development in the field of agriculture per 1 researcher of agricultural sciences" is observed, which indicates insufficient state support for scientific research in agriculture and weak involvement of commercial organizations and other institutional units in the financing process.

The negative impact of these concepts indicates the lack of balance in the system elements.

The target concept "Number of researchers in the field of agricultural sciences" of the subsystem "Human resources" is significantly influenced by the determinants "Internal expenditure on research and development in the field of agriculture per 1 researcher of agricultural sciences", thousand rubles; "Inventive activity coefficient". At the same time, there is no influence of the target concept on these determinants with their positive impact on the subsystem, which indicates an unbalanced development of educational and human resources potential. The innovation sector is characterized by weak implementation of advanced technologies and innovative products, poor provision of innovative personnel, which leads to disproportions in the system of scientific support and commercialization of innovations in agriculture in Russia.

The insufficient level of coordination of the system's elements is confirmed by the parameters of assessing the system's impact on target concepts, which in most cases are lower than the assessment of the reverse impact.

The results of cognitive modeling of the system of scientific support and commercialization of innovations in agriculture in Russia indicated the need to improve the existing mechanisms for planning and coordinating its elements.

CONCLUSIONS

To improve the balance of the elements of the system of scientific support and commercialization of innovations - scientific and intellectual, investment, production and technological, marketing and information potential, an analysis was used based on the construction of fuzzy cognitive models. Cognitive modeling allows assessing weakly structured dependencies. To assess the balance of the elements of Russia, an assessment and forecasting toolkit was developed from 16 indicators included in the subsystems: educational potential, digitalization potential, human resources, science financing; research performance. The assessment of the mutual influence of factors was carried out on the basis of regression analysis performed on the basis of 84 regions of Russia using data for 2021-2022. The greatest impact on the volume of shipped innovative goods, considered as the main concept, was exerted by the determinants "The share of organizations implementing technological innovations" and "The ratio of salaries of scientific workers to the average salary in the region". Such concepts of the subsystem as "Efficiency of scientific research" did not have a significant impact on the production of innovative products from the point of view of the influence of the coefficient of inventive activity, "Share of products of high-tech and knowledge-intensive industries in the gross regional product", "Share of budget funds in internal research and development" on the target determinant "Internal costs of scientific research and development in the field of agriculture per 1 researcher of agricultural sciences", which indicates insufficient state support for scientific research in agriculture and weak involvement of commercial organizations and other institutional units in the financing process. Insufficient level of consistency of the system elements is confirmed by the parameters for assessing the impact of the system on target concepts, in most cases lower than the estimates of the reverse impact.

The results of cognitive modeling of the system of scientific support and commercialization of innovations in agriculture in Russia indicated the need to improve the existing mechanisms for planning and coordinating its elements at the federal and regional levels.

The practical significance of the results of the conducted research lies in the possibility of assessing and forecasting the effectiveness of innovation management in the agricultural sector of the economy. The results of the research are of practical value for the development of regional programs for innovation-oriented development of the agro-industrial complex.

ACKNOWLEDGEMENTS

The reported study was funded by the Russian Science Foundation, project № 23-28- 01785 «Modeling the growth of food production taking into account the improvement of scientific support for economic entities in the agro-industrial complex ».

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ECONOMIC EVALUATION OF THE EFFECT OF THE APPLICATION OF BIOSTIMULANTS ON SPRING RAPE AND OATS

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Abstract

The effect of the application of biostimulants in agricultural crops has not been fully studied and evaluated from an economic aspect. The purpose of the research is to assess the economic efficiency of the application of biostimulants in the organic production of spring rapeseed and oats. 2-year field trials were conducted using a block method with foliar treatment with Chitosan, Vermicomposting and nature-identical growth regulator in 2 phenological stages. The biological response of the crops at different doses of the biostimulants was investigated. The obtained primary results were used as input data for the construction of an economic-mathematical model for economic evaluation. In a methodological aspect, linear modeling is applied in order to optimize the production structure of a selected agricultural holding. It is concluded that biostimulants have a positive effect on yield and biometrics of treated crops, but the complex economic effect on farm profit is organic.

Key words: *biostimulants, economic evaluation, economics model, spring rape, spring oats*

INTRODUCTION

The economic evaluation of the effect of biostimulators (BS) in agriculture is still a challenge in scientific research not only in Bulgaria, but also in the world [12, 4, 14, 6, 19, 20, 21, 22]. They are particularly relevant at the moment and in practice are an alternative for farmers in accordance with the implementation of the goals set in the Green Deal of the new CAP until 2027. In search of answers from policymakers and stakeholders [5]. Many interdependent factors should be taken into account, related not only to purely technological [13], experimental and legal constraints, but also to the diversity of economic, social, environmental and behavioral aspects [2, 26, 8]. It is currently known. Scientific research on the economic efficiency of treating agricultural crops with biostimulants (BS) has been a matter of debate for some time. In Bulgaria, this topic is a relatively new field. Although growth regulators are known to provide benefits, the economic aspects have not been fully explored. Globally, a uniform methodology for evaluating the economic benefits of the application of biostimulants in agriculture has not even been adopted. Researchers are most often limited to reporting the increase in yield, as well as some indicators in the different phenophases.

Nowadays, it is even more important to analyze whether the use of biostimulants is economically effective for farmers and whether they will contribute to increasing the profit of agricultural holdings as a whole.

Some authors indicate that treatment with biostimulators favorably affects the porosity of the soil structure, bulk density and yields [9]. Other authors in their publications emphasize that biostimulators have a positive effect on the biometric indicators of plants, as follows: branching of root structure, branching of stems, increase in leaf mass, twining, number and weight of grains, fruit yield. Often, the influence of growth regulators on the preservation of flower buds and joint ripening of fruits is enhanced [24]. From a methodological point of view, the usefulness and economic efficiency of a given biostimulator should be calculated based on the business plan of the agricultural holding. This means determining the usefulness of biostimulants in building the production structure of this farm. If the treatment of different BSs is found to have a positive economic effect on that farm, then those BSs are considered economically beneficial. We hypothesize that treatment with a certain biostimulator can increase the yield and maximize the profit of the respective crop per unit area, but to accept that this biostimulator is economically effective, it must increase the profit of the agricultural holding as a whole. The purpose of this study is to make an economic evaluation of the effect of the treatment with certain biostimulants on spring rape and oats. We proceed methodically from the point of view of the business plan. Therefore, it focuses on optimization of the production structure of a selected agricultural holding. On this basis and the obtained optimization, the economic evaluation of the effect of foliar treatment with biologically active substances with different concentrations on spring rapeseed and spring oats is given. Both crops were treated with biostimulants developed at the Institute of Cryobiology and Food Technologies at the Agricultural Academy.

The working hypothesis is that BS treatment will increase yield of rape and oats and will have a positive impact on the biometric indicators of the crops, but this will not analogously increase the economic efficiency of the specifically selected agricultural holding. Spring rape is characterized by its high yield of both seeds and oil. The oil is rich in fatty acids and has a wide range of uses. Although spring oilseed rape has a lower oil content than winter types, with the help of selection of suitable varieties with a relatively high oil content, this can be compensated. Global production of rapeseed has increased sixfold since 1975. Since the beginning of the new millennium, biodiesel production has been steadily increasing, and rapeseed oil is a good alternative among the vegetable oils required for biofuel production. Globally, in 2019, Canada was the leader in canola production with 18.5 million metric tons. In Europe, the first place is occupied by France with 3.5 million metric tons, followed by Ukraine – 3.3 million meters. etc. Spring canola will be an integral part of the future of agriculture, helping to meet new environmental and rotational requirements.

Oats are rich in fat, the amount of which can reach up to 18% [16]. In 2021, world oat production is over 22 million tons - Russia with 17% of the total and Canada with 12%. Spring oats (*Avena sativa*) are a unique species, usually ready for pasture after 50 days or for hay after 70 days. Agronomists point out that the synergistic benefit of cultivating spring oats is to control the spread of weeds and conserve soil moisture. Very often a high yield can lead to crop latency. Oats have numerous uses in food - crushed oats, a variety of baked goods, a milk substitute, several different beverages, and more.

There are numerous publications on the subject in the scientific literature. For example: Observations on the phytosanitary status of crops in organic and conventional agriculture, the degree of weeding of winter oats [1]; in organic, biodynamic and conventional oat cultivation [15]; evaluation of the yield potential of different oat cultivars [7]; the effect of growth biostimulators on oat formation grain yield and evaluation of the economic efficiency of its use [3], evaluation of four biostimulants in different concentrations on fodder oats [11], etc.

[17] studied physiological parameters and the ameliorative effect of the application of plant biostimulants on rapeseed. In natural field experiments, biostimulants have a significant effect on plant growth in autumn, acclimatization to the cold, overwintering of plants [10]. According to [23] biostimulants increase dry matter accumulation in spring rape, etc.

MATERIALS AND METHODS

For primary data, the results obtained from the Agricultural Experimental Station (AZS) are used, in an experimental field at the Institute of Agriculture and Seed Science "Obraztzov Chiflik" - Ruse at the Agricultural Academy [25]. In the two-year period 2021-2022, 19 plots of 10 square meters each were prepared, in which seeds of spring rape (*sorte Lakritz, brassica napus* L.) and oat (*sorte Alexa*) were planted. The selection of 19 plots is consistent with the condition of having 1 control plot for both crops and 18 plots on which three repetitions of three biostimulants (BS) will be made. The spring rape and spring oatwere treated with biostimulants developed at the Institute of Cryobiology and Food Technologies (ICFT) at the Agricultural Academy, Sofia at different concentrations of the active substance. Yields of spring rape and oats, 2021 and 2022 crops are presented in Tables 1 and 2 below.

Table 1. Yield of spring rape, harvest 2021 and 2022 (average)

Biostimulant	**1 rep (kg)**	**2 reps (kg)**	**3 reps (kg)**	**Total (kg)**	**Average (kg)**	**kg/dca**	**Index**	**% humidity**
Chitosan 500 ml/ dca	1.38	1.34	1.32	4.04	1.35	134.50	1.08	8.60
Chitosan-2*500 ml/ dca	1.30	1.28	1.27	3.84	1.28	127.98	1.03	8.60
Vermi compost extract 500 ml/ dca	1.21	1.26	1.30	3.77	1.26	126.25	1.02	8.40
Vermicompost + nature-identical growth regulator 2*500 ml/ dca	1.24	1.28	1.29	3.81	1.27	126.92	1.02	8.60
Vermicompost extract 2*500 ml/ dca	1.34	1.30	1.31	3.94	1.31	131.32	1.06	8.80
Vermicompost + nature-identical stretch regulator 500 ml/ dca	1.26	1.25	1.26	3.77	1.26	125.52	1.01	8.30
Control	1.20	1.24	1.29	3.73	1.24	124.17	1.00	8.60

Source: The primary data from The Agricultural Experimental Station (AES) in a test field at the Institute of Agriculture and Seed Science "Obraztzov Chiflik" – Ruse, Agricultural Academy, Bulgaria, 2021-2022 [25].

Table. 2. Yield of spring oats, harvest 2021 and 2022 (average)

Biostimulant	**1 rep (kg)**	**2 reps (kg)**	**3 reps (kg)**	**Total (kg)**	**Average (kg)**	**kg/dca**	**Index**	**% humidity**
Chitosan 500 ml/ dca	2.62	2.21	2.32	7.15	2.38	238.47	1.14	13.35
Chitosan-2*500 ml/ dca	2.21	2.47	2.51	7.19	2.40	239.70	1.15	13.50
Vermi compost extract 500 ml/ dca	2.57	2.15	2.38	7.09	2.36	236.42	1.13	13.55
Vermicomposting + nature-identical growth regulator 2*500 ml/ dca	2.09	2.06	2.22	6.37	2.12	212.38	1.02	14.45
Vermicomposting extract 2*500 ml/ dca	2.59	2.12	2.51	7.21	2.40	217.80	1.04	14.00
Vermicomposting + nature-identical stretch regulator 500 ml/ dca	2.33	2.04	2.31	6.67	2.22	222.42	1.06	13.40
Control	1.94	2.03	2.31	6.28	2.09	209.17	1.0	13.50

Source: The primary data from The Agricultural Experimental Station (AES) in a test (experimental) field at the Institute of Agriculture and Seed Science "Obraztzov Chiflik" – Ruse, Agricultural Academy, 2021-2022 [25].

In order to make an economic evaluation of the treatment with biostimulants, an economic-mathematical model based on linear programming is applied. The solution of the mathematical problem reflects with adequate accuracy the most significant dependencies of the studied problem. Methodologically, the task is constructed in a system of linear constraints. They reflect the natural-climatic and agronomic conditions that should be taken into account when searching for the optimal solution [18].

The objective function represents the optimality requirement (min, max):

$$
\begin{aligned}
&A_{11} X_1 + A_{12}X_2 + ... + A_{1n}X_n \leq B_1 \\
&A_{21} X_2 + A_{22}X_2 + ... + A_{2n}X_n \geq B_2 \\
&\qquad ....(1) \\
&: \\
&. \\
&A_{m1} X_1 + A_{m2}X_2 + ... + A_{mn}X_n = B
\end{aligned}
$$

____ ,

$F = C_1X_1 + C_2X_2 + \ldots + C_nX_n \rightarrow \max (\min)$,

where:
Xj – the extent of activities or indicators
Aij and Cj - shows the coefficients before activities Xj
Bi - shows the amounts of own resources or size of activities.
F – Objective function under optimality criterion

The objective function is constructed in such a way that it is influenced by the area of cultivated land of the different crops used on the one hand, without the application of biostimulants (wheat, corn, sunflower, spring oats - control and spring rape - control), as well as with crops with included biostimulants (spring oats and spring rapeseed). Income from commodity crops (intended for sale), and subsidies (when we use subsidies in the optimization), crops treated with different biostimulants and in different concentrations (chitosan 500 ml/ha; chitosan 2*500 ml/ha; vermicompost extract 500 ml/ha; vermicompost extract 2*500 ml/ha; vermicompost + natural growth regulator 2*500 ml/ha, production costs, gross margin and profit subsidy).

The construction of the model uses two criteria - max gross margin and max profit. There were build two economic-mathematical tasks based on these criteria:

First task. A task with optimized production structure of a farm, considering the agrotechnical requirements for crop rotation. The solution gives the most optimal production structure under both criteria of *max gross margin and max profit*. It will allow obtaining a decision on how to optimally combine available resources (land, labor force, size of arable land) and farm constraints; what crops to produce; agrotechnical requirements; which biostimulants to apply; on which cultures and in what concentration to be applied BS; in which phase to treat them to achieve the highest economic effect.

Second task. There were set bounds for the minimal and maximum size of the arable land, including crops treated with biostimulants. The aim is to find an optimal solution, achieving *max gross margin* and *max profit*. The solution gives the optimal combination of the most economically effective productions. The result is the best combination of the available resources (land, labor resources, and various biostimulants), giving specific constraints. Also, what crop to produce and what agrotechnical requirements? All this achieves the highest economic effect.

Defined variables and constrains

The subjective restrictions shrink the possible solutions. This is because including more different group criteria in the model (e.g., land, crops, BS, land constraints, labor force, etc.) searches for a balance between the defined constraints and often leads to compromise solutions to the task.

The variables used to evaluate the BS effect on economic efficiency are presented in Tables 3 and 4.

Table. 3. Variables with biostimulants treatment

Crop	Biostimulants (ha)						
	Control	BS1_CH	BS2_2CH	BS3_V	BS4_2V	BS5_VR	BS6_2VR
Spring rape	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
Spring oat	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}

Source: Authors' calculations.

Table 4. Other variables

Other crops (ha)		Resources		Finance (BGN)	
x_1	Wheat	x_{18}	Own arable land (ha)	x_{22}	Income
x_2	Corn	x_{19}	Rented arable land (ha)	x_{23}	Material costs
x_3	Sunflower	x_{20}	Permanently employed mechanics (number)	x_{24}	Labor costs
		x_{21}	Permanent employees (number)	x_{25}	Margin
				x_{26}	Gross margin
				x_{27}	Fixed costs
				x_{28}	Profit
				x_{29}	Profit with subsidies

Source: Authors' calculations.

In addition, it was used other factors such as other crops, resources (land, labor force), and financial indicators (gross margin, costs, profit).

Constrains

The constraints of the optimal plan are divided into three groups: land usage (Table 5); labor (Table 6); and supporting constrains (Table 7).

Table 5. First group of constrains related to the land usage (ha)

Constrains	Formula	
	Optimal production structure task (first)	Max and min area bounds task (second)
Area constrains (acres)	$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} + x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} = x_{18} + x_{19}$	$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10}x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17\_}17 \leq x_{18} + x_{19}$
Constrain on rented area (ha)	$x_{19} = 11{,}000$	$x_{19} \leq 11{,}000$
Constrain on owned area (ha)	$x_{18} = 1{,}000$	
Autumn cereal crops, minimum 45% of the sowing area (ha)	$x_1 \geq 5{,}400$	
Autumn cereal crops, minimum 55% of the sowing area (ha)	$x_1 \leq 6{,}600$	
Sunflower, maximum 17% (1/6) of the sowing area (ha)	$x_3 \leq 2{,}040$	
Constrains on the land, using BS, minimum (ha)		$x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10}x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} \geq 3{,}360$
Constrains on the land, using BS, maximum (ha)		$x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10}x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} \leq 4{,}560$

Source: Authors' calculations.

Table 6. Second group of constrains related to the labor (number)

Constrains	Formula
Permanently employed mechanics(number)	$x_{20} = 4$
Permanent employees (number)	$x_{21} = 2$

Source: Authors' calculations.

Table 7. Third group of constrains, supporting (BGN)

Constrains	**Formula**
Income	$116x_1 + 136x_2 + 190x_3 + 133{,}52x_4 + 135{,}48x_5 + 120{,}08x_6 + 118{,}63x_7 + 115{,}79x_8 + 127{,}12x_9 + 115{,}95x_{10} + 72{,}31x_{11} + 85{,}14x_{12} + 101{,}49x_{13} + 106{,}53x_{14} + 56{,}41x_{15} + 83{,}82x_{16} + 90{,}63x_{17} = x_{22}$
Variable material costs	$27x_1 + 27x_2 + 26x_3 + 24{,}5x_4 + 39{,}5x_5 + 39{,}5x_6 + 39{,}5x_7 + 39{,}5x_8 + 39{,}5x_9 + 39{,}5x_{10} + 31x_{11} + 46x_{12} + 46x_{13} + 46x_{14} + 46x_{15} + 46x_{16} + 46x_{17} = x_{23}$
Labor costs	$x_{24} = 18{,}000x_{20} + 18{,}000x_{21}$
Fixed costs	$x_{27} = 55x_{19}$
Margin	$x_{25} = x_{22} - x_{23}$
Gross margin	$x_{26} = x_{22} - x_{23} - x_{24}$
Profit	$x_{28} = x_{22} - x_{23} - x_{24} - x_{27}$

Source: Authors' calculations.

Objective function

The objective function and the constrained values were added in the following linear programming model, using two optimal criteria – max gross margin and max profit.

$F = 80x_1 + 102x_2 + 155x_3 + 100.02x_4 + 86.98x_5 + 71.58x_6 + 70.13x_7 + 67.29x_8 + 78.62x_9 + 71.05x_{10} + 32.31x_{11} + 30.14x_{12} + 46.49x_{13} + 51.53x_{14} + 1.41x_{15} + 28.82x_{16} + 35.63x_{17} - 18{,}000x_{20} - 18{,}000x_{21}$ →**Max gross margin,** **...**(2)

$F = 80x_1 + 102x_2 + 155x_3 + 100.02x_4 + 86.98x_5 + 71.58x_6 + 70.13x_7 + 67.29x_8 + 78.62x_9 + 71.05x_{10} + 32.31x_{11} + 30.14x_{12} + 46.49x_{13} + 51.53x_{14} + 1.41x_{15} + 28.82x_{16} + 35.63x_{17} - 18{,}000x_{20} - 18{,}000x_{21} - 55x_{19} + 31x_{18} + 31x_{19}$ →**Max profit...** (3)

In the objective function, two criteria for the optimality of the solution are set: max gross margin and max profit.

RESULTS AND DISCUSSIONS

Analysis of the obtained results

Making a management decision is an extremely important and responsible task for agrarian entrepreneurs. The results obtained from the optimization are shown in tabular form presented below.

Table 8. Production structure and economic results of application of biostimulants

Unknown	Name	dca	Number	BGN
x_1	Wheat (dca)	5,400		
x_2	Maize, (dca)	0		
x_3	Sunflower, (dca)	3,240		
x_4	Spring rape – control (dca)	0		
x_5	Spring rape - BS 1 Chitosan 500 ml/ dca	3,360		
x_6	Spring rape – BS 2 Chitosan-2*500 ml/ dca	0		
x_7	Spring rape – BS 3 Vermi compost extract 500 ml/ dca	0		
x_8	Spring rape – BS 4 Vermi compost extract 2*500 ml/ dca	0		
x_9	Spring rape – BS 5 Vermicomposting + nature-identical stretch regulator 500 ml/ dca	0		
x_{10}	Spring rape BS 6 Vermicomposting + nature-identical stretch regulator 2*500 ml/ dca	0		
x_{11}	Spring oats – control (dca)	0		
x_{12}	Spring oats - BS 1 Chitosan 500 ml/ dca	0		
x_{13}	Spring oats– BS 2 Chitosan-2*500 ml/ dca	0		
x_{14}	Spring oats – BS 3 Vermi compost extract 500 ml/ dca	0		
x_{15}	Spring oats – BS 4 Vermi compost extract 2*500 ml/ dca	0		
x_{16}	Spring oats – BS 5 Vermicomposting + nature-identical stretch regulator 500 ml/ dca	0		
x_{17}	Spring oats BS 6 Vermicomposting + nature-identical stretch regulator 2*500 ml/ dca	0		
x_{18}	Ownarableland (dca)	1,000		
x_{19}	Leased arable land (dca)	11,000		
x_{20}	Permanently employed mechanics (no.)		4	
x_{21}	Permanently employed workers (no.)		2	
x_{22}	Income (BGN)			1,675,204.8
x_{23}	Material costs (BGN)			362,760
x_{24}	Labor costs (BGN)			108,000
x_{25}	Income (BGN)			1,312,444.8
x_{26}	Gross margin (BGN)			1,204,444.8
x_{27}	Fixed costs (BGN)			605,000
x_{28}	Profit (BGN)			599,444.8
x_{29}	Profit with subsidy (BGN)			971,444.8

Source: Authors' calculations, 2023.

Table 9. Variant when including only cultures treated in different concentrations of biostimulants. Production structure and economic results of application of biostimulants

Unknown	name	dca	Number	BGN
x_1	Wheat (dca)	0		
x_2	Maize (dca)	0		
x_3	Sunflower (dca)	0		
x_4	Spring rape – control (dca)	0		
x_5	Spring rape - BS 1 Chitosan 500 ml/ dca	12,000		
x_6	Spring rape –BS 2 Chitosan-2*500 ml/ dca	0		
x_7	Spring rape – BS 3 Vermi compost extract 500 ml/ dca	0		
x_8	Spring rape – BS 4 Vermi compost extract 2*500 ml/ dca	0		
x_9	Spring rape – BS 5 Vermicomposting + nature-identical stretch regulator 500 ml/ dca	0		
x_{10}	Spring rape BS 6 Vermicomposting + nature-identical stretch regulator 2*500 ml/ dca	0		
x_{11}	Spring oats – control (dca)	0		
x_{12}	Spring oats - BS 1 Chitosan 500 ml/ dca	0		
x_{13}	Spring oats–BS 2 Chitosan-2*500 ml/ dca	0		
x_{14}	Spring oats – BS 3 Vermi compost extract 500 ml/ dca	0		
x_{15}	Spring oats – BS 4 Vermi compost extract 2*500 ml/ dca	0		
x_{16}	Spring oats – BS 5 Vermicomposting + nature-identical stretch regulator 500 ml/ dca	0		
x_{17}	Spring oatsBS 6 Vermicomposting + nature-identical stretch regulator 2*500 ml/ dca	0		
x_{18}	Own arable land (dca)	1,000		
x_{19}	Leased arable land (dca)	11,000		
x_{20}	Permanently employed mechanics (no.)		4	
x_{21}	Permanently employed workers (no.)		2	
x_{22}	Income (BGN)			1,547,160
x_{23}	Material costs (BGN)			474,000
x_{24}	Labor costs (BGN)			108,000
x_{25}	Income (BGN)			1,073,160
x_{26}	Gross margin (BGN)			965,160
x_{27}	Fixed costs (BGN)			605,000
x_{28}	Profit (BGN)			360,160
x_{29}	Profit with subsidy (BGN)			732,160

Source: Authors' calculations, 2023.

First option. In Table 8, the parameters of the solution of the objective function with optimization and maximum gross margin and maximum profit can be traced. The decision presents an option for crop rotation of the included agricultural crops with the use of different biostimulants, and with different concentration of active substance, with/without included CAP subsidy for the farm. The optimal solution of the task also includes the set precondition for dropping the requirement for the maximum size of cultivated land.

When constructing the production structure in the farm's crop rotation, the assumption is made that the own land of 1,000 decares, and the leased land -11,000 decares, are used to their full capacity.

Solving the optimization equation is expected to give us an answer to the questions concerning the area of cultivated land to be sown with certain agricultural crops (wheat, maize and sunflower, spring oats - control and spring canola - control, spring oats and spring rape - treated with biostimulants, with admissibility for distribution of different concentration of active substance).

The main influence on the results is the type of the objective function, the constraints and the set price parameters. The type of objective function is linear. The parameters and the set price parameters have an impact on the results of the optimization. Linearity affects the results in 2 ways:

1. Maximizes cost-effective crops produced, on the one hand;
2. On the other hand, it minimizes the price disadvantages to the size of their set minimum.

Due to the listed reasons and imposed restrictive conditions in the optimization, wheat is planned to cover a minimum of 5,400 decares. This is the minimum restrictive condition for autumn cereal crops for crop rotation according to agronomic requirements (min. 45% of the area of cultivated land). In the sowing rotation area, wheat occupies the minimum limits set for autumn cereal crops. The intended maximum of 55% of the area of the crop rotation, or up to 6600 decares, is not included in the solution of the task, because the mandatory inclusion of sunflower in the crop rotation is taken into account in the restrictive condition for the minimum size of the areas. In the optimal solution, he enters with 3,240 decares. In the remaining area of 3,360 decares, spring rape is included - treated with chitosan - 500 ml/decare. A leading role in the distribution of these crops is played by those with a higher economic benefit for the farm. The optimization matrix does not include the distribution of the other spring rape and spring oats - treated with the other biostimulants.

It is noteworthy that the optimization does not include spring rapeseed and spring oats - treated with the other biostimulants within the maximum set limits of 4,560 decares. The optimization has taken into account all the limiting conditions and has included in the solution other crops that are more economically profitable. In the same way, the result should be interpreted for the inclusion of the maximum amount of land under sunflower, and corn is dropped from the crop rotation. This is because no precondition has been set for its mandatory inclusion in the solution of the task. That is, the optimization model selects the most optimal solution according to the set parameters in the objective function and offers such a distribution of the production structure, consistent with the restrictive conditions of the crop rotation, presence of biostimulants, different yield, market price, and the different economic efficiency, consequence of these conditions. Naturally, it would be interesting if other restrictive and/or mandatory conditions were set in the condition of the task. It is precisely in this that the wide possibility of this type of optimization model is cut. It is also useful in that the managers of an agricultural enterprise, applying it successfully, allows offering countless possible solutions. On this basis, in accordance with the specific subjective wishes of the producers, it allows the relevant management decisions to be made.

During the development of the technical and economic regulations (TIR), the yield of agricultural crops was determined in accordance with biological production, depending on the region, the type of soil, with/without the presence of biostimulators and different market prices of the product. This accumulates on production and labor costs, income, revenue, gross profit of the farm. According to the solution of the task, the following agricultural crops with biological production - wheat and sunflower - are included in the farm's production structure. From the point of view of crops treated with biostimulants, only spring rape, treated with chitosan 500 ml/ha, is included in the crop rotation.

According to the proposed optimization model, three agricultural crops are included in the production structure of the farm - wheat and sunflower (biological production), as well as spring rape, foliarly treated with chitosan 500 ml/ha. Corn and the other crops - spring rapeseed and oats - controls and those treated with the other biostimulants in different concentrations, which fall out of the crop rotation, are of low economic efficiency.

In the solution of the task, it is possible to trace how the minimum and maximum limits are distributed, such as the restrictive condition for the area on which the use of biostimulants is allowed - min 3,360 decares and maximum 4,560 decares. The solution to the task only includes the spring rapeseed treated with chitosan 500 ml/ha in the minimum size of 3,360 ha of land, as economically the most profitable for the farm.

As a result, in the optimization model, all set restrictive conditions for achieving maximum economic effect - maximum gross margin and maximum profit - are fulfilled.

In the solution of the problem, the optimal economic efficiency is achieved with a Gross margin of BGN 1,204,444.8 or BGN 100.37/decare, the realized profit without subsidy of BGN 599,444.8 (BGN 49.95/decare) and with subsidy BGN 971,444.8, which is BGN 80.95/ decare.

Table 1 shows the results when profit is included as the objective function. The results of the optimization confirm the conclusions made so far. Adding fixed costs to the model does not change the final result for the optimal ratio of planted areas.

Of interest is whether the presence of subsidies will change the optimization results. The influence of the subsidies in the model is reflected by the subsidies per unit of sown area in the amount of BGN 31/ decare. The increase in profit from BGN 599,444.8 to BGN 971,444.8 is the result of the absorption of subsidies for direct payments under the first pillar of the EU's common agricultural policy. Regarding the structure of the areas under cultivation of the various crops and the labor costs remain unchanged regardless of whether subsidies are involved or not.

Second option. Table 9 presents the results of the optimization, according to which a limit is set for minimum limits in which the cultivated land varies, but with maximum inclusion of the permissible area with the presence of crops treated with biostimulants.

Based on the set limiting conditions in the optimization, it is planned that the entire distribution of the sowing turnover area of 12,000 decares will be occupied by spring rape treated with chitosan 500 ml/decare. It is this solution that shows the variety of possible solutions of the proposed economic-mathematical model. The optimization model selects the most optimal solution according to the set parameters in the objective function and offers such a distribution of the production structure, consistent with the restrictive conditions, different yield, market price, and the different economic efficiency of it.

In the optimization model, all set restrictive conditions are met to achieve maximum economic effect - maximum gross margin and maximum profit.

In the solution of the task, the optimal economic efficiency is achieved with a Gross margin of BGN 965,160, realized profit without subsidy of BGN 360,160 and with subsidy - in the amount of BGN 732,160.

In this option, the material costs increase from BGN 362,760 to BGN 474,000, due to the need to spray the rapeseed on the entire 12,000 decares area. Betting on this production in the agricultural economy, a decrease in income by BGN 128,044.80 is reported, or from BGN 1,675,204.8 it shrinks to BGN 1,547,160. This is a clear sign that treating crops with biostimulants in order to a good economic result is obtained, an increase in yield should be achieved in larger quantities. Apparently, the positive effect on yield, which is in the range (1-5% for 2021) for spring rape and (1-30% for 2021) for spring oats, is not enough to cover the increase in labor and material (production) costs, as a result of the application of biostimulants. In practice, this 1-30% increase in spring oats did not result in the inclusion of this crop in the problem solution. Here, in all probability, the key influence was not only the price purchase levels, but also the yield of the crop during the reporting economic year, which is in the range of about 35% of the average yield for the region, which is extremely insufficient. Theoretically, if their values are changed in the condition of the task, and this is completely possible and feasible, then the model after several iterations will give another optimization. The choice of spring oats as a crop to be treated with biostimulants in comparison with other agricultural crops is not relevant in this case (due to the unsatisfactory yield achieved). It would be more correct in this case to look for other competitive advantages to argue for the inclusion of spring oats in competition with rapeseed, wheat, sunflower and corn. For example, the added benefit of growing spring oats is weed suppression and soil moisture conservation. The advantage that oats are a dietary food should also be taken into account, as they have numerous uses in food – rolled oats, various baked goods, a substitute for milk, etc.

The constructed optimization model is a good opportunity to evaluate the economic efficiency of biostimulants in the optimization of the production structure of a specific agricultural holding. This means that with other parameters of another farm, the model will give different results. All this proves the flexibility and applicability of the model when making a management decision. The optimization model included in combination the complex of internal factors in the agricultural holding. Naturally, when applying the economics model, it should be clarified that the model works with clear and accurate input data in terms of value. In this case, some important factors of the external environment are not included, including current environmental, behavioral, social, institutional, etc. Possible future changes in the market environment, the climate, the behavior of the competition, the change in taste preferences among consumers are not foreseen in the economics task. The model does not identify the factors related to threats to the farm and potential vulnerability, which are extremely important criteria in making a management decision.

The fact that a competitive economy is built on the basis of a complex of multiple factors should not be ignored. Therefore, it is necessary to consider the importance of each one of them, to pay the necessary attention and priority. It would be difficult to reduce costs at the same time; to increase yields; to increase the quality of the manufactured product; to conserve natural resources, etc.

Additionally, some specific characteristics of the agricultural holding are not included in the construction of the limiting conditions of the optimization model. For example:

• Staff experience and management skills;
• Relationships, trust and reputation among society;
• Advantages in certain competitive positions, such as: own technology, advertising campaigns, economies of scale of production; innovative products and technologies;
• Location of the business;
• Partnerships;
• Quality management systems, etc.

These are existing positive factors in the business unit that favor the company's mission (conquered market positions, high qualification of personnel, registered patents and other objects of intellectual property).

Behavioral characteristics of managers, employees and all stakeholders are not included in the task condition. This largely predetermines the possible optimal decisions, which accordingly does not provide grounds for making the best management decision. The task does not provide an opportunity to take into account important factors for the operation of the farm, if it is in a situation of an unfavorable position compared to the competition. Also, the model does not allow recognition of the signals of the external environment. These are unused, potential opportunities and challenges facing the economy:

• Entering new markets and opening market segments;
• Implementation of new technologies;
• Vertical integration and diversification;
• Ability to adapt the existing technology for the production of new products;
• Strategic alliances, entrepreneurial networks.

Of course, all the above listed weaknesses of the proposed optimization model have a theoretical possibility to be included in the condition of the task and to construct additional restrictive conditions.

However, it should be kept in mind, purely theoretically, that the model allows to formulate such a task and seek optimization. All of the factors listed above could be involved in solving the task. In this case, when constructing the task, it would be appropriate to approach it with a certain "weight", as the qualitative indicators should be transformed into quantitative dimensions. With this option, the task will be extremely "difficult" to solve in EXCEL SOLVER. The purpose of such optimizations is based on optimality criteria: max or min of a selected economic indicator. It would be difficult to seek optimization in the objective function simultaneously to achieve maximum economic effect (purely mathematical values) with a combination of ecological, behavioral, market, etc. optimization. The more restrictive conditions are set (especially those based on expert opinion or of a purely subjective nature), the more the optimization seeks a balance between all of them, which is not always the best solution for such a case. However, priority should be given to a selected criterion. Another possibility is to compose different tasks, in which as criteria for optimality different optimization goals can be set, such as: achieving maximum ecological effect, maximum positive social effect, etc.

Another possibility provided by the model is to optimize the production structure with the use of biostimulants, in several consecutive years (for example three). In this option, it will be necessary to calculate new technical and economic norms, as well as to set different yields of agricultural crops, during the three years in which the crops are treated with biostimulants in the farm, a change in market prices of input factors of production and changes in the price of output. In the model proposed above, the effect on yield is taken from one economic year. In practice, this is a "snapshot" for a certain agrotechnical year and the obtained result is based on the defined criteria and restrictive conditions and, accordingly, results in specific agroclimatic conditions.

CONCLUSIONS

Based on the research done, the following conclusions can be summarized. Chitosan, vermicompost and nature-identical growth regulator are among the preferred and often applied products with biological activity in agricultural production. Foliar treatment with biostimulants has been found to have a positive effect on yield, technological and biometric indicators in organic cultivation of spring rapeseed and spring oats. On the basis of the experimental data from the Polish trials for two consecutive years, an optimization model was developed to evaluate the economic efficiency of the application of biostimulants. A positive economic result was reported for both treated crops, but this did not give an analogous result on the simulation model of a specific agricultural holding. It has been shown that although foliar treatment with biostimulants increases the profit per unit area, it does not affect the profit for the farm as a whole. Therefore, the optimization model should be applied independently and no hasty decisions should be made.

ACKNOWLEDGEMENTS

This work was supported by Project "Use of biostimulants in organic farming - assessment of contributions to the bioeconomy", funded by Contract № KP-06-N46 / 6 of 27.11.2020 from the Research Fund of the Ministry of Education and Science.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ANALYSIS OF THE DYNAMICS OF EMPLOYMENT AND ECONOMIC ACTIVITY OF THE RURAL POPULATION: A CASE STUDY OF UKRAINE

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Abstract

The article is devoted to the study of the problems of the formation of the economic activity of the rural population of Ukraine in the conditions of systemic market transformations. The specific features of the current situation with the labour supply of agricultural enterprises are determined, and the prospects of the dynamics of rural population migration in the context of strengthening European integration processes in Ukraine are outlined. The dynamics of the rural population of Ukraine were studied, and the prospects for its change in future periods were determined. Attention is focused on the specific migration trends of the rural population, associated with labour flows not only in the territorial aspect but also between different segments of the labour market. The peculiarities of fluctuations in the level of employment in rural areas of Ukraine during recent years have been studied, and the specifics of market changes have determined several factors affecting its dynamics.

Key words: *economic activity of the rural population, employment of the rural population, mobility of the rural workforce, migration processes in rural areas, agricultural sector*

INTRODUCTION

Ensuring the efficiency of economic systems is one of the critical tasks of building a thriving economy. In this aspect, one of the most essential factors affecting the successful functioning of the national economy and its components is the appropriate level of its resource provision. At the same time, the availability of a sufficient number of labourers and the quality of labour in the labour market are crucial prerequisites for ensuring economic growth. At the same time, it is necessary to consider the features associated with the uneven territorial distribution of the population. This problem is especially relevant in rural areas, where systemic transformations are observed in the population's employment and migration activity in connection with the long-term socio-economic crisis. At the same time, the intensive growth of the agricultural sector, which has been observed in Ukraine in recent years, objectively requires an increase in the available labour force to continue expanding production. At the same time, it is precisely for the rural population that employment problems are most noticeable, leading to the workforce's outflow and its gradual disqualification. That is why the study of ensuring the growth of the economic activity of the rural population of Ukraine is of particular importance in finding practical ways to solve the specified problems.

At the same time, dynamic changes in the global economic system transform views on specific processes related to the population's economic activity. This affects the analytical studies associated with this issue. It can be noted that currently, scientists' primary attention is related to research on migration processes and the professional mobility of the workforce.

Studies of the problems of the economic activity of the rural population are sufficiently widely disclosed in the works of such scientists as N. Bazaliiska [1], M. Dzyamulych [2-10], I. Kolmogorova [11], M. Makhsma [12], A. Popescu [13-23], M. Rudenko [24] and many others. In particular, research results show that recently there has been an increase in migration processes, a general decrease in the level of employment in agriculture and an increase in the share of the informal economy. At the same time, it is determined that such trends are due to both internal economic changes and external factors, such as globalization and integration processes.

However, taking into account the intensification of the processes of the movement of the rural population, as well as taking into account the intensive growth of the demand for labour in the agricultural sector, which has been observed recently, there is an objective need for the formation of current trends in the field of economic activity of the rural population of Ukraine and the development of ways to improve them to ensure effective socio-economic development of rural areas and their financial growth in general.

MATERIALS AND METHODS

The purpose of the publication is the study of modern specifics and trends in the field of economic activity of the rural population of Ukraine, as well as the formation of ways to improve the situation in the field of employment and professional mobility of the workforce in rural areas to ensure the general intensification of the economic development of rural areas.

Note that the dynamics of employment of the rural population reflects its desire to participate in economic activity during a specific period, thereby characterizing the situation's change with the availability of labour resources on the labour market.

At the same time, the concept of an economically active rural population is based on working age and employment parameters. In particular, in Ukraine, according to the methodology of the State Statistics Service, the population structure from the point of view of employment involves dividing it into separate groups (Fig. 1).

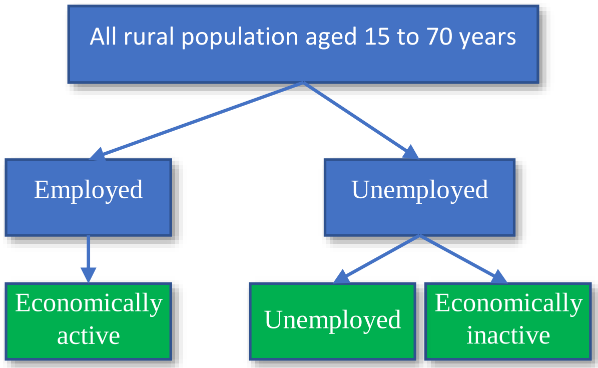

Fig. 1. The structure of employment of the rural population according to the methodology of the State Statistics Service of Ukraine
Source: Summarized based on [25].

RESULTS AND DISCUSSIONS

Modern approaches to the formation of effective employment for the rural population of Ukraine are defined by a comprehensive coverage of the problem, taking into account the role of the agricultural sector and non-agricultural industries in creating jobs, an emphasis on professional training and education to improve qualifications, stimulation of entrepreneurial activity in the countryside, as well as active support of state policy aimed at to increase employment and ensure sustainable development of rural areas. In addition, modern approaches seek to develop innovative solutions and introduce modern technologies in the agricultural sector to ensure the growth of labour productivity and the general expansion of employment opportunities for the rural population. At the same time, increased attention is paid to creating a favourable investment climate, infrastructure development and ensuring access to sales markets for rural entrepreneurs, which contributes to the development of entrepreneurial activity and stimulates employment growth in rural areas.

It is common knowledge that in conditions of reduced employment or falling income levels, the population seeks to change their place of work or migrate to another territory where the offer of jobs is more fantastic, and the wages are higher. The outlined trends are significant in the labour market of rural areas, as they are characterised by several restrictions that directly affect the labour supply, namely:

- the bulk of jobs in the village are related to agricultural production, which leads to specific deformations of the professional and qualification requirements for the rural population;
- in the case of a low level of income in the local labour market or the absence of jobs, the population migrates to cities, and recently - to other countries, where the situation with incomes and employment is more favourable, and such trends in most cases are irreversible;

In the case of professional mobility of the workforce, the rural population, which is focused mainly on professions related to agricultural production, also changes its segment on the labour market, which requires either professional training or a transition to lower, less qualified, and low-paid jobs.

Therefore, if events in the rural labour market develop negatively, the logical consequence can be a general reduction of the economically active population and its total number (Fig. 2).

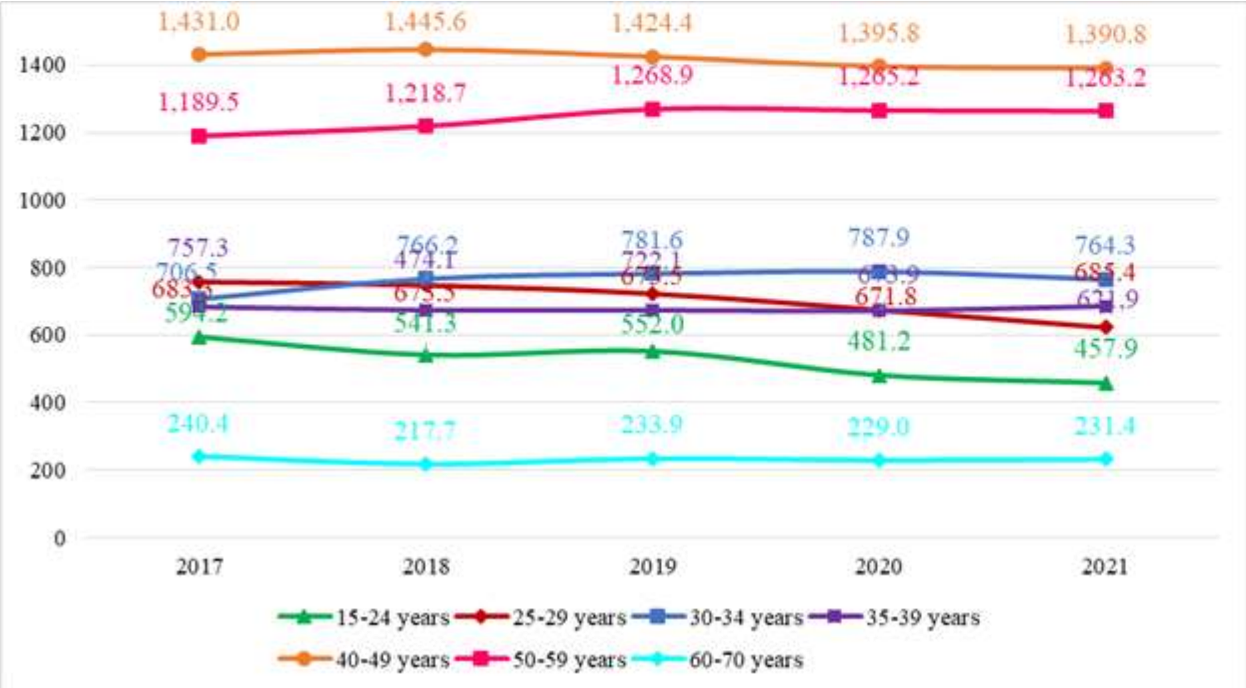

Fig. 2. Dynamics of the rural population of Ukraine of working age for 2017-2021, thousands of people
Source: own development based on [25].

As we can see, during the analysed period in the rural areas of Ukraine, only the specific weight of persons of working age 30-34, which increased from 706.5 to 764.3 thousand, and 40-49, which increased from 1,189.5 to 1,263, increased. 2 thousand people. At the same time, in all other age categories, a decrease in the number of the population or its slight change was observed. Also, we should pay attention to the age structure of the working-age population. In that case, the main share falls on the age categories of 40-49 and 50-59 years, constituting almost the same population as all other categories combined. This indicates a tendency towards ageing labour resources in rural areas and threatens to decrease the number of economically active populations in the future due to its natural reduction.

We conducted a study of the results of the grouping of the regions of Ukraine by the coefficient of natural increase (decrease) in the number of the rural population in 2021, calculated per 1,000 people of the existing population (Fig. 3). According to the results of the study, it was found that the most significant natural reduction of the rural population is characteristic of the northeastern and central regions of Ukraine (Fig. 3). At the same time, the lowest rates of natural reduction of the rural population during the analysed period are observed in the west of Ukraine.

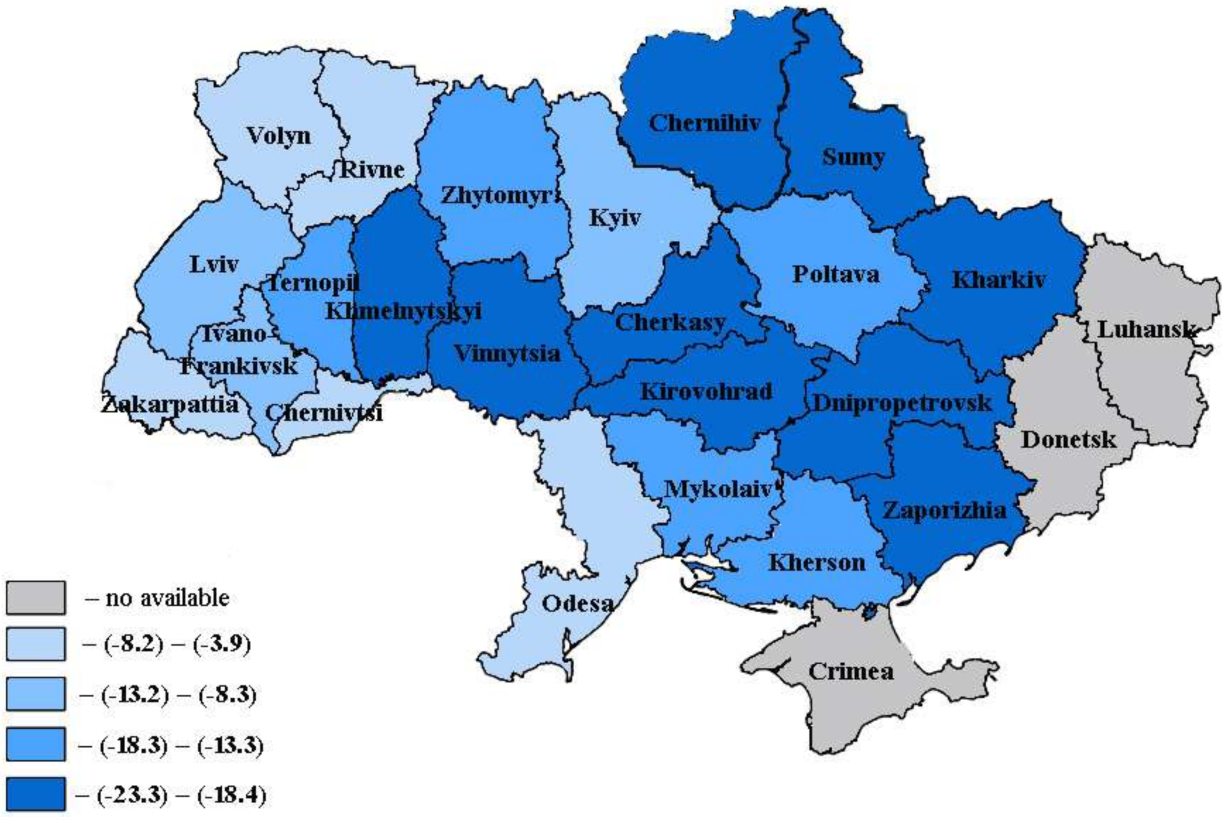

Fig. 3. Map of the results of the grouping of the regions of Ukraine by the coefficient of natural increase (decrease) in the number of the rural population of Ukraine as of January 1, 2022, calculated per 1,000 people of the existing population
Source: own development based on [25].

Thus, it can be stated that at present, in addition to socio-economic reasons, the number of economically active population in the rural areas of Ukraine is also negatively affected by demographic trends. All of the above can lead to a reduction in supply in local labour markets, which will hinder the intensification of labour development in the agricultural sector of Ukraine. Therefore, there is an objective need to apply preventive measures to stimulate the rural population's economic activity by reducing migration to other spheres of economic activity and urban areas.

According to the results of the study of the indicator of the demographic burden on the rural population of Ukraine aged 16-59 as of January 1, 2022, per 1,000 people aged 16-59, it was found that this indicator is the highest in Chernihiv, Khmelnytskyi, as well as Luhansk and Donetsk regions (Fig. 4). It is evident that for these regions the rate of ageing of the rural population is the highest, which requires the development of several special state support programs aimed at minimizing the situation that has developed in such regions, because the demographic burden in them reaches 868 people per 1000 people of the rural population aged 16-59, which is an extraordinarily high and unfavorable indicator.

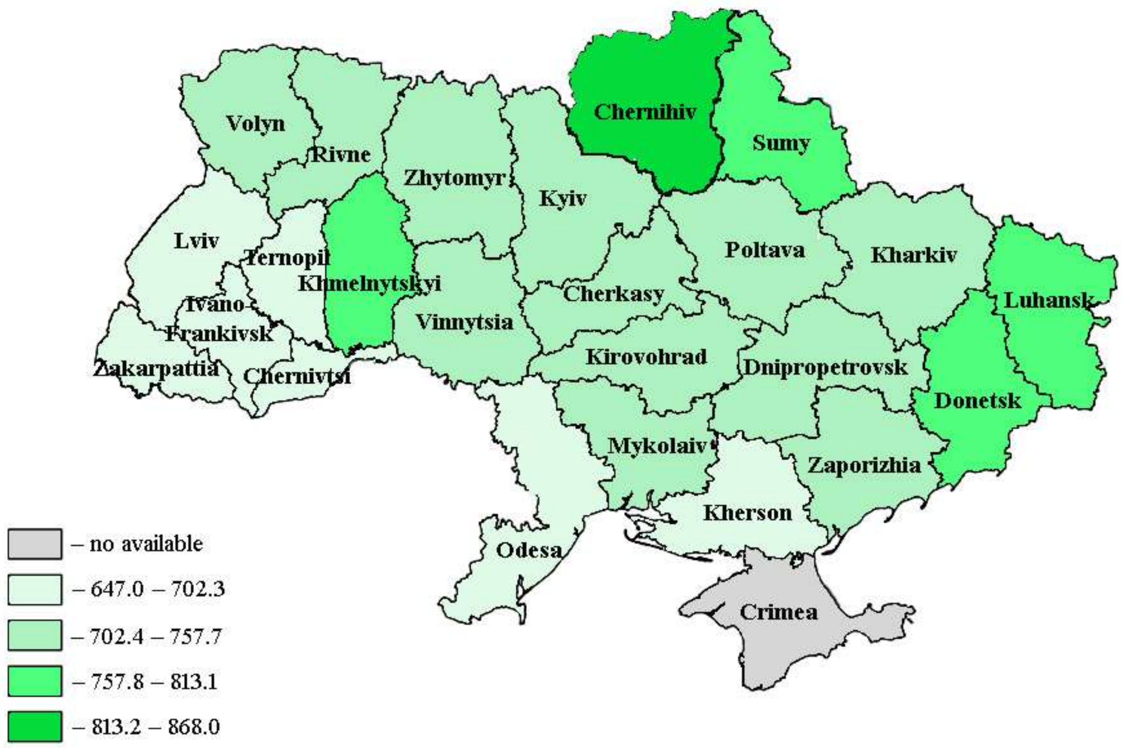

Fig. 4. Cartogram of the results of the grouping of the regions of Ukraine according to the indicator of the demographic burden on the rural population of Ukraine aged 16-59 as of Jan. 1, 2022, per 1,000 people aged 16-59
Source: own development based on [25].

It should be noted that the approaches to ensuring the employment of the urban and rural populations are different due to their different age structures. This is caused mainly by the different sectoral structures of workplaces since most enterprises in the countryside operate in the agricultural sector [10]. The outlined trend can be traced based on a comparison of the age structure of the employment of the rural population of Ukraine (Fig. 5).

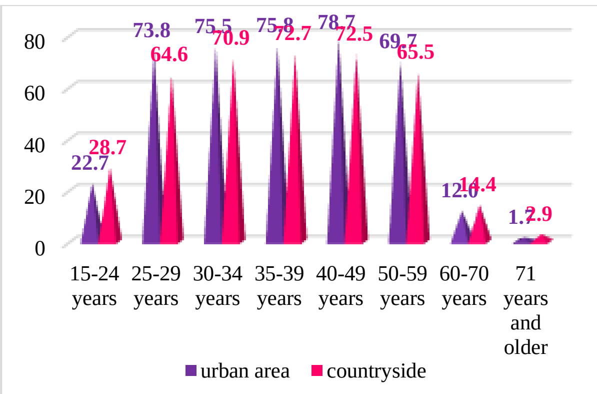

Fig. 5. Employment structure of the population of Ukraine by age and place of residence, 2021, %
Source: own development based on [25].

As we can see, in the age groups of the most active working population (25-59 years old), the employment rate is higher among residents of urban areas. In rural areas, the employment rate is higher only in the youngest age group (15-24 years old) and the oldest population group (over 60 years old). Such a disparity causes more significant problems with ensuring the employment of the rural population in rural areas. The lack of a strategy to solve employment problems threatens the growth of territorial mobility of the labour force and, in some instances, even professional mobility when the most qualified workers in rural areas change their place of residence to receive a higher level of remuneration [12].

The employment structure is also essential for regulating the population's economic activity. In particular, it is generally known that due to the rural population's sectoral agricultural orientation, a significant part of it works within the limits of self-employment by running personal peasant farms. Accordingly, this reduces the number of non-disabled people involved in production as hired workers, including in large agricultural enterprises or agricultural holdings (Fig. 6).

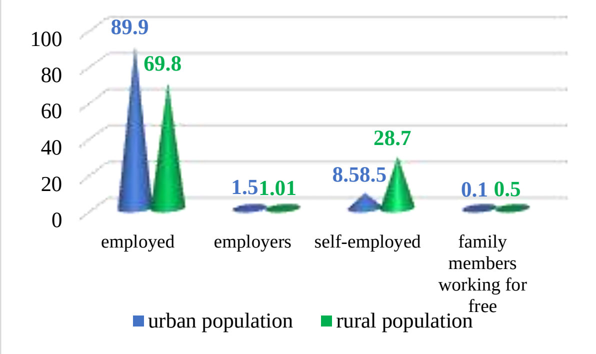

Fig. 6. Employed population of Ukraine aged 15-70 by type of area and individual characteristics, 2021, %
Source: own development based on [25].

As we can see, there is a significant difference between the urban and rural population in the employment structure of the population of Ukraine. It manifests itself in the fact that, on average, there are about 20% more self-employed people in the countryside than among urban residents. In particular, in 2021, the share of self-employed among the urban population was 8.5%, and among the rural population - 28.7%. The consequence of such disproportions is changes in the number of employed personnel. In particular, in the same period, 89.9% of urban residents worked for hire; this figure was 69.8% among rural residents. Thus, it can be concluded that the sectoral specificity of the rural labour market, focused on agricultural production, contributes to the change in the employment structure of the rural population due to a significant increase in the share of self-employed persons.
At the same time, it is necessary to note the growing role of migration processes and their influence on the number of economically active populations in rural areas. In particular, 10-15 years ago, the primary trend of territorial mobility was the relocation of rural residents to the city and related changes in the labour market; since 2015, significant changes have occurred in this area. In particular, with the strengthening of the processes of European integration and the opening of the borders of European countries for the residents of Ukraine, the flow of labour migrants to European countries has increased significantly. At the same time, this trend is felt considerably in the rural labour market, where a significant share of the population is involved in territorial interstate mobility processes, specifically in seasonal agricultural work. In particular, the largest share in such labour migration processes is the departure of the rural population to work in the countries neighbouring Ukraine - Poland, Slovakia, and Hungary. If, from a short-term perspective, such a population movement contributes to the reduction of tension in the regional labour markets in Ukraine and the growth of the flow of money coming from labour migrants, then there are negative consequences in the long-term trends.
In particular, every year, an increasing number of labour migrants from rural areas prefer not seasonal work in the field of agriculture but try to move to other countries for permanent residence, including - and with the transition to higher segments of the labour market, related with more qualified work and, accordingly, obtaining a higher level of income. At the same time, the determining reason for the increase in migration flows is precisely the low level of wages at agricultural enterprises and the low level of profitability of personal farms.
At the same time, significant investments made by national agricultural holdings in the development of agricultural production in recent years have led to an increase in the productivity and profitability of their activities, which also affects the increase in the level of remuneration of the employees of such enterprises. At the same time, it is predicted that the need for such significant agricultural associations in personnel will only grow, requiring the labour market to have a sufficient number of the economically active population ready to work as hired workers. However, the current negative migration trends pose a potential threat to the development of the national agricultural sector in the future, which requires the adoption of measures aimed at overcoming the crisis trends associated with the interstate migration of the rural population of Ukraine.

CONCLUSIONS

Thus, according to the study results, it was established that ensuring a high level of economic activity for the rural population of Ukraine is of particular importance in the context of the need to create effective employment in rural areas. An analysis of the employment situation for the rural population of Ukraine has been very favourable in recent years. At the same time, negative trends are associated with a general decrease in the working-age population in the countryside and a general population ageing, threatening a significant reduction in the available labour force. At the same time, the population's economic activity in rural areas remains relatively high, which is expressed in a significant number of self-employed persons, mainly in private agricultural production and in the growth of migration flows of the rural population for seasonal agricultural work abroad.

At the same time, it should be noted that overcoming the existing crisis phenomena in the rural labour market requires implementing several measures in the field of state and regional regulatory policy, which should be aimed at ensuring an increase in the number of jobs in rural areas. In addition, it is necessary to develop complex programs to support entrepreneurship in the agricultural sphere, which will contribute both to the increase in the level of employment of the rural population and to provide it with an increase in the level of income from such activities.

Among the main methods of ensuring the growth of employment in rural areas, it is worth including general promotion of the development of the agricultural sector of the national economy, diversification of economic activity in rural areas due to the development of small businesses and the service sector, improvement of the infrastructure of rural territorial communities to attract investments and increase the number of jobs. The need to form strategies for developing specialised training programs for local entrepreneurship and the use of migration regulation tools are also of great importance. This will make it possible to support entrepreneurship in the countryside and stimulate investment in the general development of rural areas, which will ultimately ensure employment growth. At the same time, developing an integrated approach and cooperation between the state, entrepreneurs, and local communities is necessary to provide practical, sustainable development in rural areas.

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ANALYSIS OF MODERN TRENDS IN THE TRANSFORMATION OF THE AGRICULTURAL SECTOR OF UKRAINE: A CASE STUDY OF A REGIONAL SURVEYOR

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Abstract

The article analyses the current state of the process of transformation of the agro-industrial sector of the economy of Ukraine in the context of existing challenges and prospects and the formation of the country's food security in the system of existing risks in the agricultural sector of the economy that have arisen in the realities of modern times. Possible ways of solving problematic issues are also proposed. The results of the grouping of the regions of Ukraine according to the indicator of the shortage of elevator capacities are presented. An assessment of the impact of factors that slow down agribusiness development in Ukraine in 2016-2021 is provided. The study results confirm that Ukraine`s agricultural business is an essential component of the economy, generating more than 1/10 of the country`s GDP annually. The analysis results prove the constant trends in the development of the agricultural market of Ukraine, especially in the part of large businesses operating here.

Key words: *agricultural sector, transformation trends, agro-industrial complex, agricultural production, food security, the association between Ukraine and the European Union*

INTRODUCTION

The agricultural sector was and remains one of the leading contributors to Ukraine's budget and is the basis of its food security. It should be noted that in modern realities, the "Center for Food and Land Use Research (KSE Agrocenter)" is engaged in constant monitoring of food security and agricultural policy in Ukraine together with the "Ministry of Agrarian Policy and Food of Ukraine".

Before the development of transformational phenomena in the agricultural sector of Ukraine, caused by external geopolitical influence, almost 400 million people in the world were provided with food and agricultural products due to their exports from Ukraine to the world market. According to USDA data, before the transformation processes, Ukraine supplied 46% of the world's sunflower oil exports, 9% of wheat exports, 17% of barley exports, and 12% of corn exports on international markets [23]. Thus, today, Ukraine is among the largest suppliers of agricultural products in the EU and occupies an equally significant place in the world trade of farm products.

Modern studies of the processes of transformation of the agricultural sector emphasize the regional features of the development of the agrarian sphere. The main trends include the introduction of innovative technologies, adaptation to climate change, and the role of state support for agriculture. At the same time, at the regional level, studies note significant differences in production indicators, which is caused by different availability of labor resources and management efficiency. The main studies of this issue are presented in the works of such scientists as N. Antoniuk [2], I. Arakelova [3], V. Boiko [4], M. Dziamulych [7-15], N. Khomiuk [18], V. Kostiuk [19], I. Mazniev [21], A. Popescu [24-33], M. Rudenko [34], T. Shmatkovska [35-40], R. Sodoma [41], A. Verzun [46] and others.

The existing trends in the development of Ukraine's agricultural sector, the level of its efficiency, the market balance of the leading indicators, and attractiveness factors for investors prove the relevance of the research topic. Thus, the issue of food security and the importance of the agricultural sector of Ukraine's economy have always been, are and will be relevant, especially against the background of the latest geopolitical events in the world.

In this context, The purpose of the study is to analyze the current state of the transformation process of the agro-industrial sector of Ukraine's economy in the context of existing challenges and prospects, the formation of the country's food security in the system of existing risks in the agricultural sector of the economy that have arisen in the realities of modern times, and possible ways to solve problematic issues.

MATERIALS AND METHODS

We used analysis and synthesis, induction and deduction, analytical and statistical methods, and graphic methods to visualize the presented research results during the research.

RESULTS AND DISCUSSIONS

Food security is one of the most critical components of the national security of any state. Ukraine plays an integral part in global agrarian geopolitics. That is why complications in global geopolitics involving Ukraine are a critical negative factor in many countries' deterioration of food security. In addition, it is worth noting that other factors, in particular, also influenced the functioning of the global agro-food system:

– price disparity for agricultural products;
– low quality and unsatisfactory quantity of material and technical means for agricultural production (including plant protection means and fertilizers);
– negative socio-economic consequences caused by the COVID-19 pandemic;
– change in climatic conditions on Earth [4].

The negative impact of geopolitical problems involving Ukraine on the economy of most countries is noted at world economic forums. Many Ukrainian agricultural enterprises suspended their activities during the crisis, suffering significant destruction. Some were forced to evacuate their facilities to safer places. Still, the peculiarity of agribusiness is that extensive stationary-type facilities cannot be moved and are tied to land, which, in turn, destroys the logistical ways of exporting products of agricultural enterprises, agricultural holdings, and farms.

It is worth noting that last year, 2021, Ukraine entered the agricultural history as an absolute record - more than 106 million tons of grain and oil crops were harvested, the absolute maximum in the state's history. Ukrainian farmers harvested more than 84 million tons of grain and legumes, of which a significant share is accounted for by corn, wheat, and barley (40, 32.4, and 10.4 million tons, respectively). As for oil crops, according to the results of 2021, 22.6 million tons of them were collected [16]. This shows that during the implementation of most export contracts in the agricultural sector, elevators and warehouses of Ukraine are, in most cases, wholly filled with farm products to be exported. Accordingly, the destroyed sea logistics routes and the establishment of new land routes, which are far from being able to ensure the export of the necessary volumes, negatively affected the activity of the agricultural sector. Before the "grain corridor" opening, the prospect of exporting surplus grain of corn, wheat and sunflower for the 2021 harvest was unlikely since the carrying capacity through the Danube River and the western borders was relatively low. The cost of logistics was also added, which, in turn, made the export of agricultural products from most of the country unprofitable. An additional negative factor for exporters, especially those who did not work with the countries of the European Union, was the requirement for the quality of exported products, particularly regarding the residues of pollutants, diseases, pests, and toxicity. Most exporters needed to gain experience and knowledge of EU legislation. Therefore, this logistics path did not give a 100% guarantee that the products would not be returned due to non-compliance with the requirements.

In turn, there were many concerns about the quality of grain, which had been stored and "overstayed" in warehouses and elevators for quite a long time. But, as the results of the "grain corridor" showed, the fears of sceptics about grain quality were not justified. Ukraine confirms its status as a producer of quality grain and a reliable partner in its supply to fight the world's food crisis.

At the same time, exporters faced problems such as grain processing. In particular, this problem in 2021 concerned corn, which had been stored in elevators for a long time. The main reason was the uncontrolled use of pesticides during the post-harvest treatment of grain from pests. It is worth paying attention; before using any drug on your own or treating grain with it, you need to consult with the manufacturer or supplier of drugs. To minimize such risks, it is better to involve fumigation experts and treat them with phosphine-based preparations to avoid problems with exceeding the limits of residual substances when exporting products yourself or supplying the exporter. Also, in some cases, issues with the presence of storage mycotoxins could arise, but such cases, as a rule, occur only when conditions are not met during storage.

The "Grain Corridor" remained the main logistics route for exporting the 2022 harvest. In particular, as of October 2022, about 32.7 million tons of grain and oil crops were collected from about 9.5 million hectares of cultivated areas, and 7.38 million tons of new and old crops were exported through the "grain corridor".

According to the results of the already exported products of the 2022 harvest, namely, corn, wheat, barley and rapeseed, it is possible to assess their current quality and provide a comparative characteristic with the indicators of the past year 2021.

The main problem in exporting corn is the control of mycotoxins. It is important to remember that all countries that import Ukrainian corn control mycotoxins, regardless of the purpose of the products. The level of mycotoxins increases because producers and direct elevators can accept products without drying them and without bringing them to the proper condition for long-term storage.

Several hundred different mycotoxins have been identified in the world, but the most common and dangerous to human and animal health are such mycotoxins as:

– Aflatoxins (products of Aspergillus genus);

– Ochratoxin A (OTA) (products of the Penicillium genus);

– Fumonisin, Zearalenone (ZEA) (DON) (produced, in particular, by the genus Fusarium).

At the same time, fungi that affect grains can be divided into two groups:

– fungi affecting plants in the field, that is, during its growing season (species of plant pathogenic fungi, namely the genus Fusarium);

– fungi that develop during storage (fungi of the genus Aspergillus and Penicillium) can also infect products in the field.

Deoxynivalenol, Fumonisin, Zearalenone and T2/HT2 are the most common mycotoxins for Ukrainian corn. It is also worth noting the increased content of benzo(a)pyrene, RAN4 and dioxins in corn because corn is most susceptible to drying, depending on weather conditions during harvesting, and oil crops such as soybeans, rapeseed, and sunflower, because dioxins, benzo(a) pyrene, RAN4 is a fat-soluble product, i.e., in its central mass, it passes from the seed into oil.

The increased gas price can encourage producers and those who store corn to save on dryer burning agents, using low-quality fuel, fuel oil, etc., instead of gas. Therefore, when buying and immediately before exporting corn, it is worth paying attention to a set of indicators (Table 1) and discussing with corn suppliers what types of dryers and fuel they use. It is possible to conduct sampling by an independent surveyor directly at storage locations before purchase or shipping to the port.

Table 1. Basic indicators of the export quality of corn in Ukraine

Parameters according to EN, ISO	Harvest 2021	Harvest 2022
Moisture, %	14.41	14.17
Nature, kg/hl	73.0	73.75
Beats, %	3.47	3.26
Damaged, %	1.5	0.61

Source: Generalized based on [45].

As for the quality of wheat in 2022, a significantly higher index of nature compared to last year is observed throughout Ukraine, but at the same time, a significant decrease in the index of protein and, accordingly, gluten; according to other indicators, the quality of wheat is at the level of the previous season.

In the new season, there are no significant problems for wheat concerning the presence of harmful fungi that affect quality indicators during export, namely Tilletia controversa, Tilletia laevis, and Tilletia tritici, which cannot please, since this indicator is increasingly one of the main requirements of importing countries and buyers are interested in buying batches completely clean of the genus Tilletia mushrooms.

According to the results provided by the surveying companies of the Ukrainian Grain Association members, the quality of the wheat baking indicators for some of them improved in 2022 (Table 2).

Table 2. Bakery indicators of wheat export quality in Ukraine

Parameters according to EN, ISO	Harvest 2021	Harvest 2022
Protein on dry matter, %	12.58	11.75
Nature, kg/hl	77.1	79.0
The number of falls, sec	345	351
Gluten, % (mechanical washing)	25.9	21.4
W, 10-4 J	217	186

Source: Generalized based on [45].

In particular, we can see that the grain's nature has grown significantly. This means a greater yield of flour and groats will be obtained during processing because nature characterizes the grain's flour and excellent quality.

It should be noted that the main problems for barley in 2022, as in previous years, remain the presence of quarantine objects, such as Avena ludoviciana Durien and Aegilops cylindrica, which are prohibited quarantine objects for export to China.

For the European Union, Avena ludoviciana Durien and Aegilops cylindrica, fortunately, are not a quarantine object and are therefore limited only by % litter admixture according to the contract (Table 3).

Table 3. Indicators of export quality of barley grain in Ukraine

Parameters according to EN, ISO	Harvest 2021	Harvest 2022
Protein on dry matter, %	11.25	11.70
Nature, kg/hl	62.9	62.7

Source: Generalized based on [45].

Different from wheat, according to the results of the 2022 harvest, the quality indicators for barley have mostly stayed the same from last year.

The 2022 harvest of rapeseed greatly pleased the producers with oiliness indicators that are 2% higher than last year. Also, the quality of rapeseed is accompanied by the absence of problems with erucic acid and glucosinolates, the high content of which is an indicator of technical rapeseed (Table 4).

Table 4. Indicators of export quality of rapeseed in Ukraine

Parameters according to EN, ISO	Harvest 2021	Harvest 2022
Oiliness (as is), %	42.50	44.5
Erucic acid, %	0.15	0.05
Glucosinolates, μmol/g	9.7	9.9

Source: Generalized based on [45].

An equally important export component is sunflower and sunflower oil. Sunflower yield in Ukraine in 2022 was 2.19 tons per hectare [22]. This year, the area under sunflowers is the lowest in the last ten years – 4.75 million hectares [20]. In particular, in connection with the deterioration of weather and climate conditions, namely prolonged rains in September, in addition to the shift of the harvest campaign, significant areas of sunflowers are affected by diseases, which affects their quality. In particular, 16% of the examined crops were affected by fomosis. The highest damage is observed in the Kirovohrad region – 40% of the area. Other common diseases include white and grey rot. In particular, white rot affects 6-32% of areas and 2-20% of plants, with the development of the disease 1-10% (Ternopil, Vinnytsia, Dnipropetrovsk, Kirovohrad, Zaporizhzhya, Cherkasy regions), grey rot - 12-37% of areas, 1- 20% of plants with disease development 1-10% (Ternopil, Vinnytsia, Dnipropetrovsk, Kirovohrad, Zaporizhzhya, Zakarpattia, Cherkasy regions).

Peronosporosis affected 20% of sunflower areas, 3-6% of plants with the development of the disease, 0.2% (Khmelnytskyi region), rust – 4% of the areas, 8% of plants, and 5% with the development of the disease (Kirovohrad region).

Aphids also feed on sunflower crops. They colonised 10% of the areas at 1.0-8.0 specimens/plant and damaged 1% of the plants (Khmelnytskyi region). In addition, bugs, which infested 50% of the areas at the rate of 2.0-4.0 specimens/plant, damaged 6-8% of the plants (Khmelnytskyi region), cotton bollworm – 4% of the areas at the rate of 0.5 specimens/m^2, 8% of plants were damaged (Kirovohrad region) [17]. We must admit that under such conditions and with the reduction of sunflower areas in Ukraine, significantly less grain and oil were exported from it in 2022 (Table 5).

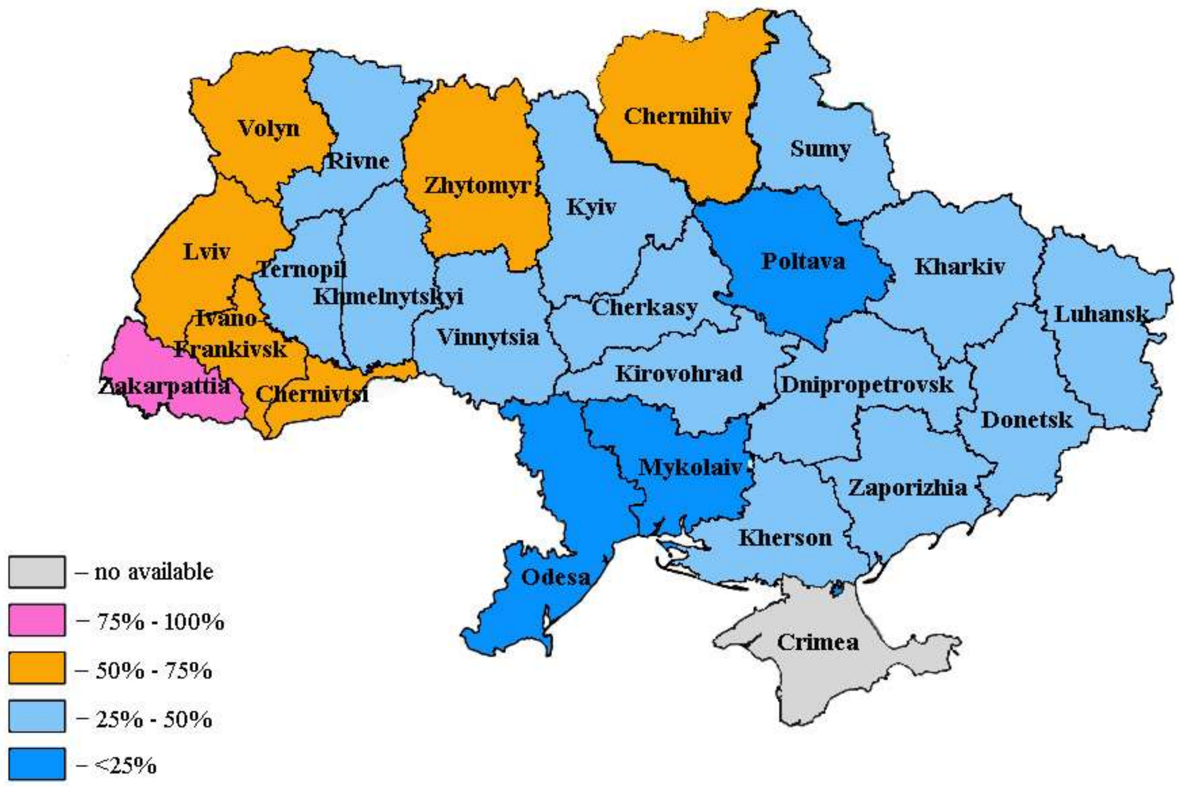
Table 5. Yield Indicators of Ukraine in 2022

Agricultural culture	Area, million ha-thousands ha	Share of the total sowing area, %	Yield, t/ha	Threshed, million t-thousand t
Wheat	4.7	100	4.12	19.4
Barley	1.6	100	3.51	5.6
Pea	111.5	100	2.34	261
Turnip	1.1	100	2.89	3.2
Millet	42	93	2.33	97
Buckwheat	104	88	1.36	141
Sunflower	3.2	68	2.19	7.0
Soy	798	52	2.36	1.9
Sugar beet	89	49	47.8	4.2
Corn	528	12	5.07	2.7

Source: [22].

Understanding the key trends of the agricultural market is necessary for correct and practical decisions made by information users. Such an understanding is provided through qualitative analysis and assessment of information as the primary tools for ensuring trust in the Ukrainian agricultural market.

It is important to emphasize that the current state of the elevator, transport, and irrigation infrastructure forms the prerequisites for the further development of Ukraine's agricultural sector. In particular, based on the study results, we grouped the regions of Ukraine according to the indicator of the shortage of elevator capacities (Map 1).



Map 1. Cartogram of the results of the grouping of the regions of Ukraine according to the indicator of the shortage of elevator capacities, %
Source: own generalisations based on [42].

It was found that the most significant shortage of elevator capacities is observed in the Zakarpattia region (Map 1). In addition, there is a relatively high deficit in most of the western border regions of Ukraine, particularly in the Volyn, Lviv, Ivano-Frankivsk and

Chernivtsi regions. The most minor shortage of elevator capacities in Ukraine is observed in the Poltava, Odesa and Mykolaiv regions, which are located in the south and centre of the country. It is important to note that the Ukrainian agricultural market developed and continues to develop under certain restrictions and the influence of negative factors (Fig. 1). We consider all limits directly from the point of view of Ukrainian farmers.

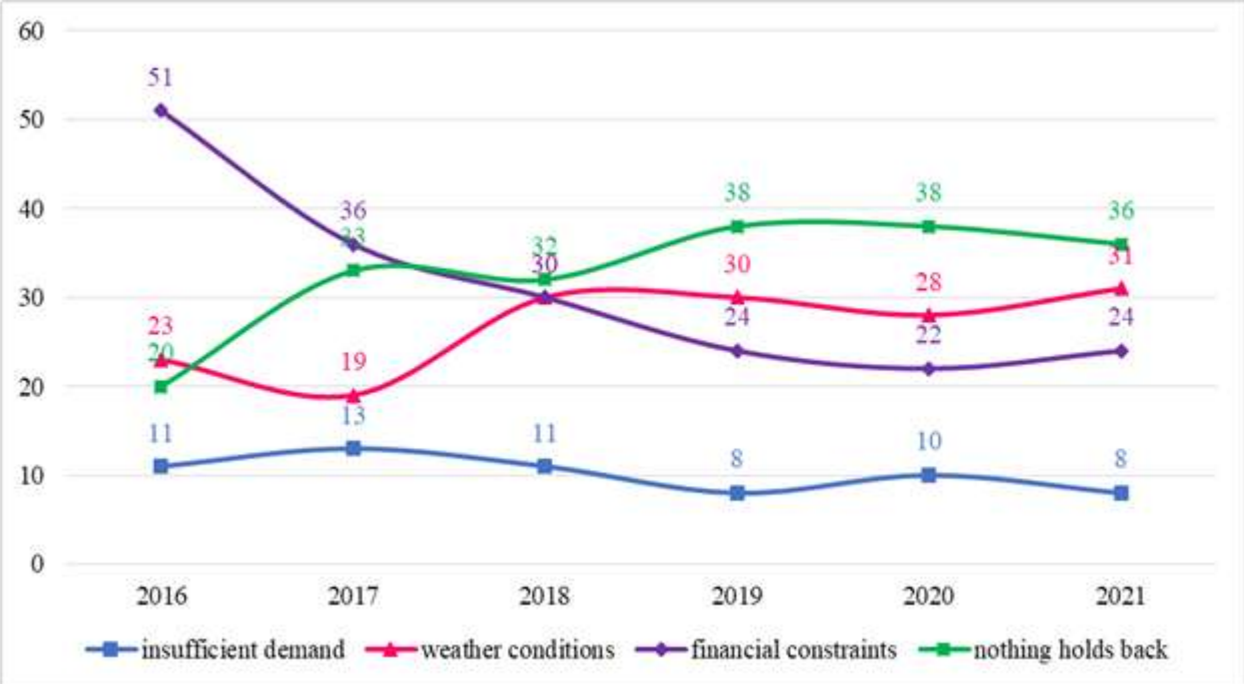


Fig. 1. Assessment of the impact of factors that slow down the development of agribusiness in Ukraine, 2016-2021, %
Source: own development based on [42].

In particular, when assessing the expectations of agrarians regarding the significance of factors restraining the development of agribusiness in Ukraine, the following was found:
1. insufficient demand (11% of respondents chose it as essential in the 3rd quarter of 2016, and only 8% in the 3rd quarter of 2021);
2. weather conditions (19-30% of respondents during 2016-2021 considered it a significant influencing factor).
3. labour shortage (the least important factor for agribusiness – only 1-4% of respondents in different years paid attention to its negative impact);
4. lack of materials and equipment (8% of respondents considered this a problematic issue in the 3rd quarter of 2016, but at the end of the 3rd quarter of 2021, only 2% of them held this opinion);
5. financial constraints (51% of respondents were concerned about this factor in the 3rd quarter of 2016, and only 22% in the same period of 2021).

Agribusinesses often need more financing than is available. In this case, cheap and long-term financing is considered available. Ukrainian banks could not ensure the fulfilment of these criteria, especially during the “bank collapse” period, since the financing of national banks and investors was expensive and short-lived, especially in 2016.
However, some Ukrainian banks now offer affordable financing tools. In addition, instruments of international financing have gained popularity. First, this concerns the European Bank for Reconstruction and Development (EBRD) [1]. Therefore, in 2021, the availability of cheap and long-term financing for farmers is much higher than in 2016.
Thus, it is worth emphasising that since 2016, agribusiness has been developing under conditions of significant financial restrictions, which were eliminated by 2021. Weather conditions, which, according to the specifics of the industry, are a normal phenomenon, have become the predominant negative factor for

agribusiness this year. At the same time, in 2021, the agricultural market feels that the factors restraining development have become weaker. The absence of a significant impact of financial restrictions, lack of materials, equipment and labour, and insufficient demand allowed farmers to be included in the list of those least affected by the quarantine restrictions introduced during the spread of COVID-19 [44].

The process of Ukraine's association with the European Community must involve implementing the provisions of the Agreement in Ukraine's legislative field and harmonising the Ukrainian legal framework. It was established that by the end of 2022, the overall progress in implementing the document was estimated at 72%, in particular, in humanitarian policy – 91%, in entrepreneurship – 88%, and in agriculture – 63% (Fig. 2).

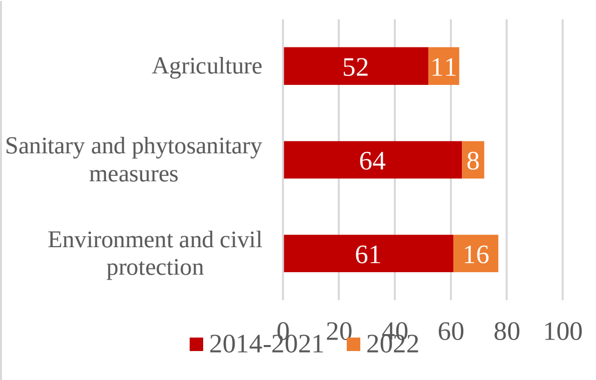


Fig. 2. Overall progress in the implementation of the association agreement between Ukraine and the European Union by spheres of activity, %
Source: own development based on [5; 43].

Ukraine has partially harmonised its own regulatory and legal environment with the requirements of the European Union. However, there are still areas of activity for which the legislation needs significant improvement, including the development of implementation mechanisms.

	No. Chapters	Ukraine	Moldova	Georgia	Turkey	Serbia	N. Macedonia	Montenegro	Albania	Bosnia	Kosovo
Total score (without chapter 23)		69	55	67	94	98	97	99.5	84.5	52	56
Basic sections											
Judicial system and fundamental rights	23	n/a	n/a	n/a	1	2	2.5	3	2.5	2	n/a
Justice, freedom, security	24	2	2	2	3	2	3	3	2.5	2	1.5
Public procurement	5	2	1	2	3	3	3	3	3	2	2.5
Statistics	18	2	2	2	3	3	3	3	3	1	2
Financial control	32	1	1	2	4	3	3	3	3	2	2
Green agenda and sustainable connectivity											
Transport policy	14	2	2	2	3	4	3	3.5	2	2	1
Energy	15	4	2	2	3	3	3	4	3	1	2
Trans-European networks	21	2	2	2	5	3	4	3.5	2	2	2
Environment and climate change	27	1	1	1	2	2	2	2	2	1	1
Resources, agriculture and cohesion											
Agrarian industry and rural development	11	1	1	1	2	2	3	3	2	1	2
Food safety, veterinary medicine, phytosan	12	3	2	2	2	3	4	3	2	2	2
Fishing	13	1	1	2	3	3	3	2	2.5	1	1
Region. policy, structure tools	22	2	1	1	2	3	3	3	3	1	1
Financial and budgetary provisions	33	1	1	1	2	2	1	2	2	1	n/a

Fig. 3. Evaluation of Ukraine as an EU candidate state in terms of approximation to European law and practice
Note:

1	**basic level**	**2**	**is some approximation**	**3**	**medium level**	**4**	**good level**	**5**	**advanced level of approximation**

Source: own development based on [6; 43].

According to the materials of the analytical report of the European Commission on the level of convergence of Ukrainian legislation with current EU law (February 2023), Ukraine demonstrates an initial level of training in the field of environment and climate change in the field of agriculture and development of rural areas, as well as a certain level of training in the field of regional policy (Fig. 3).

This provides grounds for concluding that there is a need not only to create an appropriate legal environment but also to create a system of administratively capable institutions, the functional purpose of which should be the regulation of agricultural and rural development, the protection of the natural environment, the development of mechanisms for the implementation of the provisions of European regulatory documents, the provision of systematic monitoring and control of relevant processes, etc.

CONCLUSIONS

Understanding the key trends in the development and transformation of Ukraine's agricultural sector is necessary for correct and practical decisions made by users of such information.

The study results confirm that Ukraine's agricultural business is an essential component of the economy, generating more than 1/10 of the country's GDP annually. The analysis results prove the constant trends in the development of the agricultural market, especially in the part of large businesses operating here. For example, 14% of the largest business entities in Ukraine, regardless of size and form of ownership, are agribusinesses.

The world market has recently seen a significant increase in agricultural products; in particular, the price policy for wheat and corn has increased by 20%. Many factors contributed to these processes, including crop failures in agricultural production countries due to adverse climatic conditions (droughts, fires, floods). The outlined trends in the future will lead to an increase in the cost of essential food products, especially in third-world countries. Reducing the price tension in the world market of agricultural products is possible by assisting Ukraine's leading world leaders. It should also be emphasised that agribusiness was slightly affected by quarantine restrictions and the economic crisis caused by the COVID-19 pandemic. This makes it attractive for foreign investment, which is refocusing on a more substantial business in a period of increasing number of liquidations of market entities.

In particular, the domestic agricultural market should implement a policy aimed at:

- provision of preferential loans to farmers for the restoration of equipment and production facilities;
- provision of preferential loans by foreign investors for the restoration of the infrastructure of storage, transportation and processing of plant and animal products;
- introduction of the latest advanced technologies for growing and processing agricultural products to promote their export with high added value;
- modernisation of logistics routes, namely bringing the width of the Ukrainian railway track to European standards with the involvement of foreign capital.

It is equally important to create conditions for the permanent, uninterrupted, and safe export of agricultural products by the sea with the world community's support.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

MANAGEMENT OF INFRASTRUCTURE DEVELOPMENT PROJECTS OF UKRAINE AND RURAL AREAS

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Abstract

The article examines the rapid development of the latest methods in the management of infrastructural development projects of Ukraine in the regional dimension in modern conditions, focusing on effective management, strategic vision of development and high-quality formulation of current projects, in particular infrastructure projects. Emphasis is placed on the size of the population in Ukraine and the factors affecting the unemployment rate are indicated, as well as the project index is defined for the most important areas in the regions, in particular, such as education and health care. An analysis of statistical data was carried out for various clusters of regions of Ukraine using the method of total ranks and diversified indicators of infrastructural development. A cartographic visualization of the cluster distribution of regions by classes of the regional infrastructural development index is shown. It has been confirmed that in order to achieve strategic goals, it is necessary to implement a flexible model of city management and use innovative cooperation tools. This article is important for understanding the current trends in the management of territorial communities and the need to ensure their development through effective projects and programs.

Key words: *digitalization, modelling, project management, territorial communities*

INTRODUCTION

In modern conditions, we are observing the rapid development of territorial communities, effective management of their activities, strategic vision of development and high-quality formulation of actual projects, in particular infrastructure projects, but there are still a number of unresolved problems that require financial resources. The territorial community, realizing its responsibility for its future, is forced to join the management process, including through project activities.

Any territory has different opportunities for the development and implementation of projects, programs and project portfolios, therefore, with regional differences, the state is obliged to preserve the unity of the state space and provide its citizens with a guaranteed level of access to the products of projects and programs.

Management of innovative projects requires the involvement of active people to search for creative and promising ideas to determine the potential development opportunities of territories. It is important to strengthen responsibility and introduce communications between the authorities, citizens and business [17].

Digitization as an integral component is present in the development of modern cities and territories [10]. Digitalization is the process of using technologies to improve the usage of information as a main asset and digital business. Ringenson, et al. [15], while modernization represents the transition from traditional to modern society and forms a link between the current and future state of development [9]. Bushuyev S. [3; 4; 5], Ivanusa A [8], Popescu A. [13; 14], Todorović, M. [20] on the other hand, the implementation of infrastructure projects, programs and project portfolios in the regional dimension is an important aspect of community development, in particular with the application of safety-oriented management approaches.

The purpose of the research is to find ways to improve the management of territorial development, to define the essence of the sustainable development strategy in the context of modern challenges.

MATERIALS AND METHODS

The research conducted in this article is based on general economic methods, which are most often used in the scientific works of scientists. The main method of research is economic and statistical, aimed at identifying modern patterns of socio-economic development of territories. With the help of a logical method, we form the main theoretical statements and conclusions, based on research conducted by leading scientists of Ukraine and the world. The conducted research was carried out on the basis of statistical information using methods of scientific knowledge and generalization. Graphical and tabular methods are used for the purpose of visual representation of the obtained results. Economic-mathematical modeling and the method of total ranks were used to construct a cluster distribution of regions by classes of the regional infrastructural development index.

The problems of managing the development of territories, including by uniting several communities to jointly solve problems, were highlighted in many scientific works. Perspective of strategic planning and its possibilities for the administrative component of territorial communities gained significant importance in the process of decentralization. Such a study was conducted by Torhal T. [21], who characterized the quality of the processes of reforming and the creation of united territorial communities in Ukraine and identified the problems of direct access of citizens to the government and the community, as well as the lack of a planning organization system. In their research, the authors thoroughly prescribe the need to improve the qualifications of officials who work in the framework of the development of regions.

A significant number of researched issues in today's conditions acquires new aspects of relevance, and singles out a number of problems and creates new opportunities for the implementation of creative ideas. There remain insufficiently developed issues of the current state of territorial development in Ukraine both in scientific and applied aspects. In particular, the adaptation of project tools to the specifics of the functioning of territories and the improvement of the methodology for evaluating the effectiveness of territorial development projects.

RESULTS AND DISCUSSIONS

The development of socio-economic processes, which has successfully begun, will contribute to the successful development of the territories of Ukraine. This concerns improving the effectiveness of interactions between state authorities, the leadership of territorial communities and representatives of public organizations. The combination of the security system, science, education and investment capital provide a breakthrough in innovation and become the basis of a strong economy.

Factors affecting the development of territories are divided into natural (possibility of using natural resources), geographical (good location), social (social stability, community activity), economic (level of income and expenses, as well as business prospects), ecological (natural environment), cultural (historical value of territories) and innovative (marketing policy, credit policy, territorial development programs, implementation of start-ups and projects in the territory).

Let's consider the territorial features of Ukraine in Figure 1, in the section of regions, analyzing the area and number of territorial communities. The largest number of territorial communities - 91 TC (Odesa region), 86 TC (Dnipropetrovsk region) and 73 TC (Lviv region), the smallest - 37 TC (Luhansk region) and 49 TC (Kherson region). In terms of the largest area, Odesa Oblast was also ranked 1st, and Dnipropetrovsk region was ranked 2nd. Lviv Region has the largest number of villages - 1,850, and Donetsk Region - 52 cities.

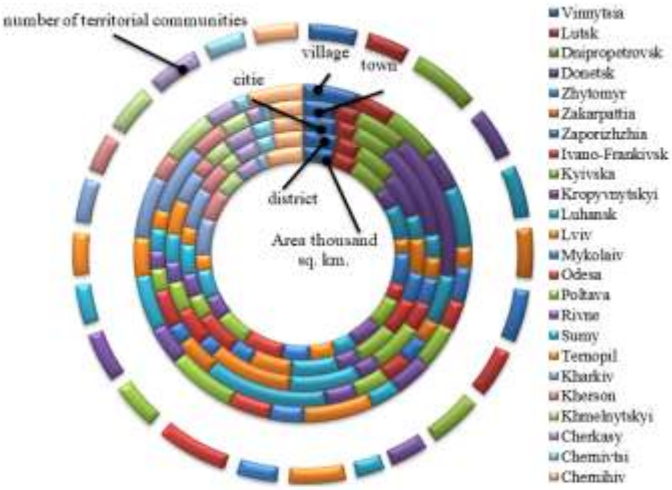

Fig. 1. Structural decomposition of territorial systems of Ukraine
Source: own development.

The administrative-territorial structure of the regions as a whole is typical for Ukraine. Territorial communities are mostly close in terms of territory, but differ significantly in population size and density. The population size is shown in detail in Figure 2.

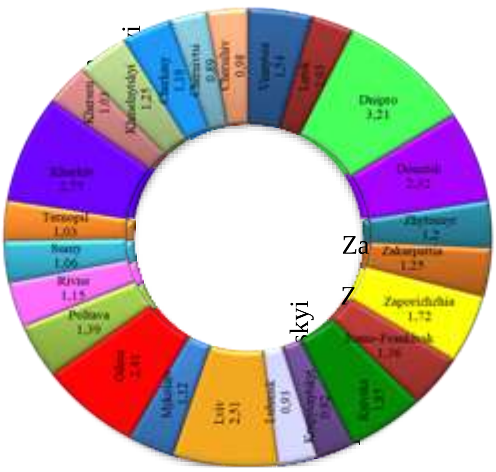

Fig. 2. Population size as of January 1, 2022, million people.
Source: own development.

In the structure of regions, there are groups of densely populated territories (Dnipro, Donetsk, Lviv, Odesa, Kharkiv) and sparsely populated (Kropyvnytskyi, Luhansk, Chernivtsi, Chernihiv). Each of these groups has its own characteristics of economic and social development. Territories that are more populated, located near the coast of the seas, are much more economically capable than mountainous areas or areas where the population density is too low. If we compare the percentage ratio of the urban population to the rural population, then in most of the country the urban population prevails, but the rural population has an advantage in Zakarpattia region (by 26%), Ivano-Frankivsk region (by 12%), Rivne region (by 4%), Ternopil region (by 8%), Chernivtsi region (by 14%).

Alternative labor market assessments have confirmed that there has been a significant increase in unemployment following a full-scale invasion, and that there is potential for job losses in some regions during the protracted war phase.

The level of unemployment increases annually, which is caused by a decrease in the financial results of enterprises, an increase in the minimum wage, thereby optimizing the number of employees, transferring them to part-time work, or completely reducing them. Unemployment, of course, has negative socio-economic consequences both for the state, which loses tax revenues and increases unemployment benefits, thereby losing about 3% of GDP, and for the population, due to insignificant additional payments, which are difficult to live on, and due to increasing the already significant burden on working people. The unemployment rate by region is shown in Figure 3.

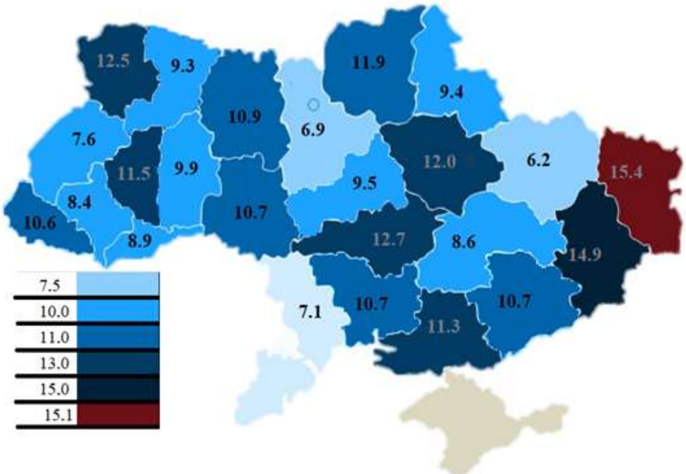

Fig. 3. Unemployment rate in the country, in %.
Source: own development.

The main cause of unemployment is various indicators both at the national level and at the level of individual regions, which depend on economic, social and political components. The worst employment situation is in Luhansk and Donetsk regions.

The highest percentage of population employment is observed in Kharkiv region (59.9% employment), Dnipropetrovsk region (58%), Kyiv region (57.8%).

In the future, the reduction of the unemployment rate will contribute to the economic growth of Ukraine. All this is possible with the correct distribution of state orders in institutions of higher education, with the training of in-demand specialists who will be relevant in the labor market, and ending with the attraction of investments in promising industries.

As a result, there is a surplus of specialists in some professions and a shortage of others in Ukraine.

The solution to this problem can be the acquisition of additional education and retraining of the temporarily unemployed. Figure 4 shows the "Education" index, formed on the basis of the number of educational institutions and the number of potential students and applicants.

Territorial differentiation of the capacity of infrastructural facilities, in particular educational ones, and the insufficient level of equipping of educational institutions remain problematic issues in education. The quality of education is based on adaptability to global development trends and society's demands. Personal orientation of the educational process and its informatization are important.

The basis of innovation is laid in the education system. The largest number of educational institutions are concentrated in Lviv, Dnipro, Odesa and Kharkiv regions.

Another important aspect of the implementation of infrastructure project portfolios is the implementation and functioning of infrastructure facilities of health care institutions.

PRINT ISSN 2284-7995, E-ISSN 2285-3952

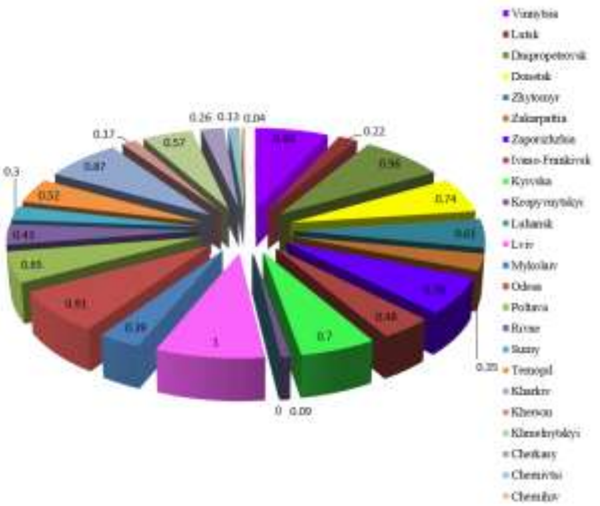

Fig. 4. Project index "Education"
Source: own development.

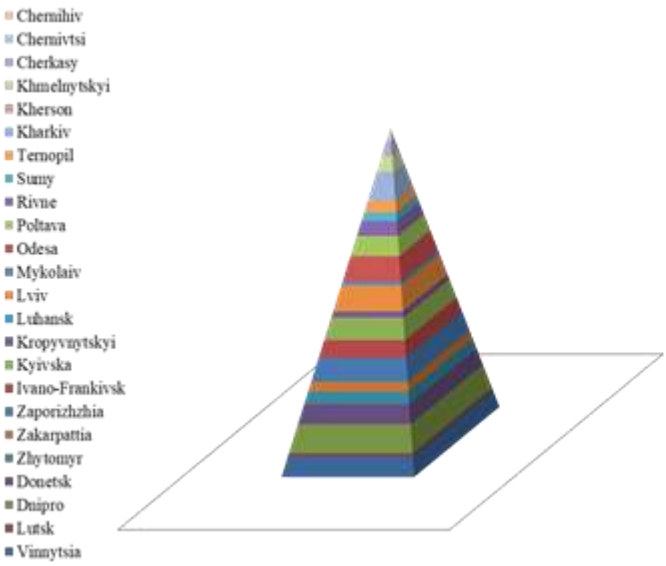

Fig. 5. Project index "Health care"
Source: own development.

During the COVID-2019 pandemic in Ukraine, the regions showed the need to coordinate the work of all structures, highlighted the importance of modern equipment with energy-efficient technologies in primary and secondary medical institutions. Apply all opportunities for the formation of a culture of health at the community level, including mental health, as well as timely response to epidemic and other emergency situations in the region [18].

To determine the financial capacity of the community, the indicator of overall income growth in conditions of budgetary and tax changes is insufficient. It is appropriate to have a practical calculations of necessary expenses and available income per 1 resident of the community, based on the provision of not only the priority important infrastructure needs of the territorial community, financing of salaries, social benefits, financing of projects to improve the social sphere of life and economic well-being of citizens living within the territorial communities [6].

It is worth using the tools of international support (on a free and non-refundable basis), fundraising (raising funds for the purpose of implementing a social project), endowment (a trust fund for the purpose of financing organizations, which is filled at the expense of charitable donations).

The main commodity items of Ukrainian imports in 2021 were: mineral fuels, oil and its distillation products, machines, equipment, products of chemical and related industries. The import and export of goods is shown in figure 5, by region (Figure 6).

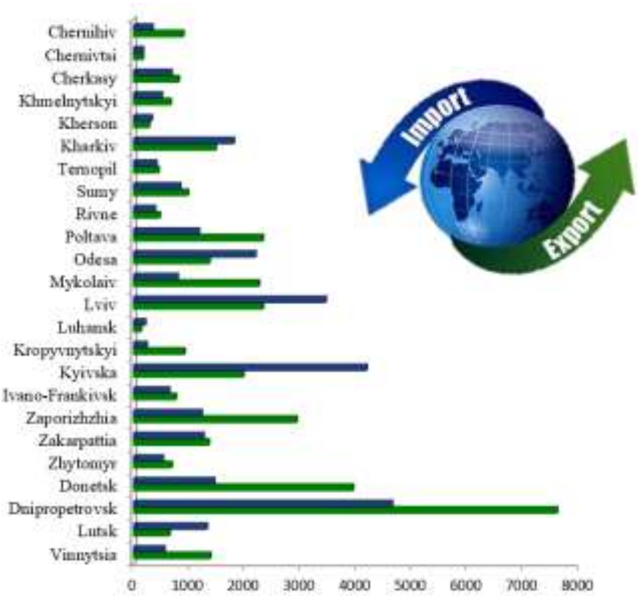

Fig. 6. Export-import transactions, million US dollars
Source: own development

As evidenced by the results displayed in Figure 6, most of the regions demonstrate an average (10 oblasts) and low (14 oblasts) level of export activity. EU countries have consistently taken a significant share in the export and import of Ukrainian goods. The share of exports of goods of one Dnipropetrovsk region to EU countries is 20% of the total export of goods of Ukraine to EU countries, and that of Donetsk region is 10%, respectively. The lowest indicators of export and import of goods in Luhansk region.

The powers of local governments are therefore directly linked to their financial strength. Both components form a functional whole. Reflecting on the scope of local autonomy, we are not only examining the scope of the tasks of local governments, but also their financial resources and freedom to shape spending policy [1].

Based on the processing of statistical data for various data clusters of the regions of Ukraine using the method of total ranks and diversified indicators of infrastructural development, we distribute the received data with the determination of the minimum, average and maximum values of the data, which is shown in Table 2.

Based on the formed classes of data clusters, we form an index of infrastructural development of the regions of Ukraine in the range [0→1]. Where 0 is the minimum indicator of the infrastructural development index, 1 is the highest indicator of the index, and we display the regional distribution of infrastructural development in the form of a diagram (Fig. 7).

Success in the implementation of digitalization of project-oriented management in the studied regions depends on the available resources in the territorial community.

Financial resources are aimed at the purchase of software that will be used in work. It is also important to be able to attract experts to conduct educational trainings on writing, submitting and implementing projects [19; 11].

Having received the general indicators of the project index of infrastructural development of the regions and indicators of infrastructural development, we form classes of infrastructure development according to the cluster distribution and the boundaries of the class boundaries (Table 3).

Table 1. Infrastructural distribution of regions by level of development

Regions	*Rank of indicators by "Territory"*	*Ранг "Територія"*	*Index "Territory"*	*Rank of indicators by "Population"*	*Rank "Population"*	*Index "Population"*	*Rank of indicators on "Employment and unemployment"*	*Rank "Employment and unemployment"*	*Index "Employment and unemployment"*	*Rank of indicators by "Education"*	*Rank "Education"*	*Index "Education"*	*Rank of indicators by "Health care"*	*Rank "Health care"*	*Index "Health care"*	*Rank of indicators by "Economic indicators"*	*Rank "Economic indicators"*	*Index "Economic indicators"*	*Indicator of infrastructure development*	*Index of infrastructure development of the region*	*Class of infrastructure development*
Vinnytsia	50	7	0.74	90	18	0.26	51	13	0.48	67	5	0.83	35	7	0.74	51	9	0.64	344	0.63	1 class
Volyn	97	19	0.22	75	9	0.65	71	24	0	159	19	0.22	101	22	0.09	76	15	0.36	579	0.17	3 class
Dnipro	24	1	1.00	51	2	0.96	35	3	0.91	31	2	0.96	6	1	1	5	1	1	152	1	1 class
Donetsk	41	6	0.78	85	16	0.35	66	23	0.04	87	7	0.74	42	8	0.7	26	4	0.86	347	0.62	1 class
Zhytomyr	52	8	0.70	78	11	0.57	62	20	0.17	123	10	0.61	70	14	0.43	68	13	0.45	453	0.42	2 class
Zakarpattia	101	21	0.13	74	7	0.74	55	16	0.35	153	16	0.35	77	16	0.35	77	16	0.32	537	0.26	3 class
Zaporizhzhia	70	12	0.52	65	5	0.83	49	12	0.52	82	6	0.78	26	5	0.83	32	7	0.73	324	0.67	1 class
Ivano-Frankivsk	88	14	0.43	79	13	0.48	52	15	0.39	135	13	0.48	44	10	0.61	79	17	0.27	477	0.37	2 class
Kyivska	40	5	0.83	74	7	0.74	27	1	1	92	8	0.7	34	6	0.78	18	2	0.95	285	0.74	1 class
Kropyvnytskyi	93	17	0.30	90	18	0.26	63	21	0.13	192	22	0.09	94	19	0.22	89	19	0.18	621	0.09	3 class
Luhansk	69	11	0.57	78	11	0.57	47	10	0.61	221	24	0	120	24	0	116	23	0	651	0.03	3 class
Lviv	29	2	0.96	58	4	0.87	48	11	0.57	23	1	1	19	3	0.91	21	3	0.91	198	0.91	1 class
Mykolayiv	107	23	0.04	77	10	0.61	32	2	0.96	141	15	0.39	96	21	0.13	56	10	0.59	509	0.31	2 class
Odesa	29	2	0.96	48	1	1	37	4	0.87	35	3	0.91	20	4	0.87	26	4	0.86	195	0.92	1 class
Poltava	63	10	0.61	82	15	0.39	59	19	0.22	102	9	0.65	42	8	0.7	34	8	0.68	382	0.56	2 class
Rivne	98	20	0.17	68	6	0.78	40	6	0.78	138	14	0.43	69	12	0.52	98	20	0.14	511	0.31	2 class
Sumy	82	13	0.48	80	14	0.43	40	6	0.78	154	17	0.3	87	17	0.3	69	14	0.41	512	0.3	2 class
Ternopil	102	22	0.09	88	17	0.3	65	22	0.09	133	12	0.52	71	15	0.39	98	20	0.14	557	0.22	3 class
Kharkiv	38	4	0.87	56	3	0.91	39	5	0.83	44	4	0.87	10	2	0.96	26	4	0.86	213	0.88	1 class
Kherson	95	18	0.26	91	21	0.13	51	13	0.48	162	20	0.17	111	23	0.04	103	22	0.05	613	0.11	3 class
Khmelnytsk	89	16	0.35	90	18	0.26	57	17	0.3	127	11	0.57	56	11	0.57	67	12	0.5	486	0.35	2 class
Cherkassy	88	14	0.43	101	23	0.04	44	8	0.7	156	18	0.26	69	12	0.52	61	11	0.55	519	0.29	3 class
Chernivtsi	132	24	0.00	93	22	0.09	44	8	0.7	189	21	0.13	95	20	0.17	116	23	0	669	0	3 class
Chernihiv	54	9	0.65	120	24	0	57	17	0.3	197	23	0.04	93	18	0.26	83	18	0.23	604	0.13	3 class

Source: own development.

Table 2. Cluster distribution of regions according to the indicator of infrastructural development and the index of infrastructural development of regions

Value	Indicator of infrastructural development	Index of infrastructural development of the region
Average value	447	0.4
The minimum in the group	152	0
The maximum in the group	669	1

Source: own development.

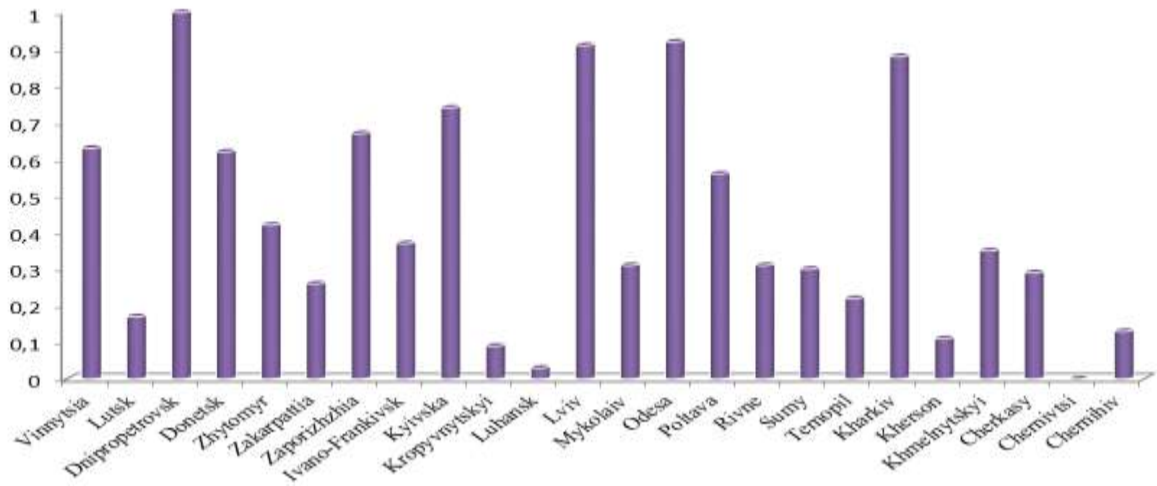

Fig. 7. Project index "Infrastructural development of regions"
Source: own development.

Table 3. Cluster distribution of regions by classes of the regional infrastructural development index

№	class of infrastructure development	lower	upper	lower	upper
1	3 class of infrastructure development	0.00	313.19	0.00	0.30
2	2 class of infrastructure development	313.19	581.64	0.30	0.56
3	1 class of infrastructure development	581.64	669.00	0.56	1.00

Source: own development.

Based on the research, we will form 3 classes of the regional infrastructural development index: 1 class – the infrastructure of the region is developed; 2 class – the infrastructure of the region is moderately developed; 3 class - the infrastructure of the region is underdeveloped.

The struggle of cities for leadership in the world market of smart solutions requires the search for directions for the development of smart technologies that make life easier for citizens, and therefore their implementation must be well planned and reliable. Considering the uniqueness of each city, including its culture, level of physical infrastructure development, socio-economic progress, as well as financial and technological capabilities for the implementation of smart technologies, the development of smart infrastructure must take into account local needs and conditions. The world experience of implementing smart projects and creating smart cities can only serve as a partial example for imitation.

The application of a digital solution in the functioning of smart cities will improve the entire infrastructure of the regions [16]. Digitalization plays an important role in the development of smart cities. Some authors believe that advanced digitalization is not enough for the successful development of a smart city, and the need for effective program management is more effective [2]. Smart cities are ready to be flexible in strategic management. Taking into account the opinion and scientific work of Ibrahim and Morsy [7], we can say that in fact smart cities are sustainable, but on the other hand, the adaptation and introduction of new technologies into already existing structures is quite difficult, because it requires the willingness of the latter to perceive new processes in projects [12].

Fig. 8. Cartographic visualization of the cluster distribution of regions by classes of the regional infrastructural development index
Source: own development.

Modern project and program management strategies actively use the latest technologies [20]. Infrastructure of territories should meet the needs of city residents in terms of lifestyle, safety, cultural foundations and modern improved behavior patterns.

CONCLUSIONS

The analysis of statistical data for different data clusters of the regions of Ukraine using the method of total ranks and diversified indicators of infrastructural development made it possible to distribute the received data with the determination of the minimum, average and maximum data values. Based on the formed classes of data clusters, an index of infrastructural development of the regions of Ukraine in the range [0→1] was formed. Where 0 is the minimum indicator of the index of infrastructural development, 1 is the highest indicator of the index, and we display the regional distribution of infrastructural development in the form of a diagram. The obtained general indicators of the project index of infrastructural development of the regions and indicators of infrastructural development made it possible to form classes of infrastructure development according to cluster distribution and the boundaries of the class boundaries. Based on the conducted research, 3 classes of the regional infrastructural development index were formed.

In today's conditions, the priority is the correct definition of priority tasks and the search for approaches, levers, methods and tools that would ensure maximum efficiency in managing the development of territories and ensure proper coordination of all government institutions. The timeliness of management decision-making should have a scientific basis with well-defined priorities.

Today, the most relevant directions of territorial development projects are: new construction in accordance with the requirements prescribed in the standards and reconstruction of existing buildings; creation of modern digitized community management systems; improving the quality of providing online services for the population; capital repair of roads and modernization of streets; ensuring the appropriate level of security and civil protection; cultural and educational development of the community; attraction of international investments for conducting business in certain territories and ensuring their competitiveness; improvement of the transport interchange; special attention should be paid to educational institutions and medicine.

It is necessary to implement a flexible model of city management, using innovative tools of cooperation, partnership relations and various forms of contracts. The development of smart infrastructure ensures a balance between all participants, namely, it involves the population, public organizations, state and local authorities, the non-state sector, as well as various business associations and international partners, to establish business processes, increases the stability and sustainability of the city, ensures the safety of citizens, improves the quality of life and contributes to the improvement of the environment.

The integration of the smart infrastructure development policy within the framework of other spheres (industrial, financial, environmental, energy, social and others) will contribute to the establishment of effective cooperation between various subjects in order to achieve the common goal of increasing the level of "smart development" of Ukrainian cities.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

BIOCHEMISTRY OF SPRING SAP OF DIFFERENT GRAPEVINE CULTIVARS AND ITS IMPACT ON CROP QUANTITY AND QUALITY

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Abstract

The aim of the study is to investigate the spring sap of 15 different grape varieties during the spring season – April 2024 in an experimental vineyard of the Institute of Agriculture – Kyustendil, Bulgaria. The methods used in this research have been: physico-chemical and agro-ecological studies of the spring grape sap and determination of the oxidation sustainability of the sap for each studied grape cultivar, using the Pourbaix pH-Eh water diagram. 1) main conclusion is that the grape sap consists salt on the level of saturation, and this delicate equilibrium in water-salt balance must not be disturbed; 2) the sap is very susceptible to oxidation and adding of ascorbic acid as antioxidant in the soil will be useful for the common physiology of the grapevine cultivars, 3) ascorbic acid circulates in nature and might pass through the root onto the plant, moreover, the roots of the plants may synthesizec ascorbic acid; 4) grape sap is a bio-indicator for contamination of the environment, and specially of the soil as cyanuric acid and nitrates passes through the root to the plant, but some other contaminators as Pb, As, Radiation cannot be claimed from the present study.

Key words: *biochemistry, physiology, grape, cultivars, sap, crop quality, soil fertility, Bulgaria*

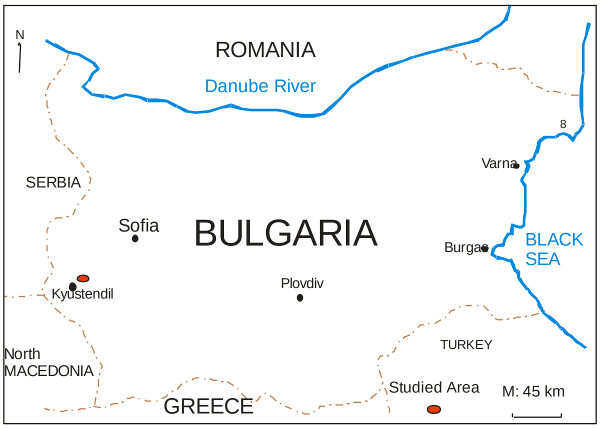
INTRODUCTION

The importance of this study in the context of the literature in the field.
Its originality, novelty, actual importance.
Make the link between the biochemistry of spring sap of various grape varieties and wine quality. The present study was provoked by an increased relative salt content in grape, cherry, and apple fruits from the Kyustendil region, The measured salt contents of grape and other fruit juices were superior to the total dissolved solids. Last winter 2022/2023 was dry, and early summer fell large amounts of precipitation during the ripening in June-July 2023. According to data of the meteorological station “Meteobot” of the Institute of Agriculture - Kyustendil, from mid-June to mid-July rainfalls were 22 days. Many of the rainfall fell in 1 hour exceeded half the monthly norm. It is assumed that this precipitation is unusual and is the result of climate changes. As a result, the grape harvest in the Kyustendil region was of poor quality, the fruits were small, cracked, with low amount. Many grape cultivars had not produced crop. The death of plants began. The reason is the activation of sodium cations, as a result of heavy rainfall, which leads to blockage of the root systems of cultivars. The mineral halite is formed – sodium chloride in the soil, which disbalance the equilibrium of the salt-water balance in the plants. Study was implemented at the experimental fields and laboratories of the Institute of Agriculture, town of Kyustendi, which is a part of Agricultural Academy, city of Sofia, Bulgaria. It is located in the geometric center of Balkan Peninsula, Europe, of about 3 km North-Eastern from the town of Kyustendil, which is settled in a valley with the same name, on the right side of the cross-border Struma River and at the foot of the Mountain "Osogovo". The studied area is located in the central part of the Balkan Peninsula exactly on the border between Bulgaria, Serbia and North Macedonia, and close to Greece. Its altitude is 512 m (Fig. 1).
The climate of the town of Kyustendil is transitional continental to Mediterranean. Rainfall in Kyustendil is not heavy. Their

average annual amount is about to 589 mm. There is a tendency to alternate dry with wet years or periods. By seasons they are distributed fairly evenly. Snowfall is usually from November to March, with snow cover up to 30 cm thick and lasting for up to 15 days. However, the water wealth of Kyustendil and its surroundings is not small. There are many rivers, springs, dams, mineral and ground waters [12].

The largest river in the region is the Struma River as Bistritsa River is the biggest tributary of Struma River on the territory of the municipality of Kyustendil. The Bistritsa River is one possible source for irrigation of the experimental fields of the Institute of Agriculture, town Kyustendil [8].

It is 51 km long and borders directly to the studied experimental fields. It springs at 2,182 m above sea level in Osogovo Mountain, northeast of Mount Ruen, and it flows on the right into the Struma River at 462 m above sea level, southwest of the village of Konyavo [4].



Map 1. Location of the area of study
Source: own drawing.

In this context, the purpose of this research work was to monitor the water-salt balance of the grapevine sap in different grape cultivars and to take measures to keep it through appropriate methods. If the balance is disturbed by dry period, the measure is artificial irrigation. If balance is disturbed by flooding – it is proposed to treat the soil with the mineral gypsum – soil plastering or the so-called gypsum fertiliser.

MATERIALS AND METHODS

The research was carried out in an experimental vineyard of the Institute of Agriculture – Kyustendil, Bulgaria in 2024.

The object of the study were grapevine cultivars with different genetic origin and direction of use: 5 red wine vine cultivars - Pamid (*Vitis Vinifera*), Cabernet Sauvignon (*Vitis Vinifera*), Kaylashki rubin (Pamid x Hybrid VI 2/15) x (Gamay noir x *Vitis Amurensis*), Trapezitsa (Dunavska Gamza x Noir hatif de Marseille) and Otelo (Clinton x Black Hamburg; 3 white wine vine cultivars – Tamianka (*Vitis Vinifera*), Slava (Dunavska Gamza x Tsvetochnyi) and Druzhba (Muskat hamburg x S.V.12375) x (Zaria Severa x Muskat hamburg); Table grapevine cultivars - Super early Bolgar (Italia x Yantar), Prista (Bolgar x Mimosa), Ryahovo (Trakia x Black Rose), Garant (Hybrid V25/20 x Druzhba), Dunav (Bicane x Ribi mehur) x Cardinal), Velika (self-pollinating Hybrid 3/23 (Bolgar x Alphonse Lavallee) and Misket plevenski (Muscat hamburg x Perle Von Csaba).

The vines of the wine cultivars were planted in 2015 and the table grapevine cultivars in 2007. They were grafted onto the rootstock Berlandieri x Riparia SO4. The wine cultivars are stem-formed, and the table cultivars are formed on the ground. Pruning is according to the Guyot system.

The aim of the study is to investigate the spring sap of 15 different grape cultivars. Digital instruments were used *in situ* and in laboratories as follow: Refractometer "Milwaukee Brix MA871"- Hungary to measure the total sugar content by Brix (%) and refractometer "Atago-Pal 1", Australia for control. Glucose content (mmol/l, %) was measured through the Austrian "Wellion WF073" glucometer. Instrument "Lovibond-SensoDirect 150"-United Kingdom and Bluetooth compatible water quality intelligent tester "Yieryi BLE-C600"-China for control are used for determination of total acidity (pH), electrical conductivity (EC, µS/cm), total dissolved solids (TDS, ppm), total salt content (Salt, ppm,%), Specific Gravity (S.G.), Eh - Redox potential (mV) of the grape sap and juices, and temperature (°C). Sap was received as each grape cultivar was cut, during spring season and collected in sterile dishes.

The juices of the fruits were produced by the cold-pressing method, using 2.5 pressure of the press, speed of the grinder 35 Hz, speed of the belt-press 48 Hz, temperature 20°C in regular air environment. Minimum 5 measurements of technological parameters were used for each kind of fruits and vegetables at the present study. Fruit juice (100%) is obtained by the method of cold pressing with a single-shaft juicer Star Light SJB-150 R, unpasteurized, without additives. Radiation (μSv/h) of the sap and juice from grape and the common radiation background were measured with a Geiger counter "Radex"RD1503, which performed 5 automatic measurements and calculated the average value. Ascorbic acid in the liquids was measured through semi-quantity colorimetric test strips with range 0-25-50-100-200-400 mg/l. Bromine is determined through test strips with range 0-0.5-1-2-6-10-20 mg/l, Fluoride 0-25-50100-200 mg/l, and Iodine 0-0.02-0.04-0.08-0.10-0.15 mg/l.

Nitrate and nitrite content in the liquids were measured by using test strips with a range of 0-10-25-50-100-250-500 mg/l. Arsenic content was measured by the usage of test strips with a range of 0.005-0.0010-0.0025-0.05-0.1-0.25-0.5 mg/l. Lead content in studied liquids is measured by through blei-test and strips with a range of 20-40-100-200-500 mg/l.

The statistical processing of the data was performed by using computer application XLStat-Pro [5].

Pourbaix pH-Eh water diagram is used for visualizing of equilibrium of oxygen plus hydrogen ions to form water. Figure 2 shows the E-pH diagram for water with no metal involved. Line (a) represents the equilibrium reaction for hydrogen ions to evolve hydrogen gas. At any potential and pH below this line the hydrogen ion in water will react with electrons to evolve hydrogen gas. Line (b) represents the equilibrium of oxygen plus hydrogen ions to form water. At any potential and pH above this line water is oxidized to evolve oxygen gas and hydrogen ions (the reverse of Equation (3)). For potential and pH conditions between lines (a) and (b), water is thermodynamically stable and there is no gas evolved [10].

RESULTS AND DISCUSSIONS

Table 1 and Table 4 show the results from the measured biochemical content of the spring sap, collected by 15 grape plant cultivars during the spring season – April 2024 at the mentioned above geographic region. Sterile laboratory dishes collected the sap for 24 hours, but the leakage was not permanent, because of this reason the data given in the tables is not debit of the leaking per hour, it is just collected amount in grams. Total sugar content by Brix (%) was measured also as the red varieties of grape fruits had higher sugar content as the sweetest sap is of Pamid, Kaylashki rubin, and Otelo. The same red varieties demonstrated the highest content of glucose as the grape variety Otelo with very different origin and very different place of growing, had 1.3% sugar which is 83,37% glucose.

Grape products as wine, vinegar and cold-pressed juice are given only for comparison.

At the histrogram Fig. 1 and Tables 2 and 3 may be seen the statistical processing of the data for acidity of the solutions. It is obvious that the acidity of the spring grape plant sap has low acidity between 5. 08 and 6.17 or average – mean 5.564 and standard deviation 0.348 for 16 observations and 0 missing results. Most of the measurements between 4.6 and 5.6.

For comparison the grape products as wine, juice and vinegar are more acid pH=3.65-3.76, but the sugar content is higher and glucose is a smaller part from the total sugar content.

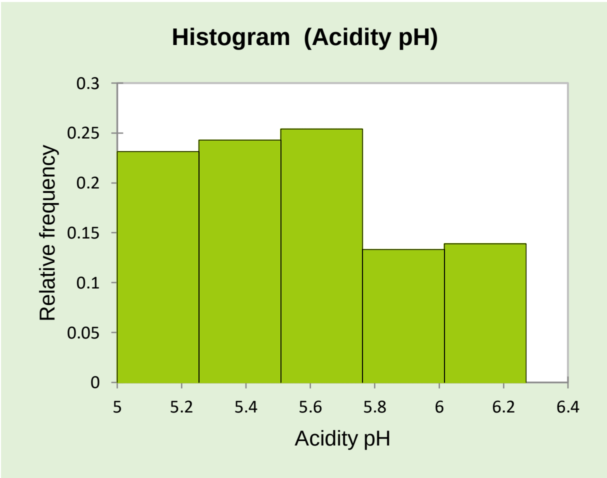


Fig. 1. Histogram of the relative frequency of the pH measurements of the spring sap of different grape cultivars
Source: own calculations with XL Stat [5].

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PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 1. Physico-chemical parameters of spring sap of different grape cultivars, n.d.-no data

Cultivar	Collected amount for, g	Total Sugar Content, Brix, %	Glucose, 5 of total sugar, %	Glucose, mmol/l	Acidity pH	Redox Oxigation-reduction Eh, Mv	Electro conductivity EC, µS	Total Dissolved Solids TDS, ppm	Salt, ppm	Salt, %	Specific Gravity of Salt, S.G.
Cultivars for red wines											
Pamid	113	0.6	15.63	3.9	6.14	17	538	269.0	269.0	0.02	1.000
Kaylashki rubin	123	0.5	4.81	1.2	5.91	15	687	343.5	343.5	0.03	1.000
Trapezitsa	220	0.1	<1.1	<4.4	5.71	35	957	478.5	478.5	0.04	1.000
Cabernet Sauvignon	32	0.1	<1.1	<4.4	5.90	27	693	346.5	346.5	0.03	1.000
Otelo	54	1.3	83.37	20.8	5.58	-50	807	403.5	403.5	0.04	1.000
Cultivars for white wines											
Slava	22	0.1	<1.1	<4.4	5.50	2	717	358.5	358.5	0.03	1.000
Tamianka	322	<0.1	<1.1	<4.4	5.62	25	732	366.0	366.0	0.03	1.000
Druzhba	155	<0.1	<1.1	<4.4	6.17	30	609	304.5	304.5	0.03	1.000
Table grapevine cultivars (white)											
Super early Bolgar	70	<0.1	<1.1	<4.4	5.61	46	457	228.5	228.5	0.02	1.000
Prista	129	0.1	<1.1	<4.4	5.38	60	718	359.0	359.0	0.03	1.000
Ryahovo	142	0.1	<1.1	<4.4	5.13	83	652	326.0	326.0	0.03	1.000
Garant	256	0.2	<1.1	<4.4	5.30	64	884	442.0	442.0	0.04	1.000
Table grapevine cultivars (red)											
Dunav	44	0.1	<1.1	<4.4	5.08	83	528	264.0	264.0	0.02	1.000
Velika	208	<0.1	<1.1	<4.4	5.14	73	616	308.0	308.0	0.03	1.000
Misket plevenski	183	0.1	<1.1	<4.4	5.15	83	796	398.0	398.0	0.03	1.000
Other grape products											
Wine (Otelo)	-	9.8	11.62	2.9	3.72	98	3,340	1,670	1,690	0.16	1.000
Vinegar (Otelo)	-	8.0	11.22	2.8	3.65	92	5,590	2,790	2,810	0.28	1.001
Fruit juice (Velika)	62	14.8	n.d.	n.d.	3.75	230	2,140	1,430	1,090	0.11	1.075
Fruit juice (Seper early Bolgar)	57	17.7	n.d.	n.d.	3.76	234	1,910	1,297	986	0.09	1.068
Fruit juice (Prista)	59	15.4	n.d.	n.d.	3.72	233	1,612	1,082	812	0.08	1.055

Source: own data.

Table 2. Summary statistics

Variable	Observations	Obs. with missing data	Obs. without missing data
Acidity pH	15	0	15
Min.	Max.	Mean	Std. Dev.
5.080	6.170	5.564	0.348

Source: own calculations with XL Stat [5].

Redox potential Eh, mV is an important physics-chemical parameter. It is essential for redox oxidizing ability of the studied solution. It is visible that the oxidizing ability of the sap is very high. As smaller is the measured Eh, the danger from oxidizing is higher. The very healthy parameters usually have negative values as the sap from grape variety Otelo has Eh=-50.

Table 3. Descriptive statistics for the intervals

Lower bound	Upper bound	Frequency	Relative frequency	Density
5.000	5.254	20.5	0.231	0.910
5.254	5.508	21.54	0.243	0.956
5.508	5.762	22.52	0.254	1.000
5.762	6.016	11.81	0.133	0.524
6.016	6.270	12.31	0.139	0.547

Source: own calculations with XL Stat [5].

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PRINT ISSN 2284-7995, E-ISSN 2285-3952

Fig. 2 presents pH-Eh water diagram and where the studied solutions are located, according to their pH and Eh and which processes are usual for their, what may we expect as behavior of the solutions. All of them are located at the lower part of the middle area between line a) and line b).

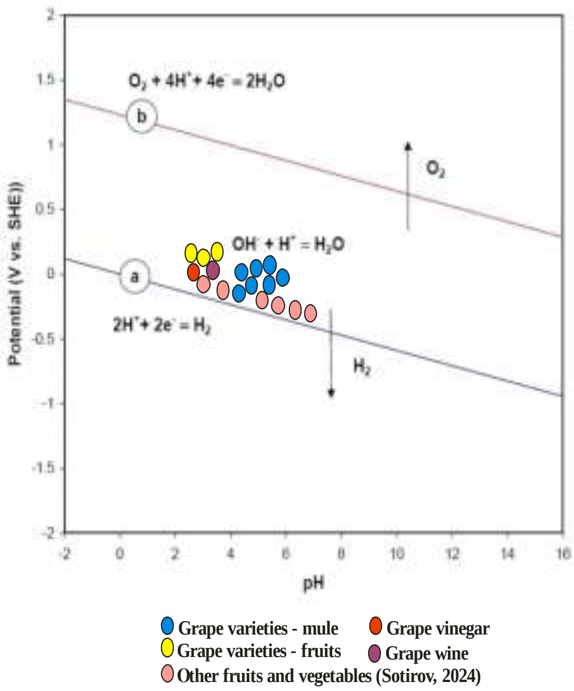

Fig. 2. Pourbaix pH-Eh water diagram for the spring sap, grape juices, wine and vinegar
Source: [1]; [7]-provided data for fruit and vegetable juices.

All types of cold-pressed juices – grape as well as apple, orange, strawberry, cherry, melon, carrot, and etc. are located directly in the entire side of the line a) in the middle part of the diagram, which is characterized with loosing of hydrogen and oxidizing of the liquid. Because of this reason, measured in situ at the terrain some of the saps had high amount of ascorbic acid (Vitamin C), which oxidized very quickly to zero. The conclusion, which is necessary after a year of observation and experiments, is that the addition of ascorbic acid as an antioxidant in the soil passes into the plant through the roots and further supplies hydrogen to the very delicate balance in the grape sap and supports the physiological processes of the plant.

Other important measured parameters of the spring grape sap is the Electroconductivity, Total Dissolved Solids and Salt content (Fig. 3). It presents TDS-Salt diagram. At this diagram the sap liquid is situated exactly on the line of salt situation. Here the ratio between TDS and Salt – TDS/Salt = 1 or TDS=Salt. It is valid for all studied samples. For comparison is shown the place of other grape products as juice, wine and vinegar. Grape juice and all other investigated in previous studies fruit and vegetable juices are above the line of saturation of the salts where Ratio TDS/Salt>1, but the products of grape as wine and vinegar have little higher salt content or ratio TDS/Salt<1. Main decision is that he grape sap consists salt on the level of saturation.

Specific gravity of the water is S.G.=0.999, the sap has S.G.=1.000 and wine, but the vinegar has specific gravity 1.001.

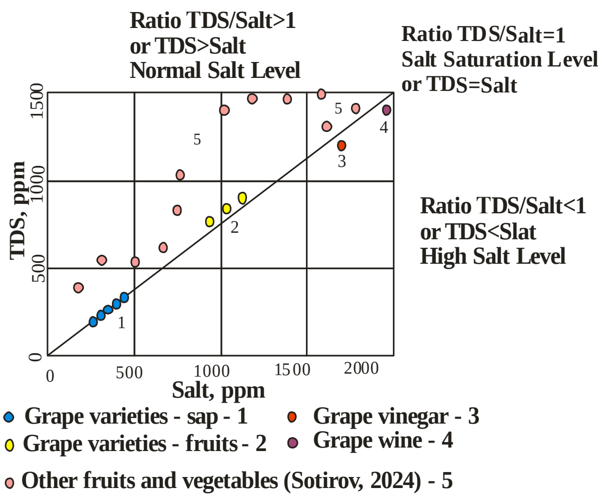

Fig. 3. TDS-Salt Diagram of the spring sap, grape juices, wine and vinegar
Source: own diagram.

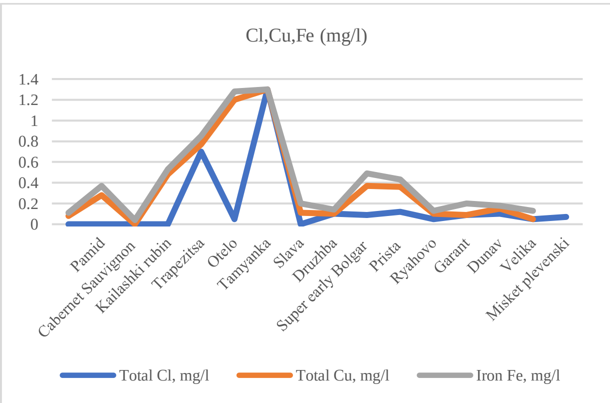

Fig. 4. Diagram of the distribution of the Cu, Fe, and Cl by cultivars
Source: own data Excel.

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PRINT ISSN 2284-7995, E-ISSN 2285-3952

Several other parameters were measured also presented in Table 4 as Cl, Fe, Cu, which appears as trace elements in low amount, but they are connected and related each other, which might be seen on Fig. 4. Sometimes the Cl is connected with the Cu and sometimes with the Fe, as in these cases it has opposite relation with the Cu. Mainly white wines are connected with high content of Cu and Cl. Fe content is almost stable for all samples.

Figure 5 shows the hardness different and total alkalinity ($CaCO_3$) distributed by the samples of the studied sap. The alkalinity of water is calcium carbonate equivalent or mg of $CaCO_3$/l equivalent. Hardness of the water is the sum of the concentrations of positively-charged ions (cations) with more than one positive charge, such as Ca^{++}, Mg^{++}, Fe^{++}, and Fe^{+++}. As we may expect both parameters are very dependent each other and has almost matching graphs. Sap investigated is threated as drinking water, according to requirements described by [6] Fig. 5.

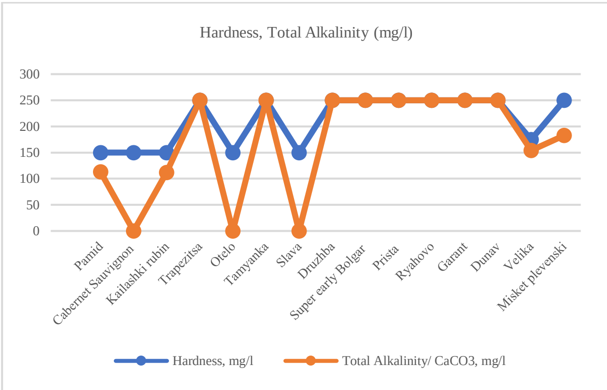

Fig. 5. Diagram of the distribution of the Hardness and Total Alkalinity by cultivars; 0-no data
Source: own data Excel.

Table 4. Physico-chemical parameters of spring sap of different grape cultivars, n.d.-no data

Cultivar	Total Cl. mg/l	Cianuric acid CYA mg/l	Hardness mg/l	Total alkalinity, $CaCO_3$, mg/l	Total Cu, mg/l	Iron, Fe, mg/l	Ascorbic acid, C vitamin	Nitrate NO^2, $NO^{2\text{-}N}$, mg/l	Nitrite NO^3, $NO^{3\text{-}N}$, mg/l
Cultivars for red wines									
Pamid	<0.05	14	150	113	0.08	0.03	200	50	<1
Cabernet Sauvignon	n.d.	21	150	n.d.	0.28	0.09	50	50	<1
Kailashki rubin	<0.05	20	150	112	<0.05	0.04	50	50	<1
Trapezitsa	0.70	15	>200	>200	0.48	0.05	0	50	<1
Otelo	0.05	14	150	n.d.	0.07	0.08	0	50	<1
Cultivars for white wines									
Tamyanka	1.30	7	>200	>200	1,15	0.08	0	50	<1
Slava	n.d.	20	150	n.d.	n.d.	n.d.	0	50	<1
Druzhba	0.10	10	>200	>200	0.11	0.09	0	50	<1
Table grapevine cultivars (white)									
Super early Bolgar	0.09	5	>200	>200	<0.05	0.04	0	50	<1
Prista	0.12	18	>200	>200	0.28	0.12	0	50	<1
Ryahovo	0.05	6	>200	>200	0.24	0.07	0	50	<1
Garant	0.09	17	>200	>200	0.05	0.03	0	50	<1
Table grapevine cultivars (red)									
Dunav	0.10	13	>200	>200	<0.05	0.11	0	50	<1
Velika	0.05	14	175	154	0.05	0.03	0	50	<1
Misket plevenski	0.07	19	>200	183	<0.05	0.08	0	50	<1
Other grape products									
Wine (Otelo)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Vinegar (Otelo)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0	n.d.	n.d.
Fruit juice (Velika)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fruit juice (Super early Bolgar)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fruit juice (Prista)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Source: own data.

Content in the studied samples of spring grape sap vary between 5 and 21 mg/l as mean is 14 mg/las many cultivars has higher content of CYA (Table 4).

Cyanuric acid is a generalized concept of waste products of the chemical industry, often used in everyday life such as bleach, adhesives, disinfectants, paints, cosmetics, chlorine stabilizers (protect chlorine compounds from rapid decomposition of sunlight and UV light) and many others. It is invariably present as an infiltrate (leachate) in places where there are domestic landfills and sewers. It was first found in urine. It is difficult to form independently in nature and its presence is a good indicator of anthropogenic activity. The formula may be different, but generally can be summarized as $(CNOH)_3$ (1,3,5-triazine-2,4,6-triol). One of its analogues is melamine [3]. This is the end product of decomposition and is a strong pollutant. Estimated dietary exposure to melamine from use of cyromazine as a pesticide ranged from 0.04 μg/kg body weight per day to 0.27 μg/kg body weight per day [11].

Below method sensibility were measured also several agroecological parameters (Table 5). Nitrate content is low - about 50 mg/l and Nitrite is about zero mg/l in the studied sap samples. Some other parameters were measured as radiation of the radioactivity of the sap and common radiation background for comparison. Results were normal for the region and crop products about 0.12-0.18 μSv/h. Obviously the plants adsorbs only the necessary elements [2] or there is no contamination of the soil with the elements given in Table 5 [9].

Table 5. Summary data of all studied grape cultivars about some agroecological parameters

Nitrate NO^2/NO^{2-} ^{N}, mg/l	**Nitrite NO^3, NO^{3-} ^{N}, mg/l**	**Radiation. sap, μSv/h**	**As, mg/l**	**Pb, mg/l**	**Br, mg/l**	**Fl, mg/l**	**I, mg/l**
50	1	0.12	0	0	0	0	0

Source: own data.

Economic impact of the study.

Monitoring of the grapevine sap for physico-chemical and agro-ecological parameters helps for corrections of the quality and quantity of the grape crop during time of ripening. Controlling the water-salt balance in the sap helps to be taken measures against salinization of the soils, it does not matter the reason: dry period and concentration of the salts or flooding and increasing of the sodium and respectively halite content into the soil. The study proved that the ratio Total Dissolved Solids (TDS)/Salts=1 in the grapevine sap in normal conditions is exactly 1 or TDS=Salt. When the salt content is higher, causes salinization of the fruits and worsening of the quality crop or full absent of crop. Because of high rain amount during early summer 2023, result was several times lower crop was received and with bed quality and short durability. Corrective measures are: is salinity is high during a dry period – artificial irrigation is necessary. If salinity is high after wet period and flooding of the terrain – using of gypsum mineral fertilizer is needed to be added in the soil. By this way the sodium drainages deep below the roots and does not block them. Moreover the salt content in the salts leads to higher content of the salt in the fruits, which harm not only fruits, but also all products processed by the fruits as whine, because of beginning of liberation of hydrogen (see Fig. 2) or oxidation processes are available.

CONCLUSIONS

As a result of the present study, the following conclusions have been drown:

The main results emphasized that the grape sap during spring 2024 is a stable salt-water solution with values of pH and Eh almost in the middle of the stable water area of the Pourbaix pH-Eh water diagram, out of values of liberation of hydrogen or oxygen where corrosion process starts, or it is a process that involves electrochemical as well as chemical reactions, which impact negatively to the grapevine crop. Other result is that the grapevine spring sap does not consist Pb, As, and high radioactivity. Third result is that the roots of the grapevine cultivars may produce ascorbic acid or also the plant may adsorb ascorbic acid through the roots. The sap of grape cultivars with established high amount of Ascorbic acid into them as Pamid, Cabernet Sauvignon and Kaylashki Rubin are less prone to oxidation or they have reservoir of hydrogen which reacts preferentially to oxygen from the environment and thus protects sap and fruit juices from oxidation.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDIES ON THE CHOICE OF THE HYBRID, AN IMPORTANT LINK IN THE TECHNOLOGICAL MANAGEMENT OF THE CORN CROP AND ITS ECONOMIC EFFICIENCY, ACCORDING TO THE TESTS CARRIED OUT ON THE CHERNOZEM SOIL FROM CARACAL, OLT COUNTY, ROMANIA

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Abstract

In the period 2020-2023, on the chernozem from Caracal, numerous corn hybrids of different origins and with vegetation periods placed in almost all FAO precocity groups were tested. In 3 of the 4 years of testing, production stability was average (CV 13.4% in 2020, 15.9% in 2021 and 17.3% in 2022). Following the boxplot analysis the hybrids P0710 (Corteva) and Kashmir (KWS) stood out as positive outliers in 2021 and MAS 448 (Mass Seeds) in 2023. Although an average of 70 hybrids were tested annually, their production average was extremely close in years with favorable climatic conditions (6,654 kg/ha in 2020, 6,603 kg/ha in 2021, 6,795 kg/ha in 2023). The studies highlighted: the adaptability of a very large number of hybrids for the chernozem area in Olt County; average production stability; the rich assortment of hybrids offered by large seed companies. The economic efficiency in the case of choosing the hybrid is primarily influenced by the production obtained per hectare, by its capitalization price, but also by the price of the sown seed and the bonuses garanted by the producing company. In the last 2 years, the low prices practiced in capitalizing the production have made the option for the better hybrid which brings profit.

Key words*: *hybrid, maize, cultivation technology, economic efficiency

INTRODUCTION

One of the most widespread plants cultivated and used for both human and animal consumption is maize [1, 10]. This plant is one of the most adaptable crops, with a great diversity of hybrids that can be found in all corners of the world and in many climatic and soil conditions [19]. The large productions of grains or green mass, together with a great diversity of its valorization, through various processing methods, have determined that this crop, along with wheat and barley, is among the most important components of economic and development programs [21].
The global production of corn annually exceeds that of any other grain globally. 11,635 million tons of grain corns are produced annually from an area of 203 million hectares, which represents an average yield of 5,700 kg/hectare [9].
In our country, maize corn is highly cultivated due to the high productivity per surface unit [20]. In Romania, the area cultivated with corn is between 2.5-3.1 million ha depending on the rainfall in the cold season [22]. Maize is one of the most adaptable plants. A wide range of hybrids can be cultivated worldwide. [2, 5].
The continents where the largest areas of corn are cultivated are America, Asia, Europe and Africa. At the global level, the largest producer of corn is America with a share of over 50% of world corn production, followed by Asia with over 30% of total corn production. Europe

ranks third with a production share of over 11% of the total world corn production [5]. In national agriculture, the corn culture is spread throughout the country, occupying the first place on a national level, surpassing the wheat culture. According to FAOSTAT data, Romania has the largest area cultivated with corn in Europe, being among the top 10 corn exporting countries globally.

In Romania, 76% of the surface of the agricultural territory, the thermal factor is favorable and very favorable for the cultivation of corn, which can ensure high harvests. Suitable areas for corn cultivation are grouped according to the sum of biologically active temperatures (sum TBA), which exceed the limit of 10°C, into six favorability regions [18]. In order to effectively capitalize on the potential of the area, special attention must be paid to the choice of maize hybrids according to earliness and the requirements of each one in relation to climate and soil conditions.

Now that the weather conditions are more and more variable, from year to year, without increasing the consumption of water and fertilizers, an important role is played by the seed used to establish crops, which through its biological, physical and physiological qualities can grow harvest without having a negative influence on the environment and people's health [21].

Choosing the best corn hybrid for your own farm is not an easy job if the farmer is very interested in the investment he makes in the spring and the profit he should make in the fall. Usually farmers are fans of hybrids of one company. From the list of the respective company's products, depending on the cultivated area, the farmer chooses between 1 and 4 hybrids. In certain cases, a small percentage of the surface is allocated to another company's corn hybrid. This way of choosing the genetic base will further affect production and profitability. Moreover, the fact that the farmer chooses the hybrid on an emotional basis and is loyal to a company has and will continue to affect the price charged in the market by the big players. For this reason, it is necessary for the farmer to have as many benchmarks as possible when choosing a certain hybrid of corn, having to set some targets depending on the technological possibilities of the farm and the pedo-climatic conditions.

A recent and very complex study from the USA clearly demonstrated how important the choice of corn hybrid/genetics is, this aspect taking the 3rd place, after weather and fertilization. Choosing the right hybrid is responsible for at least 20% of production. So, it matters more than most farmers expect [6].

Maize is characterized by a current average increase in genetic progress of about 1% and a yield range of between 30% (Iowa) and over 200% (sub-Saharan Africa). A lot of factors can reduce profit: infrastructural and institutional constraints what's going on farm costs and prices, farmers' skills, various technical constraints. There may also be mistakes in the efficiency of input use, which no longer lead to improved management of crops and resources on the principle - more with less [8].

Genetic transformation and biotechnology represent the optimal solution for transitioning from hybrids obtained by conventional breeding, to supercompetitive ones in terms of drought tolerance and induced resistance to insects and pathogens [3, 7]. Plant breeding, using the combined potential of conventional, molecular and genetically engineered technologies, will provide hybrids with increased nutrient and water use efficiency, increased heat and drought tolerance, disease resistance and adequate end-use and nutritional quality and, perhaps most importantly, the increased ability to cope with the extreme increases in temperature and precipitation that occur in a place over the years. Hybrids developed by seed companies, international crop research centers, and national breeding programs often show very broad geographic adaptation as well as wide adaptation to a range of environmental and management conditions. To identify such hybrids, testing in various locations conducted by the International Maize and Wheat Improvement Center (CIMMYT) and the International Rice Research Institute (IRRI) remains the most effective system. International evaluation networks based on the exchange and free access to germplasm and multi-site testing are ways to select the wheat, rice and maize germplasm that is best adapted to the increasingly variable growing conditions encountered due to climate change global [4].

Currently, the economic evaluation of crop cultivation technologies under market conditions is extremely important. In recent years, the prices of fertilizers, pesticides, diesel and other energy resources have increased significantly. Thus, there is an impact on the increase in corn production costs and, consequently, on the decrease in sales revenues [25]. That is why the development of corn cultivation technologies and resource-saving technologies is primarily aimed at ensuring maximum profit with sufficient cost recovery [11, 15].

However, in general, the economic effect of corn cultivation it is set by the free market, by the government's agricultural policy on cereals development industry, by the resource efficiency of the implemented culture technologies and by level and quality of the products [13, 16, 12].

In this context, the purpose of this research was to test, on the chernozem from Caracal, numerous corn hybrids of different origins and with vegetation periods placed in almost all FAO precocity groups in the period 2020-2023, in order to evaluate yield potential.

MATERIALS AND METHODS

The corn hybrids came from globally recognized companies – BASF, BIOCROP, CORTEVA, DONAU SAAT, KWS, LIDEA, MAS SEEDS, SAATEN UNION, and SYNGENTA.

Starting from the fact that the hybrids were tested under the same technological conditions, as presented in Table 1, the income per hectare and % seed cost of the income for a density of 70,000 plants/ha was calculated according to the price of the dose for each hybrid and of the number of germinating grains in each dose (50,000 g.g or 80,000 g.g).

Table 1. Technology applied to corn lots

Technological work	**Testing year**			
	2020	**2021**	**2022**	**2023**
-Pre-crop	Sunflower	Sunflower	Sunflower	Colza
-Plowing	In autumn			
-Disc work	30.03.2020	31.03.2021	24.02.2022	23.02.2023
-Fertilization:	NUTRITOP – 150 kg/ha 04.04.2020	NPK 20:20:0 – 250 kg/ha 01.04.2021	NPK 20:20:0 – 250 kg/ha 15.04.2022	NPK 20:20:0 – 250 kg/ha 08.04.2023
-Combinator:	06.04.2020	15.04.2021	15.04.2022	13.04.2023
-Sowing date:	06.04.2020	16.04.2021	16.04.2022	20.04.2023
-Emergence date:	20.04.2020	02.05.2021	24.04.2022	30.04.2023
-Pre - herbicide	TENDER 1.5 l/ha 07.04.2020	SPECTRUM 1.4 l/ha 17.04.2021	SPECTRUM 1.4 l/ha 16.04.2022	GARDOPRIM 4.5 l/ha 20.04.2023
-Post herbicide	EQUIP 2 l/ha MUSTANG 0.5 l/ha KERAFOL 1 l/ha EVOGEL 3 kg/ha WETCIT 0.25 l/ha KAISO SORBIE 0.25 l/ha 14.05.2020:	DICOPUR 1 l/ha NOVAPOWER 1.3 l/ha 22.05.2021	ELUMIS 2 l/ha 19.05.2022	ELUMIS 2 l/ha 3.06.2023
-Fertilized	UREE NG 150 kg/ha 26.05.2020	Ammonium nitrate 07.06.2021	Ammonium nitrate 28.05.2022	Ammonium nitrate 07.06.2023
-Harvested	24.08.2020	14.09.2021	29.08.2022	12.09.2023

Source: Own experiments.

The correct choice of a hybrid is given by the relationship income - % seed cost from income in the sense that at high income, the % must be lower under the conditions in which the technology applied is identical for all the hybrids analyzed, as it was in the presented experiment.

The low prices practiced in the last 2 years on the corn market are not edifying for the calculation of profit and that is why the

correlation between income and % seed cost of income/ha was used.
From a climatic point of view, the years 2020, 2021 and 2023 were favorable for corn cultivation, but the year 2022 was extremely dry and the hybrids placed in the FAO 400 group practically did not have productions above 500 kg/ha.

RESULTS AND DISCUSSIONS

The studies highlighted: the adaptability of a very large number of hybrids for the chernozium area in Olt County; average production stability; the rich assortment of hybrids offered by large seed companies.
The extremely unfavorable climatic conditions of the year 2022 meant that the corn in the FAO 400 group did not produce grains except in very small quantities, the results being very flawed. Therefore, this data will not be taken into account in the interpretation. Also noted is the very low recovery price of corn in these test years. The limits of % seed cost of income is extremely variable (Table 2).
In 3 of the 4 years of testing, production stability was average (CV 13.4% in 2020, 15.9% in 2021 and 17.3% in 2023). The average stability of hybrids (tests with hybrids of LNZ GROUP from Ukraine) was also highlighted by [24].
Although an average of 70 hybrids were tested annually, their production average was extremely close in years with favorable climatic conditions (6,654 kg/ha in 2020, 6,603 kg/ha in 2021, 6,795 kg/ha in 2023) (Table 3).
It is all the more important knowing that hybrids from all FAO groups and from the main seed companies have been tested. As mentioned before, the year 2022 should not be taken into account given the unfavorable climatic conditions for the maize crop.

Table 2. Synthesis of the percentage of seed cost of income realized/ha in the test years

The year	Yield min/yield max (kg/ha)	Selling price (lei/kg)	Limits % seed cost of income	Companies with low % seed cost	Companies with high seed cost %
2020	4,275/8,539	0.61	7.3-27.4	DSR 10.5-11.6 MAS SEEDS 7.3-13.2 SU 8.0-12.5	CORTEVA 15.4-27.4
2021	3,421/9,316	0.92	6.3-23.6	MAS SEEDS 6.3-8.4 BIOCROP 8-9.8 KWS 8.7-12.1	LIDEA 10.6-23.6
2022	100/1,943	0.93	24.2-103.5	BASF 63.4-94.5 KWS 29.6-101.5 DSR 24.2-103.5	CORTEVA 52.7-554.9
2023	4,222/9,951	0.805	6.7-33.9	BIOCROP 6.7-9.6 KWS 7.2-11.6	CORTEVA 14.5-33.9

Source: Own results.

Table 3. Coefficients of variability of production recorded in hybrids tested at Caracal

The year	No. tested hybrids	Average of yield (kg/ha)	CV (%)	CV interpretation
2020	65	6,654	13.4	medium stability
2021	71	6,603	15.9	medium stability
2022	78	1,120	40.0	instability
2023	76	6,795	17.3	medium stability

Source: Own results.

Similar research was carried out by Oltenacu and collaborators in 2023, at the Moara Domnească Station near Bucharest [17]. The SC4140 hybrid was noted which, under non-fertilization conditions, was superior in terms of production to the P9903 hybrid. Other studies made during the period 2018-2020 have shown that yield of corn hybrids, on average varied from 4.39 t ha-1 in the control variant to 6.65 t ha-1 - with the application of

N135P90K125 + N60 + N30 in two stages. The lowest income (4,573 lei/ha) was recorded in the non-fertilized variant, the highest (8,685 lei/ha) was obtained in the variant which the 150 kg nitrogen/ha, profit increased from 4,395 lei/ha at 6,694 lei/ha. In the 2021, although the yields were similar, the selling price influenced the financial result, they being lower [14]. The economic efficiency in the case of choosing the hybrid is primarily influenced by the production obtained per hectare, by its capitalization price, but also by the price of the sown seed and the bonuses granted by the producing company. In the last 2 years, the low prices practiced in capitalizing the production have made the choice of the hybrid essential in obtaining the profit. The data related to the selling price of the seed for this study were taken from the offers of the distributing firms and it refers strictly to the listed price.

The results were presented for each year separately, highlighting the hybrids at the extremes of the correlation between income/ha and % seed cost of income.

In 2020, the Berlioz and Lukaku hybrids fulfilled the condition that at a high income/ha, the part covering the cost of the seed is small (Figure 1).

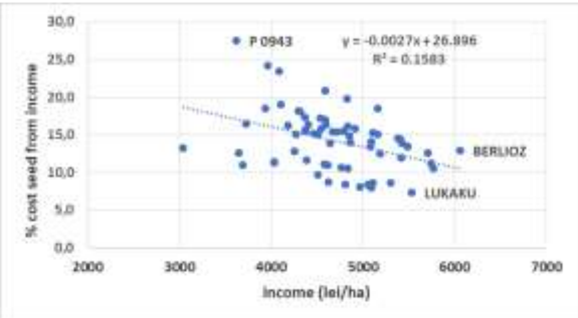

Fig. 1. The relationship between income per hectare and % seed cost of income/ha in the hybrids tested on the Caracal chernozem in 2020.
Source: Own design and calculation.

On the opposite side was the hybrid P0943 with a seed cost of over 25% of the income. In general, the hybrids of the Corteva company, because they have high prices and their productions do not differ much from the others even if they are fruitful, are not profitable in the conditions of Caracal. In this year, only 15% of the variability of income /ha determined the variability of the other character studied (Figure 2).

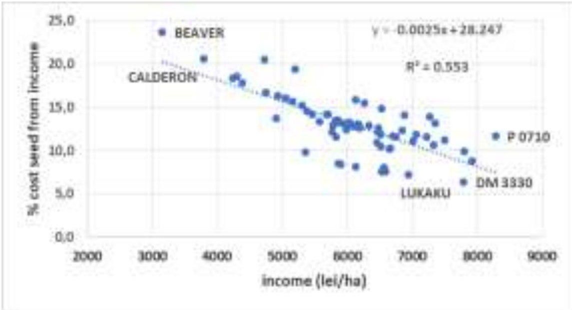

Fig. 2. The relationship between income per hectare and % seed cost of income/ha in the hybrids tested on the Caracal chernozem in 2021.
Source: Own design and calculation.

In 2022, as expected, Corteva hybrids were the most unprofitable because productions were extremely low and their price is high. The fairly high coefficient of determination (49%) shows the interdependence of the variability of the 2 characters even under unfavorable climatic conditions (Figure 3).

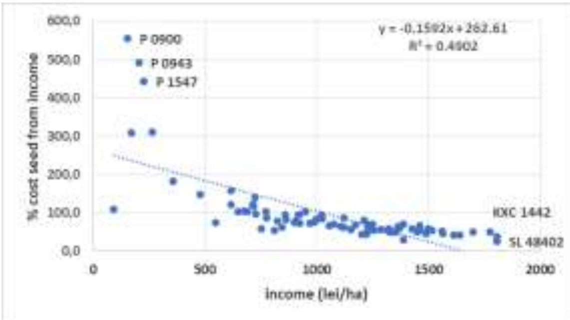

Fig. 3. The relationship between the income per hectare and % seed cost of the income/ha in the hybrids tested on the chernozem from Caracal in 2022.
Source: Own design and calculation.

In the year 2023, the Inteligens and MAS 440 D hybrids met the condition that at a high income/ha, the part covering the cost of the seed is small, even 10% for the first hybrid. The hybrids Corteva P9944, P0217 and P9975 were not so productive that the % seed cost of the income per hectare were low but between 30-35%. In this year 41% of the variability of income /ha determined the variability of the cost, also a rather high coefficient of determination (Figure 4).

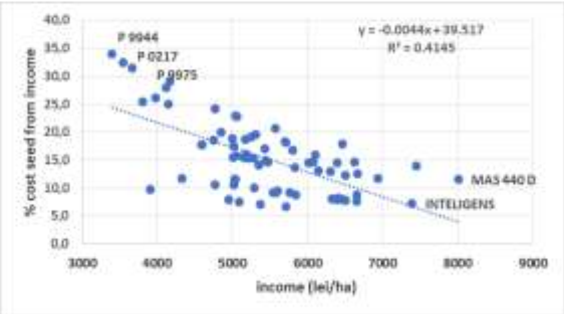

Fig. 4. The relationship between the income per hectare and % seed cost of the income/ha in the hybrids tested on the chernozem from Caracal in 2023.
Source: Own design and calculation.

Research by Hryhoriv et al. in 2022 showed that the bigger economic efficiency of maize cultivation was recorded at N135P90K125+ N60+N30 variant with a plant density of 60,000 plants ha–1, profitability index – 135%, being the highlest. The lowest profitability index was in the variant with the plant density of 80,000 plants ha–1 without mineral fertilizers - 53%. [14].

Other research showed that in 2 different systems: conventional and non-till, Adevai and LG 3232 hybrids reported the best economic efficiency [23].

However, in order to highlight the most productive or the weakest of the hybrids tested, the boxplot method was used. The hybrids P0710 (Corteva) and Kashmir (KWS) in the year 2021 and MAS 448 (Mass Seeds) in the year 2023 were noted as positive outliers, following the analysis by the boxplot method (Table 4).

Table 4. Highlighting productive or less productive hybrids using the boxplot method

BOX PLOT	2020	2021	2022	2023
MIN	4,275	3,421	100	4,222
Q1	6,085	5,970	803	6,223
MEDIAN	6,591	6,613	1,146	6,682
Q3	7,223	7,220	1,461	7,658
MAX	8,539	9,316	1,943	9,951
AVERAGE	6,654	6,616	1,120	6,795
IQR	1,138	1,250	658	1,435
LOWER LIMIT	4,379	4,094	-183	4,070
UPPER LIMIT	8,930	9,096	2447	9,811
OUTLIER POZITIV		P0710 KASHMIR		MAS 448
OUTLIER NEGATIV	MAS 56A	BEAVER		

Source: Own results.

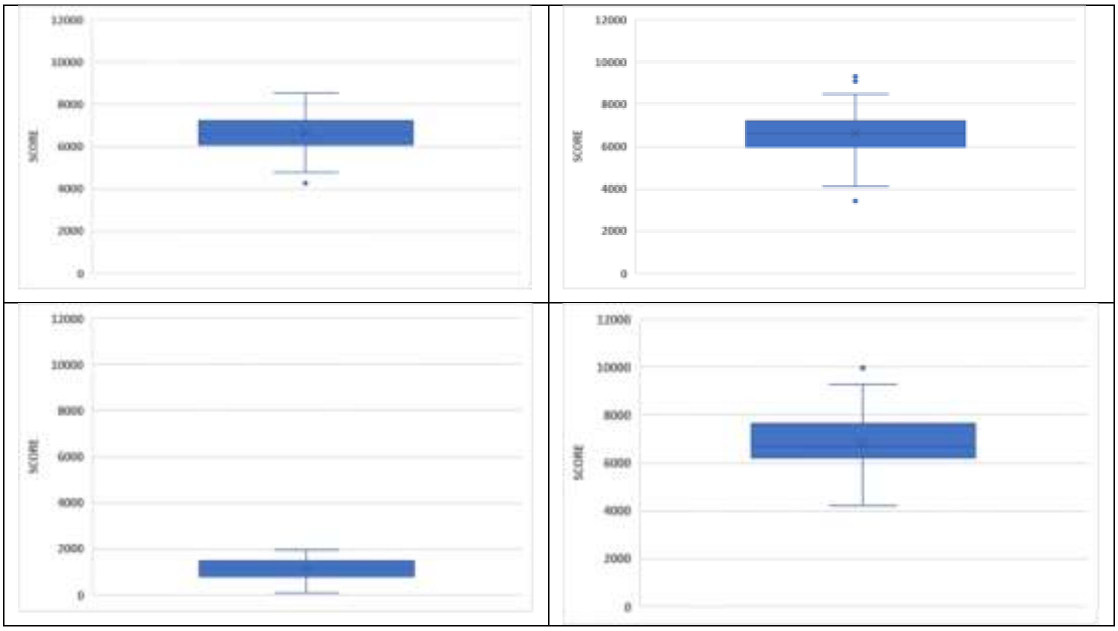

Fig. 5. Boxes of annual interquartiles for corn hybrids tested on Caracal chernozem, in the period 2020-2023
Source: Own design and calculation.

Figure 5 shows the almost identical adaptability of hybrids from the years 2020 and 2021 to the pedoclimatic conditions of Caracal, but also the greater share of 50% of the productions of the corn hybrids from the year 2023 as well as the narrow interquartile range from 2023 when the differences between the productions were practically reduced due to the drought.

CONCLUSIONS

In the conditions of Caracal, during the analyzed period, the % seed cost of the income per hectare was chosen as an indicator of economic efficiency, because the same technology was used in the hundreds of tested hybrids in each of the years of testing. Also, the unstable market against the background of the disruption of the world socio-economic context did not allow profit to be obtained in these years.

However, following the interpretation of the correlation between the obtained income and % seed cost of the income/ha, the one that led to the correct choice of the hybrid, the following were favorably noted: the Lukaku, Berlioz, DM 3330, P 0710, KXC 1442, SL 48402, MAS 440D, Intelligence.

The companies BIOCROP, KWS SEMINTE and MAS SEEDS stood out in at least 2 years out of 4 years of testing, from the point of view of reduced costs with seeds from revenues.

Strictly speaking of yield, through the boxplot method, the P0710 (Corteva) and Kashmir (KWS) hybrids in 2021 and MAS 448 (Mass Seeds) in 2023 stood out as positive outliers.

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LAND STRUCTURAL CHANGES AND DEVELOPMENT OF VEGETABLE PRODUCERS IN BULGARIA

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Abstract

Land structural changes and development of small farmers are public phenomena arising on the basis of land use as an indispensable mean of production in the agricultural sector. After the transition from one political ideology to another, which lasted more than three decades, more than 10 years were necessary for the Bulgarian government to complete the land reform. The value of the gross agricultural output had declined during the last years. The national policy in most countries maintains agricultural consultancy organizations that aim to offer additional assistance services to small-scale farmers. The legislation should set out the objectives and scope of the consultancy activity, focusing on the way of development of rural areas. The relation between research activity should be regarded as the basis for the development and implementation of agricultural programs. The purpose of this article is to present and analyze the structural changes of land use for small-scale farming and development of the vegetable producers in Bulgaria. A number of contemporary scientific quantitative and qualitative methods are used to achieve the intended objective set in this study: systematic and comparative analysis, monographic analysis and expert assessment. The methodical framework of this article provides a summary overview of the main changes in the agricultural policy and the structure of land relations in Bulgaria. The processes in land relations, as public relations, are dominated by the changes in the institutional environment and socio-cultural traditions. The paper also has a narrow focus on achieving the key goal of presenting the links between land structural changes and their impact on the development of vegetable producers in Bulgaria. The results pointed out the fragmentation of the use of agricultural land, and the existence of a large number of small farms. For the research, we used data of the Ministry of Agriculture, Food and Forestry. The main conclusions are related to the land productivity in Bulgaria regarding field vegetable production is low despite the favourable soil and climatic conditions typical of the area. The structural changes present that the land used is mainly concentrated among small producers who are mainly vegetable producers. The large number of small-scale agricultural farmers is typical for Bulgaria and the main reason for this is the land reform carried out in the 1990s, when the land was returned in real borders to its owners and their heirs.

Key words*: *land relations, land reform, land structural changes, small scale farms, vegetable sector, Bulgaria

INTRODUCTION

The main function of extension services is to provide training and professional advice in the sphere of agricultural production, marketing activities of farmers, distribution and use of natural resources, as well as the participation of young farmers and their involvement in agricultural production and improvement of services offered in rural areas. The factors that influence extension services can be categorized as economic, geographical and political. Economic factors have an impact on the internal organization of extension services. Geographical factors influence the development of agricultural farms as well as the need for specialized knowledge of the agencies which offer extension services. Political factors are related to the level of development of extension services and education [2]. The relation between research activity and extension services should be regarded as the basis for the development and implementation of agricultural programs.

The large number of small-scale agricultural farmers is typical for Bulgaria and the main reason for this is the land reform carried out in the 1990s, when the land was returned in real borders to its owners and their heirs. The key reason for the existence of so many small-scale farmers is the land reform in the 1990s. Following the implementation of the land reform, the land was returned to the owners and/or their heirs within the real boundaries before the collectivization in the 1950s. This process of agricultural land restitution has resulted in a trend of extremely fragmented ownership structure and a large number of land plots per owner as affirmed Vranken, Noev and Swinnen (2004) [11], Kostov et al. (2004), Mathijis et al. [3], Yovchevska (2016) [12], cited by Dirimanova (2023) [2].

The purpose of this article is to present and analyze the structural changes of land use for small-scale farming and development of the vegetable producers in Bulgaria.

MATERIALS AND METHODS

In Bulgaria there is no comprehensive study on the state of land relations in the implementation of the CAP policy and, in particular, the consultation of farmers.

The relevance and need for development of a methodology related to the study of land relations in Bulgaria is derived from the link between the land management and the increasingly dynamic regional and national processes related to circular economy policies, bio-economy and food security.

The methodical framework of this article provides a summary overview of the main changes in the agricultural policy and the structure of land relations in Bulgaria. The processes in land relations, as public relations, are dominated by the changes in the institutional environment and socio-cultural traditions. The paper also has a narrow focus on achieving the main goal of presenting the links between land structural changes and their impact on the development of vegetable producers in Bulgaria.

The study is focused on the role of land structural changes in the development of land relations in Bulgaria, as well as the range of development of vegetable producers in Bulgaria related to the social, economic and legal environment in Bulgaria [9].

For the research, we used data of the Ministry of Agriculture, Food and Forestry.

A number of contemporary scientific quantitative and qualitative methods are used to achieve the intended objective set in this study: systematic and comparative analysis, monographic analysis and expert assessment. The results pointed out the fragmentation of the use of agricultural land, and the existence of a large number of small farms.

The analyzed indicators are number of vegetable producers by regions in Bulgaria, semi-subsistence farms and small-scale farmers who do not participate in national and European programs.

RESULTS AND DISCUSSIONS

Most of the problems in the agricultural sector started when the cooperatives were destroyed and the land was returned to its owners within real boundaries [1].

Unfortunately, this working model was violently destroyed and the big tenants, who constitute about 3%, took over 95% of the arable land in Bulgaria. For all the known advantages of concentration, the existence of large-scale land owners in Bulgaria will inevitably have a negative impact on the recovery of Bulgarian agriculture. The monoculture farming of cereals, rape and sunflower, practiced by a number of Bulgarian farmers due to the high degree of mechanization in farming activities, has left other producers unemployed, which in turn has depopulated many Bulgarian villages [1].

Since 1991 Bulgaria has adopted the Agricultural Land Ownership Act. So far the law has been amended more than 73 times. The state neither manages nor directs land trade, and at the same time it avoids the problem of land consolidation. The land consolidation that is taking place in Bulgaria is not for the sake of the production itself, but to make it easier to sell or rent land [11].

There have also been huge changes in the structure of arable land. The area under permanent crops and vegetables has drastically decreased - by more than 10 times. There has been a trend towards preservation of areas planted with cereals, and a rapid growth of areas planted with sunflowers and rape, which number has increased more than 10 times. There has been a high degree of monoculture farming, with these two crops accounting for 94% of arable land.

The small-scale agricultural production is result not only of the land reform, it has also its

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

traditional roots in Bulgaria. In the past, before the process of collectivization, landowners cultivated small plots of land that were sufficient to produce enough agricultural produce and food to satisfy their own needs.

The results of the social and economic changes are that Bulgaria is still in a period of dynamic institutional changes that are actively affecting the state of land relations [11].

Since 1991 Bulgaria has adopted the Agricultural Land Ownership Act. So far the law has been amended more than 73 times. The state neither manages nor directs land trade, and at the same time it avoids the problem of land consolidation. The land consolidation that is taking place in Bulgaria is not for the sake of the production itself, but to make it easier to sell or rent land [9].

In this regard, the latest changes and the adoption of new legislation are a responsible economic and political act that would provide better conditions for the development of agriculture, reduce the administrative costs of farmers and lead to an improvement of the socio-economic environment in the rural areas of the country.

The Land Act sets out the rules relating to the administrative procedures for creation of land units, voluntary consolidation of agricultural land with change of the ownership right, registration of the relevant documents for the use of agricultural land for the purposes of support under Single Area Payment Schemes, etc. [9]. Compared to the basic direct payment schemes applied in most of the other Member States of the European Union, the amount of basic income support for Bulgarian farmers under this system is linked, in a simpler form, to the area of land declared by each farmer. Bulgarian authorities dedicate 13% of the allocated funds for direct payments (the maximum eligible rate) for voluntary coupled support – i.e. payments are linked not only to the number of hectares cultivated, but also to specific products or processes - beef and veal, fruit and vegetables, milk and dairy products, sheep and goat meat and protein crops. (European commission: Bulgaria and CAP, 2016) [4].

The study identified several groups of small farmers in Bulgaria:

-Newly established farms /by young people/;
-Semi-subsistence farms;
-Small-scale farmers who do not participate in national and European programs.

The limitation of the large number of small-scale farmers is based on several criteria: Farmers must be aged up to 40 years to be vegetable growers, they must cultivate at least two crops and the farm size must be up to 4 economic units. This group of young farmers in most cases has no agricultural education and needs different types of extension services [10]. Their needs are related to the development of business projects requiring the application of specific measures of the Rural Development Program (RDP) for period 2014-2020. Most of the small-scale and semi-subsistence farmers specialize in vegetable production. This production is typical for them and they can easily provide the final vegetable products in the markets. The vegetable producers are mainly located their production in the South Central Region of Bulgaria. They use 47% of the farmland in the South Central Region for vegetable production (Figure 1).

The area of the South Central Region is 22,365.1 km² or 20.1% of the country's territory. The utilized agricultural area in the south central region amounts to 779,818 hectares. The territorial structure is as follows: agricultural territories are 48.1%, forest territories – 45.1%, and the urbanized territories occupy only 3.9%. The south central region is among the most biodiverse areas in the country. They are located on the territory of the region 11 nature reserves, 9 maintained reserves, 155 protected areas [13].

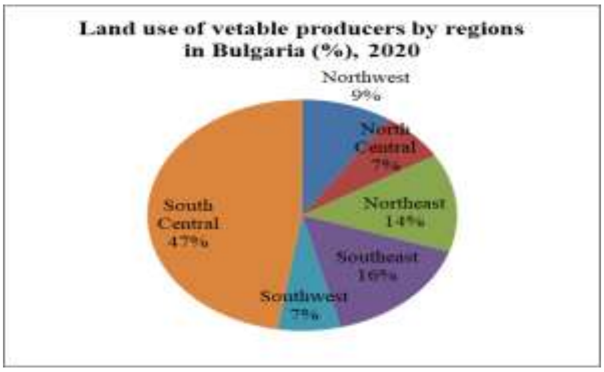

Fig. 1. Land use of vegetable producers by regions in Bulgaria (%)
Source: Own figure, by using data of the NSI [5] processed by MAFF [4].

Bulgaria is characterized by a large number of small-scale farmers, who produce mainly to meet household needs, while another part of the production is sold on the market. The key reason for the existence of so many small-scale farmers is the land reform in the 1990s. The large numbers of small-scale farmers who are vegetable producers are again in South Central Region of Bulgaria - 41% and Southwest Region - 24% (Figure 2). Most of them do not participate in national and European programs. One reason is that they do not meet the requirements of the RDP measures for which they can apply. Another reason is that a large number of small-scale farmers are reluctant to participate in EU and government programs because of the high transaction and administrative costs during project implementation period. The tendency is that these producers are mostly interested in applying good agricultural practices and innovation [7].

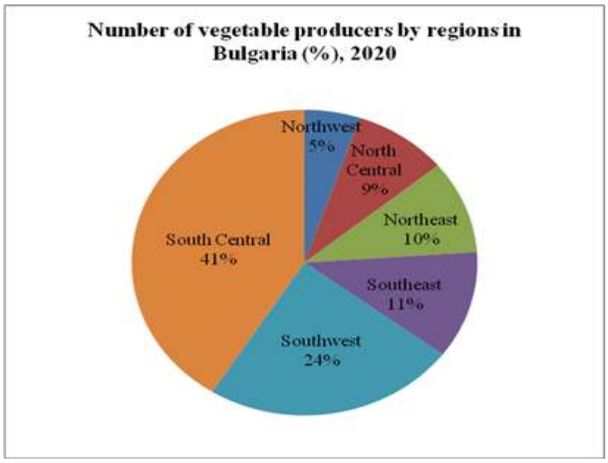

Fig. 2. The share of vegetable producers by regions in Bulgaria (%)
Source: Own research by using data of the NSI [5] processed by MAFF [4].

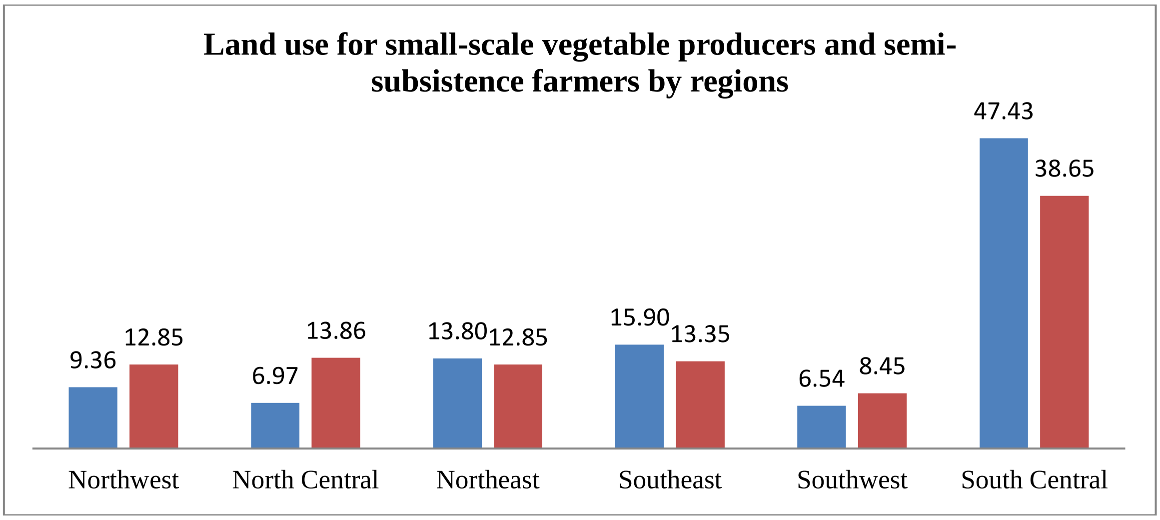

Fig. 3. Land use for small-scale vegetable producers and semi-subsistence farmers by regions (%), 2020
Source: Own research by using data of the NSI [5] processed by MAFF [4].
Note: Land use for semi-subsistence farmers (Red); Land use for small-scale vegetable producers (Blue).

There have also been huge changes in the structure of arable land. The area under permanent crops and vegetables decreased by more than 10 times [8]. There has been a trend towards preservation of areas planted with cereals, and a rapid growth of areas planted with sunflowers and rape, which number has increased more than 10 times.

There has been a high degree of monoculture farming, with these two crops accounting for 94% of arable land.

In recent years, registers a permanent trend to reduce the harvested areas and realization of average yields far from the biological potential of cultivated vegetable varieties. Often, the obtained production is also weakly competitive compared to the increasing quality requirements of the national, regional and general European market. Small semi-subsistence farms in Bulgaria produce mainly for domestic consumption and to supplement their household income. This type of farming has economic potential for the future development of these farms. The number of such small-scale farms in the country is very high. The land use for small-scale (47.43%)

and semi-subsistence (38.65%) vegetable farmers is again very high for South Central Region of Bulgaria (Figure 3).

They are usually not well-developed and need to be restructured in order to be competitive on the Bulgarian and European markets. According to the interviewed semi-subsistence farmers who have participated in RDP measures, all of them have used extension services to prepare business plans required for the application process [6].

CONCLUSIONS

Bulgarian vegetable producers are among the farmers most affected by economic and political changes in the last 30 years despite their reputation as the best gardeners in Europe before 1989. The administration of land relations and, in particular, of land use, sets out important boundary conditions for land markets and the institutional framework is a decisive factor [13]. The focus of the new CAP in the next programming period will continue to support small and medium-sized farms. Financial support for small-scale farmers will also increase in the new programming period, which would encourage the younger generation to take up farming. The provision of extension services in Bulgaria should continue to be one of the CAP policy priorities in the future.

The return of the land, and above all within real limits, took place without a clear vision for the future. The link between science and production was severed, which set our agricultural development back in its developmental age. The law on the return of land within real boundaries was associated with the idea of creating conditions for a land market. The landowners, to whom the property of the land was returned, were unable to create a material basis for managing the land, fragmented into thousands of pieces among the heirs, most of whom lived in the cities. The relation between research activity and extension services should be regarded as the basis for the development and implementation of agricultural programs.

The land productivity in Bulgaria regarding field vegetable production is low despite the favorable soil and climatic conditions typical of the area. The structural changes present that the land used is mainly concentrated among small producers who are mainly vegetable producers.

The region in which they develop production is the South Central region, which is characterized by a large number of small farms and fragmented production.

The policy of the new EU measures should be aimed at supporting small and semi-market farmers.

ACKNOWLEDGEMENTS

This research has been made within the framework of the project “Land Relations and European Policy: Synergy and Prospects for Bulgarian Agriculture” - KP-06–H35/2, funded by the Research Fund of the Ministry of Education and Science in Bulgaria.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

DIGITAL MATURITY OF THE COMPANIES IN SMART INDUSTRY ERA

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Abstract

The advent of Industry 4.0, marked by the integration of cyber-physical systems, the Internet of Things (IoT), and advanced data analytics, is revolutionizing the logistics industry. The paper proposes to use a survey developed and provided by the Research group Logistics and Alliances of the HAN University of Applied Sciences (the Netherlands). The survey was edited in March and April of 2023 and used from April 2023 to February 2024. Participants were from six partners in Europe (Finland, Spain, Ireland, Croatia, Romania, Austria) and one in Argentina. Students from all partnering universities interviewed their chosen case companies. The questions were categorized in the next sections: Background questions; Organization questions; Competencies; Tools and applications; Ranking; Company's performance compared to others. Results shows that the digitalization process in companies has started, with significant improvements in companies profit and customer satisfaction. From an organizational point of view, about 10% of companies consider themselves "Analytics as a business vision" and 20-25% are in the "data-driven organization" phase. Excel remains the most used tool for data processing, but there are preparations for integrated ERP applications in the digital management of companies. The results of the study are also confirmed by other analyses carried out by other institutions such as the Digital Maturity Assessment (DMA) tool of the European Digital Innovation Hubs Network, KPMG or BDC, and underlines the opportunity and importance of integrated digitization efforts of companies, as well as the need for standardized applications both in the field of local data processing and in international logistics chains.

***Key words**: Digital maturity assessment, smart industry*

INTRODUCTION

In today's digital age, companies face the challenge of adapting to constantly evolving technologies and effectively integrating them into their business strategies [4, 8].

Climate change, rising production costs, and shifting consumer demands are just a few of the difficulties they have been dealing with recently. These industries may be able to overcome these obstacles, introduce innovation, and produce gains for everyone involved in the value chain thanks to the digital economy.

The use of digital technologies to modify business models and offer new chances for revenue generation and value creation is known as the "digital economy," or more accurately "digitalization." It seems that digitalization and the rapid development of numerous new technologies will cause disruptions. Technologies that fundamentally change how companies or entire industry's function are known as disruptive technologies. These technologies frequently compel businesses to adapt their methods of doing business, or else they run the risk of losing customers or going out of style. Additionally, the development of smarter industry is made possible by digital technologies, which also give consumers a lot more power.

The next stage of digitization, known as Industry 4.0, is being driven by four disruptive forces [15, 23, 28, 29]:

(i)An increase in **connectivity**, processing power, and data volumes, particularly in new low-power wide-area networks;

(ii)The development of **artificial intelligence-**based analytics and business-intelligence capabilities;

(iii)Novel avenues for **human-machine communication**, like Internet of Things and augmented reality systems;

(iv)Advanced robotics is one example of how digital instructions are better transferred to the real world.

Information and communication technology, or ICT, is now regarded as a commodity technology that facilitates the development and/or adoption of more sophisticated technologies, including smart phones, satellites, cloud computing, and remote sensing.

E-business platforms are software technology solutions that serve as the foundation for additional processes, applications, or technologies, primarily related to digital commerce.

The advent of Industry 4.0, marked by the integration of cyber-physical systems, the Internet of Things (IoT), and advanced data analytics, is revolutionizing the **logistics industry** [7, 17].

Smart logistic chains are emerging as a pivotal component in this new industrial era, offering unprecedented efficiency, transparency, and adaptability.

The key elements, benefits, and challenges associated with smart logistic chains in the context of Industry 4.0 are:

(a)Internet of Things (IoT): IoT technology enables real-time tracking and monitoring of goods throughout the supply chain. Sensors and connected devices collect and transmit data on location, temperature, humidity, and other critical parameters. This data allows for immediate adjustments and proactive management of logistics operations.

(b)Big Data and Analytics: The vast amounts of data generated by IoT devices are analyzed using advanced analytics. Machine learning algorithms and predictive analytics can forecast demand, optimize routes, and improve inventory management. This data-driven approach ensures more accurate decision-making and resource allocation.

(3)Automation and Robotics: Automated systems and robotics are increasingly used in warehouses and distribution centers. Automated guided vehicles (AGVs) and robotic arms enhance the speed and precision of sorting, packing, and shipping processes. This reduces labor costs and minimizes human error.

(4)Blockchain Technology: Blockchain provides a secure and transparent method for recording transactions and tracking goods across the supply chain. It enhances trust among stakeholders by ensuring the immutability and traceability of records, thus reducing fraud and discrepancies.

(5)Artificial Intelligence (AI): AI enhances logistics by providing smart planning and optimization solutions. AI-driven systems can adapt to changing conditions, such as traffic patterns and weather, to optimize delivery schedules and routes. Additionally, AI can manage dynamic pricing and supply chain risks.

The main **benefits** of Smart Logistic Chains are:

(6)Enhanced Efficiency: Smart logistic chains streamline operations through automation and real-time data analytics. This leads to faster processing times, reduced downtime, and optimized resource use. The result is a significant boost in overall efficiency.

(7)Cost Reduction: Automation and predictive analytics help reduce operational costs. By optimizing routes and inventory levels, companies can lower transportation expenses and minimize holding costs. The reduction in manual labor further decreases operational expenditures.

(8)Improved Customer Satisfaction: Real-time tracking and transparency allow customers to monitor their orders and receive timely updates. This visibility enhances trust and satisfaction, as customers are better informed about their deliveries.

(9)Flexibility and Adaptability: Smart logistics systems can quickly adapt to changes in demand, supply disruptions, and other unforeseen events. This flexibility ensures continuity and reliability in the supply chain, even under challenging conditions.

(10)Sustainability: Optimized routes and efficient resource use contribute to reduced carbon emissions and environmental impact. Sustainable practices in logistics are increasingly important for meeting regulatory requirements and fulfilling corporate social responsibility goals.

Smart logistic chains are at the forefront of the Industry 4.0 revolution, transforming the way goods are transported and managed. By leveraging IoT, big data, automation, blockchain, and AI, these systems offer enhanced efficiency, cost savings, improved customer satisfaction, and greater adaptability. However, the transition to smart logistics is not without **challenges**, like:

(1)Integration Complexity: Implementing smart logistic systems requires significant investment in technology and infrastructure. Integrating various IoT devices, data analytics platforms, and automated systems can be complex and time-consuming.

(2)Data Security and Privacy: With the increased reliance on data, ensuring its security and privacy is paramount. Companies must invest in robust cyber security measures to protect sensitive information from breaches and cyber-attacks.

(3)Skill Requirements: The shift towards smart logistics necessitates a workforce skilled in handling advanced technologies. Companies must invest in training and development to equip their employees with the necessary skills to manage and operate these systems.

(4)Interoperability: Ensuring seamless communication and interoperability between different systems and technologies is a significant challenge. Standardization and collaboration among industry stakeholders are crucial for achieving effective integration.

(5)Regulatory Compliance: Companies must navigate a complex landscape of regulations related to data protection, safety, and environmental standards. Compliance with these regulations is essential to avoid legal penalties and maintain operational integrity.

Companies must address integration complexities, data security, skill gaps, interoperability issues, and regulatory compliance to fully realize the benefits. As technology continues to advance, the potential for smart logistic chains to further optimize and innovate the logistics industry is immense, promising a future of more intelligent and sustainable supply chains.

The digital maturity of companies refers to the level at which a company has embraced and effectively leveraged digital technologies to drive innovation, efficiency, and competitiveness [1, 11, 14, 16].

Digital maturity can be assessed based on a variety of factors, including the extent to which digital technologies are utilized throughout the organization, the level of digital skills among employees, and the overall digital transformation strategy of the company [4, 19, 20, 26, 27]. Digital maturity is crucial for companies to stay relevant and thrive in the competitive landscape.

To understand the level of digitalization of an enterprise, the paper proposes to use a survey developed and provided by the Research group Logistics and Alliances of the HAN University of Applied Sciences (the Netherlands).The digitalization efforts of companies can vary greatly, with some companies being more advanced in their digital maturity than others.

According to a study on the digitalization efforts of leading manufacturing firms, many companies are still far from ready to fully benefit from digitalization [2, 18]. They may be focused on achieving greater efficiency through digitalization rather than pursuing a growth agenda. This imbalance is attributed to the difficulties related to identifying profitable configurations of competencies, assets, and data generated from digital technologies, orchestrating them, and exploiting them in an agile organization [4].

However, it is essential for companies to prioritize digital maturity and embrace a holistic approach to digital transformation [2]. This includes developing a clear digital strategy, investing in the necessary infrastructure and tools, fostering digital skills and capabilities among employees, and continuously monitoring and evaluating the progress and impact of digital initiatives. Companies that have a higher level of digital maturity are more likely to successfully adapt to changing market conditions, seize new opportunities, and deliver value to their customers in a digital-first world [6].

Additionally, digital maturity enables companies to gather and analyse large amounts of data, allowing for more informed decision-making and the ability to identify trends and patterns that can drive innovation, efficiency, and competitiveness. Overall, digital maturity of companies is crucial for their success in today's digital era [13, 24, 25, 33].

The level of digital maturity within a company can be determined by factors such as the utilization of digital technologies throughout the organization, the level of digital skills among employees, the integration of digital systems and processes, the data-driven decision-making culture, and the company's ability to adapt and innovate in response to technological advancements [4].To better understand the digital maturity of companies, various assessment models and tools can be used [2].

One such model is the "Industry 4.0" maturity index developed by the National Academy of Science and Technology of Germany [4]. This index measures the level of digitalization and integration of technologies such as automation, artificial intelligence, and Internet of Things in manufacturing processes. Another model is the Big Data Maturity Model which assesses an organization's maturity level in utilizing big data and analytics [2]. By evaluating different dimensions such as people, governance, technology, methodology, and strategy alignment, the Big Data Maturity Model can provide deep insights into an organization [21, 31].

The goal of this research is to find out the current level of data maturity of companies, taking into consideration different aspects regarding:

-Organizational aspects of data maturity (Digital literacy, Leadership and support, Measuring);

-Competences (Decision making for clear connections between data analysis and decisions; Specialists for deployment of specialised data analysts; Software and methods);

-Infrastructure (Quality of data; Access to data; Management of data processes);

-Tools and applications;

-Ranking;

-Companies’ performance to others.

MATERIALS AND METHODS

The data maturity scan in brief

The data maturity scan was developed and provided by the Research group Logistics and Alliances of the HAN University of Applied Sciences (the Netherlands) and was used for research purposes in Erasmus + project SMARTER. The survey for SMARTER project was edited in March and April of 2023 and used from April 2023 to February 2024.

The data gathered was analyzed in March 2024.

The survey is a data maturity scan. The higher the organization scores on the survey, the more analytically mature they are in their business. Organizations that are analytically mature are likely to have processes for building and deploying analytical models that are robust and built according to schedule.

As such the scan provides a valuable framework for companies to understand their current level, and where they still need to go to achieve their future desired level in analytics and data science (Halper, 2014), particularly when used as a tool for a dialog on this subject. The results from the scan can then be discussed together. And solutions on how to grow in maturity can be tailored for the organization.

The current scan was developed based on a diverse set of scientific and practical data science maturity models, such as The TDWI Analytics Maturity Model [10], Informs.org Analytics Maturity Model [12], and [3, 5, 9, 22, 30, 32, 34, 35, 36].

Participants (Sample):

In total 187 answers to the survey of which 70 number was scientifically reliable. From the 187 answers, the partially finished ones were eliminated. Participants were for six partners in Europe (Finland, Spain, Ireland, Croatia, Romania, Austria) and one in Argentina.

Data Collection:

The students from all partnering universities interviewed their chosen case companies.

The questions were categorized in the next sections:

(a)Background questions

This section includes the following questions:

-I work as ... (name of position): Please choose the one which is the most suitable for you or use the option other and describe your job position.

-I work for ... (company name): As mentioned above the company name will not be used for research nor will it be published. It is recorded in case the data needs to be adjusted or other clarification is needed afterwards; we can then identify your response among the others.

-In which country is your organization located? The options are in English to ensure the reliability of the answer and to ease the analysis phase after all the surveys have been completed. The final analysis is conducted by the SMARTER research team, meaning that that is not included in teaching.

-How many people are employed in your organization (approximately)? This question is asked for comparison reasons.

-In which sector is your organization active? This question is asked for comparison reasons.

(b)Organization questions

The section on **Organization** involves three blocks that deal with **organizational** aspects of data maturity. The extent to which the organizations strategy and culture fosters an analytics program. The interviewee is asked which of the five maturity phases (1. Learning and discussion phase; 2. Novice user; 3. Not yet data-driven, 4. Data-driven organization; 5. Analytics as a business vision) resembles his or her company the best on these specific maturity aspects.

The three blocks are:

(1)***Digital literacy:*** this aspect refers to the general digital/data literacy of the workforce.

(2)***Leadership and support:*** this aspect refers to the extent there is support from the (top) management for working smart with data

(3)***Measuring:*** this aspect refers to the extent there is emphasis on data and data analysis when making decisions.

(c)Competencies *–involves three blocks dealing with the following aspects:*

-***Decision making for: Clear connections between data, analysis and decisions***

--***Specialists for: Deployment of specialized data analysts***

--***Software & Methods***

(d)Questions about Infrastructure

The section on Infrastructure involves three blocks that deal with the data management aspects of data maturityresembles his or her company the best on these specific maturity aspects. The three blocks are:

-***Quality of data: this*** aspect refers to interviewee's judgement on the quality of data, and of data analysis

-***Access to data:*** this aspect refers to the ease with which data can be accessed and analyzed

-***Management of data processes:*** this aspect refers to interviewee's judgement of the control of the data process, from the source of the data to data-driven decision-making

(e)Tools and Applications

This section of the survey deals with the data-related applications and tools used in the case company. The interviewee is asked to check the apps and tools used in his or her company for data gathering, -usage and -storage.

(f)Ranking

In this section the interviewee is asked on which of the three blocks (Organization, Competencies, and Infrastructure) his or her company experienced the most challenges. The interviewee is asked to rank these blocks from most challenging to least challenging.

(g)Company's performance compared to others

In this section the interviewee is asked to indicate how well his or her company performs, compared to similar companies or competitors.

(h)Open-ended Questions

After the interviewee has answered the above questions, it will initiate a more in-depth conversation on specific responses. Supplementary answers can and should be recorded in this section, with concrete examples.

Data Preparation and Demographics

The first step in data preparation was to extract the data in Excel format from Qualtrics. The valid data and the invalid responses were then separated. The survey received 187 responses in total. The previews and incomplete answers were also included in this figure. Prior to sorting the data, the preview responses were removed. Responses that lacked a company name or had an invalid name were removed. Finally, the incomplete responses were removed, leaving 70 valid responses at the end of this procedure.

Finland accounted for 28% of the respondents (19), with Argentina making up the second-largest group (14 respondents) (21%). Spain, Austria, and Romania also contributed significantly to the valid responses (9).

There were also few responses from the United States, United Kingdom, the Netherlands, Ireland, and Croatia. Twenty-five percent of organizations regularly employ more than 500 people. The second-largest group, comprising 22%, employs between 50 and 250 people. There were four companies with a single employee.

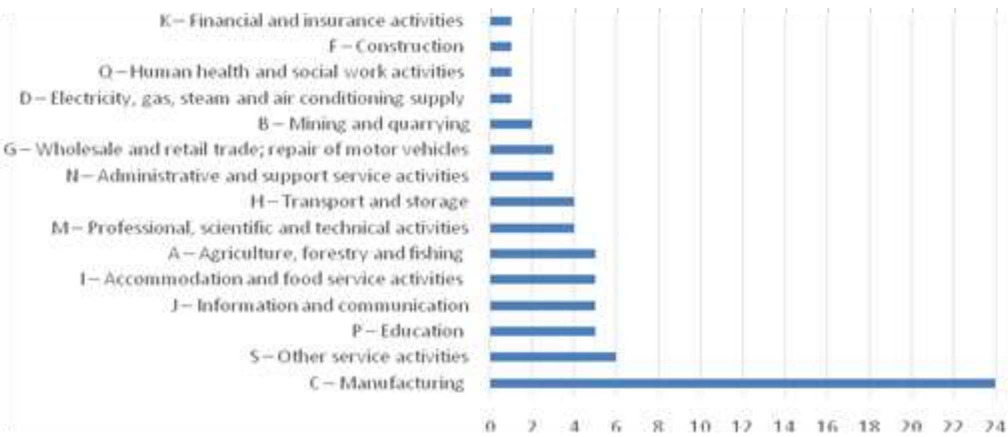

Fig. 1. Business sector of the respondent organizations
Source: Results of the survey.

The business sector of the respondent organizations is shown in Figure 1. Every respondent company selected the industry that most accurately reflects their line of work. The majority of the organizations that responded work in the manufacturing sector.

RESULTS AND DISCUSSIONS

The results of the study were processed using the Excel application and are briefly presented below in graphic form, being organized similar to the categories of questions included in the online questionnaire.

(1)Organization

Regarding the organizational aspects, from Figure 2 it can be seen that about 58% of the companies are still in the "learning and discussion phase - 23.88%" or "novice user - 34.33%" phase. Only 10.45% consider themselves "Analytics as a business vision" and 22.39% are in the "data-driven organization" phase.

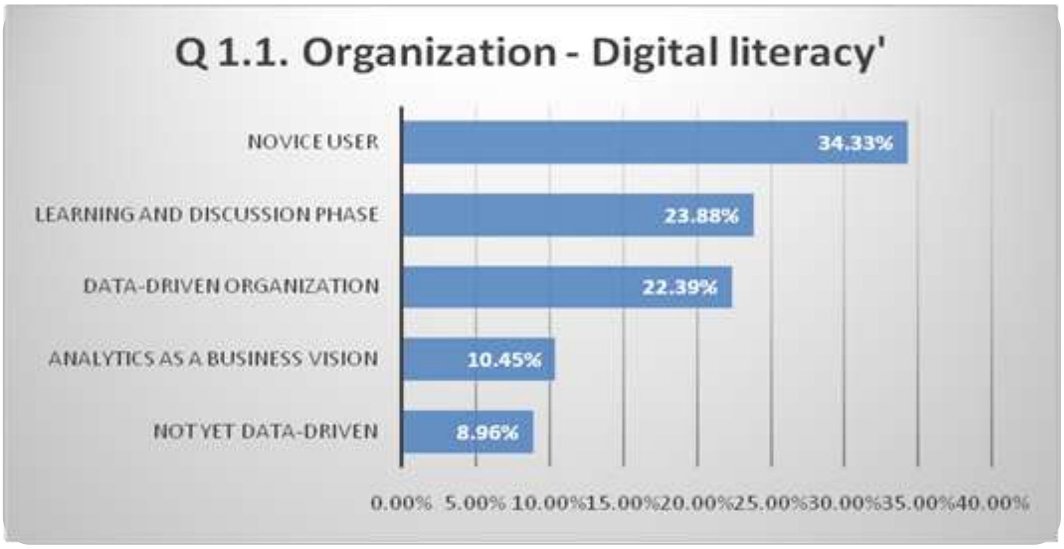

Fig. 2. Organization - Digital literacy
Source: Original results of the survey.

Fig. 3. Organization - Leadership and support
Source: Original results of the survey.

Regarding "Leadership and support" (Fig. 3), the situation is somewhat better, about 30% of companies are in the "data driven organization" phase and about 12% in the "Analytics as a business vision" phase. About 24% of the companies are in the "Learning and discussion" phase, respectively "Novice user".

Figure 4 shows results related to "Measuring and data analysis when making decisions". 28.36% of the companies are of the "Data driven organization" type, about 9% are in the "Mature/Visionary" stage, about 33% are "Novice user" and 19.4% are in the "Learning and discussion phase".

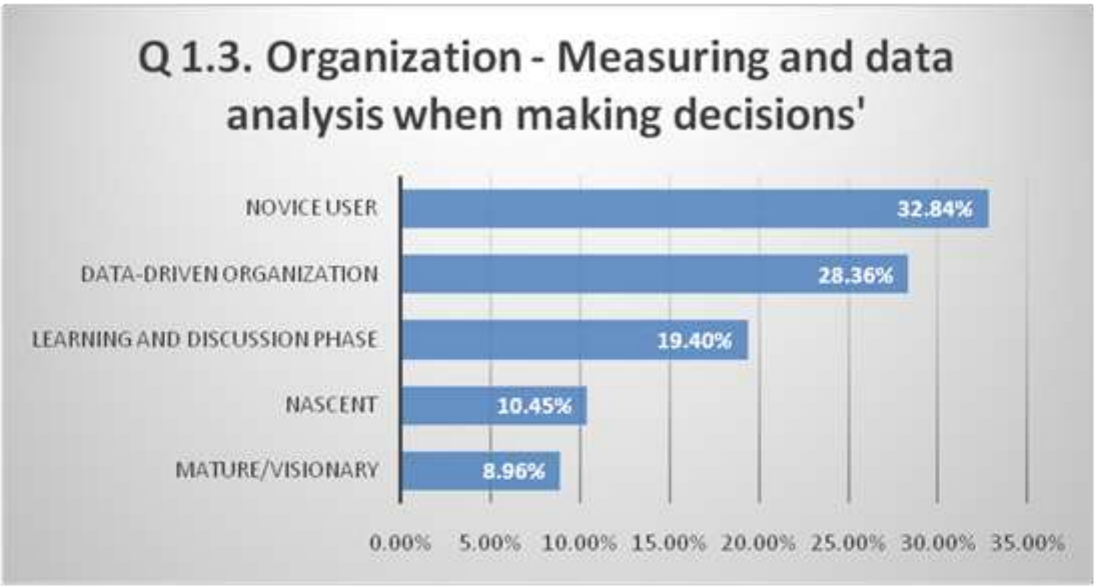

Fig. 4. Organization - Measuring and data analysis when making decisions
Source: Original results of the survey.

(2)Competencies

Figures 5...7 show aspects related to the degree of maturity in matters related to digital skills. Thus, in making decisions, about 30% of companies rely on digital data analysis, while 50% of them are in the beginning phase of the digitalization of the decision-making process (Fig. 5).

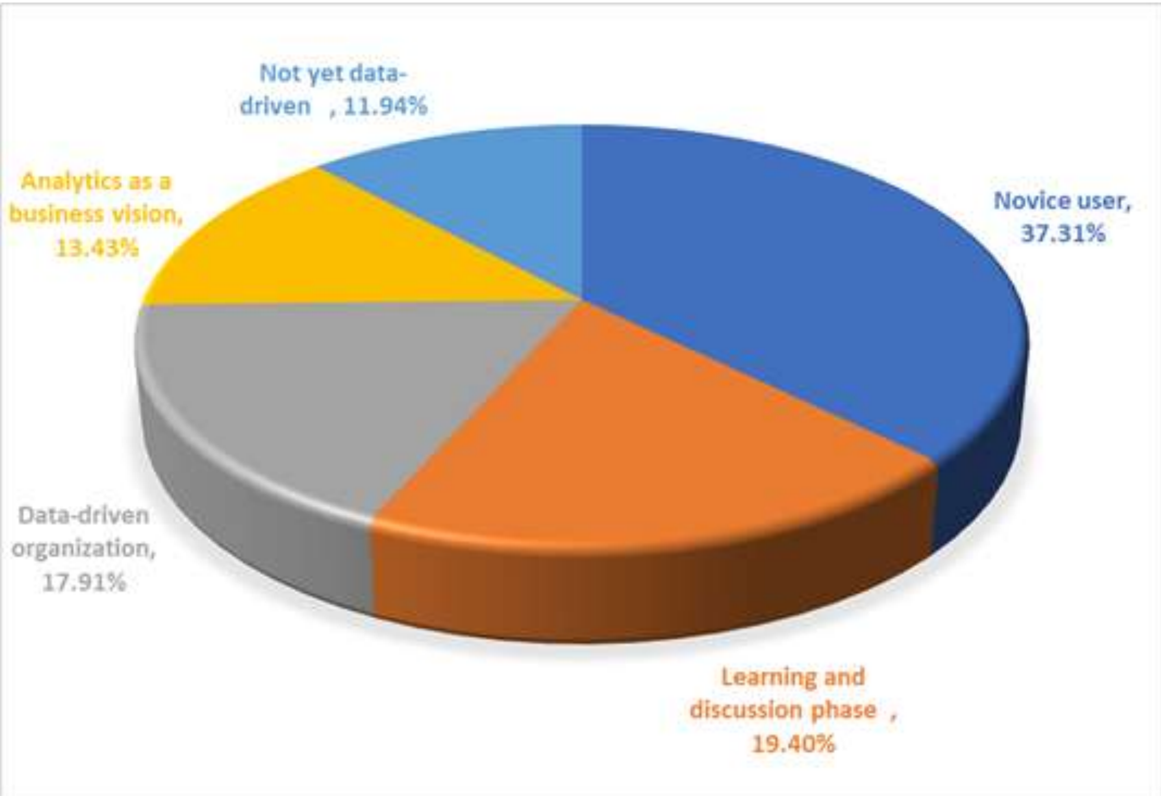

Fig. 5. Competencies - Decision making
Source: Original results of the survey.

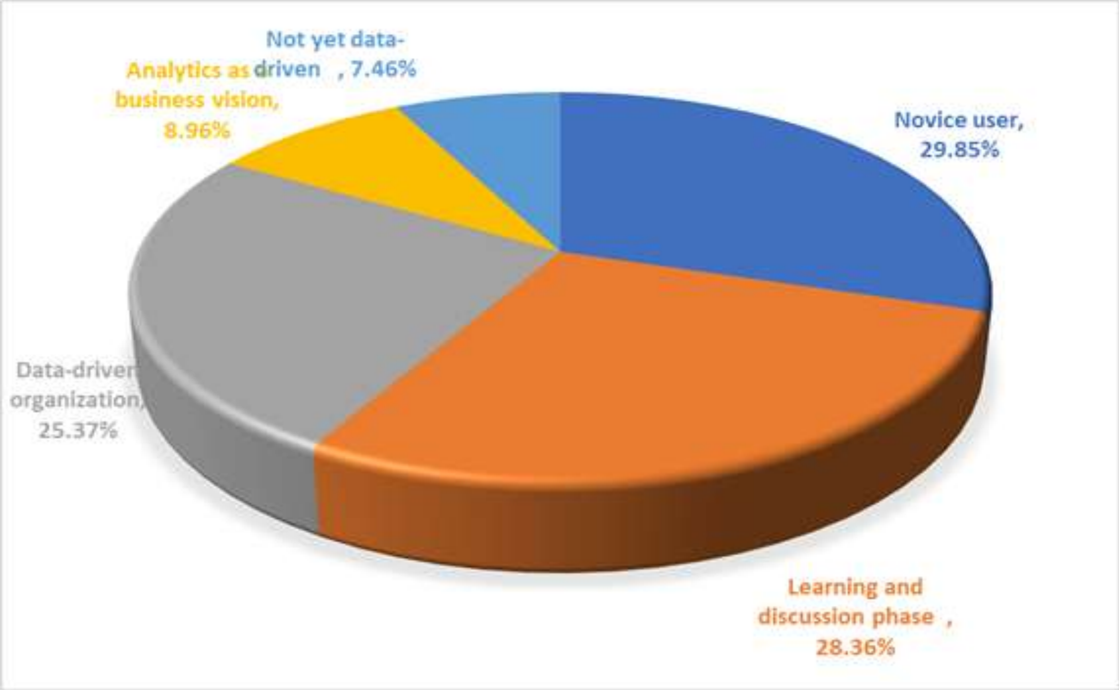

Fig. 6. Competencies - Deployment of specialized data analysts
Source: Original results of the survey.

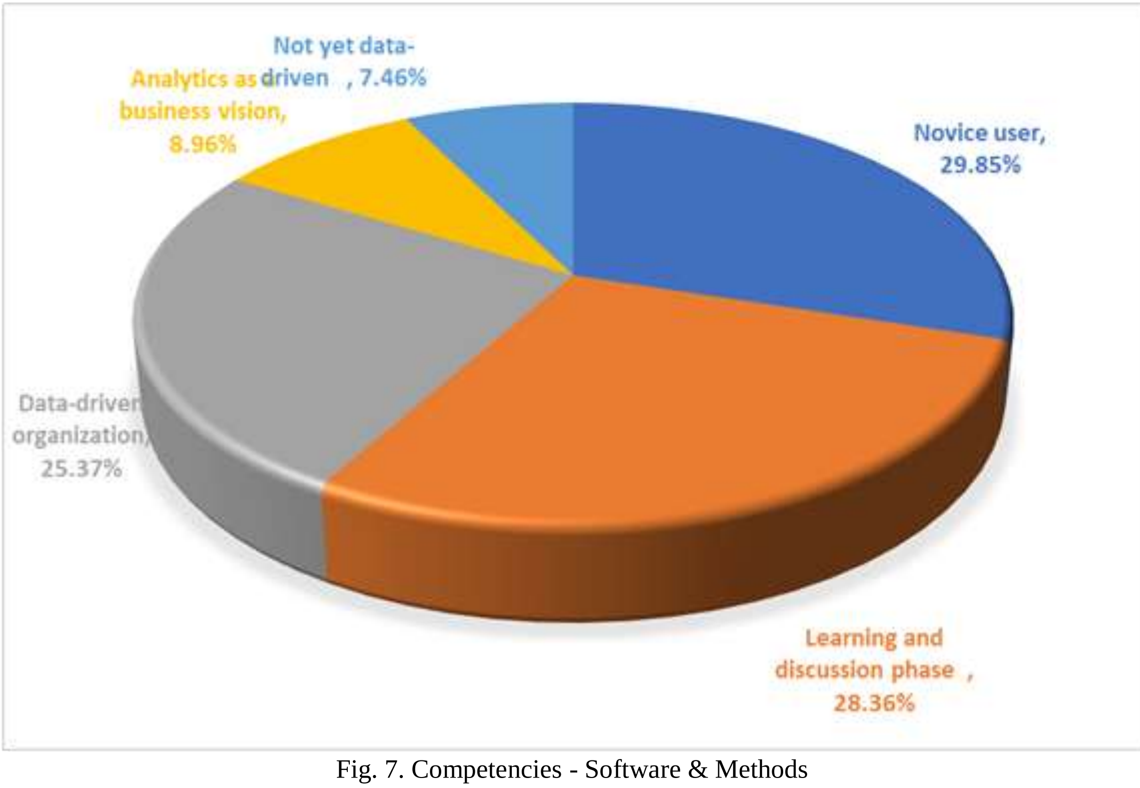

Fig. 7. Competencies - Software & Methods
Source: Original results of the survey.

In the "deployment of specialized data analyst" process, about 1/3 really perform, while over 50% are in the beginning stage or the discussion/learning phase (Fig. 6).
The situation is similar in the case of the software applications used (Fig. 7).

(3) Infrastructure
Regarding the digital infrastructure of the companies, the analysis of the answers provided the results presented in Figures 8, 9 and 10, from which it can be seen that data quality is an important problem for 60% of the

companies, only about 30% having notable performances (Fig. 8).
Figure 9 also shows that about 37% of the answers indicated a very easy access to the data, 62% being still in the beginning or training phase, and 10.45% in an intermediate phase.

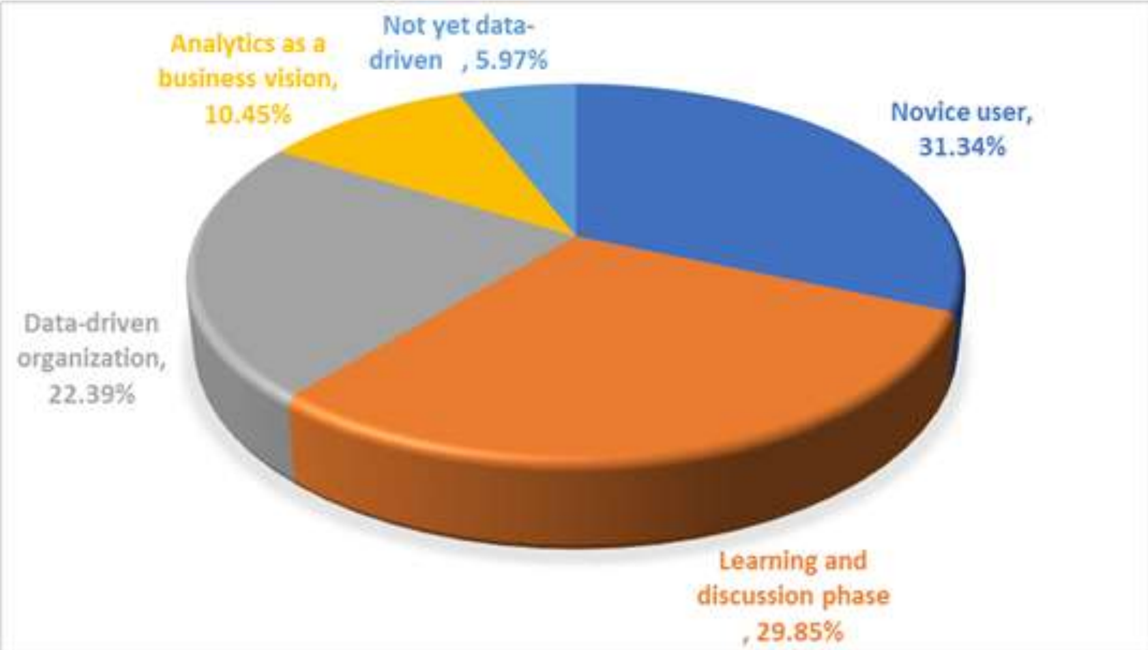

Fig. 8. Infrastructure - Quality of Data
Source: Original results of the survey.

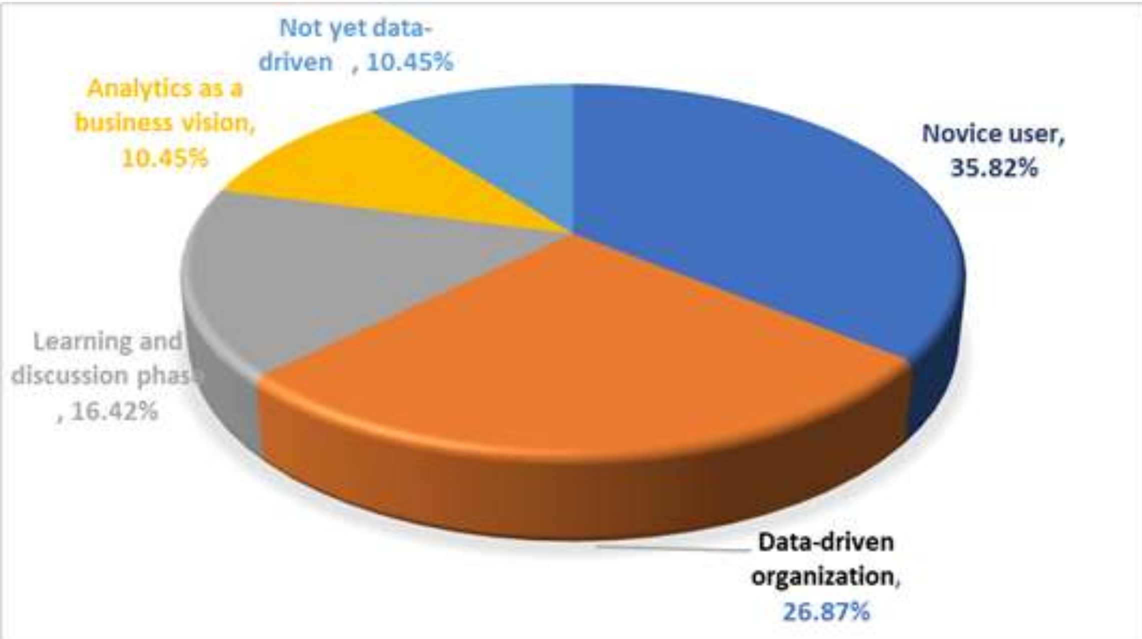

Fig. 9. Infrastructure - Access to Data
Source: Original results of the survey.

Similar results were recorded in the analysis related to data control, where only 8.96% of companies are in the "Analytics as a business vision" phase, 25.37% in the "Data driven organization" phase and about 55% in the " Learning and discussion" or "Novice user" (Fig. 10).

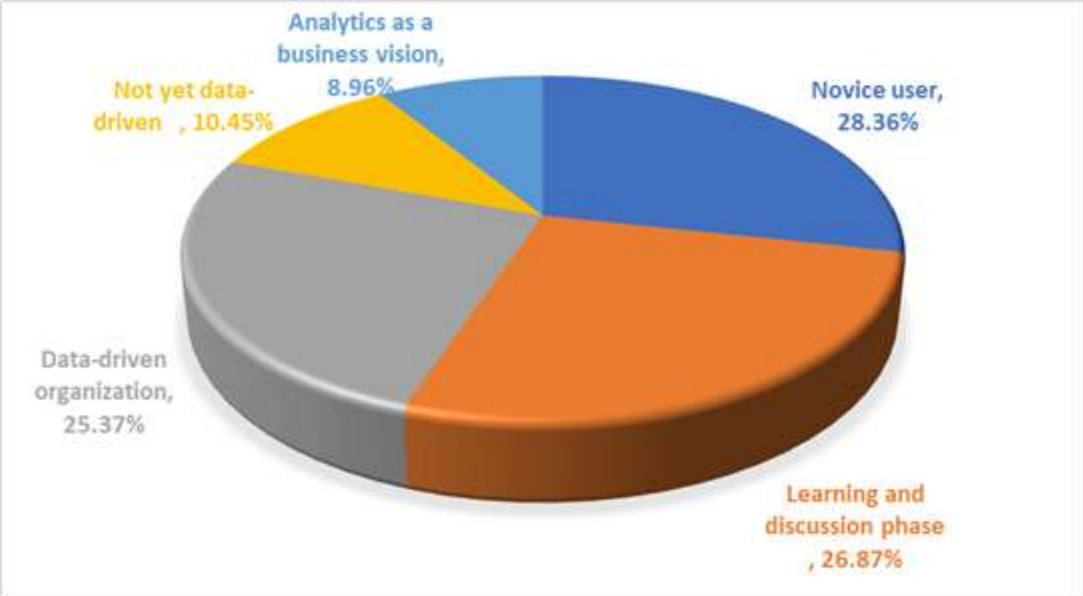

Fig. 10. Infrastructure - Management - Control of the data process
Source: Original results of the survey.

(4) Tools

The analysis related to the tools used in data processing provided interesting results. For the "Management reports" segment (Fig. 11), the Excel application is used uniquely in over 35% of cases. And in another 20% of cases, it is used in combination with applications such as Python or Tableau. 13.43% of companies use other types of software applications.

Fig. 11. Tools used for: Management reports
Source: Original results of the survey.

Related to the "Charts, and data visualization" chapter, it is noted that the Excel application also holds the first place in preferences, being used exclusively in over 40% of cases and in another 15% of situations together with Python, Tableau or others (Fig. 12).

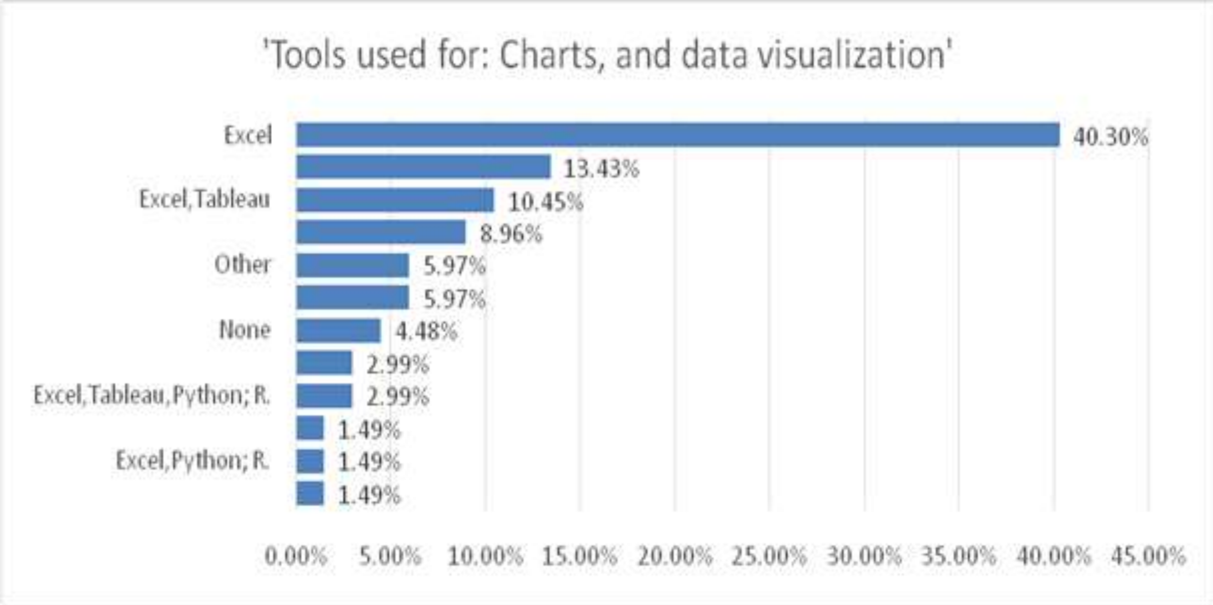

Fig. 12. Tools used for: Charts, and data visualization
Source: Original results of the survey.

Excel is also the application used in about 25% of cases for "Forecasting using time series" (Fig. 13) as well as for "Correlation" (Fig. 14). Instead, Python is used in most situations for "Machine learning" processes, over Excel, used in about 6-7% of cases (Fig. 15). The analyzes for the following cases show the preference for the Excel application (13.43%) in the "Process Mining" chapter (Fig. 16), but with regard to the processes of "Simulation"(Fig. 17), "Optimization"(Fig. 18), "Data Mining"(Fig. 19), or "EDI ”(Fig. 20), it is out ranked by other applications, with percentages between 14 and 22.

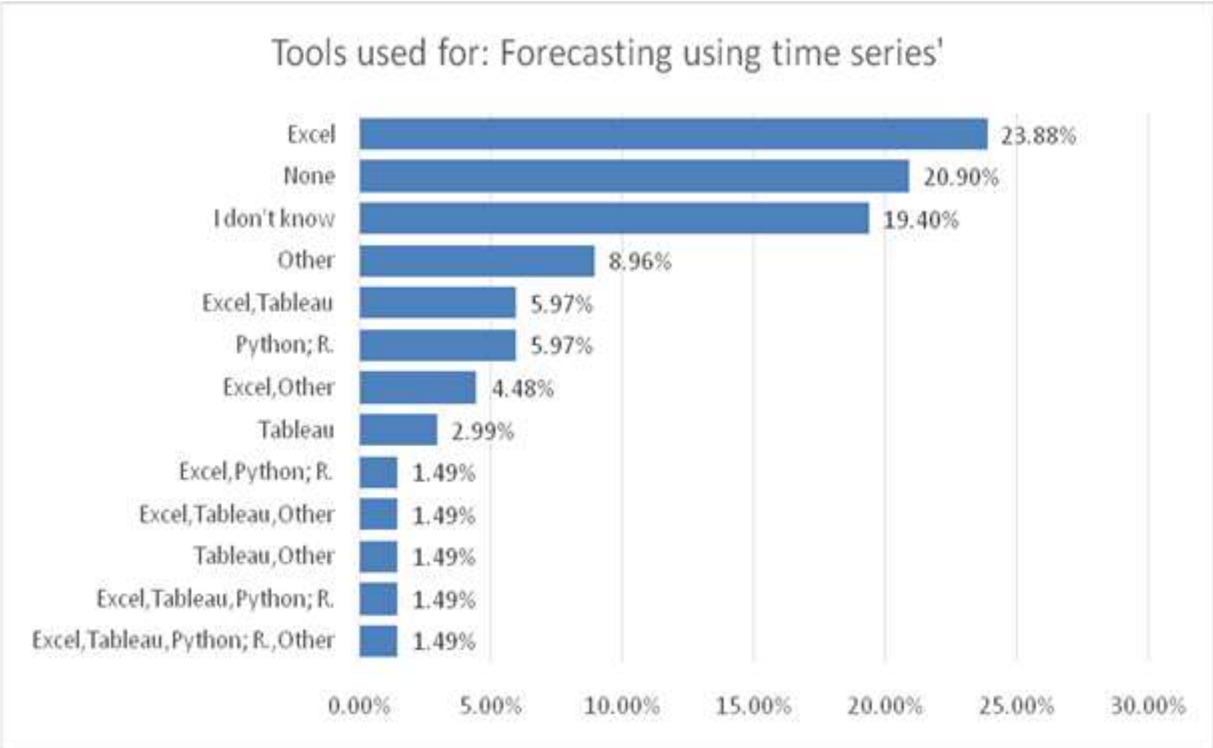

Fig. 13. Tools used for: Forecasting using time series
Source: Original results of the survey.

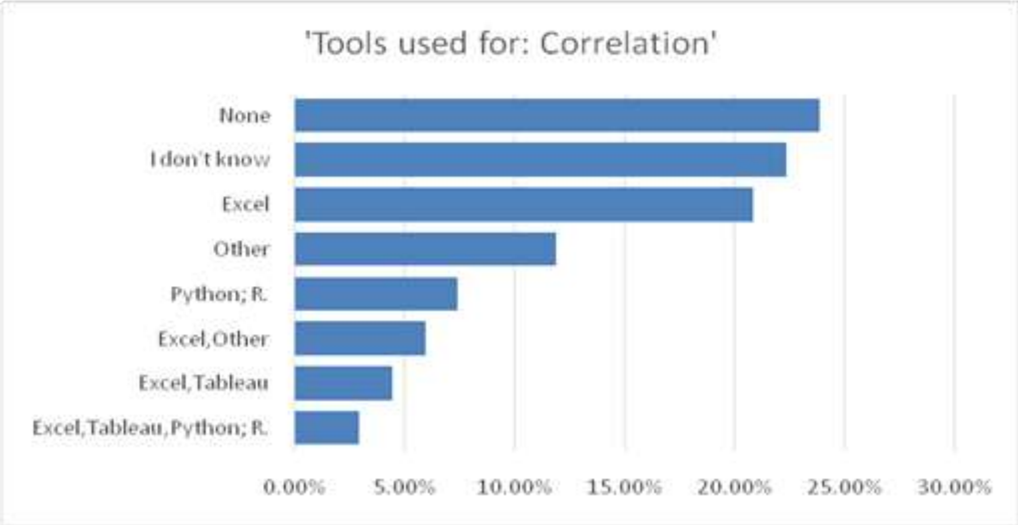

Fig. 14. Tools used for: Correlation
Source: Original results of the survey.

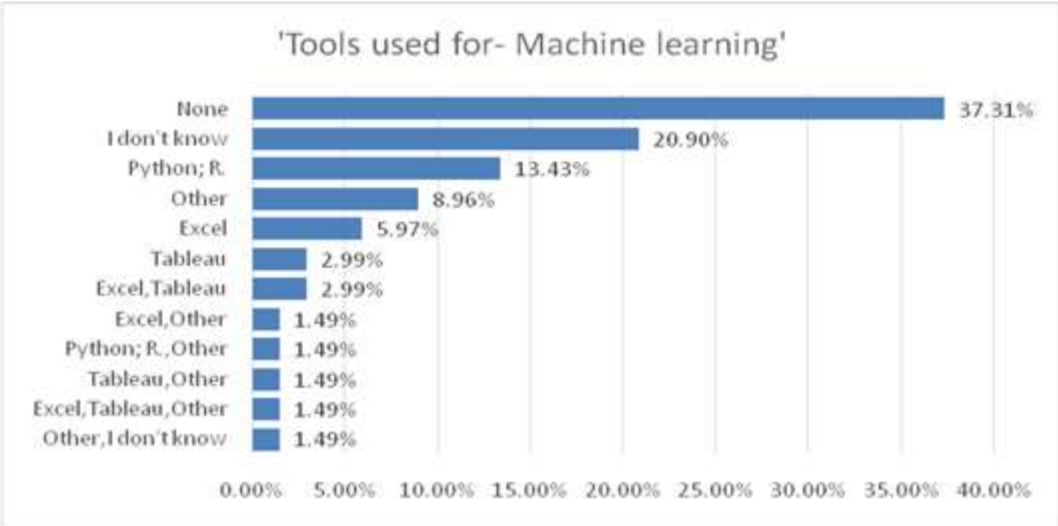

Fig. 15. Tools used for: Machine learning
Source: Original results of the survey.

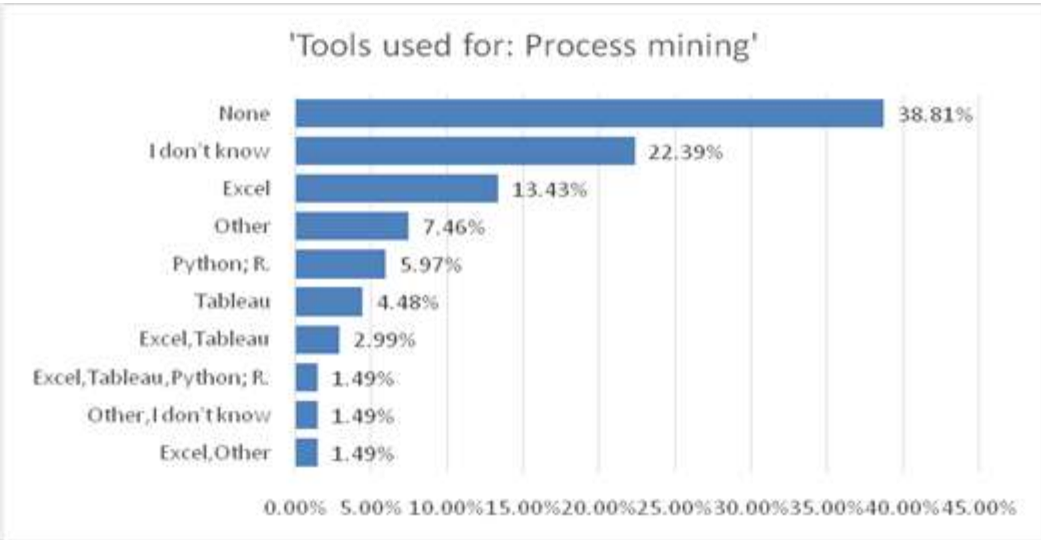

Fig. 16. Tools used for: Process mining
Source: Original results of the survey.

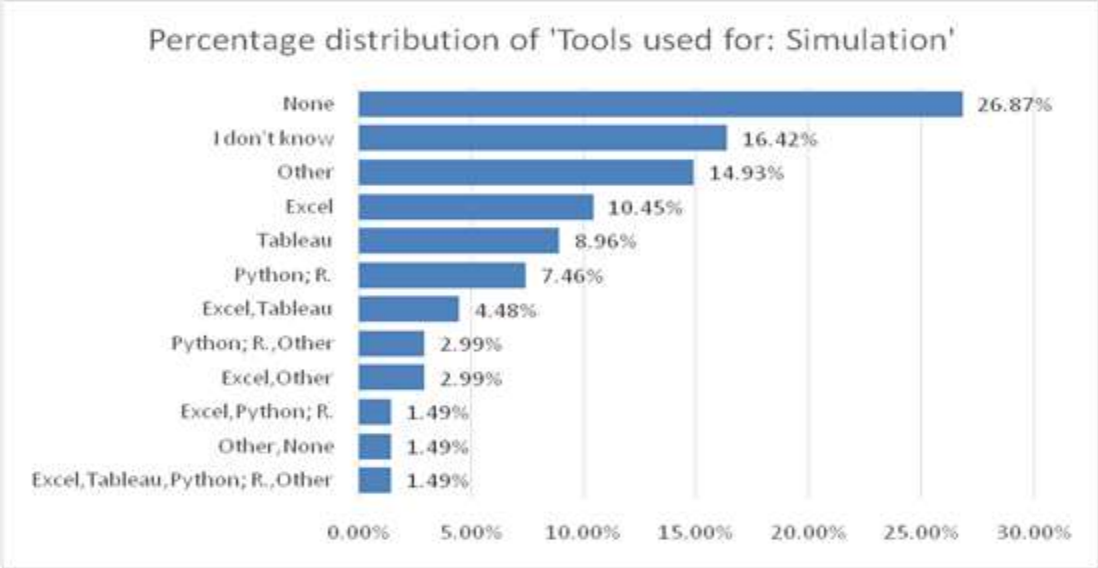

Fig. 17. Tools used for: Simulation
Source: Original results of the survey.

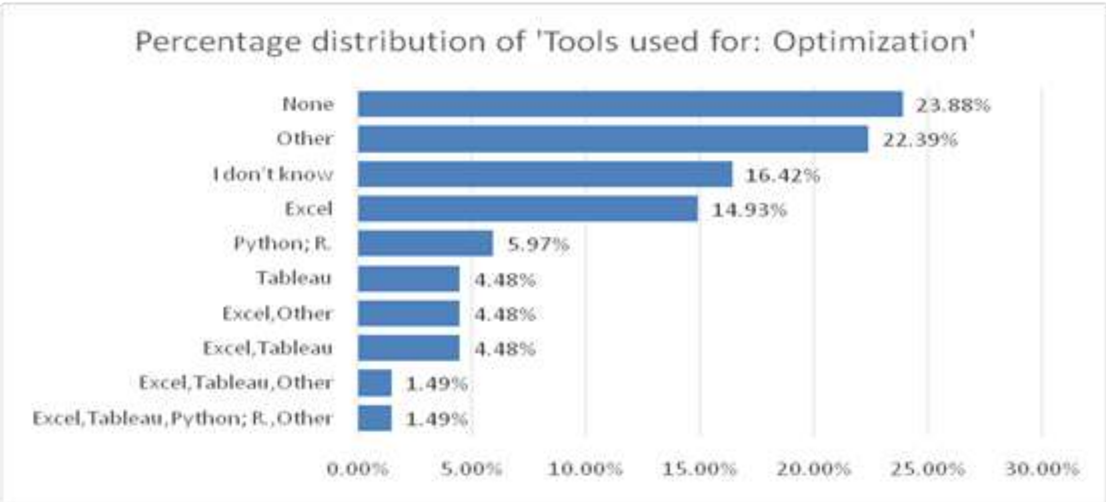

Fig. 18. Tools used for: Optimization
Source: Original results of the survey

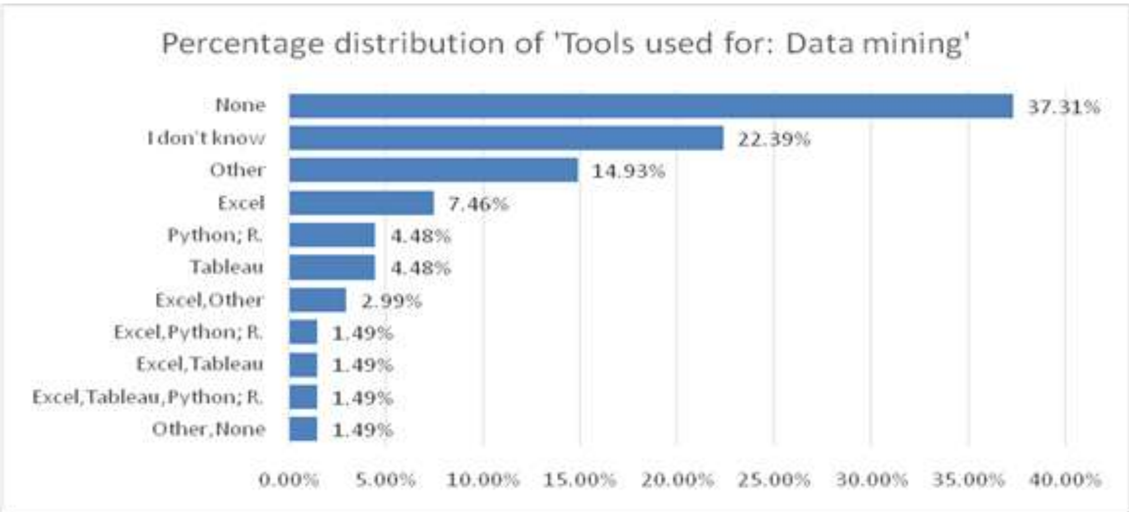

Fig. 19. Tools used for: Data Mining
Source: Original results of the survey.

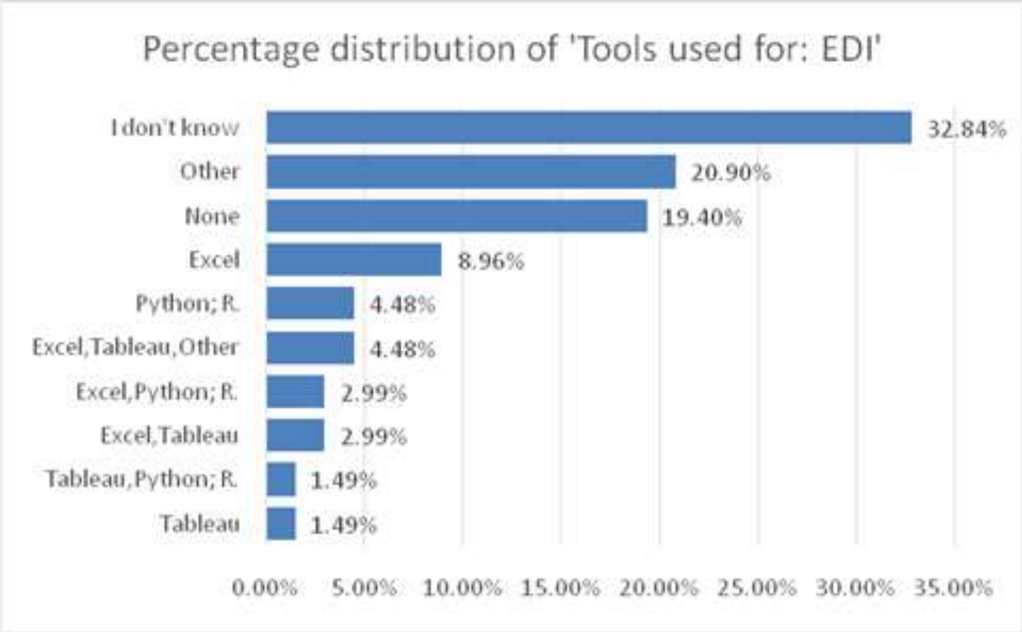

Fig. 20. Tools used for: EDI
Source: Original results of the survey.

As expected, the "None" or "I don't know" responses were present in a proportion of over 40% to questions related to the advanced use of data in companies, an element correlated with previous results related to organization and competent.

(5) Other tools

Since a significant number of responses to the chapter on applications used for advanced data processing were of the "Other" type, it is considered important to present them in Figures 21...29.

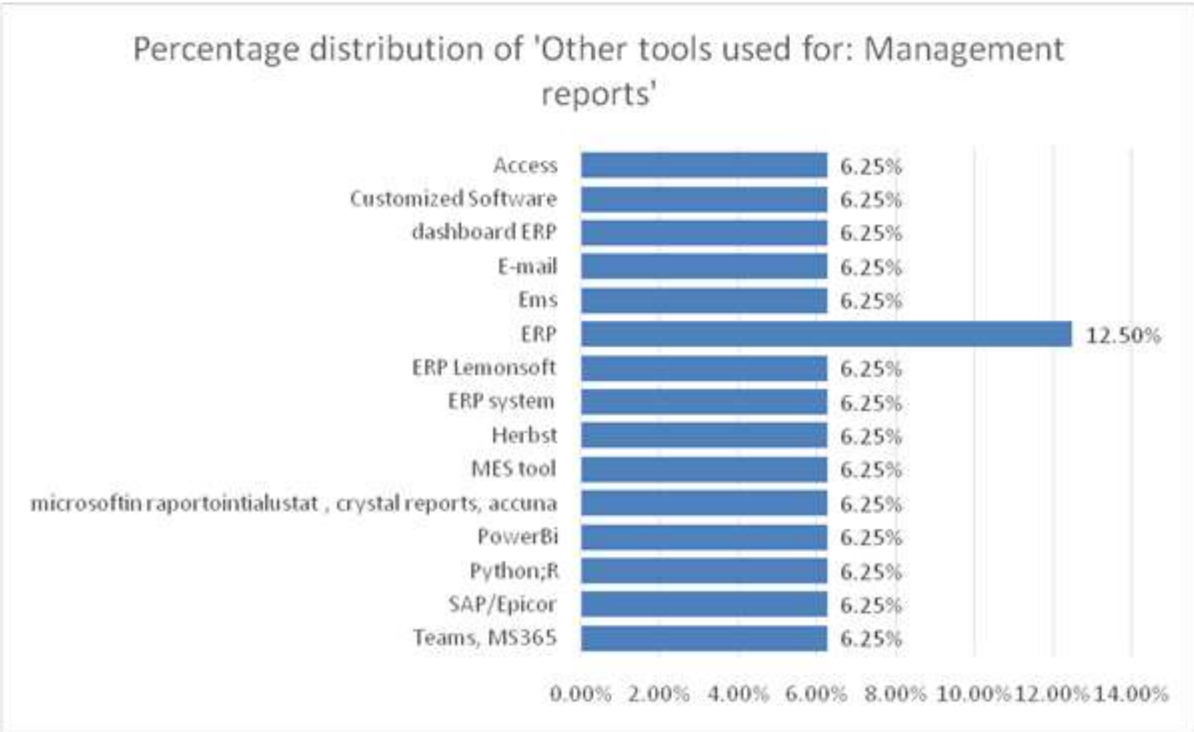

Fig. 21. Other tools used for: Management reports
Source: Original results of the survey.

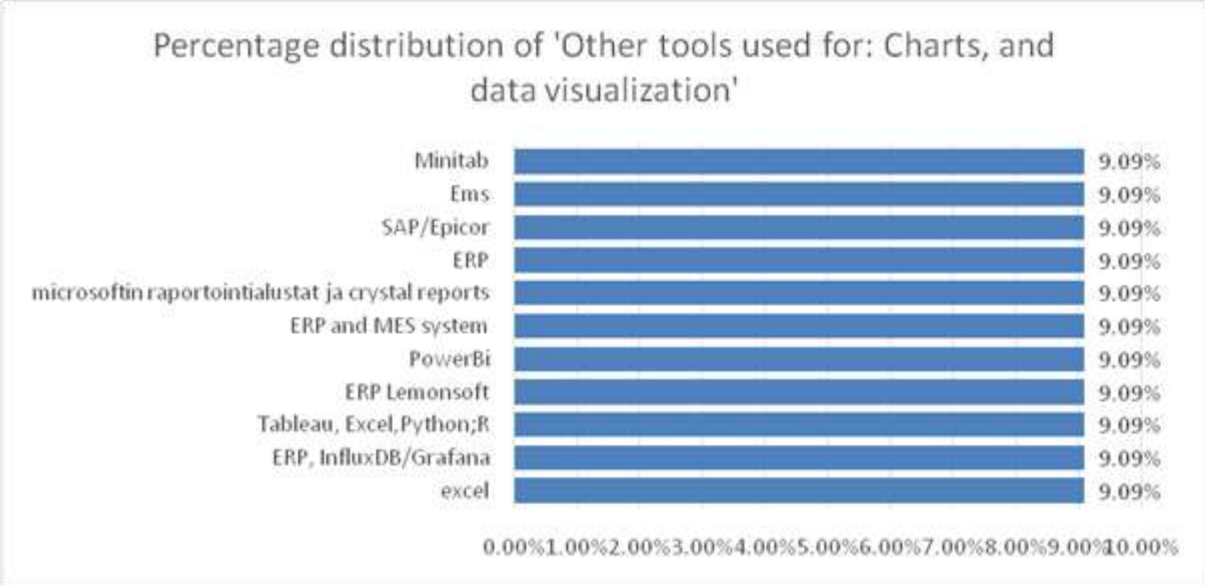

Fig. 22. Other tools used for: Charts, and data visualization
Source: Original results of the survey.

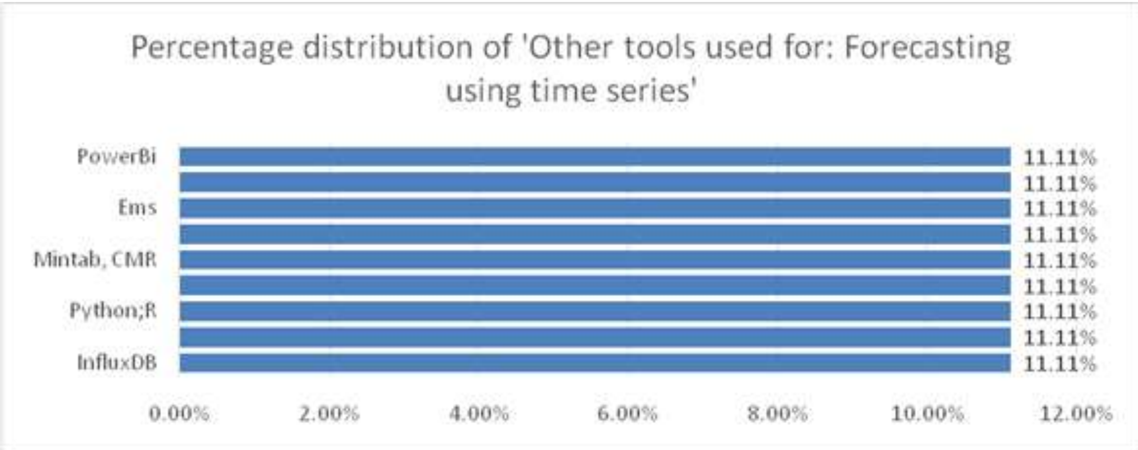

Fig. 23. Other tools used for: Forecasting using time series
Source: Original results of the survey.

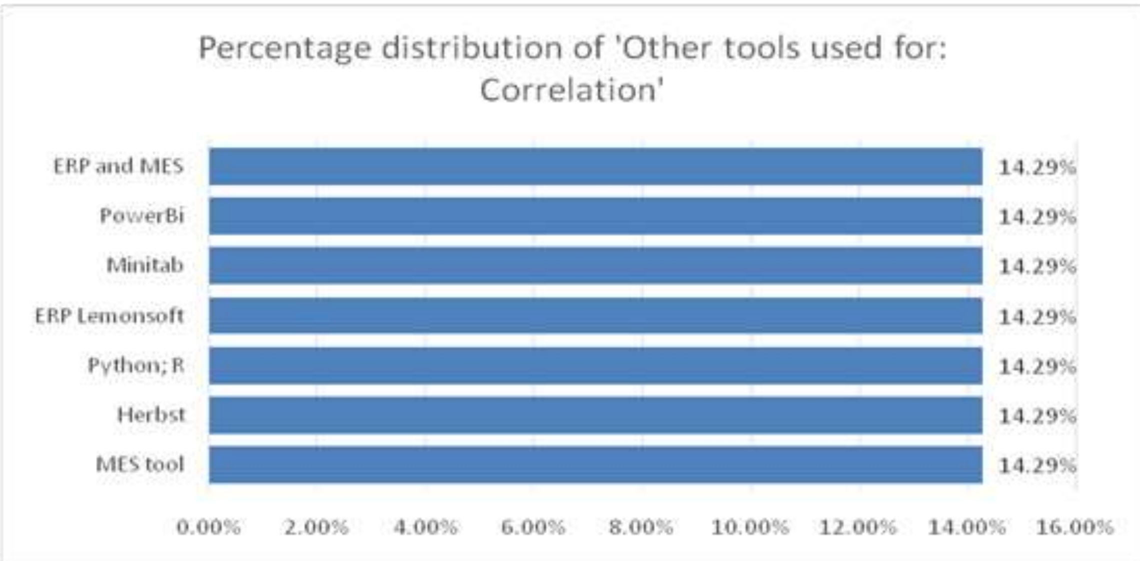

Fig. 24. Other tools used for: Correlation
Source: Original results of the survey.

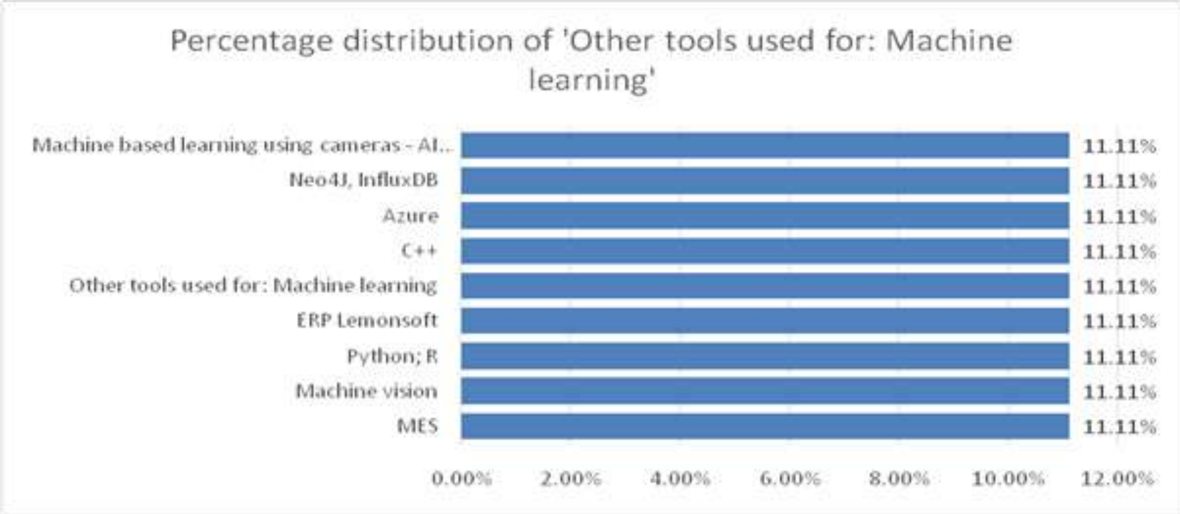

Fig. 25. Other tools used for: Machine learning
Source: Original results of the survey.

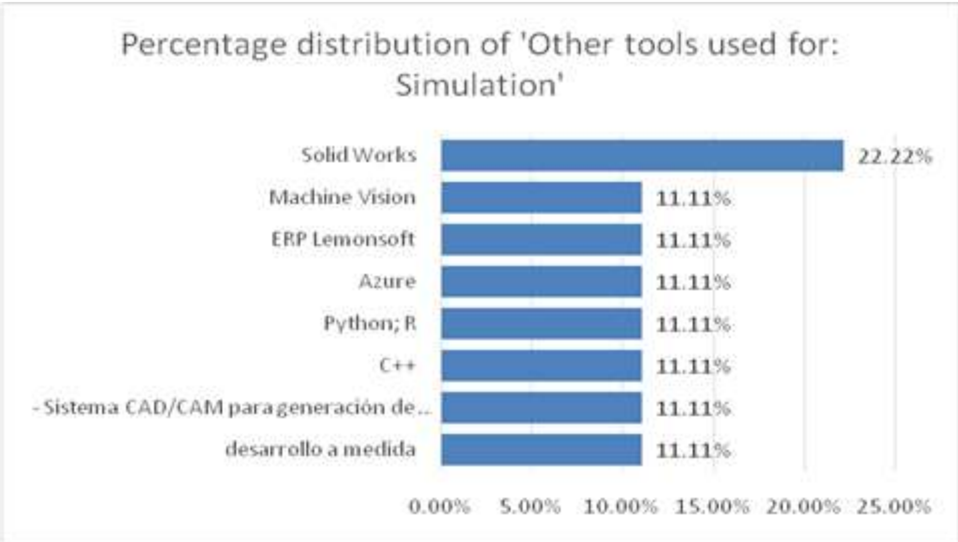

Fig. 26. Other tools used for: Simulation
Source: Original results of the survey.

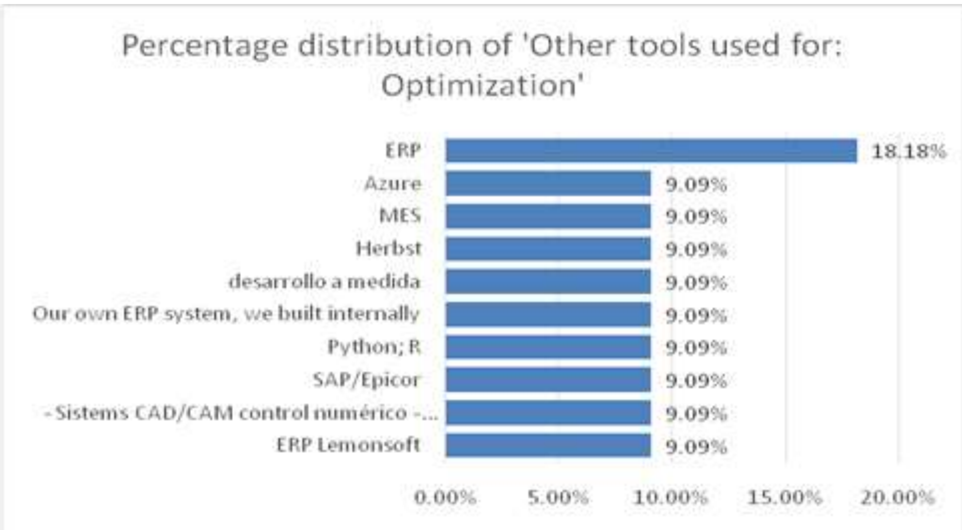

Fig. 27. Other tools used for: Optimization
Source: Original results of the survey.

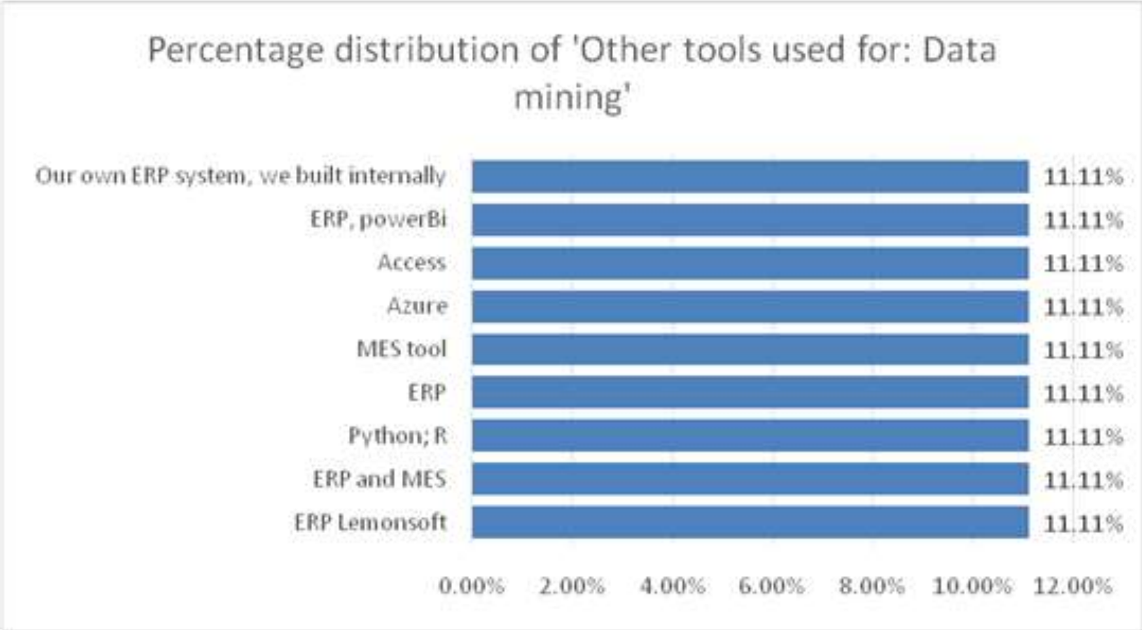

Fig. 28. Other tools used for: Data mining
Source: Original results of the survey.

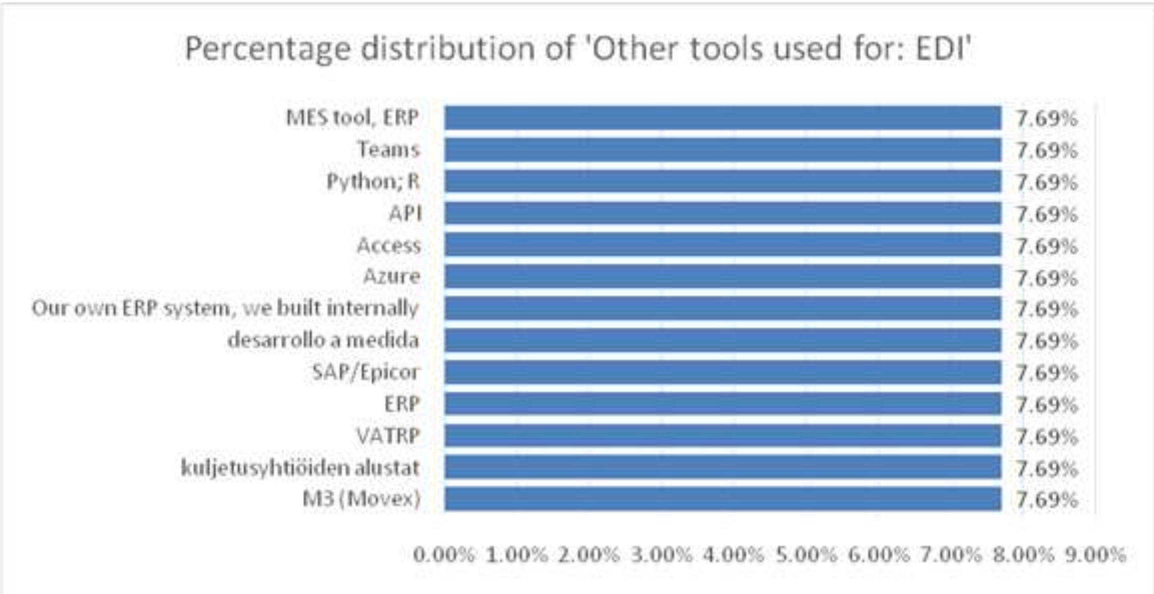

Fig. 29. Other tools used for: EDI
Source: Original results of the survey.

Among these applications, there is a preference for the use of ERP-type integrated systems, which reach percentages of 18% in the "Optimization" chapter or Solid Works with 22% in the "Simulation" chapter.

(6) Performance

An interesting analysis refers to the reflection of the digitization advance in the companies' performance, as it is perceived by the respondents.

Regarding the company's profit, "Much better than other organizations" was recorded in only about 12% of cases, which suggests that the digitalization of companies does not always imply a significant increase in profit. However, there is an optimistic perception, as almost 50% of the answers foresee a "Slighly better than other organizations" type situation (Fig. 30).

It is also interesting that under these conditions, the growth of companies in the last year was 41% "Slighly better than other organizations" and almost 27% "Much better than other organizations" (Fig. 31).

Digitization brings benefits in the relationship with clients, as can be seen from Figure 32 in which it can be seen that 39% of cases are "Slighly better than other organizations" and about 25% are "Much better than other organizations".

Fig. 30. Performance in: Profitability
Source: Original results of the survey.

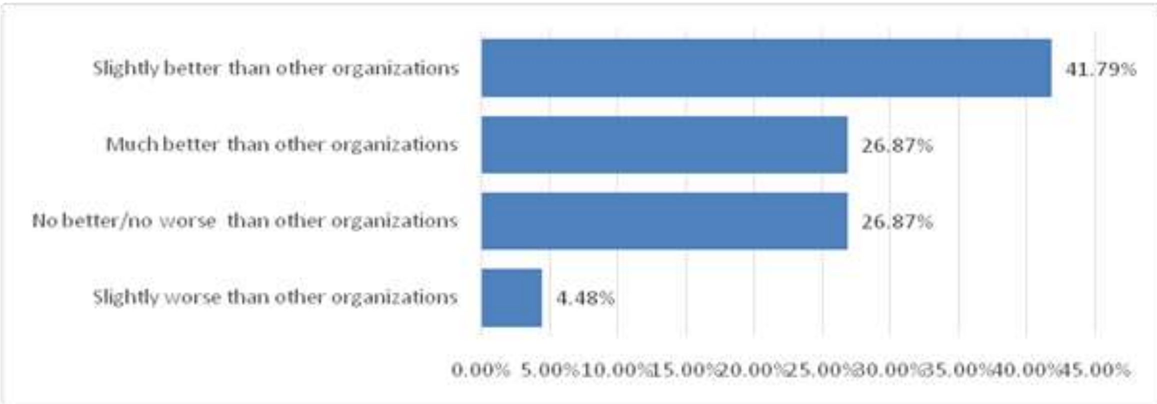

Fig. 31. Performance in: Growth in past years
Source: Original results of the survey.

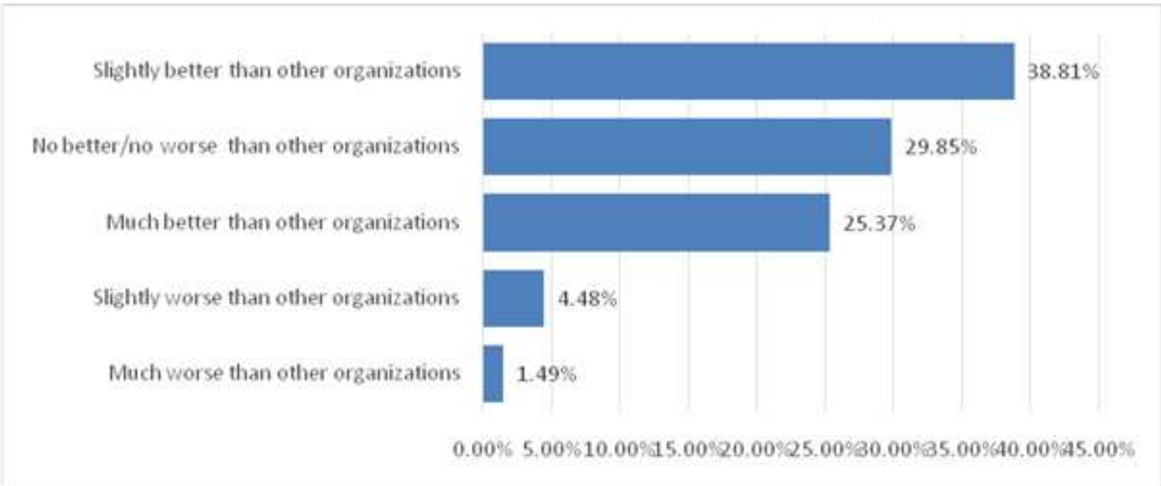

Fig. 32. Performance in: Customer satisfaction
Source: Original results of the survey.

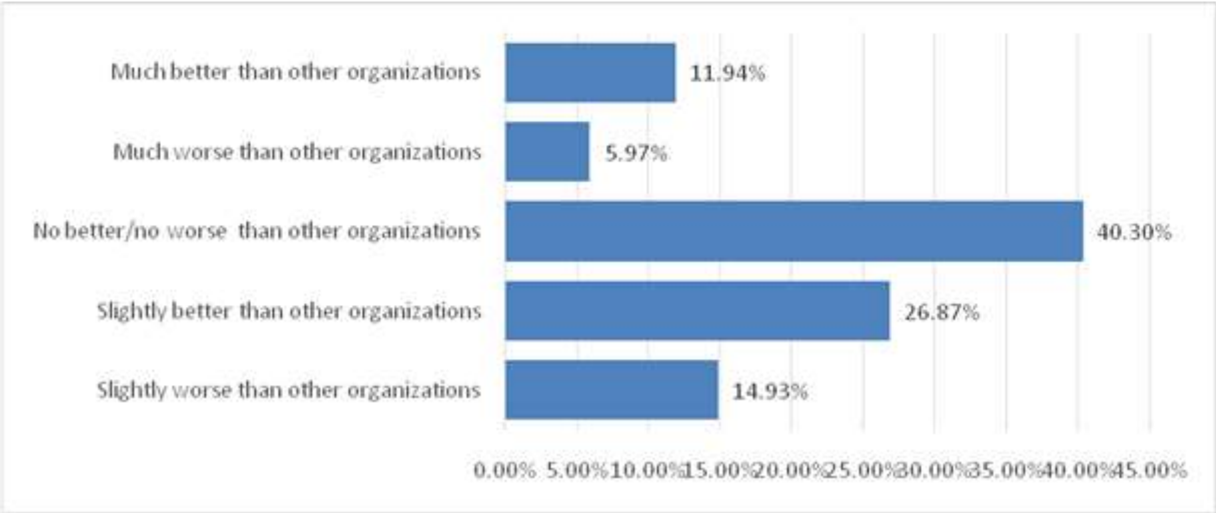

Fig. 33. Performance in: Employee satisfaction
Source: Original results of the survey.

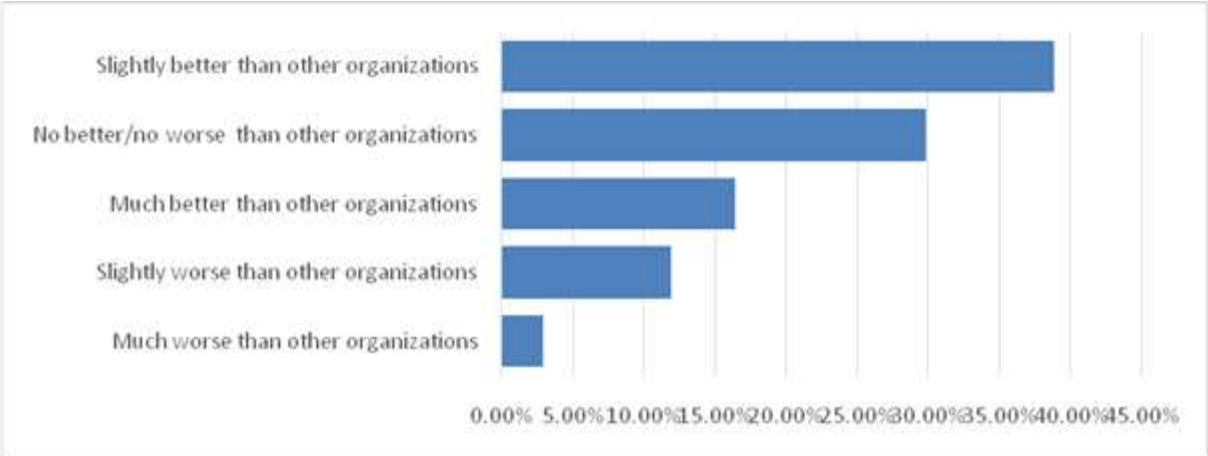

Fig. 34. Performance in: Social & Environmental practices
Source: Original results of the survey.

It seems that employees still do not fully appreciate the benefits of digitization processes, as their satisfaction is below the impact on profit, growth in recent years or customer satisfaction. From Fig. 33, employee satisfaction reaches rates of about 12% "Much better than other organizations" and 26% "Slightly better than other organizations".

The performance in "Social & Environmental practices" is relatively high, the perception being about 40% "Slightly better than other organizations" and over 15% "Much better than other organizations" (Fig. 34).

CONCLUSIONS

The study on the digital maturity of companies in the context of the Industry 4.0 era highlights several key aspects regarding the degree of digitalization, the use of digital technologies, and their impact on organizational performance. Analysing data collected from seven partner countries, including Finland, Spain, Ireland, Croatia, Romania, Austria, and Argentina, the results suggest that although many companies have begun the digitalization process, the majority are still in the early stages of this transition.

A significant percentage of companies, about 58%, are in the "learning and discussion" phase or are novice users of data, with only 10% fully embracing analytics as a business vision. Additionally, only 22% of companies identify as being "data-driven organizations," which indicates that digitalization is still developing in most cases.

Another important observation is the predominant use of Excel for data management and reporting, despite the existence of more advanced solutions such as Python and Tableau. This suggests a strong reliance on traditional tools and a limited adoption of integrated applications like ERP for data management and process automation.

However, there are positive signs regarding the performance of companies that have started adopting digitalization.

Approximately 50% of companies reported a slight improvement in profitability, while nearly 27% reported significant growth in recent years.

Furthermore, digitalization has contributed to increased customer satisfaction, with around 39% of companies reporting better performance compared to other organizations.

Nonetheless, the impact of digitalization on employee satisfaction remains limited, with only 12% of companies reporting much higher employee satisfaction than other organizations. This suggests that digitalization processes are not yet fully leveraged to improve the work environment.

In conclusion, while the analysed companies have begun to implement digital technologies in their operations, most are still in the early stages of digital maturity.

It is crucial for organizations to adopt a clearer strategy for digitalization, invest in employee training, and continue developing the necessary infrastructure to fully benefit from the advantages of digitalization.

Full digital transformation remains an ambitious but achievable goal, provided that current challenges, such as data security, interoperability, and digital skills development, are addressed in an integrated manner.

This conclusion reflects an ongoing transition where companies have the potential to improve operational performance, competitiveness, and sustainability by better integrating digital technologies into their business processes.

ACKNOWLEDGEMENTS

The research project was supported by the Grant SMARTER 2022-1-FI01-KA220-HED-000086152 -Experiential Learning tools to obtain supply chain competences.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

DETERMINING OPERATIONAL EFFICIENCY IN AQUACULTURE ENTERPRISE TO BOOST FISH PRODUCTION FOR IMPROVED FOOD SECURITY IN SOUTHWEST, NIGERIA

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Abstract

The mainintent of the research is to: (i) establish the cost-effectiveness of aquaculture fish farmers in the study area; (ii) evaluate how efficient the fish farmers are in theiruse of resources; (iii) ascertain the variables inducing the efficient use of resources; (iv) and establish the majorlimitations encountered by the owner and manager of fish farm enterprisein the area of study. Multistage samplingprocedure was used to select 180 aquaculture fish farmers in the area of study. Some analytical methods such as net profit margin ratioand efficiency model were used to investigate the collected data on the field.The result revealed that the average age of the respondents was 35.8 years. Their average years of experience in fish farming enterprise was 12.9 years. The net profit margin ratio was 21.96%, the operating expense ratio was 72.76% and the fixed cost ratio was 5.29%. The study further shows thatgender, educational level, aquaculture fish farming experience, pond size, association/cooperative membership and access to extension agents had positive value and significantly influence the aquaculture fish farmer's operational efficiency in the area of study. The research recommends that aquaculture fish farmers should be sensitized on the need to acquire more education and make use of the extension agents in their aquaculture fish farming.

Key words*: *aquaculture, fish farmers, profitability, operational efficiency, efficiency

INTRODUCTION

The prevailing food arrangement in Nigeria are not capable of achieving the main objective of ensuring the availability of nutritious and healthy food for all to fulfil the Sustainable Development Goals (SDGs) of food security for all. There are a lot of factors militating against this goal, such as dynamic diets, technology, urbanization and climate change [10].One of the very good attributes of fish is that it is a low-cost source of animal protein [15]. The deficit in national fish output in Nigeria is due to the declination of the sub-sector and climate change risk effects on fish production. This has led to increase in importation of fish in Nigeria [36].The available information on aquaculture in Nigeria bear witness to this fact. In 1990, aquaculture's contribution to total fish production was 2.3% and by 2021, its contribution has increased to 21.7% [22].

In Nigeria, farming is one of the primary responsibilities of many in the rural area of the country, even those in the urban cities often involve in farming activities. This is in various and diverse form like crop production, livestock breeding, fishery and forestry. Hence, many are employed in the agricultural sector of the economy [29]. More than 80% of Nigeria population are poor, and such reside in rural areas and work mainly in agriculture sector of the economy [1]. Up to 25% of Nigeria's Gross Domestic Products (GDP) emanates from agriculture related activities, and about 70% of the national labour force is engaged in agriculture, manufacturing industry and mining accounts for 10%, while 20% are in services [20]. Therefore, Nigeria's economy is mainly agricultural dominated economy; agriculture is the dynamic force for the country's economic growth. It is well known that fish is an inexpensive source of animal protein, the shortage in national production as a result of inattention of the sub-sector by government at all levels (Federal, State and Local Government Area (LGA)) led to increase in importation of fish in Nigeria [5]. So, the growth of aquaculture industry in Nigeria came to reduce the gap between supply and demand [23].

Due to the shortfall of fish in Nigeria, there is critical need to investigate all avenues to ensure sustainable increase in fish supply. Various factors such as water pollution from oil spillage in the oil producing part of the country led to drop-off catches from capture. In view of the above, there is need to step up the aquaculture fish production to arrest the demand-supply deficit for fish in Nigeria. This involves culturing fish in a controlled environment that ensure proper monitoring of their feeding, growth, reproduction and health. Such cultured fish are already bridging the deficit gap in Nigeria and most less develop countries of the world [37].

Fish contribution to the national daily dietary energy supply is also very crucial in Nigeria. It is very difficult to come by alternative locally produced protein, therefore, in most family, preference for fish is very high. Fish contribution to dietary energy is highly substantial in Nigeria [8]. Essential foods like rice, wheat, maize and cassava constitute most of the food consumed by the people, and accounting for the bulk of energy and nutrients [6]. However, the necessary nutrients are not found in these staples or are found only in little quantities. So, these nutrients must be provided by other foods such as fish, therefore, the contribution of fish to food and nutrition security in Nigeria cannot be overestimated.

However, Nigeria national fishery products supply falls short of the demand. Based on continuous increase in aquaculture's contribution to the total fish production, then can the profit in aquaculture production sustain the growth in aquaculture business overtime? Also, what are factors influencing operational efficiency in aquaculture enterprise and what are the main limitations to fish farming enterprise in the area of study?

Therefore, the manuscript identified the socio-economic characteristics of aquaculture fish farmers, established the cost-effectiveness of fish production, evaluated how efficient the fish farmers are in their use of resources, ascertained the variables inducing the efficient use of resources and established the major limitations encountered by the owner and manager of fish farm enterprise in the area of study.

MATERIALS AND METHODS

Study area, source of data, sample techniques and size

A multi-stage selection method was employed for the research. Southwest Nigeria was randomly selected. Three states namely Lagos, Ogun and Ondo State were intentionally sampled because the three states account for 65.9% of aquaculture fish production in Southwest Nigeria[20], from each state; two Local Government Areas (LGAs) that are known for aquaculture fish production were deliberately chosen for the research. In each LGA, three communities that are known for aquaculture fish production were selected for the study and in each community, ten aquaculture fish farmers were selected for the research. So, the total number of respondents for the research was 180 aquaculture fish farmers.

Sample Analysis

Various investigative approaches were used to evaluate the data collected from the respondents. The demographic characteristics of the respondents were evaluated using descriptive statistics. The cost-effectiveness of the fish farmers and how efficient they are in their operation of fish farm enterprise were ascertained with Net Profit Margin Ratio (NPMR). The NPMR is **estimated with equation 1:**

$$NI = TR - TC \qquad (1)$$

$$NPMR = \frac{NI}{TR} \times \mathbf{100} \qquad \mathbf{(2)}$$

The Operating Expense Ratio (OER) was used to ascertain how efficient the aquaculture fish farmers are at keeping operating costs low while also earning revenue or making sales. The operating cost ratio is calculated thus:

$$\textbf{OER} = \frac{TVCTVC}{TR\ \ TR}$$
(3)

Fixed Cost Ratio (FCR) was employed to determine the ability of the aquaculture fish farmers to improve their profit margins, financial sustainability and the economies of scale of the aquaculture fish farm business. The fixed cost ratio is calculated thus**:**

$$\textbf{FCR} = \frac{TFCTFC}{TC\ \ TC} \qquad \textbf{(4)}$$

where:
NI = Net Income
TR = Total Revenue
TVC = Total Variable Cost.
TFC = Total Fixed Cost
TC = Total Cost (TVC + TFC)

Efficiency model was employed to determine the variables influencing the aquaculture fish farmers' operational efficiency in the area of study. The model is specified as:

$$U_{ij}\, U_{ij} = \delta_0 \delta_0 + \delta_1 \omega_1 \delta_1 \omega_1 + \delta_2 \omega_2 \delta_2 \omega_2 + \delta_3 \omega_3 \delta_3 \omega_3 + \delta_4 \omega_4 \delta_4 \omega_4 + \text{--------------} + \delta_n \omega_n \delta_n \omega_n + \mu \qquad (5)$$

$U_{ij}\, U_{ij}$ = operational efficiency of the ith aquaculture fish farmer and jth observation of the aquaculture fish farmer.
where:
$\omega_1 \omega_1$ = Age (years)
$\omega_2 \omega_2$ = Age^2 (years)
$\omega_3 \omega_3$ = Gender (1 = male; 0 = female)
$\omega_4 \omega_4$ = Marital Status (married = 1 and 0, otherwise)
$\omega_5 \omega_5$ = Educational level (years)
$\omega_6 \omega_6$ = Aquaculture fish farming experience (years)
$\omega_7 \omega_7$ = Pond size (Cubic meter)
$\omega_8 \omega_8$ = Family labour (man day)
$\omega_9 \omega_9$ = Hired labour (man day)
$\omega_{10} \omega_{10}$ = Access to credit (yes = 1,otherwise = 0)
$\omega_{11} \omega_{11}$ = Household size (number)
$\omega_{12} \omega_{12}$ = Association/Cooperative membership (yes = 1, otherwise = 0)
$\omega_{13} \omega_{13}$ =Access to extension agents
$\delta_0 \delta_0$ = Constant
$\delta_1 \delta_1 - \delta_n \delta_n$ = Unknown parameters to be estimated
μ = Error term

In order to analyse and determine the important constraints faced by aquaculture fish farmers in the area of study, 4-points Likert Rating Scale (LRS) was used to expound how crucial the constraints were to the aquaculture fish farmers in the area. The 4-point LRS ranges from 1 to 4 (i.e. Very serious, serious, mild and not serious). Relative Important Index (RII) was used to ascertain the crucial constraints. The RII equation is as follows:

$$\text{RII} = \frac{\varepsilon W \varepsilon W}{AN\, AN} \qquad (6)$$

where:
W is the weighting given to each problem by respondents (1 to 4)
A is the highest weight (4 in this case)
N is the total number of respondents.
RII ranges between 0 and 1, the higher the value the more important the constraint. 0.70 and above was considered as important constraints.

RESULTS AND DISCUSSIONS

Summary of statistics
Socioeconomic Characteristics

Table 1 presents the demographic result of the respondents. As shown in the Table, majority of the respondents were in their economic productive age as revealed by their average age of 36 years. Hence, they are very energetic and have the vigour to carry out the expected chore required in aquaculture fish farming. This is line with the findings of [11] that fish farming enterprise is highly laborious, hence, those who will be involved in such enterprise must be in their economic active age. This probably account for the reason why the enterprise is male dominated especially in most developing countries like Nigeria. Therefore, since majority of the respondents are in their productive economic age, their productivity will be enhanced because they will be able to optimise their strength in production of fish. The interviewed fish farmers are highly educated as shown in the Table where 92.1% of the respondents had Higher Institution Education (HIE) (Bachelor degree or equivalent). Appropriation of knowledge through training, seminars and workshop will be enhanced. Such can make better use of research findings and apply knowledge gained from reading scientific journals and articles on how best to improve aquaculture fish production. This supports the assertion of [24], that the correlation between educated farmers and their productivity is high. The more educated a farmer is, the higher his/her productivity.

The household size of the respondents was four (4). Household size is very important to farmers in Africa, the contribution of family labour to farm work is a function of the household number, because the cost of labour is often high and beyond the reach of the peasant farmers [7]. Therefore, most of the respondents will probably result to using hired labour for their aquaculture fish farming since the household size is small (four). Regarding marital status, 76.1% of the aquaculture fish farmers were married. There is likelihood of husband and wife involvement in the farming business. In most cases, the woman will often involve in value addition, such as smoking and packaging to sell. Thus, the production aspect of the value chain lies within the purview of the husband, and the value addition and marketing aspect lies within the purview of the wife. This buttresses the findings of [39], that the value chain (i.e. production, processing, packaging and marketing) of agricultural produce in most developing countries revolve within the family since they are peasant farmers who cannot produce on large scale because of lack of finance and technology.

More than 88% of the respondents had less or equal 13 years farming experience, with mean fish farm experience of 12.9 years. This presupposes that the respondents are not novice in the business of aquaculture fish farming. Therefore, they are knowledgeable in the act of aquaculture fish farming. As the case in India, [33], posited that the more experience a farmer is in farming, the more knowledgeable he/she will be in the act. So, the more his/her productivity, because farming is an act that requires mastery overtime. The mean pond size of 1,125m^{3}of the respondents shows that they are small scale aquaculture fish farmers according to [38]. Most aquaculture fish farmers in the Southwest of Nigeria are small scale fish farmers unlike their counterparts in the South-south Nigeria. Above 92% of the respondents are member of an association or cooperative society. This is a good development, it enhances their access to pricing and marketing information, credit facilities and extension agents. This is one of the key benefits of belonging to an association or cooperative organization as the case of dairy marketing in the United States [17].

Table 1. Aquaculture fish farmers' demographic characteristics

	Aquaculture Fish Farmers' Key Socioeconomic Characteristic Values	
	Mean	**Dominant Indicator**
Age	35.8	86.2% falls below or equals 40 years (active)
Gender		87.8% were male
Education Level		91.2% had Higher Institution education (B.sc/HND)
Household Size (Number)	4	93.2% between 1and 5 persons
Marital Status		76.1% married
Fish Farming Experience (Years)	12.9	88.2% less or equal 13 years
Pond Size (Square M^2)	1,125m^3	91.5% had more than or equal to 1,120m^3
Membership of Cooperative/Association		92.2% belong to cooperative society or association

Source: Author's estimations based on data from survey 2023.

Estimation of Profitability and Operational Efficiency of Aquaculture Fish Production of the Area of Study

Table 2 presents the costs and returns of table size aquaculture fish production of the area of study. From the Table, the average Total Revenue (TR) of respondents was ₦19,704,600 ($25,425.29). The average quantity of fish sold by the respondents was 9,612kg fish per annum in two cycles. The average price of 1kg fish in the area of study was ₦2050($2.65) from the aquaculture farmers (farm gate). The average amount of feeds used by the farmers was 24 tons per annum. The feeds cost is the most crucial cost in fish production accounting for 60.09% of the Total Cost (TC). This buttresses the assertion of United State Agricultural Department (USAD)that feeds cost is between 60% and 70% production cost of table size aquaculture fish [27]. Most of the respondents explained that they use allerqua for a start, blue crown for the grower stage and eco float for the last state. Some of the ingredients used in the production of the feeds are imported and the average price per bag was ₦19,250 ($24.84). There was about 100% increase in the price of feeds around June 2023. This was because the Central Bank of Nigeria (CBN) merged all segments of the foreign exchange market collapsing all windows into one. This was part of a series of immediate changes to operations in the Nigerian Foreign Exchange (FX) Market, in a bid to improve liquidity and stability [3]. In Nigeria, there were two windows to access dollars, pounds and euros which are black market and from CBN which is regarded as official. This led to increase in the price of the feeds and is impacting negatively on the production cost of aquaculture fish in Nigeria.

The average costs of labour according to the respondents was ₦4,250,000 ($5,483.87) accounting for 27.64% of the Total Cost (TC). The Federal Government of Nigeria (FGN) announced the removal of fuel subsidy in Nigeria. This led to increase in prices of goods and services which has led to increase in cost of labour in Nigeria. According to [40], cost of labour often fluctuates in less develop countries because of lack of stable economy policies. Therefore, cost of production of goods and services often become unpredictable. The Total Variables Costs (TVCs) which is the operating cost was ₦14,336,800 ($18,499.10) which accounted for 93.23% of the total cost of production of aquaculture fish in the area of study. Minimal operating expense ratio is better for an enterprise; it shows that expenses of such enterprise is reduced compared to the sales. Costs incurred by such enterprise are minimal and more efficient [2]. So, 72.76% operating expense ratio by the respondents is high and shows inefficiency of fish farm enterprise in the area of study. According to [18], lower operating expense ratio below 50% shows a good sign of higher efficiency which is optimal. An increasing operating expense ratio over time may indicate increasing expenses compared to Total Revenue (TR).

The Total Fixed Cost (TFC) which includes depreciation and cost of renting pond was ₦1,041,400 ($1,343.74) and accounted for 5.29% of the total cost of aquaculture fish production. Therefore, fixed cost ratio of the fish farm enterprise was 5.29%. This is low (below 20%) showing that the fish farm enterprise has minimal operating leverage. So, the fish farm enterprise profitability will be impaired even when the volume of sales increases, because variable costs, or other costs that depend on the number of units sold, increase with volume of sales [16]. The Gross Margin (GM) of the fish farm enterprise was ₦5,367,800 ($6,926.19) and the Net Income (NI) was ₦4,326,400 ($5,582.45). This supports the findings of [37]that fish farm enterprise is lucrative in the Southwest, Nigeria. Since majority of the fish farmers interviewed are on different economic scale of production, so, on the average, aquaculture fish farming was profitable.

To determine the productivity of capital employed and operational efficiency, profitability analysis is one of the best techniques. Therefore, Net Profit Margin Ratio (NPMR) was calculated as it shows the holistic representation of business profitability, returns on investment for any business and allows two or more businesses to be compared over a period. The higher the net profit margin ratio, the better would be the operational efficiency of the aquaculture production. A higher net profit margin ratio means that the business has been able not only to increase its sales but also been able to cut down its operating expenses. About 21.96% Net Profit Margin Ratio (NPMR) of the aquaculture fish farmers in the area of study implies that the fish farmers were not operating at their optimum expected minimum 25% of NPMR of any efficient business [2].This corroborates the findings of [18] that an operational efficient business is expected to make a minimum of 25% NPMR to ensure sustainability.

Table 2. Average estimated costs and returns of aquaculture fish production per year

Item of Cost	Quantity	Unit Cost ₦	Total Revenue ₦/$	
A. Revenue Quantity of fish sold	9,612kg	2050/kg	**19,704,600 25,425.29**	
Item of Cost	**Quantity**	**Unit Cost ₦**	**Total Cost ₦ $**	**% of TC**
B. Variable cost				
Brood stock male & female	2	22,000	44,000 56.77	0.29
Feeds	24 tons	450,000 per ton @ 19,250 per bag	9,240,000 11,922.58	60.09
Labour			4,250,000 5,483.87	27.64
Ovaprim, Syringe, Saline Solution			65,000 83.87	0.42
Cost of Managing Hatchery (Electricity)			387,350 499.81	2.52
Tax and Levy			350,450 452.19	2.28
Total Variable Costs (TVC)			**14,336,800 18,499.10**	93.23
Gross Margin (GM)			**5,367,800 6,926.19**	
C. Fixed cost				
Depreciation (ponds/equipment)			785,650 1,013.74	5.11
Cost of Renting Pond			255,750 330.00	1.66
Total Fixed Cost (TFC)			**1,041,400 1,795.94**	6.77
Total Costs (TC) (B+C)			**15,378,200 19,842.84**	
Net Income C - (A+B) **Net Profit Margin Ratio =NI/TR x 100** **Operating Expense Ratio = TVC/TR** **Fixed Cost Ratio = TFC/TR**			**4,326,400 5,582.45 21.96% 72.76% 5.29%**	

Note: $1 = ₦775 official Central Bank of Nigeria (CBN) rate
Source: Author's estimations based on data from survey 2023.

Estimate Results of Factors Influencing Operation Efficiency of Aquaculture Fish Production in Area of Study

From Table 3, the value of R – square was 0.917 which implies that 91.7% of total variation in the operational efficiency of aquaculture fish production in the area of study was accounted for by all explanatory variables in the model while the remaining 8.3% was explained by the random error. The significance of F-value of 4.184 implies that all the explanatory variables jointly exerted significant influence on the operational efficiency of aquaculture fish production in the study area. The Table revealed that gender of the aquaculture fish farmers was positively significant (1% level of significant) to their operational efficiency. In the study carried out in Rwenzori region of Uganda, it was confirmed that most aquaculture fish farmers are male because fish farming requires strength and vigour [34]. So, in most cases, it is mostly dominated by young male as confirmed in Table 1 (86.8% were male and the mean age was about 36 years). Aquaculture farming chore can best be handled by young male fish farmers who are energetic and can run around [26].Therefore, the higher the number of male fish farmers, the higher the operational efficiency of fish farm enterprise in the area of study.

The fish farmers' educational level was positive and significant (1% level of significance) to the operational efficiency. So, additional education of fish farmers will probably lead to additional increase in their operational efficiency. Findings in rural Vietnam revealed that there is positive correlation between the educational level and operational efficiency level of farmers [21]. An increase in the educational level of aquaculture fish farmers in the study area will lead to an increase in their operational efficiency. Most educated farmers operate on large scale economics, they can make better use of knowledge gained through reading, attending seminars and conference. They often harness the benefit of their education to access fund through grants, and writing feasibility study to access loan from financial institutions, government agencies and international donors. Therefore, educated farmers are often more productive than the uneducated farmers.

Fish farming experience was positively significant (1% level of significance), implying that the more experience aquaculture fish farmers are, the higher their operational efficiency. Aquaculture fish farming is an act that requires mastery over time [19]. As usual in agricultural production, the longer one is in the farming business, the more you learn the process and master it over time. Mastery of the agricultural production process reduces wastage, enhances good mix of agricultural inputs that give room for more yield and ensures operational efficiency. Pond size was positively significant (1% level of significance), increase in pond size will lead to increase in operational efficiency. So, aquaculture fish farmers with bigger pond size or more ponds, will be more operational efficient than those with small pond size. This buttress the finding of [25] in Ghana that most large-scale aquaculture fish farmers with large ponds size harnesses the benefit of economic of scale, so, they are more operationally efficient. They often take advantage of technology and infrastructure know-how to get the best out of the farming process.

Access to credit was positively significant (1% level of significance), implying that the more aquaculture fish farmers in the area of study has access to credit facilities like loan, grants and financial support from government, national and international Non-Governmental Organizations (NGOs), the more their operational efficiency. Therefore, having access to credit will lead to increase in their operational efficiency. Finance is very important in agricultural production, when money is available to buy the needed inputs as at when due, operational efficiency is enhanced. Most farmers in less developed countries lack access to finance, and in few cases when they have access to such finance, it is not timely and sufficient [30]. Financial institutions are often sceptical to give credit facilities to smallholder farmers because of lack of collateral and inability to provide a convincing feasibility study. However, large scale farmers have deed of title of their land to use as collateral and are able to pay for bankable feasibility study, hence, they often access credit facilities from financial institutions easily and in some cases receive aids in form of grants from national and international organizations.

Association/Cooperative membership made positive and significant (5% level of significance) contributions to the operational efficiency of aquaculture fish production in the area of study. Reflecting that the more aquaculture fish farmers join or belong to association or cooperative society the more their operational efficiency. Membership of an association or cooperative society enables the farmers to get more information like how best to get improved seedlings, new methods of production and how best to market their produce. The information enhances operational efficiency. The key factors that enhance operational efficiency in agricultural production are access to improved seedlings and cost saving method of production [35]. These can only be accessed through information from other co-farmers, hence, membership of association and cooperative society will impact positively on aquaculture fish farmers' operational efficiency in the area of study. This buttresses the findings of [12], that if farmers can organize themselves to form an association or cooperative, they have a lot to benefit. Funding raising for agricultural purposes will be very easy, several national and international donors will be willing to give financial aid to them through the association or cooperative society.

Access to extension agents was positive and significantly (5% level of significance) influence the operational efficiency of the aquaculture fish farmers in the study area. This implies that the more access the aquaculture fish farmers in the study area have to extension agents, the more their operational efficiency. Extension agents are very important in the 21st century agricultural production. They provide critical information that will enhance farmer's operational efficiency. Such information includes how to access improve seedlings, how to mitigate risks, training on improved technique of production among others. Therefore, access to them equip farmers with inherent ability to achieve more productivity. [31] stated that any farmer ignoring the services of extension agents is doing that at his/her own disadvantage.

Table 3. Determinant of factors influencing efficiency of aquaculture fish production

Variables	Parameters	Coefficients	Standard Errors	T- values
Constant	δ_0	0.127	1.512	0.0839
Age	ω_1	-0.0107***	0.0022	4.864
Age^2	ω_2	-0.185	0.159	1.164
Gender	ω_3	0.0567***	0.01	5.67
Marital Status	ω_4	-0.326	0.725	0.450
Educational level	ω_5	0.241**	0.0989	2.437
Aquaculture fish farming experience	ω_6	0.202***	0.065	3.108
Pond size	ω_7	0.0688***	0.0195	3.528
Family labour	ω_8	0.138	0.447	0.309
Hired labour	ω_9	0.116	0.107	1.084
Access to credit	ω_{10}	0.0423**	0.0148	2.858
Household size	ω_{11}	0.0544	0.0359	1.515
Association/Cooperative membership	ω_{12}	0.0476**	0.0236	2.016
Access to extension agents	ω_{13}	0.06712 **	0.03308	2.029
R - Squares		0.917		
F-value Statistics		4.184***		

***Significant at 1%, **Significant at 5%, *Significant at 10%
Source: Author's estimations based on data from survey 2023.

Age of aquaculture fish farmers was negatively significant to their operational efficiency, which connotes that increase in the age of aquaculture fish farmer will lead to reduction in their operational efficiency. Therefore, the older an aquaculture fish farmer is, the lower his/her operational efficiency.

Estimate Results of Constraints Facing Aquaculture Fish Production

Table 4 revealed that the major limitation encountered by the fish farmers in the area of study was excessive cost of feeds with RII of 0.95.This supports the findings of [4]that instability in the price of feeds is one of the main problems affecting aquaculture fish production in Nigeria and other less developed countries. The cost of feeds accounts for more than 60% production cost even in the United State of America (USA). Therefore, any variation in such cost affects reasonably the variable costs which makes operation expenses unpredictable, making planning very difficult. The second critical problem facing the fish farmers was excessive cost of labour (0.93). Aquaculture fish farming is very herculean and requires energy and strength to execute it successfully. Consequently, there is need for dedicated labour to be successful in the business. However, due to minimum wage policy of the Nigeria government and subsidy removal on fuel, the hired labour cost (wage) is now very high. According to [28], keeping a committed labour in farming activities requires good wages, because hired labour are highly mobile in less developed countries.

Insufficient fund (0.90) was the third serious constraint militating against the aquaculture fish farming in the area of study. Most smallholder aquaculture fish farmers were unable to procure the feeds as at when due, because there was sudden surge in the price of feeds and labour. They could not approach any financial institution for credit facilities, thus, they had serious problem in their production process. Aquaculture fish farming require adequate and timely fund, if not, the expected operation efficiency will not be achieved [14].

Absence of structural market (0.88) is the fourth major constraints hindering smooth aquaculture fish farming in the area of study. Due to lack of structure market, the middlemen often exploit the fish farmers. They often buy from them at the farm gate price which is very low and they sell at higher price to the Hotels, Eateries and final consumers. Therefore, there is need for standardization aquaculture fish price that will ensure that farmers are not short-changed by the middlemen. In agricultural production value chain, middlemen often benefit more than the farmers who are the producers [9]. This is due to lack of agricultural produce price control that will benefit the farmers.

Lack of better-quality seeds (Fingerlings and Juveniles) (0.83) was the fifth constraint militating against the aquaculture fish farmers in the area of study. At the initial stage, it is very difficult to know if fingerlings or the juveniles procured were actually improved seedling or not. Until they start to grow that the fish farmers often detect that the fingerlings and the juveniles are not growing as expected even when they are well fed. This often leads to waste of money and resources as explained by the fish farmers. This buttresses the findings of [32] in Tanzania, that fish seed market in developing countries is like a black-market that fish farmers are not sure of what they are buying.

Insufficient technical management of pond (0.72)is another major problem militating against the aquaculture fish farmers in the area of study. Pond management require some technicalities, especially the modern fiber ponds.

Table 4. Distribution by Rank of Constraints Faced by Aquaculture Fish Farmers

Constraints	**Very serious (4)**		**Serious (3)**		**Mild (2)**		**Not at all (1)**		**RII**	**Rank**
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**		**1st**
Excessive cost of feeds	143	79.4	37	20.6	0	0	0	0	**0.95**	**2nd**
Excessive cost of labour	127	70.6	53	29.4	0	0	0	0	**0.93**	**3rd**
Insufficient fund	112	62.2	65	36.1	3	1.7	0	0	**0.90**	**4th**
Absence of structural market	112	62.2	47	26.1	20	11.1	1	0.6	**0.88**	**5th**
Lack of better-quality seeds (Fingerlings and Juveniles)	60	33.3	117	65.0	0	0	3	1.7	**0.83**	**6th**
Insufficient technical management of pond	52	28.9	72	40.0	36	20.0	20	11.1	**0.72**	**7th**
Frail extension support	49	27.2	70	38.9	33	18.3	28	15.6	**0.70**	**8th**

Source: Authors' estimations based on data from survey 2023.

Earthen pond is going out of vogue in the area of study, most of the fish farmers are using fiber pond. Hence, there is need for technical knowledge of how best to manage the pond to achieve optimal production.

According to [32] pond management is very important to optimal efficiency of fish farmers.

Frail extension support (0.70) is another very important constraint to aquaculture fish farmer's productivity in the area of study. Most smallholder farmers cannot pay for the services of the extension agents; hence, they do not benefit from their expertise. Extension agents are very important in all agricultural production process, they train the farmers on good agricultural practices, they demonstrate to them modern and improved method of production, supply farmers with information on how to mitigate risk among others [13].

CONCLUSIONS

The study evaluated the aquaculture fish farmers profitability, their operational efficiency, factors influencing their operational efficiency and determined the important constraints faced by aquaculture fish farmers in southwest, Nigeria. Using net profit margin ratio**, operating expense ratio, fixed cost ratio,**efficiency model and relative important index, the study revealed that aquaculture fish farming is profitable but inefficient in the area of study. Though government at various levels (Federal, State and Local Government Area (LGA) have put in place a lot of schemes to encourage fish farm enterprise in Nigeria and other less developed countries of the world. No concrete research to support the fish farm enterprise operational performance over the years in Nigeria and other emerging countries of the world. Therefore, the research findings will provide other scholars the needed insight into the fish farm enterprise operational performance in Nigeria. The findings will add to the existing knowledge on cost-effectiveness of aquaculture fish farmers in the study area, how efficient the fish farmers are in their operation of fish farm enterprise, ascertain the variables inducing the efficiency of their operation of fish farm enterprise and establish the major limitations encountered by the owner and manager of fish farm enterprise in the area of study. Findings from the research suggest that there is need for the government and international organizations to create educational awareness among the aquaculture fish farmers in the area of study. Also, to encourage them to belong to an association/cooperative society. Likewise, there is need to enlighten the fish farmers in the area of study to embrace the services of the extension agents. Again, government should introduce subsidy policy in fish farm enterprise of the agricultural sub-sector of the economy. This will help in reducing the price of feeds.

ACKNOWLEDGEMENTS

We appreciate the Tertiary Education Trust Fund (TETFUND), Abuja, Nigeria for sponsoring this research through Institution Based Research (IBR) grant from our University: The Federal University of Technology, Akure, Nigeria.

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PECULIARITIES OF THE MANAGEMENT PROCESS IN THE HYDROPONIC GREENHOUSE SECTOR IN THE CONTEXT OF ENSURING SUSTAINABILITY: A CRITICAL REVIEW

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Abstract

Agriculture's impact on the environment, such as biodiversity loss, water pollution, and soil degradation, necessitates a balanced approach to farm management that integrates the ecological, economic, and social dimensions. This article aims to investigate the evolution of farm management practices towards sustainability and highlight current management approaches aimed at improving resource efficiency and reducing environmental impact. Our assessment suggests that innovative technologies such as precision agriculture, smart greenhouses, and soilless cultivation systems lead to increased sustainability. However, despite these advances, the adoption of sustainability assessment tools remains limited due to data availability, high costs, and implementation challenges. In conclusion, effective farm management requires a comprehensive integration of sustainability principles into all decision-making processes. Continued research and development of more accessible and practical sustainability assessment tools are critical to improving agricultural practices' long-term sustainability.

Key words: *farm management practices, sustainable agriculture, hydroponic greenhouses, sustainability assessment tools*

INTRODUCTION

The horticultural sector represents an important part of agriculture, providing the necessary vegetables and fruits for the population. The horticultural sector has been subject to continuous modernization to ensure food security in the face of limited agricultural resources and climate change. Thus, agriculture in protected spaces has increasingly developed, especially in greenhouses with modern technology designed to provide an optimal environment for maximizing agricultural productivity and protecting crops from adverse weather conditions. The expansion of intensive agriculture in greenhouse-type structures has been facilitated by technological progress in recent decades. It involves numerous inputs, such as chemical fertilizers, pesticides, mechanical equipment, fuel, electricity, etc. [46]. Currently, smart greenhouses use sophisticated control methods, communication networks, monitoring systems, and, above all, management systems that precisely control microclimate factors, guaranteeing optimal conditions for crop development.

Promoting horticulture in protected areas brings social and economic advantages but can hurt biodiversity and ecosystem services (such as water resources, soil erosion, etc.). However, there are several important elements for ensuring the sustainability of horticulture in protected areas, such as [10]: governance; sustainable and efficient use of water; conservation of biodiversity; circular economy; technology and knowledge transfer; image and identity. Designers created greenhouses to foster the growth of high-yielding crops and safeguard against unfavorable weather conditions. With technological advances, greenhouses have evolved from basic structures to advanced facilities that optimize agricultural production and minimize costs. In recent years, the horticultural sector in protected spaces has grown significantly, focusing on the creation of greenhouses that achieve higher production throughout the year while using fewer resources. For example, vertical systems (vertically stacked layer crops) aim for system sustainability and improve production by optimizing land and water use. This concept has led to the introduction of new farming methods like hydroponics, which reduce agriculture's ecological impact. Greenhouses that rely on automation and robotics include environmental sensors (programmable controllers, control systems, and cyber systems), automated decision-making tools, wireless sensor networks (tools that provide a friendly interface for greenhouse visualization and remote control of environmental parameters via GSM/GPRS, 3G/4G, Wi-Fi, Bluetooth, etc.), autonomous mobile robots that collect data on humidity, temperature, carbon dioxide concentration, etc.

Hydroponic greenhouses use the practice of growing plants without soil but with a nutrient-rich water solution that allows for increased yield and water conservation. In practice, there are two types of hydroponic greenhouses, namely DFT (Deep Flow Technique) and NFT (Nutrient Film Technique) [84]. Because it requires less water and allows for nutrient solution recirculation, hydroponics maximizes production while minimizing resource use. Hydroponic systems are fully automated and use fewer water resources compared to traditional methods. Elvanidi et al. [16] implemented the circular economy concept in hydroponic greenhouses using two-level cascade culture systems. These systems use a primary crop's drainage solution to irrigate a secondary crop, reducing freshwater consumption by approximately 30%. Benko et al. [6] say that hydroponic greenhouses have many benefits, such as the ability to grow plants in places that aren't good for it, no need for crop rotation, less water use, automatic nutrient application based on plant development stage and greenhouse microclimatic conditions, fewer diseases and pests, faster harvests, and higher productions. The following disadvantages are indicated: high initial investment; higher costs; technical skills; requires high-value species to cover costs; difficulties in disposal/reuse of inorganic and synthetic substrates. Unlike open field cultivation, hydroponics minimizes the use of resources (land, pesticides, water, etc.), avoiding biotic and abiotic stress factors, and greenhouse cultivation allow control of temperature, humidity, light, and carbon dioxide. This approach enhances production yield, optimizes scheduling, and enhances irrigation efficiency, all while reducing water consumption [80]. This type of greenhouse uses a nutrient solution for plant support, which is a mixture of water, macronutrients, and micronutrients, either with or without a substrate. Substrates for hydroponic growth can be *organic* (peat, coconut fibers, sawdust, straw, etc.), *inorganic* (perlite, sand, clay, pumice stone, zeolite, etc.), *synthetic* (polystyrene, polyurethane, and urea-formaldehyde foam). This type of smart greenhouse contributes to sustainability because it can integrate renewable energy (solar, including photovoltaic systems, hybrid photovoltaic/thermal modules, etc.) to maximize production yields and minimize water and energy consumption. Moreover, by integrating solar and wind energy sources, such a greenhouse can become energy-independent [37].

Due to these specificities, the management at the hydroponic greenhouse level must ensure the proper management of the environmental factors that affect production, namely light, temperature, air humidity, and carbon dioxide concentration. This can be achieved by controlling the light intensity, the optimal temperature, the relative humidity, and the water pH [36]. In the pursuit of sustainability, we underscore the significance of managing organic waste and converting it into energy [52], while also stressing the necessity of cost reduction to maintain profitability and efficiency [53]. From the perspective of business management, it's crucial to highlight that hydroponic greenhouses necessitate sophisticated management expertise. This includes understanding crop production, possessing technical skills to operate the automated system, understanding production flow, nutrient supply, and storage, and understanding disease and pest management, with a focus on sanitation measures.

In this context, the paper aimed to investigate the evolution of farm management practices towards sustainability and highlight current management approaches aimed at improving resource efficiency and reducing environmental impact.

MATERIALS AND METHODS

The study highlights the unique aspects of hydroponic greenhouse management by synthesizing the major specialized works in the field. To achieve the mentioned goal, it was carried out a bibliographic study that allows to present the aspects related to management in agriculture and the horticultural sector, the managerial challenges faced by hydroponic greenhouses, and methods and indicators for the evaluation of sustainability at the level it's firm. In other words, this paper uses a systematic approach to analyze management processes in the hydroponic greenhouse sector, with a focus on sustainability.

Our review considered articles presenting management practices, sustainability indicators, or case studies focused on sustainability assessment in hydroponic systems. This allowed us to carry out a qualitative analysis to assess the effectiveness of different management practices and their impact on sustainability. In the process of critical evaluation, we assessed the methodologies used in the studies, the validity of their findings, and their relevance to contemporary challenges in hydroponic greenhouse management. We have paid particular attention to how these practices either contribute to or hinder the goals of sustainability.

So, by systematically reviewing and synthesizing the literature, this paper aims to provide a comprehensive overview of the current state of management practices in hydroponic greenhouses and their implications for sustainability.

RESULTS AND DISCUSSIONS

General aspects of agricultural management and adaptation to sustainability requirements

Agriculture is the most important activity in human society, and farm management has become a vital endeavor for the efficient acquisition of food, fiber, fuel, etc. Interest in sustainable farm management has increased in recent decades, with a focus on concerns related to rural communities, ecosystems, biodiversity, ethics, technology, and agricultural policy. Under these conditions, we can say that farm management has become a complex process, depending on the different approaches to it. In general, however, it is considered that agriculture requires a sustainability-oriented approach that includes the management of biological, financial, social, etc. resources [35]. To develop sustainable food systems, it is necessary to understand that the increased use of agricultural practices (pesticides, fertilizers, and tillage) as well as the abandonment of agricultural land (due to urbanization, job prospects, or population aging) have significant negative effects on biodiversity and natural resources [10]. Since this is the case, we need to use new farming methods and management styles that are more in line with sustainable farming models. These models should make sure that the social, economic, and environmental parts of farming systems are all connected and affected by each other [22].

Farm management involves choosing the best way to allocate agricultural resources (nutrients, water, etc.) to protect the environment and efficiently transform plants and animals into products that meet consumer needs [59]. At the same time, farm management integrates elements such as the manager's technical expertise, pedo-climatic conditions, risk management, etc., or in other words, technical knowledge and land use technologies with commercial business practices [53].

Since the 2000s, there has been a growing discourse on management practices that integrate sustainability principles [45]. This is due to the emergence of numerous viewpoints about the adverse effects of agriculture on the environment, including water pollution, heightened greenhouse gas emissions, and biodiversity loss. Consequently, the

agricultural policies of the European Union and other regions have shifted their focus towards promoting sustainable agriculture, a move further solidified in the European strategy of 2006.
Under these conditions, EU agricultural policy has targeted elements such as water quality (pollution by pesticides, nutrients, and chemical fertilizers), air quality (ammonia and greenhouse gas emissions), soil erosion (extensive grazing, river clogging, and desertification), biodiversity conservation (affecting ecosystems by reducing species and natural habitats), landscape protection (loss of landscape features provided by hedges and ponds), food safety and animal welfare (use of pesticides and medicines found in the product), and finally, genetically modified organisms [42]. Additionally, cross-compliance, which introduces rules for good agricultural practices, links direct payments to agricultural practices, while the second pillar of the CAP introduces agri-environment schemes, providing incentives to farmers who surpass the minimum requirements outlined in the code of good agricultural practices.

Farmers' decisions at the farm management level, in the context of these incentives and restrictions, represent the basis for implementing sustainable development in practice. Management applied at the farm level must use specific techniques to achieve sustainability goals, which has often led to protests from producers against environmental requirements that, from their point of view, affect market competitiveness. Since 20 years ago, we have observed a clear behavioral shift in farmers' management practices, a result of both political mandates and technological advancements.

Thus, we currently have farmers who have improved their management by gradually introducing environmentally friendly agricultural practices (related to resources, soil, water, animal welfare, etc.); farmers who directly implemented new technologies based on innovations in the sector (precision-agriculture based on sensors, drones, etc.); farmers who introduced from the state "turnkey businesses" with computerized solutions based on specific pedological and climatic indicators (such as hydroponic greenhouses, aquaponics, etc.) [86]. In other words, in the process of controlling the harmful effects of agriculture on the environment, farmers have had a variety of options available, from minor changes in the management process to meet the demands of agricultural policy to a complete change in agricultural practices.

Sustainability management, commonly known as the integration of sustainability elements into a company's strategic planning and strategic management process, has become necessary to ensure firms' competitiveness [24]. Schaltegger and Hörisch [64] assert that sustainability management upholds economic competitiveness by mitigating negative social and environmental impacts.

Peculiarities of the management process in the horticultural sector

Given that the agro-food industry intensively uses natural resources, accounting for 70% of water resources for irrigation, animal husbandry, and aquaculture [18] and 25% of global energy consumption [19], it is evident that conventional agricultural methods are inadequate to meet the increasing food demands.

In recent decades, there has been increasing talk of implementing sustainable agriculture principles and precision agriculture equipment as solutions to improve agricultural production and protect the environment at the same time [34]. Specialized farming, such as greenhouses with SCSs, allows horticultural crops to be grown in various environments, including marginal and arid lands. These systems maximize yield and extend growing seasons by controlling environmental factors like light, temperature, and humidity. This leads to improved economic and environmental sustainability [47].

Smart greenhouses, which offer improved energy and water management solutions and enable automatic and intelligent indoor climate adjustment, are starting to be created to support the growth in agriculture [51]. They incorporate the most recent advancements to minimize water usage and achieve zero energy and pesticide consumption [7].

Controlled environment agriculture involves growing plants (in horizontal or vertical greenhouses, chambers/compartments, or plant growth factories) using advanced horticultural techniques and technologies to increase yields and improve product quality [25]. Greenhouses, constructed from transparent materials, regulate microclimatic parameters to boost plant growth and productivity, ensuring year-round production [68]. However, obtaining horticultural products in greenhouses represents one of the most intensive agricultural systems in the world, due to the following elements: high yield and energy consumption per surface unit [85], excessive use of chemical fertilizers and pesticides [46]; climatic factors (sunlight, temperature, and air composition), etc. Designed and engineered to stimulate off-season fruit and vegetable production, greenhouses allow harvesting over multiple production cycles throughout the year, which can lead to some environmental problems, including high use of non-renewable energy, loss of biodiversity, nitrogen and phosphorus pollution, etc. [71].

In the case of protected spaces and modern greenhouses, we find many innovative technologies, such as sensors for real-time monitoring, computerized decision systems that control heating, ventilation, lighting, irrigation, etc., retractable roofs, movable walls, thermal curtains, infrared growing systems, UV protection, and climate filters, improved plastics, hydroponic and aquaponic growing systems, etc. Soilless cultivation techniques, such as hydroponic, aeroponic, and aquaponic systems, not only enhance productivity and quality by providing greater control over the root-level environment but also significantly reduce the need for water and nutrients due to the lossless recirculation of solutions [62]. As previously noted, greenhouses have become technologically complex production units (automated and with sophisticated climate and irrigation control systems) in recent decades, necessitating crop management systems adapted to these technologies [81]. Furthermore, managerial activity itself has become more complex due to quality and environmental standards, price fluctuation [82], and supply-demand imbalances caused by intermediaries [4].

Improving the management process can be achieved by using sophisticated crop management approaches, such as adhering to good agricultural practices, using integrated production and pest management strategies, practicing integrated soil health management, and adopting organic farming methods. These techniques guarantee the long-term sustainability of horticultural crop production systems.

Farm management entails the optimal use of production resources and profit maximization, emphasizing risk management (which ensures the response to uncontrollable natural conditions and market price volatility), production management (including protection of crops, the environment, etc.), marketing management, human resource management, financial management, and so on. It must implement strategies that ensure sustainability (including long-term profitability), use increasingly automated technologies and identify resource planning tools adapted to constraints given by varieties, climatic conditions, and so on. To maximize productivity, effective management in horticulture requires the transfer of know-how and technology to be integrated into classic farming systems on modern varieties and equipment. In addition to these, there is an increasing emphasis on market orientation, post-harvest management and loss reduction, farm-level processing, ensuring quality standards, developing export activities, organic products, developing marketing cooperatives, and crop development in protected areas [70].

To operate efficiently, horticultural companies must ensure the efficient use of management functions (planning, organization, human resources, leading, and control) but also ensure the functional activities of management (production, marketing, and finance). Thus, production management must be ensured. Marketing management, financial management, human resource management, resource and inventory control, quality management, and so on. Decisions regarding functional areas are interrelated and influenced by production volume, input accessibility, access to funds, employee motivation, etc. In theory, we encounter a multitude of tools for evaluating and implementing management decisions, such as operational, technological, strategic, and risk response plans; financial instruments (budgets, annual reports, financial forecasts, break-even analysis, etc.); risk management tools, etc. However, most managers in horticulture do not implement complex analysis tools to ensure increased profitability and value creation in the agri-food chain. According to McConnell and Dillon [43], farmers refuse to implement management theories and tools for several reasons: they are based on experience; decision-making according to theory can be too complex and expensive; it requires a lot of data, the collection of which is time-consuming and costly; there is uncertainty in the sector that does not justify the use of analytical tools, etc.

Understanding how we can use management tools effectively makes a difference in the market, especially due to the changes of the last decades: the orientation of farmers to the market and the reduction of support from the state; increased competition; logistics capabilities supporting large supply chains; concentration of processing at the level of transnational and multinational companies; the development of short market chains and increased vertical integration; consumer demand for horticultural products throughout the year; technological changes (plant genetics, precision agriculture, automated decision products, pest management, irrigation scheduling, etc.); capitalizing on production based on patents, property rights and certifications; concern for biodiversity and sustainability, etc.

Techniques and metrics for assessing the company's sustainability in an attempt to enhance the decision-making process

Understanding how management decisions at the farm level influence the environment helps to develop management plans that can improve long-term sustainability [57]. Measuring and evaluating the sustainability of agricultural practices at the farm level is also believed to be crucial to achieving a sustainable food system [1] [17]. It is believed that the transition of agriculture towards sustainable development necessitates the use of sustainability assessment tools to support on-farm decision-making [23], but that the actual adoption of sustainability assessment tools by agricultural practice is relatively limited [75].

The realization of sustainability assessment tools is influenced by several factors, such as available data, time limitations, and financial limits, but also by the integrative aspect, i.e., by the integration of the three dimensions of sustainability [55]; the scope, the target group (farmers, decision-makers, etc.), the selected indicators, the aggregation method, the time of realization and interpretation, etc. [8].

According to Franks and Frater [21], literature research indicates that existing tools for assessing agricultural sustainability are based on four main approaches:

-Life cycle analysis (LCA) is a method that requires a lot of data over long periods and abstracts from economic and social indicators or qualitative data [39];

-Ecological accounting, a method that requires a significant amount of data and a monetary translation of ecosystem services, was introduced by Halberg et al. in 2005 [30].

-The ecological footprint considers elements such as greenhouse gas emissions and carbon footprints but disregards others [83].

-The sustainability index (the method does not have a unique way of selecting factors and variables but allows obtaining a single value that provides an overview of sustainability and allows comparisons at the farm level [26], industries [50], localities [32], or countries [2].

The OECD and the Institute for Sustainable Development created the "Bellagio STAMP" sustainability assessment and measurement principles in 1996, and they revised them in 2009 [54]. The Bellagio STAMP proposes to consider the following elements in the assessment process: vision, objectives, perspective, purpose, progress, accessibility, communication, participation, permanence, etc.

However, there is a multitude of works that propose different models and indicator systems for measuring sustainability ([78], [48], [67], [27], [38], [3], [61], [49], [1], [72], [33], [12], [44], [66], etc.

Numerous studies in the specialized literature have addressed the creation of an index for measuring sustainability at the farm level. Among them, we mention:

-Rigby et al. [58] aimed to build an indicator of the sustainability of agricultural practices. The methodology was based on sustainable land management indicators, land quality indicators, and sustainable agriculture indicators. The sample consisted of 80 organic and 157 conventional producers from the United Kingdom.

-Hanuš [31] used three aggregate indicators and a set of partial indicators to assess the ecological, economic, and social aspects of the agricultural system at 30 farms. The author took into account six groups of indicators: environmental monitoring indicators (soil quality, nutrients, biodiversity, etc.); energy and material consumption (total mass transformed for a given process; biomass production and its use; indirect energy from pesticides and fertilizers and direct energy from machinery and the irrigation system, etc.); ecological footprint (fossil energy expressed by surface area, impact of activities on resources, waste production and environmental function, etc.); the production process (crop rotation, frequency of cultivation, nutrients, plant protection; inputs and outputs during packaging, distribution and consumption of agricultural products, etc.); socio-economic indicators (income, input suppliers, direct links with transport and processing companies, marketing, risks, decision-making process, etc.); size of the agricultural system (subsidy dependence, use of equipment, chemicals and non-renewable energy, jobs, feed use and feed production);

-Gomez-Limon and Riesgo [26] created a composite indicator of agricultural sustainability comparing non-irrigated and irrigated agriculture. The model encompasses economic, social, and environmental indicators, which include income from agricultural products, the contribution of agriculture to GDP, the insured area, employment in agriculture, labor force stability, the risk of abandoning agricultural activity, the economic dependence on agricultural activity, the degree of specialization, indicators related to phosphorus, pesticides, and nitrogen, water for irrigation, energy balance, the subsidized area for agri-environment, average area per plot, and the degree of soil coverage. The methodology was based on multicriteria analysis and weighted sums.

-Castoldi and Bechini [9] created a global sustainability index based on the following economic and environmental indicators: variable costs, gross income, gross margin, nitrogen and phosphorus quantities, energy input, energy output, energy balance, land cover, amount of soil carbon, etc.

-Reig-Martínez et al. [56] constructed composite indicators for the three dimensions of sustainability for 163 farms in Spain, applying a combined DEA-MCDM methodology on a database of 12 indicators. The authors showed that farm size, agricultural cooperative membership, and agricultural technical education exert a significant positive influence on sustainability.

-Franks and Frater [21] created a sustainability index for a dairy farm, taking into account over 40 indicators, grouped into the following categories: nitrogen, phosphorus, and potassium balance; profit margin; dependence on subsidies; productivity; biodiversity; average field size; cultural diversity index, etc.

-Majewski [40] created a sustainability index (consisting of five partial indices and 56 parameters), which served as the basis for the comparison of 120 farms in Poland and allowed us to conclude the importance of low-cost investments and activities in ensuring sustainability.

-Marchand et al. [41] created an indicator for the assessment of total sustainability based on 11 key characteristics that aim to strengthen the management function. However, the tool is not very practical, requiring data collection costs, processing time, and an overly complex interface for farmers.

-Coppola et al. [13] developed an economic sustainability index using FADN data. This index relies on an efficiency indicator and two income indicators, namely a factor profitability indicator and a comparable income indicator, to help determine the balance between efficiency and revenue factors.

We found these works interesting, but the specialized literature identifies a multitude of sustainability assessment methodologies. They differ according to:

-*the techniques and indicators used, the target group, the period, etc.* [15];

-*approach:* top-down or bottom-up assessment [8]; based on automated calculation models (online, Excel, or specialized software like "Decision Support Tools"), protocols, or econometric models.

-*the sustainability assessment method*: the SAFE framework of principles, criteria, and indicators [77]; the RISE systems-oriented holistic approach (Hani et al., 2003); multicriteria analysis [74]; framework of principles, criteria, and indicators (SAFA) [20]; SEAMLESS [79]; the COSA indicator framework [14], etc.

-*the normative, systemic, and procedural dimensions* [87];

-*the type of impact pursued* (economic, social, and/or environmental impact) [11];

primary data source:

-indices based on FADN data [69]; indices based on surveys and FADN data [73];

-experts and surveys [28];

-farm-level data [29];

-Sebestyén et al. [65] propose an aggregate indicator calculated based on indicators classified into six categories, namely: waste management, water management, climate change, energy, greening, and transport. These categories include the important elements of sustainability in line with other studies that have addressed GreenMetric, GRI standards, etc. Based on these indicators, the authors propose the aspects that require improvement and the objectives to be pursued to increase sustainability.

In one of the most extended analyses in the field, Janker and Mann [33] analyzed 87 agricultural sustainability assessment tools and component indicators, showing that many tools do not properly integrate the social component. Chopin et al. [12] classified almost 120 sustainability assessment tools into five groups, seven different models, and only two impact elements after analyzing 2,567 papers. Figure 1 displays the five groups of tools identified.

In 2020, Tzouramani et al. [76] used FADN data and a sustainability criteria weighting system based on the AHP methodology to make a composite indicator-based comparative score. The following criteria and indicators were taken into account: environment (GHG emissions at the farm level, the percentage of UAU in the farm with nitrate risk, water consumption per kg of product, N balance, pesticide use); social security (no. of consulting approvals per year per farm, degree of agricultural training of the manager, annual work units; satisfaction with quality of life; social diversification index); economic (output/input, subsidies/FFI, (FFI/FWU)/income, net value added).

Bathaei and Štreimikienė [5] analyzed 157 papers and identified an extensive framework of more than 100 indicators (30 social indicators, 31 economic indicators, and 40 environmental indicators) that can assess the sustainable development of an agricultural firm. The authors group these indicators into the following categories: economic dimension—technology, market access, price; environmental dimension—farm structure, pollution, soil; social dimension—product quality, farmers' and employees' rights. However, simply identifying these indicators does not imply that they are truly commensurable.

Starting from the analysis of 40 articles comparable to the Swedish dairy sector and the RISE 2.0 indicator framework, Robling et al. [60] found that they could not measure 20 indicators ranked below 12 out of a total of 20 sustainability themes, and they could not validate 16 indicators from 8 themes due to a lack of data. Therefore, they selected only 49 indicators from a total of 69 to describe sustainability in Swedish dairy farms. As a result, Robling et al. [60] recommend that sustainability assessment models only use indicators that are comprehensible, transparent, available, and useful in describing the phenomenon.

Regardless of the tool's creation, the primary issue lies in the indicators employed, as they can significantly impact the research outcomes. Schader et al. [63] evaluate 35 sustainability assessment approaches and highlight that they are rarely feasible, and the selection of indicators is actually what determines the assessment results as the indicators are different and inconsistent. Once you select the indicators, you can apply various techniques such as summation, weighting, normalization, and scaling to integrate the information and present it more straightforwardly and comparably. Analysis methodologies such as multicriteria analysis, which allows for the grouping of indicators in classification criteria, and econometric modeling, among others, can be added to these techniques.

Fig.1. Sustainability assessment models in agriculture
Source: Adapted from Chopin et al. (2021) [12]

CONCLUSIONS

Achieving sustainable agricultural management requires a holistic approach that integrates ecological, economic, and social dimensions. This approach is critical to addressing the negative environmental impacts of conventional agricultural practices and meeting the growing global demand for food. The adoption of advanced technologies such as smart greenhouses and soilless cultivation systems has increased resource efficiency and reduced environmental impact. Advanced technologies such as automated greenhouse climate control systems and precision irrigation contribute significantly to reducing the environmental footprint of agricultural practices and improving overall sustainability.

Currently, there is a clear trend to integrate sustainability principles into farm management practices. This integration involves not only adopting new technologies but also incorporating sustainability considerations into strategic planning and operational decisions. Despite the availability of various sustainability assessment tools, their adoption on farms remains limited. Challenges include data availability, high costs, and the complexity of integrating these tools into existing farm management systems. However, for effective farm management, comprehensive sustainability assessment tools that consider economic, social, and environmental factors are critical. These tools help make informed decisions that balance productivity with sustainability goals. Continued research and development of new sustainability assessment tools and methodologies is essential. This paper draws attention to the current limitations and aims to contribute in this way to improving the efficiency of sustainability assessments in agriculture. Research demonstrates that to enhance long-term sustainability, agricultural management practices must strategically integrate sustainability considerations into all levels of decision-making. This involves adopting new technologies, optimizing the use of resources, and continuously evaluating and improving practices based on sustainability parameters.

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THE INTEGRATION OF ENVIRONMENTAL, SOCIAL AND GOVERNANCE (ESG) PRINCIPLES INTO FARM MANAGEMENT: A GENERAL OVERVIEW

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Abstract

The last decade's development and implementation of non-financial reporting culminated in the approval of the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS). These have become mandatory for large companies, but it is estimated that in the future all companies will have to consider environmental, social, and governance (ESG) factors in the management process. The CSRD, effective from January 2024, aligns sustainability reporting with financial reporting, requiring standardized disclosures on ESG issues. This paper explores the challenges and opportunities of the future implementation of ESG standards in agricultural companies. Key issues include data collection, compliance costs, and the need for sector-specific reporting. Despite these challenges, ESG reporting offers potential benefits such as improved reputation, risk management, and market access. The paper assesses current practices and future directions for integrating ESG in agriculture, highlighting the need for improved reporting frameworks and methodologies.

Key words**:** *sustainability reporting, ESG factors, ESRS, agricultural management*

INTRODUCTION

Agriculture is the most important activity in human society, and farm management has become a vital endeavor for the efficient acquisition of food, fiber, fuel, etc. Interest in sustainable farm management has increased in recent decades, with a focus on concerns related to rural communities, ecosystems, biodiversity, ethics, technology, and agricultural policy. Under these conditions, we can say that farm management has become a complex process, depending on the different approaches to it. In general, however, it is considered that agriculture requires a sustainability-oriented approach that includes the management of biological, financial, social, etc. resources [19].

Given that agricultural policies and certification systems require information that demonstrates farm sustainability and the relationship with the environment, researchers in the specialized literature draw attention to the gaps between the data required for sustainability reporting and farm data management [27]. Currently, agriculture requires the provision of data on food security management (GlobalGap), evidence of cross-compliance requirements for direct payments and eco-schemes, and evidence of corporate sustainability on suppliers, among other things. Software designed to provide all this necessary information to support the management process can generally be used by large farms due to both utility and cost. These are not typically available or adaptable for families and small businesses. On the other hand, farm accounting does not provide much of the information needed to measure sustainability either. In fact, according to Poppe et al. [27], key performance indicators on a farm's sustainability performance integrate information from both farm financial accounting and farm management systems, which makes reporting very difficult.

In terms of environmental impact, we often focus on pollution from the energy sector, but many studies indicate that the agri-food sector has the greatest impact on maintaining environmental stability, contributing to deforestation and pesticide contamination of land, an increase in the number of endangered species, depletion of freshwater resources, etc. [13]. Under these conditions, increasing promotion of ESG principles in governmental and corporate commitments is estimated to support achieving sustainable development goals. We predict that the environmental, social, and governance (ESG) policies of firms across the agri-food sector will influence their future performance.

However, to impact ESG performance over the medium and long term, strategic integration of sustainability considerations is essential [1].

There is not much research that analyzes how the internal management of companies incorporates elements of sustainability, but the existing ones suggest the following: it is necessary to expand the analysis to the level of all interested parties, such as management members, shareholders, employees, competitors, etc. [16]; ESG performance does not always translate into higher profits [14]; increased ESG performance attracts capital [26].

In this context, the purpose of this paper is to explore the challenges and opportunities of the future implementation of ESG standards in agricultural companies.

MATERIALS AND METHODS

This study uses a mixed methods approach to evaluate how well agricultural enterprises integrate ESG requirements. It includes case studies of early adopters of ESG reporting, interviews with industry experts, and a review of the body of research on European non-financial reporting standards. The requirements and implications of CSRD and ESRS for agricultural enterprises are the main topics of the literature review. We gathered information from various sources such as scholarly articles, industry reports, and regulatory records. The papers underline the advantages and practical difficulties of implementing ESG and take into consideration both major agricultural firms and smaller farms that have begun to use ESG principles. Finding recurring themes and problems, such as troubleshooting data collection, reporting expenses, and sector-specific obstacles, was part of the analysis. The study also scrutinized comparative practices in other industries to identify commonalities and optimal practices that agriculture could adopt.

RESULTS AND DISCUSSIONS

European non-financial reporting standards

Agriculture is a vital human activity, and farm management is crucial for acquiring food, fiber, and resources. Sustainable farm management has gained interest in recent decades, focusing on issues affecting rural communities and ecosystems. To ensure long-term sustainability and mitigate negative effects on the environment, society, and economy, it has become imperative to assess and measure an entity's sustainability performance, which reflects how well it incorporates environmental, social, and economic factors in operational activities. To promote transparency and accountability in the field of financial performance, the Non-Financial Reporting Directive (NFRD) was developed in 2014. The reporting allowed companies to track their sustainability performance and develop sustainability management. The Corporate Sustainability Reporting Directive (CSRD) (2022/2464/EU) [7] replaced Directive (2014/95/EU (NFRD) [6], placing sustainability reporting on par with financial reporting. The CSRD Directive aims to standardize reporting and enable simple comparison of sustainability data on environmental, social, and governance issues. On January 1, 2024, the Corporate Sustainability Reporting Directive (CSRD) (the law requiring reporting) and the European Sustainability Reporting Standards (ESRS) (the framework followed to meet the CSRD) came into force.

The CSRD requires the creation of a management plan focused on sustainability on the standardized model of the ESRS, which must include elements such as the business strategy, the sustainability objectives set by the company, the role of the people involved in the management of the company in ensuring sustainability, the company's policies, the due process diligence implemented by the company, risks in ensuring sustainability based, etc. Starting in 2025 (for the financial year 2024), the obligation to report appears only for companies with more than 500 employees that are either public interest institutions or non-EU entities listed on European markets. In the next year, companies that meet two of the following criteria will have to report: over 250 employees, turnover of over 40 million euros, and total assets of over 20 million euros. From 2027, listed small and medium enterprises will report, and from 2028, regulations will be introduced for other categories of companies. Given these circumstances, we anticipate that all EU market companies will submit this sustainability report within a few years, particularly if they commit to maintaining their climate neutrality until 2050.

In July 2023, the first set of 12 ESRS standards ("two transversal standards and 10 thematic standards") was adopted, the sectoral ones and those intended for SMEs to be approved only in 2026. These standards aim to provide a transparent picture, precise and comparable regarding the impact on the ESG (environmental, social, governance) domains. According to (Denkstatt the ESRS indicators are based on already established standards and frameworks, such as: GRI ("The global standards for sustainability impacts"), SASB ("Sustainability Accounting Standards Board"), TCFD ("Task Force on Climate-Related Financial Disclosures"), GES provisions (Greenhouse Gases), Carbon Disclosure Project, etc. [5].

The transversal standards provide for: ESRS 1 - reporting areas, due diligence obligations, value chain, reporting period, method of collection and presentation, and double materiality analysis; ESRS 2 - policies, measures, objectives, themes, reporting pillars. The ESRS 1 standard is based on the GRI rules, and the ESRS 2 on the TCFD rules. ESRS standards on ESG topics are presented in Fig. 1.

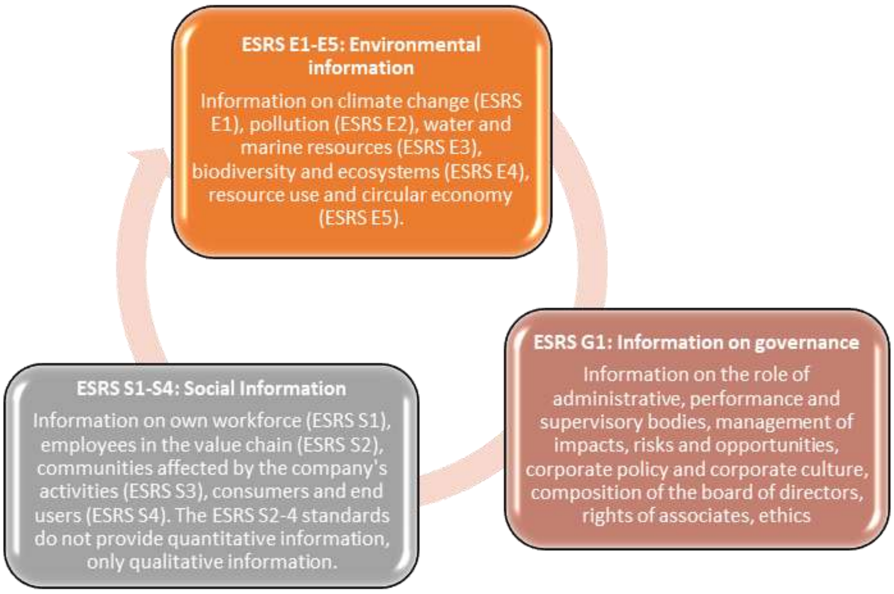

Fig.1. Structure of ESRS standards
Source: adapted from https://denkstatt.ro/prezentarea-pe-scurt-a-standardelor-europene-de-raportare-a-sustenabilatii-esrs/ [5].

The challenges of the ESG implementation process for company management

To achieve sustainability, organizations must make informed decisions, provide transparent reporting, and communicate a detailed plan for meeting their ESG goals. A sustainability strategy should consider social issues such as diversity, equity, inclusion, employee well-being, social responsibility, and supply chains, and CEOs should incorporate sustainability into business strategy and operational decisions and create key indicators and quantifiable performance measures to monitor and enforce sustainable practices.

A multitude of companies, including those from Romania, began implementing voluntary non-financial reporting as early as 2022, but there are currently over 700 companies that fall under the reporting conditions. The implementation experience has led to the identification of several challenges faced by the participating companies (Table 1).

Table 1. Challenges in the process of implementing ESG reporting

Author	The challenges are posed by:
Green Report Conference (CGR, 2023) [3]	Data Collection and Verification High costs Time and effort for communication. Reporting on employee statistics Data uniformity Reporting procedures Substantial investments in systems and technologies
ESG:ro Conference [2]	Lack of Comparability The lack of sector-level reporting. Lack of the necessary infrastructure for data collection
Stratos Company (2024) [32]	The Volume of Information and Figures Lack of experienced personnel in sustainability. The difficult language of standards and guidelines. The transposition of necessary measures into plans. The high costs of reporting (approximately 106,000 euros on average for large companies that need to report the entire value chain)
PWC (2023) [28]	The correlation between regulations and the creation of a sustainable business model
Green Start-Up (2024) [12]	Collection of prospective and retrospective data The application of double materiality (the impact on the company and the environment ("impact materiality"); how sustainability affects the company ("financial materiality"))
Eurofi (2022) [9]	Availability of data related to risks, greening, decarbonization The lack of quality data and transparency. The multitude of ESG data. (hundreds of indicators)
The CSRD compass [33]	The lack of expertise and resources. Alignment with other reporting standards The necessary changes in internal management processes

Source: own elaboration based on the studied literature.

To achieve sustainability, organizations must make informed decisions, provide transparent reporting, and communicate a detailed plan for meeting their ESG goals. A sustainability strategy should consider social issues such as diversity, equity, inclusion, employee well-being, social responsibility, and supply chains. CEOs should incorporate sustainability into business strategy and operational decisions and create key indicators and quantifiable performance measures to monitor and enforce sustainable practices.

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ESG reporting plays a crucial role in firm management.

Sustainability can create value and ensure long-term profitability, but this remains difficult as investors seek high returns on investment and customers demand low prices from suppliers. Of course, we can ask how this reporting helps companies. ESG experts highlight several opportunities for companies, including: enhancing the company's reputation and bolstering investor or bank confidence through the ESG rating; lowering the costs of mitigating the environmental impact of the company's investments; ensuring optimal management of environmental financial risks; venturing into emerging markets; and enhancing access to loans with preferential interest rates through transparency and data quality.

By including practices such as climate change impact assessment, workplace culture, and diversity, the ESG framework improves risk management decisions. The governance processes ensure that the management (manager, board of directors, etc.) adapts to the reporting standards, thereby ensuring the company's effectiveness. On the other hand, the organizational culture's approach to risk assessment influences management decisions, which in turn align with the company's mission and values. To put it another way, all aspects of the unitary management process, including the business model, vision, mission, values, and strategy, must adhere to the ESG objectives.

This means taking action on mitigating greenhouse gas emissions; establishing viable supply chains; adapting to climate change; adopting circular economy models; water use; air and water pollution; waste management; biodiversity; conflicts of interest; business ethics; energy use; the relationship with the community; responsible partnerships; financial transparency; compensation of management and employees; health and safety at work; treatment of customers and suppliers; data protection; cyber security; employee experience and engagement; hiring and retaining employees, etc.
Firms that have specific environmental, social, and governance policies are better prepared to prevent and minimize potential problems that lead to penalties, reputational damage, and legal liabilities. Various authors have studied the relationship between risk management in companies and ESG performance.

The study of Maharani and Yonnedi [22] investigated the impact of risk management on ESG performance by considering governance components and company activities. The results show that risk management has a significant impact on financial performance and organizational value, and ESG plays a moderating role.

-The study of Zaporowska and Szczepański [35] sought to identify the role of ESG factors in operational risk management, with an emphasis on how ESG components are reflected in performance reporting as part of the management control function.

-According to Senadheera et al. [30], sustainability risk management and environmental risk management in the production process have the potential to significantly impact a company's financials. The same authors suggest that factors such as waste management, pollution levels, climate change, fossil fuel dependence, resource management, and carbon footprint can significantly impact long-term financial viability.

Based on a survey of over 500 firms, Mărcuță et al. [23] highlights that Romanian companies investing in social responsibility enhance their reputation, marketing, economic performance, adaptability, financing access, and sales.

In conclusion, any firm can use the ESRS as a framework to assess the sustainability of its business model and integrate ESG principles into management decisions. Management decisions can align with the standards by focusing on the following areas:

-We are strengthening the IT infrastructure (programs, technology, lower energy consumption, etc.);

-Retrofitting focuses on energy efficiency.

-Enhancing human resources policies and purchasing materials and products while considering environmental factors are key priorities.

-Marketing initiatives that encourage the adoption of ESG

-Elimination of fraud and corruption, etc.

We can measure the impact on the business using a multitude of quantitative (input consumption, gas emissions, workforce, etc.) and qualitative (work practices, codes of conduct, ethics, etc.) indicators. To have an impact, the company's business model must integrate ESG. Siao et al. [31] show, however, that there are too few empirical studies that concretely highlight this integration.

Non-financial sustainability reporting in the agri-food sector

Agriculture is a sector of the world economy that employs over a quarter of the world's population and has a significant impact on society in general and the environment in particular, as it uses a lot of pesticides, fertilizers, and other chemicals that can damage the earth, water, and air. The polarizing development of agriculture in certain regions also leads to negative social effects, such as the uprooting of populations, violations of labor regulations, and so on. Under these conditions, the organization of activities in agriculture and the food industry according to ESG principles becomes a useful tool for evaluating how a company's actions would impact ethics and sustainability. ESG standards in agriculture assess the impact of an agricultural enterprise on the environment and society and include: an environmental component that involves energy use, waste management, and carbon emissions; a social component that takes into account how a company interacts with society (human rights, labor laws, community involvement, etc.); and a governance component that looks at the leadership and management of the company, taking into account things like manager pay, board composition, and shareholder rights.

These standards have emerged amid many issues arising from environmental concerns over the past decade. Due to imposed agro-environmental conditions, deforestation, soil erosion problems, climate change, and pollution from plastic packaging, society is faced with a contradiction between the processes related to the production of agricultural and food products and environmental aspects. Political measures for the implementation of sustainable development objectives (assumed by the UN 2030 Agenda from 2015), growing consumer preference for organic products, and geopolitical measures arising from commercial disputes have been added to these challenges. Political pressures have been exerted at the producer level to reduce fertilizer amounts, reduce water consumption, and eliminate certain raw materials from the composition, among other measures. For instance, the EU's decision to ban the use of palm oil affected the profits of the entire palm oil producer sector. Additionally, the geopolitical issues of recent years have demonstrated that agriculture has transformed into a powerful weapon due to the interdependence fostered by the promotion of globalization after the Second World War. This interdependence impacts all food sectors, resulting in increased consumer prices for essential goods or dumping prices that have the potential to bankrupt local businesses.

Agriculture plays a vital role in achieving environmental goals, particularly in reducing biodiversity, meeting the food and textile needs of the population, sequestering carbon from soil and tree biomass, and reducing greenhouse gas emissions. These emissions include direct emissions from farms owned or controlled by farms (such as fertilizers and agricultural equipment), indirect emissions from energy consumption, and indirect emissions in the supply chain (such as transportation and packaging).

Producers and processors in the agri-food system have implemented current ESG reporting, which has led to a transfer of responsibility to farmers along the value chain. Economic agents downstream of agriculture impose restrictions on farmers in terms of pesticides, fertilizers, and so on, as well as new requirements in terms of quality and price. Under these conditions, it is normal for there to be a real reluctance of farmers to adopt sustainability criteria, especially when they involve investment in innovation and automation.

The EU Taxonomy (“EU Taxonomy for Sustainable Activities," Regulation 2020/852) [29] outlines the criteria for ecological sustainability in agriculture, such as reducing the impact of climate change, adapting to climate change, monitoring water resources, and protecting soil [17]. However, the taxonomy does not currently encompass all agricultural activities, including greenhouse crops, as it excludes agriculture from the adaptation annexes until the finalization of the current agricultural policy. The Farm2Fork strategy within the Green Deal, which imposes regulations such as agri-environmental measures, quality seeds, and emission reduction, does not fully integrate agriculture into non-financial reporting. However, the implementation of ESG measures in the supply chain has effects on farmers, even if they have not yet reported it.

The study of Mititean [25] looks at how European agriculture companies' corporate performance is affected by sustainability disclosure. Companies need to develop strategies for their environmental, social, and governance initiatives in light of the expanding global population and the new rules in Europe. According to the results, businesses with higher ESG scores outperform their competitors, giving investors a better idea of which industry to invest in.

Hristova [17] gives the example of Fonterra (a New Zealand milk cooperative), which, through its carbon reduction objective, required dairy farmers and upstream suppliers to reduce on-farm emissions to maintain access to the market. Various changes brought to the agricultural sector by agribusiness companies that have implemented ESG are also presented, such as traceability technologies, short supply chains, food e-commerce, technological solutions to reduce waste from harvest to delivery to the consumer, images from satellite, automatic systems in the farm, measures to improve the management of productive areas, tracking the carbon footprint, etc.

With the implementation of ESG standards, large companies in the agricultural and food sectors have implemented various measures at the supplier level to meet the requirements, such as ensuring product certification (Mega Image), promoting regenerative agriculture (Nestlé), collecting data on GHG emissions (Cargill), management software that allows automatic data collection (GHG, carbon footprint), etc. Moreover, agriculture can implement measures such as increasing the use of renewable energy, reducing energy consumption, decreasing food waste, reducing packaging pollution, reducing water consumption, and conserving biodiversity. In May 2024, the European Council postponed by two years the mandatory reporting in the agri-food sector. However, the possibility of farmers being required to report directly within the CSRD (even with partial data) in the next decade necessitates the integration of data collection into farm management processes such as agricultural stock management and input consumption.

Indicators used for ESG evaluation in the management process

When classifying indicators to meet ESG objectives, we identify several practical assessment methods, including those suggested by rating firms, specialized scientific papers, and European Commission standards.

The rating firms until now have used their systems to create aggregate indicators that included metrics such as: water used, energy, biodiversity, product innovation, carbon emissions, carbon footprint, land use, raw material supply, packaging materials, fuel consumption, recycling, resource efficiency, etc. (rating firms such as Refinitiv, Global ESG, Bloomberg, and MSCI). Veenstra and Ellemers [34] quantified 130 ESG scoring agencies using 237 unique indicators and over 600 corporate ESG indicators. Despite the abundance of indicators, they assert that an effective assessment of the integration of ESG objectives into the business model or its progress remains unattainable. Different rating companies communicate how to integrate ESG objectives into the corporate strategy through their sustainability scores, but Erokhina [8] asserts that these scores fail to demonstrate the cause-and-effect link. Moreover, sustainability reports based on ESG standards, be they ESRS, GRI, or SASB, manage to outline strategic directions but do not present quantifiable indicators of impact. All companies apply the general conditions universally, but they only consider the environmental, social, and governance criteria and their components as "material," meaning they are relevant to the specific type and operations of the company. However, we must understand that at the level of corporations, ESG reporting includes hundreds of indicators, many of which are not adaptable or commensurable to small and medium-sized companies.

Under these conditions, several scientific works have accounted for a series of key environmental, social, and governance performance indicators to analyze the performance of companies, referring to the scores given by different rating companies. For example, Gebhardt et al. [11] analyzed the effects of implementing key performance indicators (KPIs) within the internal management system on ESG performance. The study found a positive relationship between indicators, total ESG performance, and social performance, but with no conclusive results on the environmental and governance dimensions; Zhu et al. [36] analyzed the performance of

Chinese companies using 10 ESG indices adapted to different investment strategies; and Junius et al. [18] studied the impact of ESG performance on firm performance and market value across 271 companies. They studied the statistical relationship between the ESG score and 3 performance indicators (return on assets, return on equity, and Tobin's Q). Various criteria, including relevance, practicality, value for the end user, measurement method, representativeness, availability, etc., must be considered when selecting indicators, according to specialized works [21]. Another crucial factor is the unit of expression, as some indicators, like environmental goods, quality, and biodiversity, are challenging to measure. The selection of indicators must also consider the company's sector. In agriculture, such indicators, measured and combined within sustainability assessment tools, can reflect short- and long-term farm resilience as well as the ability to cope with market shocks [4].

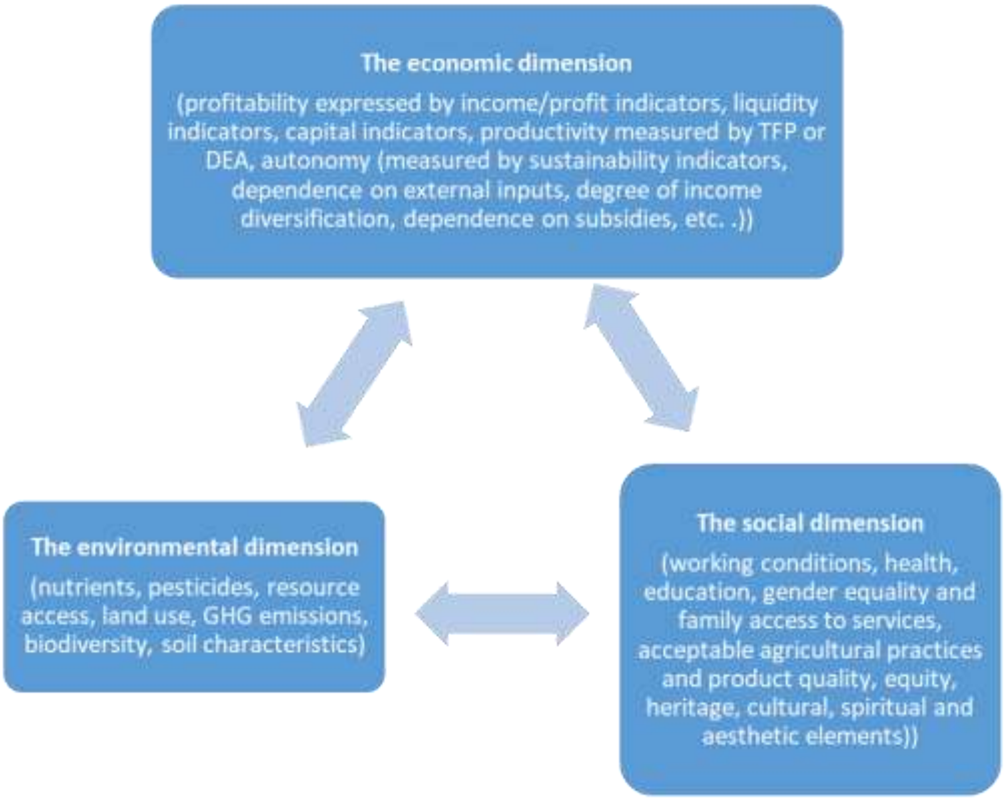

Fig. 2. Recommended indicators in sustainability assessment
Source: adapted from Latruffe et al. [20].

Existing techniques for monitoring agricultural sustainability often rely on measurement indicators that may not always be easily accessible, even when they assess these indicators separately (by weighting) or create a composite index [10]. Despite clearly established criteria for selecting indicators within the created models, significant constraints often arise in their construction due to their unavailability or limited commensuration capacity [21]. The indicators must provide a clear picture of the three dimensions of sustainability. For example, according to Latruffe et al. [20], the indicators used to measure sustainability at the farm level are presented in Figure 2.

The following elements are also important in agriculture:

-The characteristics of the indicators (whether utilized in financial or non-financial reporting). For instance, Hoinaru et al. [15] compared the requirements of the international accounting standard IAS 41-AAgriculture ("the accounting treatment and presentation of information on agricultural activities") and the GRI standard 13-AAgriculture, Aquaculture, and Fisheries. They showed that these standards are different but also work well together. The authors state that the GRI standard provides information on soil quality, ecosystem conservation, adaptation to climate change, food security, etc., while the IAS standard provides information on farm economics and agricultural environmental accounting that contribute to business sustainability.

-The sustainable development indicators used can be categorized according to the RISE method (54 indicators with scores from 1 to 100 classified into 10 categories), the Position Green software's method, other platforms for generating sustainability reports, or specific standards [24].

CONCLUSIONS

Integrating ESG standards into agricultural management presents both challenges and opportunities. The purpose of the CSRD and ESRS frameworks is to standardize sustainability reporting by giving businesses an organized way to reveal the effects they have on the environment, society, and government. However, there are some challenges in putting these standards into practice, such as the high expense of data collection and reporting, the intricacy of ESG factors, and the requirement for sector-specific modifications.

The issues mentioned by businesses included inconsistent data, a lack of industry-specific guidelines, and technical difficulties in adhering to reporting standards. Notwithstanding these difficulties, ESG reporting can boost a business's standing, enhance risk control, and provide new business prospects. Enhancing IT infrastructure, funding employee training, and implementing technologies for improved data management are necessary for a successful deployment.

To make adoption easier, future research should concentrate on improving ESG indicators and investigating industry-specific reporting requirements. Overall, despite its many challenges, the agricultural industry's transition to comprehensive ESG reporting has the potential to advance sustainability objectives and strengthen long-term economic resilience.

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SCENARIO FOR THE DEVELOPMENT OF VITICULTURE IN BULGARIA THROUGH THE CONTEXT OF THE GREEN DEAL

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Abstract

The challenges facing the development of agriculture and rural areas in Bulgaria during the CAP program period 2023-2027 are related to the renewal of production potential and the modernization of activities to improve competitiveness, added value, and well-being in rural areas. The enhanced environmental requirements laid down in the new CAP resulting from the "Green Deal" and the "Farm to Fork" strategy define the need to accelerate the pace of modernization of farm operations and improve the viability of rural areas. Closer linking of the Green Deal targets with economic, social, and environmental goals, as well as the mechanisms to achieve them, will define the future of the industry and rural areas in the coming decades. The purpose of this study is to forecast the main trends in the development of agriculture and rural areas in Bulgaria until 2027 in the context of the Green Deal. A linear scenario model is applied and the sensitivity of selected indicators is identified under certain assumptions in the independent variables. In crop production and specifically in the viticulture sector, efforts to close the production cycle must continue, while at the same time working in the direction of the possibilities for the realization of the final product - wine, increasing its competitiveness and using the potential of diversifying activities, such as wine tourism. The scenario approach is widely used in assessing the impact of climate changes on the future development of the viticulture sector in Bulgaria. According to the proposed scenarios for the selected indicators in rural areas, it can be assumed that the negative trend of depopulation in rural areas will continue, but at a slower pace than before, without a sharp deterioration in demographic indicators.

Key words: *scenario approach, agriculture, rural areas, Green Deal, Bulgaria*

INTRODUCTION

The challenges facing the development of agriculture and rural areas in Bulgaria during the CAP program period 2023-2027 are related to the renewal of production potential and the modernization of activities to improve competitiveness, added value, and well-being in rural areas (Borisov, P., Radev, T., Petrov, K., Kolaj, R., Arabska, E., 2023) [3]. The enhanced environmental requirements laid down in the new CAP resulting from the "Green Deal" and the "Farm to Fork" strategy [5] define the need to accelerate the pace of modernization of farm operations and improve the viability of rural areas. Closer linking of the Green Deal targets with economic, social, and environmental goals, as well as the mechanisms to achieve them, will define the future of the industry and rural areas in the coming decades.

The expected variability of the environment in which agriculture will function under the changed conditions of the agrarian policy creates uncertainty among producers. In this aspect, the application of the scenario analysis is a means of developing and discussing different options for the development of the individual sectors of agriculture, as a basis for determining appropriate policies and decisions applicable in the coming years.The scenario method is a process of forecasting the expected value of a certain indicator or set of indicators that are likely to occur in the conditions of a changing environment (Balaman, 2019) [2]. According to Kosow and Gaβner (2008) [8], the widespread definition of a "scenario" covers two main aspects: a description of a possible future situation and the development paths that could lead to that situation.In recent years, the scenario approach has been widely used in assessing the impact of climate change on the future development of the viticulture sector (Fraga et al., 2013, Quénol et al., 2014, Aouadi et al., 2021, Moral et al., 2022) [6, 11, 1, 9].

The purpose of this study is to forecast the main trends in the development of agriculture and rural areas in Bulgaria until 2027 in the context of the Green Deal. A linear scenario model is applied and the sensitivity of selected indicators is identified under certain assumptions in the independent variables.

MATERIALS AND METHODS

For the purposes of the present study, the application of the scenario method is reduced to the development of three main scenarios – pessimistic, moderate and optimistic, describing the expected state of the viticulture sector by 2027.

A comparative analysis and probability calculation methodology was applied (Ivanov, 2022) [7]. Scenario probabilities were determined based on covariance and z statistics. The measurement units of the selected indicators are expressed in parts per million (%o), according to the accepted methodology of the National Statistical Institute [12]. Only the average age of the mother at birth of a child is presented in years.

Three scenarios are envisaged for the population projections.They have been determined in accordance with the expert opinion of leading researchers and analysts in the country - University of National and World Economy, Sofia, Agricultural University, Plovdiv and Higher School of Agribusiness and Regional Development, Plovdiv. They were built on the basis of the expected socio-economic development in the rural areas of Bulgaria. According to the accepted general methodology of the planning topic, developed by Ivanov, B., 2022 [7] is set as the base year 2019/2020.As a reference point, the positive attitudes among the public regarding the Strategic Plan proposed by the Ministry of Agriculture and adopted by the European Commission for the new Program Period 2023-2027 are taken into account [13]. The scenarios reflect the final 2027 year of the period and are constructed based on the criteria and methodology of the National Statistical Institute, as follows:

I scenario - temperate. It complies with the norms of the European Union regarding the demographic and socio-economic development of the member countries;

II scenario - optimistic. It foresees that favourable socio-economic processes in the country with positive demographic indicators will be taken into account;

III scenario - pessimistic: A variant is set for unfavourable demographic and socio-economic processes in the country.

Based on the proposed scenarios, the model's algorithm gives a certain coefficient in the solution, which is practically accepted as an evaluation scale.It can be represented from 0 to 1. When in a range:

• From 0 - 0.2 - unfavourable assessment;
• From 0.2-0.45 - unsatisfactory assessment;
• From 0.45 - 0.65 - satisfactory assessment;
• From 0.65 - 0.8 - good assessment;
• 0.8- 1.0 - excellent rating.

The last group of coefficients (Scenario Likelihood) in the matrix gives information about the probability of the scenario to (not) happen.

RESULTS AND DISCUSSIONS

In crop production and specifically in the viticulture sector, efforts to close the production cycle must continue, while at the same time working in the direction of the possibilities for the realization of the final product - wine, increasing its competitiveness and using the potential of diversifying activities, such as wine tourism (Petrov, K., Borisov, P., 2021) [10]. The scenario approach is widely used in assessing the impact of climate changes on the future development of the viticulture sector in Bulgaria. According to the proposed scenarios for the selected indicators in rural areas, it can be assumed that the negative trend of depopulation in rural areas will continue, but at a slower pace than before, without a sharp deterioration in demographic indicators.

The starting point for the development of the scenarios is the situation in the viticulture sector during the base period 2019-2020.The total area of harvested vineyards with wine and dessert vine varieties, averaged over the two years, amounts to 29.4 thousand ha, of which 27.3 ha is the area of wine vineyards, and 2.1 ha - of dessert vines (Table 1).Viewed in dynamics over the years from 2007 to 2020, the trend of area change, both for wine grape production and for dessert grapes, outlines a decline.The comparison between the level of the indicator during the two periods of CAP application in the country shows that the negative dynamics is stronger in wine viticulture.The average level of the harvested area of vineyards with wine grape varieties in the period 2007-2013 was 56,699 ha, and in 2014-2020 it decreased to 31,039 ha (-45.3%).The area of harvested vineyards with dessert varieties averaged 2,614 ha in the first period of CAP application compared to 2,016 ha in the second, marking a decrease of 22.9%. The reasons for the reduction of harvested areas in the two sub-sectors are largely similar and primarily related to the significant capital and labor intensity of production, as well as the economic conditions and difficulties in the market realization of the production.The pace of renewal of plantations is extremely slow, and according to official data, as of 2020, the area of young, unfruitful vines represents 3% of the area of vines on farms, or approximately 1,410 ha.The slower rate of reduction in harvested areas in dessert viticulture can be explained to some extent by the subsidy provided under the production-linked support scheme.

The main financial resource that provides support in wine viticulture is the National Program to Support the Viticulture Sector for the period 2019-2023 [14]. The greatest importance in terms of maintaining and renewing the production potential is the measure "Restructuring and conversion of the vineyards", which is carried out in three main directions - conversion of the varietal composition of the plantations, change of the location of the vineyards and improvement of the management techniques the vineyards. Total, for 2019 and 2020, the issued participation certificates under the measure cover area of 3,745 ha, but the replanting permits for the same period cover 971 ha.

Table 1. Scenarios for the development of viticulture by 2027

Indicators	Base period 2019-2020	Scenario		
		Pessimistic	Temperate	Optimistic
Harvested areas of vine plantations, thousand ha	29.4	27.5	29.0	30.5
Production of grapes, thousand tons	168.2	179.0	188.5	197.9
Wine grape producer price index (%)	108.0	128	133	148
Material cost index (%)	126.0	170	140	130
Net farm income per hectare for wine grapes (euro)	-212.30	166	220	300
Share of the Gross product of grapes in the gross production of agriculture (%)	1.2	0.9	1.0	1.2

Source: Own calculations using Ivanov's methodology, Chapter I (2022) [7].

The constantly decreasing areas of vineyards in the country also determine the decline in grape production. Average for the base period, the total amount of production was 168.2 thousand tons, of which 155.6 thousand tons were wine grapes and 12.7 thousand tons were dessert grapes.

The decrease in the production of dessert grapes is less significant - by 2.6%.During the two base years, the production of grapes for fresh consumption remained above 12 thousand tons and above the level of 2018 – 11.8 thousand tons, which outlines a certain stability of the subsector.

Wine grape producers who do not have processing facilities are highly vulnerable to the change in price conditions, both in terms of inputs into production and in the realization of production.The producer price index, taken as a base, shows the increase in the price level in 2020 compared to the level of 2015, according to the official information of National Statistical Institute [12].

The established index of increase of material costs in wine viticulture for the base period 2019-2020 compared to 2015 is 126%.The value of the indicator was calculated based on data from the Agricultural Accounting Information System (FADN) for the input specific costs (expenses for plant protection preparations, fertilizers and other specific costs) per hectare of farms specialized in wine viticulture, which represent respectively 57% and 61% of the total amount of direct investments in the production activity in 2019 and 2020.

The net income is a result indicator of the activity of wine farms with a determining importance for the viability of the economic units operating in the sector.During the base period, its value is a negative, realized primarily due to the decrease in income from production in the conditions of growing maintenance of production.

The contribution of viticulture to the general development of agriculture is expressed through the share of the gross production of grapes in the total production of agriculture, and during the base period it is 1.2%.During the years from 2014 to 2020, the value of the indicator varies between 0.9% and 1.6%.

The system of primary (initial) and result indicators is the basis on which three scenarios have been developed for the development of viticulture in the period 2023-2027.

Pessimistic scenario

The scenario assumes that by 2027 the total area under vines with wine and dessert varieties will decrease by 2.6 hectares compared to the average level of 2019-2020.The loss of the part of the low-productive plantations will reduce the size of the farmed areas for the production of wine grapes to 25.6 thousand ha by the end of the forecast period and for dessert grapes to 1.9 thousand ha.The investments made in the renewal of the varietal composition, implemented with the mechanisms of the CAP 2014-2020, are likely to support the growth of productivity per unit area in wine viticulture in the coming years, which will ensure a level of wine grape production close to that of 2019 - 165.7 thousand tons.Production of dessert grapes will be slightly above the level of the base period - 13.3 thousand tons, but below the average level for 2015-2017 - 13.6 thousand tons.A relatively small increase in the price per producer of wine grapes is expected - by 28%, while direct material costs may increase by around 70%, as a result of continued increases in energy and fuel prices.The scenario envisages a minimum level of net farm income per hectare, determined on the basis of the average for the period 2017-2020, according to FADN data.This can be achieved with an increase in the volume of the obtained production and a certain reduction of the fixed costs of the activity (interest, insurance, rent payments) and other specific costs. The relative share of the gross production of grapes in the total production of agriculture will decrease to 0.9%, which determines the decreasing importance of the sector in the general framework of development of the Bulgarian agriculture.

Temperate scenario

The total harvested area of vineyards with wine and dessert varieties will be below the base level - 29 thousand ha.The area of vineyards for the production of wine grapes will decrease to 26.8 thousand ha.Under favorable market and economic conditions, the investment interest in dessert viticulture may increase, as a relatively small increase in the area harvested with dessert varieties is predicted - up to 2.2 thousand ha.The amount of wine grapes produced in the scenario by 2027 is 173.1 thousand tons and dessert grapes - 15.4 thousand tons.The scenario determines a temperate growth in the price of a producer of wine grapes - by 33%.The indicated increase in direct material costs in the amount of 40% is primarily the result of the expected inflationary processes and the increase in the price of resources with a slight to temperate increase in the amount of resources invested in production.The intended net farm income per hectare (€220) exceeds by 32.5% the pessimistic scenario, but the level of profitability remains relatively low compared to what is needed to improve and expand the production process.The described development of viticulture under the temperate scenario implies the retention of the sector's position in the general framework of agricultural dynamics by 2027 at the level of the base period - 1.2% share of the value of grape production in the total production of the sector.

Optimistic scenario

The scenario envisages more favorable economic conditions and a certain increase in entrepreneurial interest in viticulture, which can be supported by a complex of mechanisms within the framework of the agrarian policy applied in the country during the period. The total area of harvested vine plantations in this option is 30.5 thousand ha.It is expected that the areas of vineyards with dessert varieties will expand to 2.5 thousand ha, and those of vineyards with wine varieties - to 28 thousand ha.The simultaneous increase in average yields and harvested area will ensure a greater amount of production - 197.9 thousand tons, of which 180.4 thousand tons are wine grapes and 17.5 thousand tons are dessert grapes.The predicted increase in the price of a wine grape producer is more tangible than in the previous two scenarios - by 48% and exceeds the expected growth in material costs - by 30% more compared to the base period.On this basis, a higher level of net income per hectare (EUR 300) is outlined, with the excess compared to that predicted in the pessimistic scenario is 80.7%, and compared to that in the temperate scenario is 36.4%.As a result of the increase in grapes produced in the country and the significantly higher production price, the share of gross production from viticulture in the total production from agriculture may reach 2%.

The calculated covariance in Table 2 shows one-way change and almost insignificant differences between the indicator estimates and the real values of the indicators covered in the scenarios. The differences are smallest in the temperate scenario.

The probability for realization is highest in the temperate scenario (41.4%), followed by the optimistic one (40.9%).The pessimistic scenario is characterized by the lowest probability of implementation – 35.5%.

Table 2. Probabilities for realization of the scenarios

Indicators	Scenario		
	Pessimistic	Temperate	Optimistic
Covariance (CoVAR)	0.033	0.003	0.005
Primary probability for realization of the scenarios (PPROS)	0.367	0.415	0.412
Final probability for realization of the scenarios (FPROS)	0.355	0.414	0.409
Scenario Likelihood	0.129	0.151	0.149

Source: Own calculations using Ivanov's methodology, Chapter I (2022) [7].

The concept on which the temperate scenario is built is based on the expectation of a slowdown in the rate of manifestation of the negative dynamics in the harvested areas of vineyards with wine varieties and weak growth towards the end of the forecast period in the areas with dessert varieties.The range of intervention mechanisms in the viticulture sector will be expanded, such as those implemented in the last two program periods - "Restructuring and conversion", "Investments in the viticulture sector", "Harvest insurance", "Green harvesting" , "Information in Member States" and "Promotion in third countries" the measures "Promotion of wine tourism" and "Investment in environmental facilities" are added.Wine tourism is an opportunity to diversify the sources of income in viticulture and winemaking, and for a large part of wineries in the country this is not a new and unknown activity. The justification of the measure envisages that it will be implemented through recognized inter-branch organizations in the viticulture sector, which requires the maintenance of lasting relationships and cooperation between wine grape producers, wine enterprises and grape and wine traders.Supporting investments in renewable energy sources, treatment plants, composting installations and processing of other waste products is an opportunity to implement eco-innovations that can also contribute to more efficient implementation of the activity.

In dessert viticulture, it is planned to continuethe scheme for support tied to production, and in addition to it, a scheme for support tied to production will be applied for the income of plantations until they begin to bear fruit.Theapplication of the two measures may lead to some increase in investment activity in the subsector, which supports the expectation of a slight expansion of the area planted with dessert vines, indicated in the temperatescenario.

The increase in the production of wine and dessert grapes, according to the scenario, will occur mainly on the basis of the growth of average yields.In this aspect, increased environmental requirements and the desire to reduce the use of chemical preparations will be a challenge.The European Commission's medium-term forecast for the development of the European viticulture sector by 2032 envisages a decrease in average yields about 0.1% per year, both due to the recommended limitation of the amounts of pesticides and fertilizers used in production, and due to the climate changes- temperature and water stress [4].

These processes will also effect on the Bulgarian production of grapes and wine, but in view of the fact that the average yields from the vineyards in the country lag behind those in European countries with developed viticulture and wine production, the expectations are that the established trend of increasing the level of productivity from a unit area to continue in the coming years mainly on the basis of varietal renewal.

CONCLUSIONS

The results of the statistical analysis show that there is a probability of realization of all three developed scenarios. The most likely to be realized is the temperate scenario for the development of viticulture by 2027.The prerequisites for the realization of the temperatescenario are primarily related to the expansion of the complex of interventions in wine and dessert viticulture foreseen in the Strategic Plan for the Development of Agriculture 2023-2027.The threats for the implementation of this scenario, in view of the current economic situation seem much more serious.The rising prices of resources, the pressure of inflationary processes on consumers and the uncertainty of the international environment represent a challenge especially in terms of profitability in farms, and from there on investment intentions.In this aspect, improving the positions of wine and dessert grape producers along the supply chain is extremely important.Especially in the viticulture sector, efforts to close the production cycle must continue, while at the same time working towards the possibilities of realization of the final product - wine, increasing its competitiveness and using the potential of diversifying activities, such as wine tourism.The fact that this option is most likely to be implemented shows the need for political influence and support of the activity in the wine sector to achieve better than expected results.

The enhanced environmental requirements laid down in the new CAP, resulting from the "Green Deal" and the "Farm to Fork" strategy, determine the need to accelerate the pace of modernization of the activity in farms in connection with the implementation of digital technologies and technologies for precision agriculture and wider occurrence of varieties with increased resistance to stress factors.In this regard, it will be important to strengthen the links between manufacturers and scientific research organizations and to expand scientific research in this direction.

However, it should not be forgotten that the obtained results are the result of selected indicators and forecasts at an expert level.There are also a number of assumptions and assumptions built into the model, which means that trends are more important than exact numbers.The results can serve policymakers as a guideline for choosing impact policies, but in no case should concrete actions be taken based on the evaluation of the indicators from the application of the model.

ACKNOWLEDGEMENTS

This publication was developed in accordance with the implementation of the work program under the project "Stochastic analysis of the prospects and effects of the Green Deal in Bulgarian agriculture - GREENBASE", financed by the "Scientific Research" Fund, "Fundamental Scientific Research-2022" competition. Contract № КП-06-Н 66/3 - 13.12.2022. We express our thanks to FNI.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

EXPORT OF PRODUCTS OF THE AGRICULTURAL INDUSTRIAL COMPLEX OF UKRAINE IN THE PERIOD MARCH 2022–JANUARY 2024: ANALYSIS OF SEASONAL FLUCTUATIONS

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Abstract

The purpose of this article is to analyze seasonal fluctuations in the export of agricultural crops from Ukraine in the period March 2022–January 2024. The research used data from a dashboard created by the Office for Entrepreneurship and Export Development together with the Ministry of Agrarian Policy and Food of Ukraine and the Ministry of Infrastructure of Ukraine. In March-April 2022, the total export of a number of types of agricultural products was very low, but over time began to increase significantly and reached its peak in March 2023. This happened due to the adaptation of Ukrainian producers and exporters of agricultural products to the emergence of new challenges. Among Ukrainian agricultural products, corn and wheat have the greatest export potential (over 1.1 million tons per month on average), sunflower oil, meal, rape, soybeans, barley, and sunflower seeds have less potential (over 150,000 tons per month on average), the smallest potential has soybean oil (more than 20,000 tons per month on average). Most types of agricultural products have two distinct phases of export seasonality: growth and decline. In the analyzed period, a seasonal increase in exports was observed for corn – in November-March; wheat – September-February; meal – August-February; rape – August-December; soybeans – October-February. For other types of products, export growth and decline phases changed more often: the increase in sunflower oil exports occurred in November-February and September; barley – in September-February and July; sunflower seeds – in October-December, February and May-July; soybean oil – in October-January and May-July.

Key words: *export, agricultural crops, Ukraine, seasonal fluctuations, analysis*

INTRODUCTION

Starting from February 2022, the agro-industrial complex of Ukraine faced new challenges: problems with sowing campaigns and grain exports. Since export is a source of foreign exchange earnings for the country and contributes to its economic growth, which is extremely important in the current conditions, it is advisable to study the dynamics of export of agricultural products from Ukraine, in particular, to analyze seasonal fluctuations.

A number of publications by domestic authors are devoted to the study of various seasonal indicators in the activity of Ukrainian enterprises: N. I. Chystiak and K. V. Kovtunenko, (2017) – determined the content and essence of the influence of seasonality and factors of seasonality on the activity of wholesale trade enterprises [2]; A. V. Khmelyuk (2021) – analyzed seasonal fluctuations in the sale of water by a small business entity [5]; V. A. Yefanov (2018) – highlighted the dependence of the intensity of logistics operations on the seasonality of grain production [16]. Other domestic scientists focused their attention on the study of seasonal indicators in the foreign economic activity of Ukraine: O. V. Berezovska (2017) – revealed the peculiarities of the use of seasonal duties in the system of customs regulation of foreign trade of Ukraine [1]; N. V. Khalipova *et al.* (2009) – studied seasonal fluctuations in cargo flow during foreign economic activity [4]; O. K. Tkachova (2017) – investigated the use of separate economic and mathematical methods and models for the analysis and forecasting of seasonal fluctuations in the field of foreign economic activity [9]; O. K. Yelisyeyeva (2020) – clarified the need for seasonal adjustment of data from foreign trade statistics [17]. In addition, O. Totska investigated the foreign trade in products of the agricultural sector of Ukraine (2022a, 2022b, 2022c, 2022d) [10, 11, 12, 13]. Regarding the research of seasonal indicators in the agro-industrial complex of other countries, here we highlight the following publications: E. Stoian *et al.* (2014) – analyzed the seasonality of the international flower trade in Romania [8]; M. Velev (2018) – estimated the impact of the seasonality factor on employment and remuneration in agriculture in Bulgaria [14]; I. M. Vlad *et al.* (2014) – studied the seasonality of the total import and export of live animals and the separate sector of the live livestock trade in Romania [15].

The purpose of this article is to analyze seasonal fluctuations in the export of agricultural products from Ukraine in the period March 2022–January 2024.

MATERIALS AND METHODS

The research used data from the dashboard created by the Office for Entrepreneurship and Export Development together with the Ministry of Agrarian Policy and Food of Ukraine and the Ministry of Infrastructure of Ukraine (2024) [6]. Seasonality indices are calculated according to the formula:

$$i_s = \frac{\bar{y}_i}{\bar{y}} \times 100 \quad \text{..........} \qquad (1)$$

where:

$\bar{y}_i = \frac{\sum_i y_i}{k}$ is the average value of the indicator for each month;

$\bar{y} = \frac{\sum_j \bar{y}_i}{n}$ is the average value of the indicator for the entire period;

k is the number of years;

n is the number of months $(n = 1, 2, \dots, 12)$ [3].

In our case $k = 1, 2$ for all months except February; $k = 1$ for February.

RESULTS AND DISCUSSIONS

The actual export data of nine types of agricultural products of Ukraine from March 2022 to January 2024 are shown in Table 1. Since there are no data on the export of rape for March-June 2022, we will put zeros there. The average values of export indicators calculated on their basis for each month are given in Table 2.

Table 1. Export of agricultural products, tons

Year	Month	Corn	Wheat	Sunflower oil	Meal	Rape	Soybeans	Barley	Sunflower seeds	Soybean oil
2022	March	176,614	33,209	29,061	28,954	0	36,034	6,599	9,535	11,550
	April	600,966	9,199	129,607	39,177	0	57,159	11,776	104,049	16,384
	May	959,352	43,541	202,652	100,954	0	66,642	11,601	341,796	16,084
	June	1,013,841	138,435	267,487	93,219	0	71,274	26,045	540,118	18,015
	July	1,098,555	411,755	306,924	141,500	90,523	141,550	183,093	362,110	15,646
	August	1,850,670	899,627	390,571	286,224	624,460	128,369	206,798	153,924	22,401
	September	2,260,019	1,906,493	566,809	391,039	877,254	240,467	397,376	203,031	25,508
	October	2,316,591	1,979,534	433,181	457,234	777,602	230,364	383,477	290,421	25,867
	November	2,024,006	1,581,392	466,368	344,540	412,188	385,032	296,078	376,644	16,548
	December	3,261,374	1,554,649	467,833	330,653	236,796	387,419	179,003	311,550	20,386
2023	January	2,597,230	1,328,623	346,991	294,865	185,868	344,716	168,651	189,787	26,730
	February	3,162,981	1,496,912	409,149	376,190	59,588	401,929	248,137	154,413	20,683
	March	3,806,887	1,786,966	584,215	405,774	64,727	387,374	200,467	186,487	28,731
	April	2,720,112	1,537,772	514,750	284,344	21,980	172,800	193,653	63,485	22,881
	May	2,035,696	1,090,123	456,637	341,642	16,543	260,672	166,391	40,546	28,556
	June	2,352,834	1,271,566	452,732	446,064	9,971	190,839	81,620	21,893	29,234
	July	1,099,313	841,480	502,410	239,716	250,856	70,145	352,228	4,067	27,881
	August	877,138	1,224,404	412,676	332,665	670,340	29,869	146,566	5,688	11,354
	September	627,608	1,272,959	359,964	376,586	649,820	210,399	120,198	6,488	11,286
	October	1,283,543	1,341,132	374,676	391,470	385,798	431,512	54,408	52,379	22,180
	November	2,330,109	1,130,590	506,218	387,397	349,495	505,832	181,368	38,584	27,551
	December	3,116,164	1,844,404	672,776	487,957	330,703	418,074	250,514	27,079	29,757
2024	January	2,930,642	1,503,671	525,940	421,502	320,871	312,616	290,370	36,310	22,052

– minimum values, – maximum values.

Source: Generated by the author based on dashboard data (2024) [6].

Table 2. Average values of agricultural products export indicators for each month ($\bar{y}_i$), tons

Month	Corn	Wheat	Sunflower oil	Meal	Rape	Soybeans	Barley	Sunflower seeds	Soybean oil
January	2,763,936	1,416,147	436,466	358,184	253,370	328,666	229,511	113,049	24,391
February	3,162,981	1,496,912	409,149	376,190	59,588	401,929	248,137	154,413	20,683
March	1,991,751	910,088	306,638	217,364	32,364	211,704	103,533	98,011	20,141
April	1,660,539	773,486	322,179	161,761	10,990	114,980	102,715	83,767	19,633
May	1,497,524	566,832	329,645	221,298	8,272	163,657	88,996	191,171	22,320
June	1,683,338	705,001	360,110	269,642	4,986	131,057	53,833	281,006	23,625
July	1,098,934	626,618	404,667	190,608	170,690	105,848	267,661	183,089	21,764
August	1,363,904	1,062,016	401,624	309,445	647,400	79,119	176,682	79,806	16,878
September	1,443,814	1,589,726	463,387	383,813	763,537	225,433	258,787	104,760	18,397
October	1,800,067	1,660,333	403,929	424,352	581,700	330,938	218,943	171,400	24,024
November	2,177,058	1,355,991	486,293	365,969	380,842	445,432	238,723	207,614	22,050
December	3,188,769	1,699,527	570,305	409,305	283,750	402,747	214,759	169,315	25,072
Average ($\bar{y}$)	1,986,051	1,155,223	407,866	307,327	266,457	245,126	183,523	153,117	21,581

Source: Calculated by the author based on Table 1.

As we can see, in the analyzed period, corn and wheat were mostly exported from Ukraine (over 1.1 million tons per month on average), while sunflower oil, meal, rape, soybeans, barley, and sunflower seeds were exported to a lesser extent (over 150,000 tons on average per month), soybean oil was the least exported (more than 20,000 tons per month on average).
In the first two months of the war (March-April 2022), the total export of analyzed agricultural products was very low, but over time began to increase significantly and reached its peak in March 2023.
The negative factors that influenced the decrease in exports in connection with the hostilities in the region were:
1) a significant decrease in cultivated areas. Thus, in 2022, for the first time since 1991 the sown area for grain and leguminous crops reached a minimum value of 12,171 thousand hectares, although in 2021 their area was 15,995 thousand hectares [7];
2) decrease in the number of agricultural enterprises;
3) emigration and internal displacement of citizens;
4) mobilization of agricultural machinery and transport for other purposes;
5) logistical problems, etc.
Therefore, domestic producers and exporters of agricultural products had to adapt to new circumstances. Indexes of seasonality of agricultural products export indicators are presented in Table 3, and seasonal waves are shown in Figures 1–3.

Table 3. Indices of seasonality of agricultural products export indicators (i_s), %

Month	Corn	Wheat	Sunflower oil	Meal	Rape	Soybeans	Barley	Sunflower seeds	Soybean oil
January	139	123	107	117	95	134	125	74	113
February	159	130	100	122	22	164	135	101	96
March	100	79	75	71	12	86	56	64	93
April	84	67	79	53	4	47	56	55	91
May	75	49	81	72	3	67	48	125	103
June	85	61	88	88	2	53	29	184	109
July	55	54	99	62	64	43	146	120	101
August	69	92	98	101	243	32	96	52	78
September	73	138	114	125	287	92	141	68	85
October	91	144	99	138	218	135	119	112	111
November	110	117	119	119	143	182	130	136	102
December	161	147	140	133	106	164	117	111	116

– less than 100 %, – more than 100 %.
Source: Calculated by the author based on Table 2.

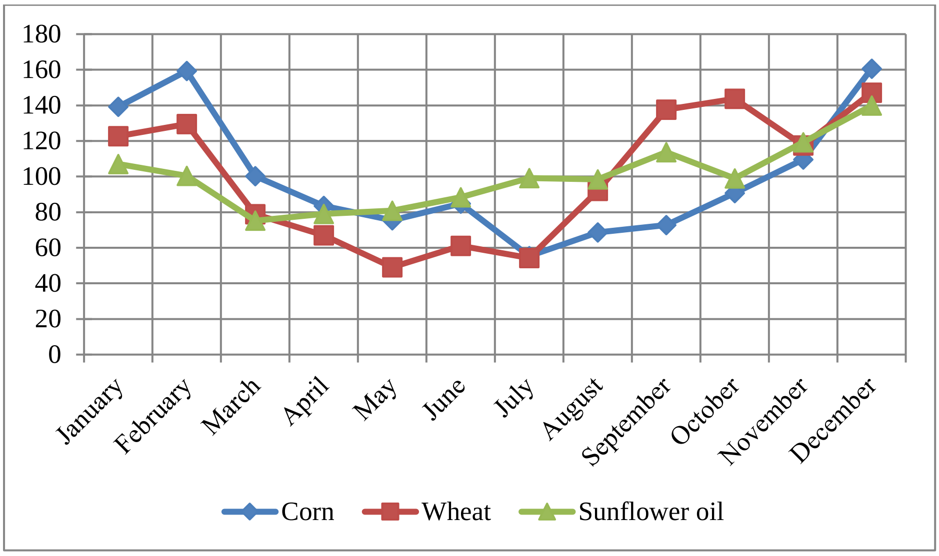

Fig. 1. Seasonal waves of export of corn, wheat, sunflower oil
Source: Author's development based on the data of Table 3.

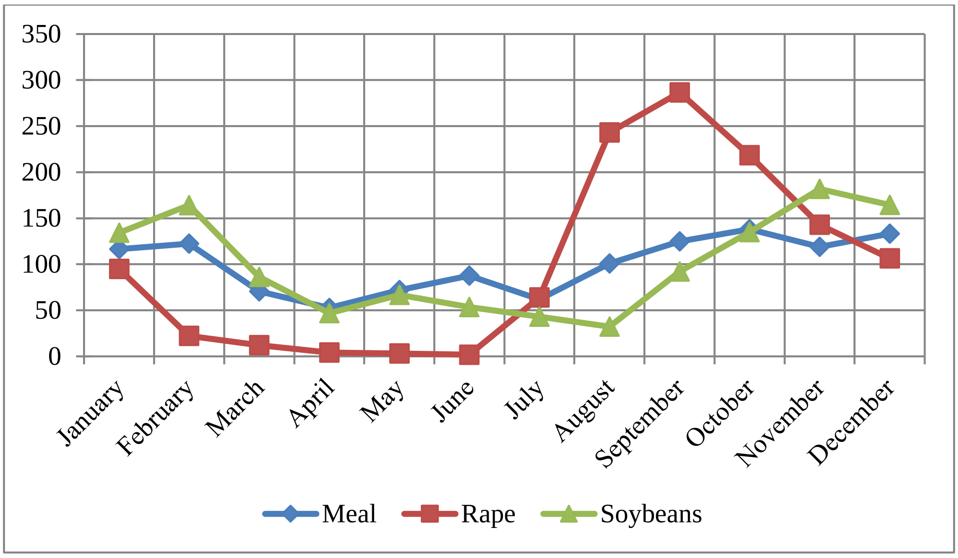

Fig. 2. Seasonal waves of exports of meal, rape, soybeans
Source: Author's development based on the data of Table 3.

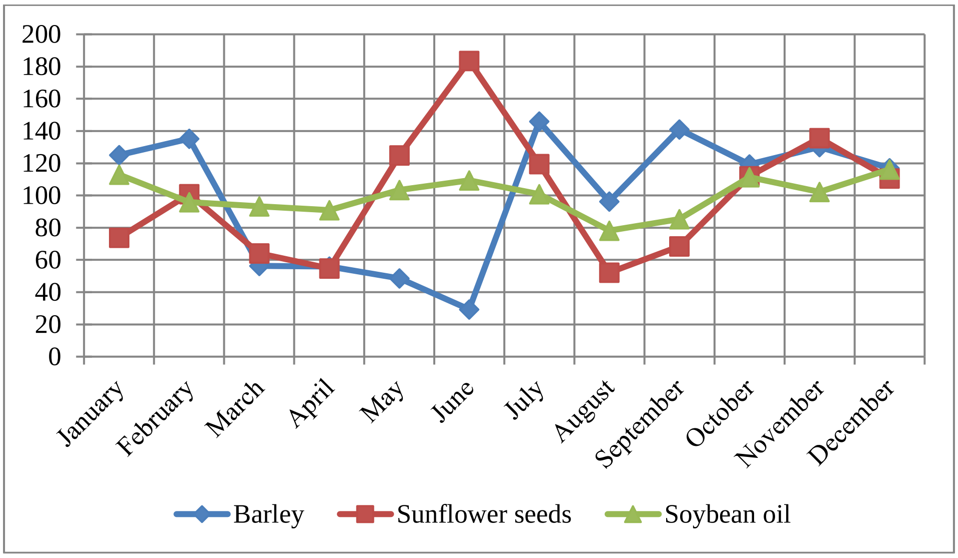

Fig. 3. Seasonal waves of export of barley, sunflower seeds, soybean oil

Source: Author's development based on the data of Table 3.

Note that seasonality indices are used to study seasonal fluctuations. Seasonal fluctuations are more or less stable intra-annual fluctuations in a number of dynamics, which are caused by specific conditions of production and consumption of certain goods or services [2].

Fig. 1 shows that the peak seasonality of corn exports falls on three winter months: December, January and February; wheat – September, October and December; sunflower oil – September, November and December. The seasonal minimum of corn exports is observed from July to September; wheat – from May to July; sunflower oil – from March to May.

As shown in Fig. 2, the maximum values of the seasonality of export of meal occur in September, October and December; rape – August-October; soybeans – February, November, December. And the minimum indices of seasonality of meal export fall on March, April and July; rapeseed – April-June; soybeans – April, July, August.

Fig. 3 shows that the export of barley, sunflower seeds, soybean oil does not have a pronounced seasonality.

CONCLUSIONS

In 2022, the Office for Entrepreneurship and Export Development, together with the Ministry of Agrarian Policy and Food of Ukraine and the Ministry of Infrastructure of Ukraine, created a dashboard for operational interactive information of the public and business regarding the export of agricultural products. Based on the data of this panel, it is possible to analyze the dynamics of export indicators by month and calculate seasonality indicators.

In particular, in the period March-April 2022, the total export of a number of agricultural products (corn, wheat, sunflower oil, meal, rape, soybeans, barley, sunflower seeds, soybean oil) was very low, but over time began to increase significantly and reached its peak in March 2023. This happened thanks to the adaptation of Ukrainian producers and exporters of agricultural products to the emergence of new challenges: a decrease in cultivated areas and the number of agricultural enterprises, emigration and internal displacement of citizens from the affected area, mobilization of agricultural equipment and transport for other purposes, as well as logistical problems.

Among Ukrainian agricultural products, corn and wheat have the greatest export potential (over 1.1 million tons per month on average), sunflower oil, meal, rape, soybeans, barley, and sunflower seeds have less potential (over 150,000 tons per month on average), the smallest potential has soybean oil (more than 20,000 tons per month on average).

The construction and analysis of seasonal waves of exports of agricultural products for the period from March 2022 to January 2024 allow us to draw the following conclusions: most types have two distinct phases of export seasonality: growth and decline. In particular, a seasonal increase in exports was observed for corn – in November-March; wheat - September-February; meal – August-February; rape – August-December; soybeans – October-February. For other types of products, export growth and decline phases change more often: sunflower oil exports increase in November-February and September; barley – in September-February and July; sunflower seeds – in October-December, February, May-July; soybean oil – in October-January, May-July.

We see further directions of scientific research in the study of the dynamics and analysis of the seasonality of the export of agricultural products of Ukraine by type of transport (ferry, car, railway, ports).

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ANALYSIS OF THE DYNAMICS AND IDENTIFICATION OF SEASONAL FLUCTUATIONS IN UKRAINIAN AGRICULTURAL EXPORTS BY TYPE OF TRANSPORT

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Abstract

The purpose of this article is to analyse the dynamics and identify seasonal fluctuations in Ukraine's agricultural exports by type of transport from March 2022 to February 2024. The analysis uses a dashboard on the state of foreign trade in agricultural products. It contains a number of interactive diagrams on border crossings for nine types of goods (corn, wheat, sunflower oil, meal, rapeseed, soya beans, barley, sunflower seeds, soya oil) and four types of transport (ports, rail, road, ferries). The analysis shows that in March 2022 – February 2024, Ukrainian farmers exported an average of 4.768 million tonnes of products per month, of which 3.548 million tonnes were exported through ports, 837.9 thousand tonnes by rail, 321.2 thousand tonnes by road, and 61.6 thousand tonnes by ferries. The lowest volumes of exports of agricultural products were observed in March 2022, followed by a gradual increase. Exports by all types of transport are characterised by two waves of seasonality: growth (seasonality indices exceeding 100%) and decline (seasonality indices below 100%). For ports, these phases last in September-February and March-August; for rail transport, in August-February and March-July; for road transport, in July-November and December-June; and for ferries, in July-October and November-June. The seasonality of agricultural exports is related to the seasonality of their production, weather conditions, and the work of the customs services of Ukraine and the countries through which they are exported.

Key words: *exports, agricultural products, seasonal fluctuations, types of transport, Ukraine*

INTRODUCTION

Ukraine is a major agricultural country that supplies agricultural products not only to the domestic market but also to other countries around the world. Due to the special conditions that the country faced in February 2022, domestic farmers faced a number of challenges, including transporting their products for export. Today, exporters can use the following four types of transport: ports, rail, road, and ferries.

Various aspects of the use of transport by agricultural enterprises of Ukraine have been studied by the following domestic scholars: M. V. Babii (2017) analysed the problems of transport logistics in the agricultural sector of Ukraine and proposed directions that would increase the balance between different types of transport due to the developed highly efficient logistics programmes [1]. K. S. Chymosh, (2020) studied the conditions for the development of transport logistics in the agricultural sector of the economy [2]. I. Yu. Lesnikova *et al.* (2023) determined the optimal route for the transportation of agricultural products under martial law [6]. M. O. Mikulina *et al.* (2020) investigated methods of improving the efficiency of transport technologies in agricultural production [7].

K. V. Nechyporenko (2014, 2015) studied the peculiarities of organisation and management in the use of vehicles by agricultural enterprises [9], analysed the state and trends in the development of transport logistics of agricultural enterprises [10].

S. V. Pron and I. I. Vysotska (2016) formed the author's definition of the "transport system of agricultural works", taking into account the peculiarities of growing crops and resource-saving technologies [13].

H. Yu. Rodashchuk (2013) determined the importance of taking into account the transport factor in the production sector of agriculture [14].

A. M. Shashman and I. Yu. Hlukhova (2017) studied the organisation of the work of motor transport of agricultural enterprises in the Donetsk region and provided directions for improving the efficiency of motor transport use in modern conditions [15]. A. Ye. Velychko and I. Yu. Hlukhova (2013) analysed the work of motor transport units of agricultural enterprises of Donetsk region to determine unused reserves [21].

In addition, L. Nekrasenko *et al.* (2021) identified the peculiarities of logistics and searched for alternative forms and methods of delivering grain products to storage and sales locations (ports) [11].

O. Totska analysed the foreign trade in agricultural products of Ukraine (2022a, 2022b, 2022c, 2022d) [16, 17, 18, 19].

Foreign scientists have studied the following aspects of agricultural transporting: P. Coto-Millan *et al.* (2018) estimated the price and income elasticities for transporting agribusiness products for air import and export in Spain [3].

S. M. Ferguson and M. R. Olfert (2016) assessed the impact of the abolition of railroad subsidies on the adoption of production technology on Western Canadian farms [4]. R. S. Gray (2020) assessed how disruptions in transport services related to COVID-19, as well as new demands for transport services, could affect Canadian agricultural supply chains [5].

J. C. Perez-Mesa *et al.* (2020) studied the viability of intermodal transporting of horticultural products from southeastern Spain to the rest of Europe [12].

B. Wetzstein *et al.* (2021) studied the cost of transporting agricultural goods on the Mississippi River system in the USA [22].

The purpose of this article is to analyse the dynamics and identify seasonal fluctuations in Ukraine's agricultural exports by type of transport since March 2022.

MATERIALS AND METHODS

Agricultural exports from Ukraine are taken from the dashboard "State of Foreign Trade in Agricultural Products" (2024) [8].

Seasonality indices are calculated using the formula:

$$i_s = \frac{\bar{y}_i}{\bar{y}} \times 100, \qquad (1)$$

where:

$\bar{y}_i = \frac{\sum_i y_i}{k}$ – the average value of the export indicator for the i-th month;

y_i – the value of the export indicator for the i-th month;

k – number of years ($k = 2$);

$\bar{y} = \frac{\sum_{i=1}^{12} \bar{y}_i}{n}$ – the average value of the export indicator for the entire period (in our case, March 2022 – February 2024);

n – number of months ($n = 12$).

RESULTS AND DISCUSSIONS

The dashboard "State of Foreign Trade in Agricultural Products" is a joint development of the Ministry of Agrarian Policy and Food of Ukraine, the Ministry of Infrastructure of Ukraine, and the State Agency "Entrepreneurship and Export Promotion Office".

It contains a number of interactive diagrams to inform stakeholders about export volumes by certain types of goods and modes of transport according to the Unified Automated Information System "Delivery Control".

The charts show exports by the following types of agricultural products: corn;

wheat; sunflower oil; meal; rapeseed; soya beans; barley; sunflower seeds; soya oil.

Border crossings of agricultural products are shown in Table 1 and Table 2.

The dynamics of the indicators in Table 1 indicates that the lowest exports of agricultural products were observed in March 2022, followed by a gradual increase (due to the adaptation of commodity producers and carriers to the new conditions in which the country found itself).

The highest export figures were observed for ports in February 2024, rail transport in December 2022, road transport in November 2022, and ferries in August 2023.

The maximum exports of agricultural products by all types of transport could be observed in March 2023.

Table 1. Dynamics of border crossings of agricultural products by type of transport, tonnes

Year	Month	Ports	Railways	Road	Ferries	Total
2022	March	55,670.16	252,916.31	22,893.92	76.20	331,556.59
	April	265,656.93	601,739.47	91,551.34	9,368.31	968,316.05
	May	798,803.25	709,616.00	212,089.23	22,112.31	1,742,620.79
	June	1,069,847.23	746,792.96	323,375.32	28,418.82	2,168,434.33
	July	1,405,173.25	832,374.84	477,605.67	36,501.87	2,751,655.63
	August	2,941,375.62	954,962.84	624,886.59	41,817.72	4,563,042.77
	September	5,166,260.36	1,030,253.74	639,668.89	31,814.16	6,867,997.15
	October	5,239,526.23	970,199.89	638,569.51	45,974.34	6,894,269.97
	November	4,060,184.42	1,119,027.16	676,682.37	46,902.71	5,902,796.66
	December	5,075,521.89	1,152,357.52	480,113.75	41,669.32	6,749,662.48
2023	January	3,959,208.86	1,069,546.31	422,996.71	31,711.64	5,483,463.52
	February	4,802,926.46	1,020,485.31	465,462.33	41,105.69	6,329,979.79
	March	5,792,583.48	1,075,272.58	483,404.16	100,369.66	7,451,629.88
	April	4,568,183.86	644,344.29	229,811.22	89,438.16	5,531,777.53
	May	3,526,873.83	638,584.70	186,095.84	85,251.47	4,436,805.84
	June	3,900,758.38	675,281.24	190,290.32	90,423.91	4,856,753.85
	July	2,364,863.25	681,612.15	197,672.66	143,948.12	3,388,096.18
	August	2,391,881.80	913,325.72	258,925.37	146,566.97	3,710,699.86
	September	2,322,819.09	956,812.94	247,689.16	107,985.04	3,635,306.23
	October	3,130,703.28	861,969.62	225,879.79	118,546.48	4,337,099.17
	November	4,294,667.09	941,695.65	184,747.15	36,034.05	5,457,143.94
	December	6,141,763.71	839,775.62	135,648.78	60,239.08	7,177,427.19
2024	January	5,485,271.20	685,686.52	139,925.62	53,092.94	6,363,976.28
	February	6,381,011.52	733,861.21	153,672.54	69,821.87	7,338,367.14

– minimum values,
– maximum values.

Source: Generated by the author based on dashboard data (2024) [8].

Table 2. Border crossings of agricultural products by type of product and type of transport, tonnes

Products	Ports	Railways	Road	Ferries	Total
Corn	35,450,311	10,122,373	1,674,427	172,260	47,419,371
Wheat	24,545,504	2,877,778	1,080,980	223,670	28,727,932
Sunflower oil	6,780,251	1,491,728	1,310,974	387,662	9,970,615
Meal	4,651,958	2,069,256	486,321	308,359	7,515,894
Rapeseed	3,747,157	1,739,467	1,054,743	53,338	6,594,705
Soya beans	3,944,485	941,584	729,355	150,235	5,765,659
Barley	3,948,160	210,841	136,031	67,439	4,362,471
Sunflower seeds	2,042,766	394,432	1,023,585	94,185	3,554,968
Soya oil	30,943	261,034	213,243	22,043	527,263
Total	85,141,535	20,108,493	7,709,659	1,479,191	114,438,878

Source: Generated by the author based on dashboard data (2024) [8].

According to Table 2, during the analysed period, the overall exports of agricultural products by individual types of transport were as follows: ports: 85.142 million tonnes; rail transport: 20.108 million tonnes; road transport: 7.710 million tonnes; ferries: 1.479 million tonnes.

In other words, domestic farmers mainly use ports and rail transport to export their products, and to a lesser extent, road transport and ferries. Ports are the leaders in terms of transportation of corn, wheat, sunflower oil, meal, rapeseed, soya beans, barley and sunflower seeds; railways are the leaders in terms of soya oil.

It is worth noting that, according to the Register of Seaports of Ukraine [20], nine ports are currently open: Bilhorod-Dnistrovskyi seaport; Izmail seaport; Mykolaiv seaport; seaport of Odesa; specialised seaport of Olvia; seaport of Pivdennyi; seaport of Reni; Ust-Dunaisk seaport; seaport of Chornomorsk.

Their number has decreased: in 2014, the ports of Yevpatoria, Kerch, Sevastopol, Feodosia, Yalta were closed in the temporarily occupied territory of the Autonomous Republic of

Crimea; in 2022, the ports of Berdiansk, Mariupol, Skadovsk, and Kherson were closed due to the inability to ensure an adequate level of shipping safety.

The average values of the indicators and the seasonality indices calculated on their basis are presented in Table 3.

Table 3. Average values ($\bar{y}_i$) and seasonality indices (i_s) of agricultural exports by type of transport for each month

Month	Average values, tonnes					Seasonality indices, %				
	Ports	Railways	Road	Ferries	Total	Ports	Railways	Road	Ferries	Total
January	4,722,240	877,616	281,461	42,402	5,923,720	133	105	88	69	124
February	5,591,969	877,173	309,567	55,464	6,834,173	158	105	96	90	143
March	2,924,127	664,094	253,149	50,223	3,891,593	82	79	79	81	82
April	2,416,920	623,042	160,681	49,403	3,250,047	68	74	50	80	68
May	2,162,839	674,100	199,093	53,682	3,089,713	61	80	62	87	65
June	2,485,303	711,037	256,833	59,421	3,512,594	70	85	80	96	74
July	1,885,018	756,993	337,639	90,225	3,069,876	53	90	105	146	64
August	2,666,629	934,144	441,906	94,192	4,136,871	75	111	138	153	87
September	3,744,540	993,533	443,679	69,900	5,251,652	106	119	138	113	110
October	4,185,115	916,085	432,225	82,260	5,615,685	118	109	135	133	118
November	4,177,426	1,030,361	430,715	41,468	5,679,970	118	123	134	67	119
December	5,608,643	996,067	307,881	50,954	6,963,545	158	119	96	83	146
Average ($\bar{y}$)	3,547,564	837,854	321,236	61,633	4,768,287	100	100	100	100	100

– less than 100 %,
– more than 100 %.

Source: Calculated by the author on the basis of Table 1.

Thus, during March 2022 – February 2024, Ukrainian farmers exported an average of 4.768 million tonnes of products per month, of which 3.548 million tonnes were exported through ports, 837.9 thousand tonnes by rail, 321.2 thousand tonnes by road, and 61.6 thousand tonnes by ferries.

Seasonality indices with a value of more than 100% were observed for ports in September-February, for rail transport in August-February, for road transport in July-November, and for ferries in July-October. Seasonality indices with a value of less than 100% were observed for ports in March-August, for rail transport in March-July, for road transport in December-June, and for ferries in November-June, respectively. This is due to the seasonality of production, weather conditions and the work of the customs services of Ukraine and the countries through which the goods are transported.

Seasonal waves of agricultural exports for each type of transport are shown in Figures 1–4.

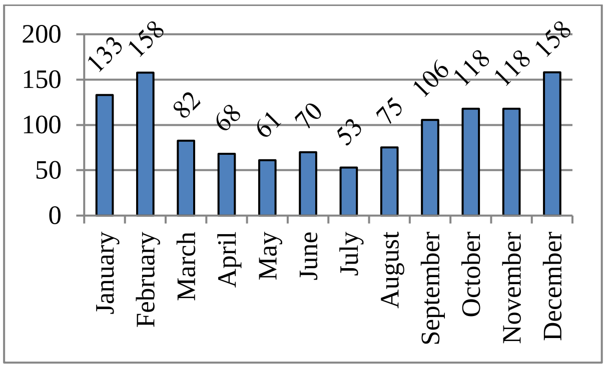

Fig. 1. Seasonal wave of agricultural exports through ports
Source: Built by the author on the basis of Table 3.

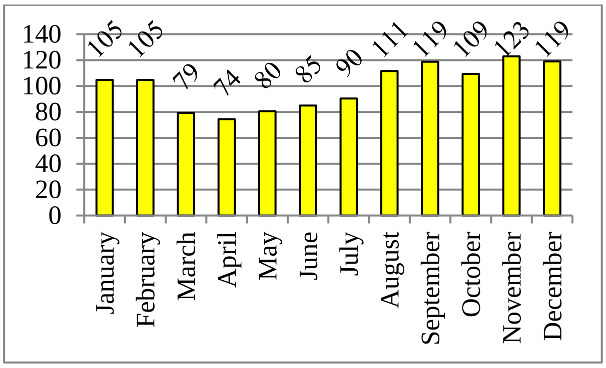

Fig. 2. Seasonal wave of agricultural exports by rail
Source: Built by the author on the basis of Table 3.

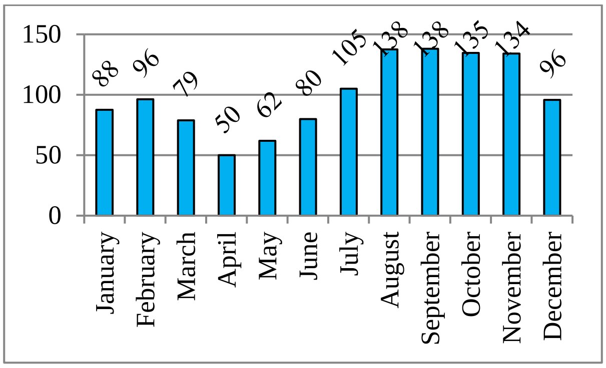

Fig. 3. Seasonal wave of agricultural exports by road
Source: Built by the author on the basis of Table 3.

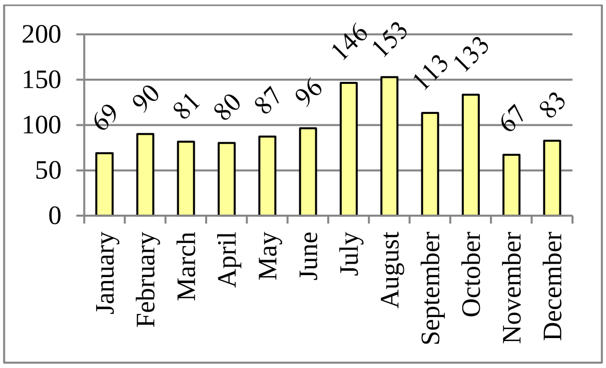

Fig. 4. Seasonal wave of agricultural exports by ferries
Source: Built by the author on the basis of Table 3.

Figures 1–4 show that the peak seasonality of agricultural exports through ports was in December-February; by rail – September, November-December; by road – August-October; by ferries – July-August and October. The seasonal minimum for exports of agricultural products through ports was observed in April-May and July; by rail and road – from March to May; and by ferries – in January, April, and November.

CONCLUSIONS

Ukrainian farmers, carriers and other stakeholders have been able to track information on agricultural exports since March 2022, using a dashboard developed jointly by the Ministry of Agrarian Policy and Food of Ukraine, the Ministry of Infrastructure of Ukraine, and the State Agency "Entrepreneurship and Export Promotion Office". It contains a number of interactive diagrams on border crossings for nine types of goods (corn, wheat, sunflower oil, meal, rapeseed, soya beans, barley, sunflower seeds, soya oil) and four types of transport (ports, railways, road transport, ferries).

The dynamics of exports of agricultural products indicates that the lowest volumes were observed in March 2022, after which they gradually increased (due to the adaptation of producers and carriers to the new conditions in which the country found itself). The highest export figures were observed for ports in February 2024, rail transport in December 2022, road transport in November 2022, and ferries in August 2023.

Between March 2022 and February 2024, Ukrainian farmers exported an average of 4.768 million tonnes of products per month, of which 3.548 million tonnes were exported through ports, 837.9 thousand tonnes by rail, 321.2 thousand tonnes by road, and 61.6 thousand tonnes by ferries.

Exports by all modes of transport are characterised by two waves of seasonality: growth (seasonality indices exceeding 100%) and decline (seasonality indices below 100%). For ports, these phases last in September-February and March-August; for rail transport, in August-February and March-July; for road transport, in July-November and December-June; and for ferries, in July-October and November-June. The seasonality of agricultural exports is related to the seasonality of their production, weather conditions, and the work of the customs services of Ukraine and the countries through which the goods are transported.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

NATIONAL RURAL DEVELOPMENT PROGRAMME - NRDP 2014-2020 CONTRIBUTION TO MARKET INTEGRATION OF SMALL AND MEDIUM-SIZED FARM PRODUCTION IN ROMANIA

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Abstract

The Romanian system of small and medium farms generates significant amounts of agricultural raw materials, an important part of which remains outside the market. On the other hand, Romania registers ever-increasing deficits in the trade balance with food products for which, however, it would have sufficient potential to be covered from national resources. In the current context of frequent crises and external shocks affecting the flow of goods and the availability of food globally (pandemics, armed conflicts, blockages in international transport, price volatility resulting from the growing demand for food for food from an increasingly large global population), increasing autonomy in ensuring food from internal sources appears as a necessity for ensuring economic and social stability. Agricultural policies are called to contribute to this goal by supporting a better integration of Romanian farm products in national agri-food chains. The paper aimed to carry out an assessment of Romania's vulnerability to food insecurity caused by dependence on agri-food imports during the 2013-2022 period, supplemented by an analysis of the contribution of the National Rural Development Plan 2014-2020 to the reduction of this risk. The study caried out an literature review on the analysed topic and a descriptive analysis of secondary statistical data provided by the National Institute of Statistics - regarding the trade balance and by the Payments and Interventions Agency for Agriculture - regarding the public intervention through NRDP 2014-2020. The study showed that, during the analysed period, Romania consolidated its position as a supplier of agricultural raw materials with low added value and, on the same time, its dependence on processed food imports significantly increased. NRDP measures have had low effectiveness in reducing food insecurity risks. The authors recommend re-shaping of public policy to support the local processing sectors for which the trade balance registers the largest deficit and for which Romania already supports the increase in the performance of primary production.

Key words**:** *market integration, agri-food system, agri-food trade balance*

INTRODUCTION

According to experts' calculations, Romania has a significant agricultural potential, having the possibility to cover the food consumption needs of 38.5 million people [12], almost double the country's population. However, after 1989, the agri-food trade balance was and remains deficient [10], [2].

Romania's dependence on agri-food imports entails a whole series of risks in terms of ensuring the food security of the population, out of which the most important are:

- food availability - sufficiency of agricultural and processed food production, the risks in ensuring food supply generated by different shocks and crisis (climatic, social and economic conflicts etc.), the ability to distribute food at national level,
- food accessibility - evaluates the ability of consumers to buy food, their vulnerability to price variations that could be generated also by above mentioned kind of crises [3].

Both parameters mentioned above can suffer significant damage in situations of import dependence especially when shocks and crises intervene in the functioning of global supply chains (see the blockages in international transport generated by the recent pandemic with COVID-19) or humanity facing a global food shortage [1]. In this context, increasing the coverage of the Romanian population's food consumption from domestic production must represent a priority objective of policies and programs in the field of agri-food industry, as stated by the experts of the Romanian Academy. The emphasis is placed on those agri-food products where the Romanian trade balance is deficient (processed foods, vegetables, fruits, meat) [18].

As a result, the purpose of this research is to carry out an ex-post analysis of the responsiveness of the National Rural Development Plan (NRDP) 2014-2020 to the need to increase degree of self-sufficiency from domestic production, especially for processed foods, products for which Romania has a significant dependence on imports.

MATERIALS AND METHODS

Firstly, a descriptive statistical analysis of the structure and evolution of agri-food trade balance for Romania was performed, to capturing the *vulnerability to food insecurity* that our country faces from the perspective of import dependence.

Main aggregates of the trade balance was performed based on a statistical analysis and led to deepening the study on agri-food sector structural deficiencies.

NRDP interventions aimed at correcting the structural deficiencies of Romanian agri-food industry responsible for most of the deficit in the trade balance were analysed in the second part of the study to evaluate their effectiveness and formulate recommendations leading to the increase of the efficiency of this category of public policies in the future and, through this, to decrease the food vulnerability of Romanian population.

Both, for descriptive analysis of the trade balance with agri-food products and for the structure of the Romanian agri-food sector, the secondary statistical data provided by the National Institute of Statistics (NIS) for NRDP 2014-2020 implementation period were used. The data of the Payments and Interventions Agency for Agriculture (AFIR) for the implementation of the NRDP 2014-2020 constituted the documentary basis for the second part of the analysis and mainly concerned the Multi-annual programme measures dedicated to supporting the integration of domestic products into the agri-food chains:

i) investments in processing / marketing of agri-food products (sM4.2) and

ii) supports horizontal and vertical cooperation between the actors in the agri-food supply chain (sM 16.4).

RESULTS AND DISCUSSIONS

Although for the year 2013, statistical data on agri-food foreign trade show that Romania's trade balance was a bit positive, however, a significant imbalance is revealed by the structural analysis. Thus, a large part of Romania's agri-food exports consists of agricultural raw materials (with low added value) and imports are primarily represented by processed food products (with high added value). Moreover, exports are dominated by cereals and oilseeds, which have become the main specialization of (large) farms in Romania [1]. Therefore, in order to increase the contribution of the agri-food industry to the GDP, a change in the productive paradigm would be necessary through: restructuring through the diversification of agricultural production, increasing the processing capacity of domestic agricultural raw materials [4] to cover the consumption needs of domestic production (not from import). The need for these changes was revealed by the SWOT analysis and included into the objectives of the NRDP 2014-2020.

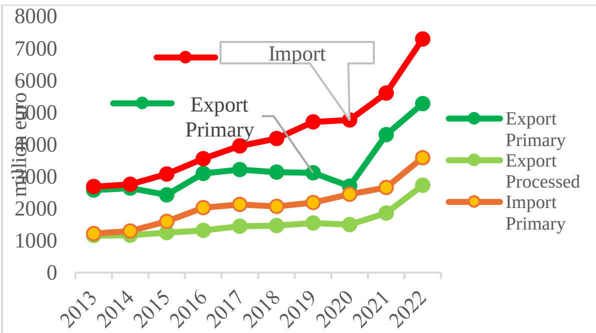

Fig. 1. Structure of Romanian agrifood trade balance
Source: NIS, Tempo on-line database, [TBQ0253] [9].

However, during the period on implementation of the NRDP 2014-2020, Romania's trade balance with agri-food products continued to

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

deteriorate, with the value of processed food imports increasing almost three times while exports of raw materials increased only two times (Fig. 1).

Degree of market integration of agricultural raw materials, especially those of animal origin, fruits and vegetables produced, in particular, by small and medium-sized farms in Romania [14] was and continues to be at a low level. Thus, statistical data for 2013 showed that less than a third of the quantities of these primary agricultural products reached the market. On the other hand, the agricultural products of the large farms (cereals, oilseeds and industrial plants) are primarily intended for the market (Fig. 2).

Limited market integration of small and medium-sized agricultural producers is motivated, primarily by the poor development of the marketing and processing infrastructures for the raw materials offered by them, as well as the poor suitability of the marketing and processing capacities to the characteristics of their supply (territorial fragmentation and low homogeneity) [15], [17], [16].

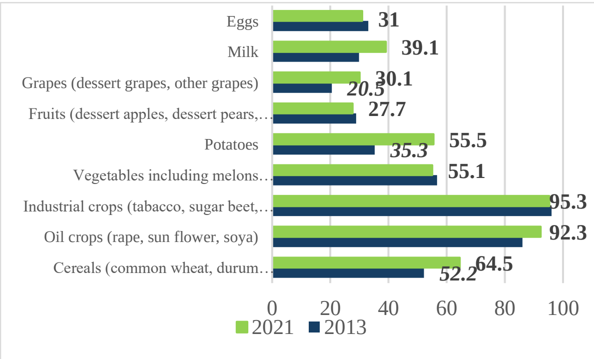

Fig. 2. Share of sales outside the industry in total gross agricultural production-quantitative (2013 & 2021)
Note: sales outside the agricultural industry = transfer of agricultural raw products to processing, consumers or export (exclusive self-consumption and transfer for other uses within the agricultural branch)
Source: NIS, Tempo on-line database, [TBP0252] [9].

NRDP support for market integration of domestic products

The most important of the NRDP 2014-2020 measures which, in the opinion of the authors, aimed at increasing the market integration of Romanian products were sub-measure 4.2. "Investments for processing/ marketing of agricultural products" and sub-measure 16.4. "Supports horizontal and vertical cooperation between the actors in the agri-food supply chain".

Next, we will analyse the implementation of these measures during the 2014-2021 programming period with reference to their effectiveness in responding to the needs of sustainable integration of domestic agricultural production on the market.

Sub-measure 4.2. "Investments for processing/ marketing of agricultural products"

The incomes of individual farmers are low in Romania, to a great extent because they sell unprocessed raw agricultural products. To increase the incomes of small farmers, an important role can be played by adding value to farm products through processing, accompanied by an adequate marketing to promote the final products on the market. Sub-measure 4.2 "Investments for processing/ marketing of agricultural products" responds to this major challenge that Romanian farmers are facing, small farmers in particular.

Adding value through the processing of raw agricultural products and the approach to new market niches through the development of new agri-food products are the main activities for which support is received under this sub-measure.

The degree of accessing sM 4.2 was low among potential beneficiaries. The highest addressability was found for the Commercial companies (85% from total number of project that received fund under sM 4.2), functional Cooperatives and Producer groups. However, we mention that the share of beneficiaries in total eligible operators reached low weights, between 2 and 3% (2.3% for Commercial companies and Producer groups, respectively 2.9% for Cooperatives). For the other categories of eligible operators for sM 4.2, the number of funded projects was much lower (Table 1).

Only 25% of the amounts invested through sub-measure 4.2 were directed to projects for processing and marketing of products with animal origin, and other ¾ were dedicated to crop products processing (Fig. 3).

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 1. Structure by legal forms of eligible operators and beneficiaries of sM 4.2

Legal status	No. of registered operators potentially eligible for support	No of projects financed by s.M 4.2****
Registered person	16,042*	7
Commercial companies	13,308*	305
Cooperatives	1,486**	43
Producer group	131***	3
Total	**31,293**	**358**

Sources: *NIS – Farm structure survey 2016; ** MARD - National register of agricultural cooperatives in Romania; ***MARD – Producers groups database, https://www.madr.ro/docs/dezvoltare-rurala/grupuri-producatori/grupurile-producatorilor-recunoscute-update-01.04.2021.pdf; **** AFIR database [9, 5, 13].

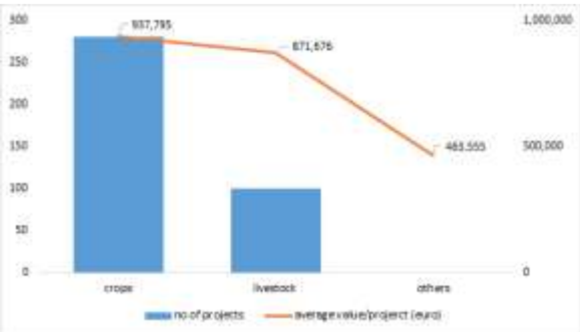

Fig. 3. Structure of projects financed under sub-measure 4.2 by specialization and average value in euro
Source: AFIR database [13].

The reduced investment in processing facilities for animal products, leads to the export as raw products of the live animals, meat, milk etc. (which are additionally created as a result of investments in the development of livestock farms through sub-measures 4.1, 6.1, 6.3 of NRDP 2014-2020). The reduced synergy between measures financing the development of livestock farms and those supporting the processing of livestock products can lead to negative effects such as: low value added and minimum effects on farmers' welfare and also on the economic performance of the Romanian agri-food industry.

According to the respondents benefitting from NRDP support through sM4.2, "the measure had a medium contribution to the support of associative forms, such as producer groups and agricultural cooperatives, which contribute to the creation of synergies between farmers" [5].

Sub-measure 16.4. "Supports horizontal and vertical cooperation between actors in the agri-food supply chain"

Sub-measure 16.4 was dedicated for promoting local actors' cooperation for sell the agri-food products through short food supply chains under cooperation partnerships. Through that, sM16.4 provided support for a horizontal and/or vertical cooperation between different actors from the (local and short) agri-food supply chain: farmers, processors, traders, NGOs, local councils, schools, healthcare, leisure and public catering units. Into this, sub-measure 16.4a was dedicated to cooperation in the fruit sector.

For sM16.4, eligible applicants were partnerships among actors in the primary production sector (farmers, farmer's cooperatives, producer groups) and final consumption actors (local councils/townhalls, school units, medical units etc.). The data from AFIR database showed that by the end of March 2021, 136 contracts had been signed under sub-measure 16.4 (99 projects for sub-measure 16.4 and 37 projects for sM 16.4a). Hypothetically, 9.2% of functional cooperatives, benefitted from support under sub-measure 16.4.

40% of the projects signed for sM16.4 were concentrated in only 2 counties (Cluj- 32% and Hunedoara – 8%). For sub-measure 16.4.a, most projects were contracted by the counties Cluj 27% and Satu Mare 19%. There are counties with tradition in fruit farming, with no contracted project under sub-measure 16.4a: Covasna, Iași, Brașov, Sălaj, Dolj, Buzău, Sibiu, Alba, Arad, Argeș, Bacău, Caraș-Severin, Mehedinți, Neamț, Prahova, Suceava (AFIR database).

Also, NPRD had a beneficial impact in other counties from the South Muntenia region like Calarasi, Teleorman, Dambovita, Ialomita [11].

By type of investment promoted through sM16.4 and sM16.4a, the funded projects could be classified as follows:

-16% aimed to establish and develop short supply chains,

-4% had as objective the establishment and development of local markets,

-80% aimed to establish and develop local markets through short chains exclusively [6].

According to the Evaluation Study of NRDP, 90% of respondents in the opinion poll consider that the projects under sM 16.4 had a major impact in the integration of small agricultural producers in the agri-food chain. The survey addressed to sM 16.4 beneficiaries (from the Evaluation Study II of NRDP) showed that the projects had averagely about 5 partners. The created partnerships rather represent the first cooperation attempt between the involved subjects than the continuation of previous cooperation or the extension of the experience of partners who have collaborated or cooperated in other development programs [5].

Indeed, "Local markets" principle applied in the selection of projects funded through sM 16.4 and sM 16.4a stimulated the integration of small producers in the short supply chains on local markets [8] but the absorption rate of the amounts allocated in the NRDP for this measure barely exceeded 20% at the end of the year 2021. It seems that a major impediment in accessing the measure was the given definition of the local market, considered impractical by small farmers whose farms are located at distances greater than 50 km of urban markets [15].

The conclusions of the evaluation studies indicate that the impact of NRDP 2014-2020 measures on the increase of the bargaining power of small farms is low - only 50% of beneficiaries noticed an improvement in this respect. But all beneficiaries agree that the NRDP strategy facilitates cooperation, with the following considerations: for the larger-sized holdings (over 12,000 standard output), NRDP capacity to support integration in the supply chain and promotion on local markets is considered relatively low (6 scores were assigned, on the average, of total 10 scores), while for the small holdings (less than 12,000 standard output), NRDP seems to have a higher contribution (an average of 7 scores were assigned for the integration of small holdings and 9.5 scores for promotion on local markets). These findings can be explained by the farm size, the smaller the farm, the greater the effectiveness of NRDP support. Moreover, the partnerships, mainly consisting of medium-sized farms, are not necessarily interested in the demand of local markets, as their products (e.g. grains, durum wheat, etc.) are not products intended for sale on the local market, but for processing or wholesale marketing and export. In the near future, the association forms could affect and even modify the supply chain, provided that the demand for local products becomes stronger [7].

CONCLUSIONS

The capacity of the Romanian agri-food system to cover the food needs of the population from internal sources seems to be deteriorating rapidly, especially in terms of processed food. The Romanian farm system, especially the small and medium ones, produces significant quantities of primary agricultural products that are not integrated into the market. Attracting the currently under-utilized primary agricultural production into the agri-food chains could cover part of the deficit in the trade balance with agri-food products.

The NRDP 2014-2020 support contributed to the increase of small farms participation in agri-food chains, but there are impact differences across sectors and measures. Thus, NRDP support through sM 4.2 was less effective in the integration in the value chain of animal products, vegetable and fruits of small holdings and supported more processing and market integration of cereals, oilseeds and industrial crops produced mostly by bigger farmers. Also, sM 16.4 and 16.4a were considered helpful on integrating small farmers on short food supply chains but was hindered by "local market" definition applied.

Therefore, the impact of the NRDP 2014-2020 on balancing the agri-food trade balance was reduced.

A more appropriate targeting of public policy measures is recommended to support the development of those processing sectors for which the trade balance registers the largest deficit and for which Romania already supports the increase in the performance of primary production: meat, milk, tomatoes, fruits. Adequacy of support to the characteristics of primary production (fragmented) through the establishment of local / micro-territorial capacities for storage and primary processing of agricultural raw materials could contribute to limiting the under-utilization of the production of small farmers.

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MARKET LEVEL OF AGRI-FOOD PRODUCTS IN ALBANIA, LOCAL PRODUCTION, COMPETITIVENESS AND IMPACT OF MARKETING

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Abstract

The climate that prevails in Albania and the type of agricultural land are favourable for new cultures and agricultural products that have higher benefits than other products that have been cultivated so far. Developing and increasing the capacities of existing products is one of the main components in a small or medium-sized company. A progressive company should preemptively address the planning and expansion of its product range and diversity of culture where it operates in order to remain competitive in the market. To achieve this, companies nowadays need to implement the most effective marketing strategies. Marketing is increasingly emerging as the most significant aspect for companies in the agri-food sector, serving as the primary means of customer orientation, with arguments as to why they should choose a company's products or services over other competitors. With the advancement of technology, the utilization of marketing and its elements is increasing more and more, as the best way to achieve the desired profit, target performance and competitiveness in the market. The purpose of this paper is the analysis of the existing situation in the development of the competitiveness of agri-food products as a result of the application of marketing, through which the market will be studied and make the agricultural producer aware of the increase of their performance in the market, through the production of quality and cost-effective products. Regarding the methods used, this research is supported by the data collected through the questionnaires distributed to the interviewed business managers, while the secondary data is the result of the information provided through the literature. This method has facilitated the comparison of the different variables used to test the hypotheses. The results reveal that agri-food production companies and farms have started to apply marketing in various forms, both in social and traditional media, creating better competitive positions in the market and increased production capacities allowing for the substitution of imported products with local products. Consequently, it has influenced the increase in consumer confidence in Albanian products and brands.

***Key words*:** *marketing, agricultural products, competitiveness, competitive advantages.*

INTRODUCTION

Agriculture and Agro-industry are among the main sectors of development of the Albanian economy, also due to the fact that Albania is a developing country with increasing employment needs. The sustainable development of agriculture holds a multi-functional importance because, in addition to the production of foodstuffs, its role is to extend to rural employment, revitalizing social life in underdeveloped areas, maintaining population balances, protecting nature and improving health. Agriculture bears greater economic importance for countries that intend to be members of the EU (Albania, Kosovo, North Macedonia, Montenegro, Bosnia and Herzegovina, and Serbia) than EU member countries (Council of Ministers of the Republic of Albania, 2016) [2].

Despite facing many challenges, Albania has created evidenced policies to support the agricultural sector, through which it has aimed to increase local production capacities, increase competitiveness and reduce agricultural imports, as well as alignment of agricultural policies with the common EU agricultural policies. These policies aim to improve competitiveness, increase productivity, and reduce import dependence for agricultural products. Albania has yet to identify comparative potentials and competitive advantages as well as increase production, in order to replace imported products with local products, particularly agri-food products (SASPAC, 2022) [10].

In this paper, special importance is given to the impact of marketing and its elements on increasing the performance of businesses, mainly companies in the agri-food sector. In fact, the marketing plan includes four main aspects: 1) your customers; 2) your market; 3) your niche; 4) your budget (AGMRC, 2021) [1]. In Albania, minimal attention has been given to the treatment of marketing strategies both in the theoretical aspect, as well as in the analysis of the practical implementation of these strategies (International Trade Administration, 2021) [5]. This article aims to address marketing with its elements, functions, advantages, and the positive effects it has on the products of this sector. Marketing in agriculture and agroindustry differs from marketing in other sectors of the economy because of the specific features of this sector. This is due to the fact that production is seasonal and concentrated in geographical areas that are usually far from the final consumer (Xhepa and Liperi, 2021) [12]. With these seasonal agritourism businesses, it is essential to make sure you offer your customers an unforgettable experience (PennState Extension, 2023) [9]. Additionally, agricultural products must be collected, carefully selected and transported to the market or stored in warehouses for a certain period of time. Referring to these characteristics of agricultural products, until they are presented on the market, they go through several other stages, such as: storage, transport, processing, and sale.

Based on all the aforementioned features, it can be concluded that marketing in agriculture can be defined as a combined activity that enables the movement of products from the producer to the final consumer, while the marketing system can be defined as a set of systems and factors that enable movement of the goods from the producer to the final consumer (Ministry of Agricultural and Rural Development, 2019) [8]. Marketing stands out as one of the most important elements that influence the increase in the performance of agri-food products. Marketing is essential and has a direct impact, for achieving goals and increasing competitiveness in the target market.

This study focuses on Albanian producers who have conducted prior market research, managed to secure contractual agreements within or outside the country with buyers, based on the quality of the product and being competitive in the market, and also have managed to provide better prices for their products compared to other competing products and in addition have provided some form of guarantee and security in the market for the following years (Hoxha, 2022) [4].

Given these circumstances, it is imperative to find a marketing model, suitable for producers, that enables them to be more competitive in the local market, but also penetrate regional markets and beyond, based on marketing strategies which enable the creation of a suitable and easily applicable model by the manufacturers of these products with the main goal of reducing costs and creating competitive advantages in this very competitive market category not only from domestic products, but also from imports. Actually, in the future years, intelligent marketing of agricultural products, which is based on big data analysis, is predicted to the major growing trend in agricultural production and marketing services (Liu, 2020) [7].

The purpose of this paper is to analyze the current situation in the development of the competitiveness of agricultural products as a result of the application of marketing. This analysis involves studying the market and raising awareness among agricultural producers about increasing their performance in the market. Additionally, the paper aims to propose a marketing model for the Albanian agricultural producer to reduce cost and increase competitiveness in the market.

The main objectives in achieving the purpose of the work are:

Analysis of marketing implementation and preparation of research methodology according to the requirements arising from the questionnaires and basic hypotheses.

Drawing conclusions and providing recommendations and proposing a marketing model to be followed by agricultural producers.

MATERIALS AND METHODS

In order to carry out this work and to achieve the aim and objectives of the work, a basic hypothesis has been put forward:

Hypothesis 1: *The application of marketing to agricultural products increases their competitiveness in the market.*

Research questions and expected contribution

Throughout the paper, two fundamental research questions are addressed:

(1)What is the state of implementation of marketing and how oriented are agricultural businesses in the application of marketing?

(2)What is the competitive position of local producers in comparison to agricultural products that are imported from abroad?

While the expected contribution will be the proposed model for marketing to agri-food companies in Albania.

Methodology

This research can be considered exploratory or confirmatory. In this context, confirmatory research tests hypotheses. The results achieved help in decision-making, suggesting a specific orientation of actions.

The quantitative method of data collection includes the analysis of the main data collected mainly through questionnaires. The sample size is not less than 30 and not more than 50, which is deemed suitable for conducting this study.

It is essential to emphasize that the applied methodology in this paper aligns with its purpose and is based on these research elements:

-Data sources: Combination of secondary and primary data were used. The main research is supported by the data collected through the questionnaires distributed to the interviewed business managers, while the secondary data is the result of the information provided through the literature.

-Research methods: Throughout this paper, the quantitative method of data collection was employed, mainly utilizing questionnaires. This method has facilitated the comparison of the different variables used to test the hypotheses presented.

-Data processing: It is based on the application of various statistical methods such as SPSS Excel, descriptive analysis, cross tables and analysis methods, as well as representation and correlations between phenomena.

-Research samples: 30 different businesses involved in the production or processing of agricultural products were surveyed, from which: 5 producers/processors of milk, 7 producers/processors of non-alcoholic beverages from trees, 7 producers from vegetables, 5 producers of alcoholic beverages, 2 meat processors, 2 processors of flour products, and 2 processors of oil products.

-Period the study: this research was carried out in the period March - November 2023.

Research methods

Research methods in this study encompass statistical methods, multivariable methods along with factor analysis, regression techniques, correlation and forecasting techniques.

The multivariable method serves as a technique aiming to unveil relationships and decisions about marketing models, which emerge as a result of the interaction and interdependence between the main variables simultaneously. For this purpose, the following frequency model was used:

The variable

	Frequency	Percent	Valid Percent	Total Percent
Valid				

Factor analysis helps identify relationships between variables and forms "scores" (factors) for these variables. It usually determines the company's marketing image, consumer behaviour and attitudes. In our case, the **"Pearson Correlation"** was used, whose formula is expressed as:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

where:

r =correlation coefficient

n = number of pairs or points

Σxy= sum of products or points

Σx= sum of **x** points

Σy = sum of **y** points

Σx² = sum of **x** points squared

Σy² = sum of **y** points squared

RESULTS AND DISCUSSIONS

Study Results Analysis

The findings of the research are primarily based on responses to general questions, followed by questions related to marketing activities and concluding the validation of hypotheses according to the Pearson Correlation model.

To analyze this paper, the study involved interviewing 30 managers of 30 companies representing various agricultural sectors. The selection criteria include companies and farms with more than 10 employees.

Question 1: What are the forms of marketing that your company mostly implements?

The results given by the respondents reflected that the most commonly forms of marketing used by the interviewed business managers are as follows:

-The combination of Internet Marketing + Television and Radio Marketing + Catalogue Marketing with 31.7%,

-The combination of Internet Marketing comprises 25%,

-The combination of Internet Marketing and catalogs makes up 21.7%.

Competition in the market is perceived as strong by all sectors, as more than 80% of the company managers in each sector have stated that they encounter strong competition (Table 1).

Table 1. What are the forms of marketing that your company mostly implements?

		Frequency	Percentage	Valid Percentage	Total Percentage
Valuable	Internet Marketing	15	25.0	25.0	25.0
	Television and radio marketing	4	6.7	6.7	31.7
	Catalogue marketing	2	3.3	3.3	35.0
	Internet Marketing + Television and Radio Marketing	6	10.0	10.0	45.0
	Internet Marketing + Television and Radio Marketing + Catalogue Marketing	19	31.7	31.7	76.7
	Internet and catalogue marketing	13	21.7	21.7	98.3
	Internet Marketing + Fairs	1	1.7	1.7	100.0
	Total	60	100.0	100.0	

Source: Results based on the respondents' answers.

Question 2 - What competition does your business face in the market?

Based on the data from Table 2, it is evident that more than 80% of the surveyed business managers think they encounter strong competition in the market, while 18.3% perceive the competition as average, and only 1.7% or one business considers that there is no competition.

Table 2. What competition does your business face in the market?

		Frequency	Percentage	Valid Percentage	Total Percentage
Valuable	Strong competition	48	80.0	80.0	80.0
	Average	11	18.3	18.3	98.3
	We have no competition	1	1.7	1.7	100.0
	Total:	60	100.0	100.0	

Source: Results based on the respondents' answers.

Question 3. Do you consider that your competition is increasing the pressure to reduce product prices?

It appears that 71.7% of respondents believe that competition heightens the pressure to lower product prices. 16.7% of respondents feel that competition exerts average pressure to reduce prices, while one interviewee, who faces no competition in the market, asserts that there is no pressure from competitors to reduce prices (Table 3).

Question 4. How do you rate your customers in terms of purchasing power?

Of all the interviewees, 78.3% of them evaluate the purchasing power of the consumer as average. 11.7% evaluate the purchasing power of the consumer as low, while 10% of the interviewees evaluate the purchasing power of the consumer as high (Table 4).

Table 3. Do you consider that your competition is increasing the pressure to reduce product prices?

		Frequency	Percentage	Valid Percentage	Total Percentage
Valuable	Yes	43	71.7	71.7	71.7
	Average	10	16.7	16.7	88.3
	Low	7	11.7	11.7	100.0
	Total:	60	100.0	100.0	

Source: Results based on the respondents' answers.

Table 4. How do you rate your customers in terms of purchasing power?

		Frequency	Percentage	Valid Percent	Total Percent
Valuable	High	6	10.0	10.0	10.0
	Average	47	78.3	78.3	88.3
	Low	7	11.7	11.7	100.0
	Total:	60	100.0	100.0	

Source: Results based on the respondents' answers.

Results from crosstabs

In this section, the results obtained through processing with SPSS are presented, mainly through the model of cross tables. This model is used to showcase the correlation between the independent variables (x) and the dependent variables (y), as well as the cross tables where the results confirming the correlation or rejecting it are presented through the "Pearson Correlation" accompanied by a two-sided significance test (sig 2 – tailed).

"Market price-market success" correlation

In Table 5, two variables are compared and the results indicate that a Pearson Correlation coefficient reveals no positive relationship between the two variables, r = -.196, n = 60, p = 0.133.

Table 5. Correlation- Market price- market success- Correlations

		Do you think that the price of the product is decisive in creating a competitive advantage in the market?	Do you think that for success in the market, the company should be based on: quality, price, or both?
Do you think that the price of the product is decisive in creating a competitive advantage in the market?	Pearson Correlation	1	-.196
	Dig(2-Tailed)		.133
	N	60	60
Do you think that for success in the market, the company should be based on: quality, price, or both?	Pearson Correlation	-.196	1
	Dig(2-Tailed)	.133	
	N	60	60

Source: Own results.

In general, there is no strong positive relationship between “Do you think that product price is decisive in creating a competitive advantage in the market?” and “Do you think that for success in the market, the enterprise should be based on: quality, price, or both?”

The robust relationship does not exist as the price of the product does not create a competitive advantage in the market in relation to success as a result of quality, price or both.

Consumers of agricultural producers place a higher value on the brand (brand name) and exhibit loyalty built over years towards the agricultural products of the companies/farms that serve as a case study for this paper.

"Market success- product price" Correlations

In Table 6, the following two variables were compared: “Do you think that the price of the product is decisive in creating a competitive advantage in the market?” and “Do you think that for success in the market, the company should be based on: quality, price or both?”

The results indicate that a Pearson Correlation coefficient revealed no positive relationship between the two variables, r = -.196, n = 60, p = 0.133.

In general, there is no positive relationship between the following two variables: “Do you think that for success in the market, the enterprise should be based on: quality, price, or both?” and “Do you think that the price of the product is decisive in creating a competitive advantage in the market?”

The absence of a positive relationship between the two variables indicate that companies do not consider only price and quality when determining competitive advantage. Consequently, other variables that have an impact on creating competitive advantage in the market should be analysed.

"Place of action- industry" Correlations

In Table 7, the variable “Country/Region of operation” is compared with the variable “Industry where it operates?”. The calculations reveal a Pearson Correlation coefficient, indicating a strong positive relationship between the two variables, r = .250, n = 60, p = 0.045.

Table 6. Correlation- Market success- product price- Correlations

		Do you think that for success in the market, the company should be based on: quality, price, or both?	Do you think that the price of the product is decisive in creating a competitive advantage in the market?
Do you think that for success in the market, the company should be based on: quality, price, or both?	Pearson Correlation	1	-.196
	Dig(2-Tailed)		.133
	N	60	60
Do you think that the price of the product is decisive in creating a competitive advantage in the market?	Pearson Correlation	-.196	1
	Dig(2-Tailed)	.133	
	N	60	60

Source: Own results.

Table 7. Correlation- Place of action- industry- Correlations

		Country/ Region of Operation?	Industry where it operates?
Country/Region of Operation?	Pearson Correlation	1	.250
	Dig(2-Tailed)		.045
	N	60	60
Industry where it operates?	Pearson Correlation	.250	1
	Dig(2-Tailed)	.045	
	N	60	60

Source: Own results.

In general, a strong positive relationship exists between the two variables, signifying that the place of activity or operation and the industry, mainly the sector, have a positive relationship that is reflected in the working conditions, geographical region, origin of the raw material, proximity to the supplier, proximity to the collection points, and also in the proximity to the potential consumer, which consequently can be concluded that all these elements combined influence the reduction of the cost of agri-food products.

Verification of hypotheses

The tables below present the validation of the hypotheses

H1: Consumer loyalty to agricultural product brands shows a positive correlation with the studied consumer activities directed by the companies that offer these products.

Table 8 summarizes the results of the first hypothesis which can be proved as fully accepted. The first hypothesis posits that consumers who are loyal to a firm's brand compared to competitors is correlated with consumer search activities.

A Pearson correlation coefficient revealed that there is a positive relationship between the two variables, r = 0.289, n = 60, p = 0.025.

In general, a strong positive relationship exists between consumer brand loyalty and the marketing activities conducted by firms for consumer analysis aimed at meeting consumer needs.

Table 8. Hypothesis 1. Correlations

		How loyal are consumers to your brand, compared to those of the competition?	Have you ever analyzed your customers (through observation or survey)?
How loyal are consumers to your brand, compared to those of the competition?	Pearson Correlation	1	.289
	Dig(2-Tailed)		.025
	N	60	60
Have you ever analyzed your customers (through observation or survey)?	Pearson Correlation	.289	1
	Dig(2-Tailed)	.025	
	N	60	60

Source: Own results.

This correlation is further supported by the responses from the participants, where a significant majority, 83.3%, affirm that they consistently undertake activities for customer analysis, either by engaging the internal staff (the marketing department and personnel from other departments) or in cooperation with in-house and outsource personnel, predominantly specialized marketing agencies.

Hypothesis 2: The profitability of companies that deal with agricultural products has a positive correlation with consumer loyalty towards the brands of these companies.

Table 9 presents the results related to the second hypothesis, which is also proved as fully accepted.

The second hypothesis was based on the assumption that the business profit of firms is strongly associated with the loyalty of their customers.

The Pearson correlation coefficient sheds light on the positive correlation? between the two variables, r = 0.354, n = 60, p = 0.006.

In this context, we can conclude that firm profitability exhibits a robust positive relationship with customer loyalty.

Table 9. Hypothesis 2. Correlations

		Do you consider that the industry in which you operate is profitable?	How loyal are consumers to your brand, compared to those of the competition?
Do you consider that the industry in which you operate is profitable?	Pearson Correlation	1	.354
	Dig(2-Tailed)		.006
	N	60	60
How loyal are consumers to your brand, compared to those of the competition?	Pearson Correlation	.354	1
	Dig(2-Tailed)	.006	
	N	60	60

Source: Own results.

This is confirmed by the responses of 63.3% of managers who asserted that the agricultural sector is profitable, and 37% of respondents who believe that there is an average profit in this sector.

These opinions are aligned with and reinforce the hypothesis based on consumer satisfaction and consumer loyalty towards the products of the surveyed companies.

Many managers have stated in many of their responses that they have assessed customer loyalty, and this has influenced the increased profits of these firms.

Hypothesis 3: The annual performance measurement for meeting the managerial objective through the marketing activities of enterprises has a positive correlation with the increase in sales of agricultural products

Table 10 summarizes the results of the third hypothesis which can be proven and accepted as accurate.

The third hypothesis assumes that the annual performance measurement for meeting the managerial objective through the marketing activities of enterprises has a positive correlation with the increase in sales of agricultural products.

A Pearson correlation coefficient revealed that there is a very strong positive relationship between the two variables, r = 0.612, n = 60, p = 0.000.

In general, a very strong positive relationship exists between performance measurement and effective marketing activities carried out by the enterprises that are part of this study.

Over 55% of the respondents express satisfaction with the achievement of management objectives and the increase in sales as a result of good performance in the market, while 36.7% of them are moderately satisfied with the improvement in performance and its impact on sales growth.

Table 10. Hypothesis 3 Correlations

		If yes, have you concluded that the performance has met the management objective?	If so, has this marketing activity had an impact on increasing sales?
If yes, have you concluded that the performance has met the management objective?	Pearson Correlation	1	.612
	Dig(2-Tailed)		-.000
	N	60	60
If so, has this marketing activity had an impact on increasing sales?	Pearson Correlation	.612	1
	Dig(2-Tailed)	-.000	
	N	60	60

Source: Own results.

Proposed model for agricultural producers

Based on the literature reviewed in the course of this work as well as the results derived from the research conducted with processing companies in the agricultural sector with the aim of enhancing competitiveness in the market, the companies that are a case study in this work, but not limited to them, are proposed a model to improve competitiveness in the market, taking into account all the actors (interest groups) important in the process of closing the cycle, spanning from the producer to the final consumer. Interest groups encompass the immediate competitive environment (suppliers, creditors, competition and consumers) and the broader environment (government and international organizations), as illustrated in Figure 1.

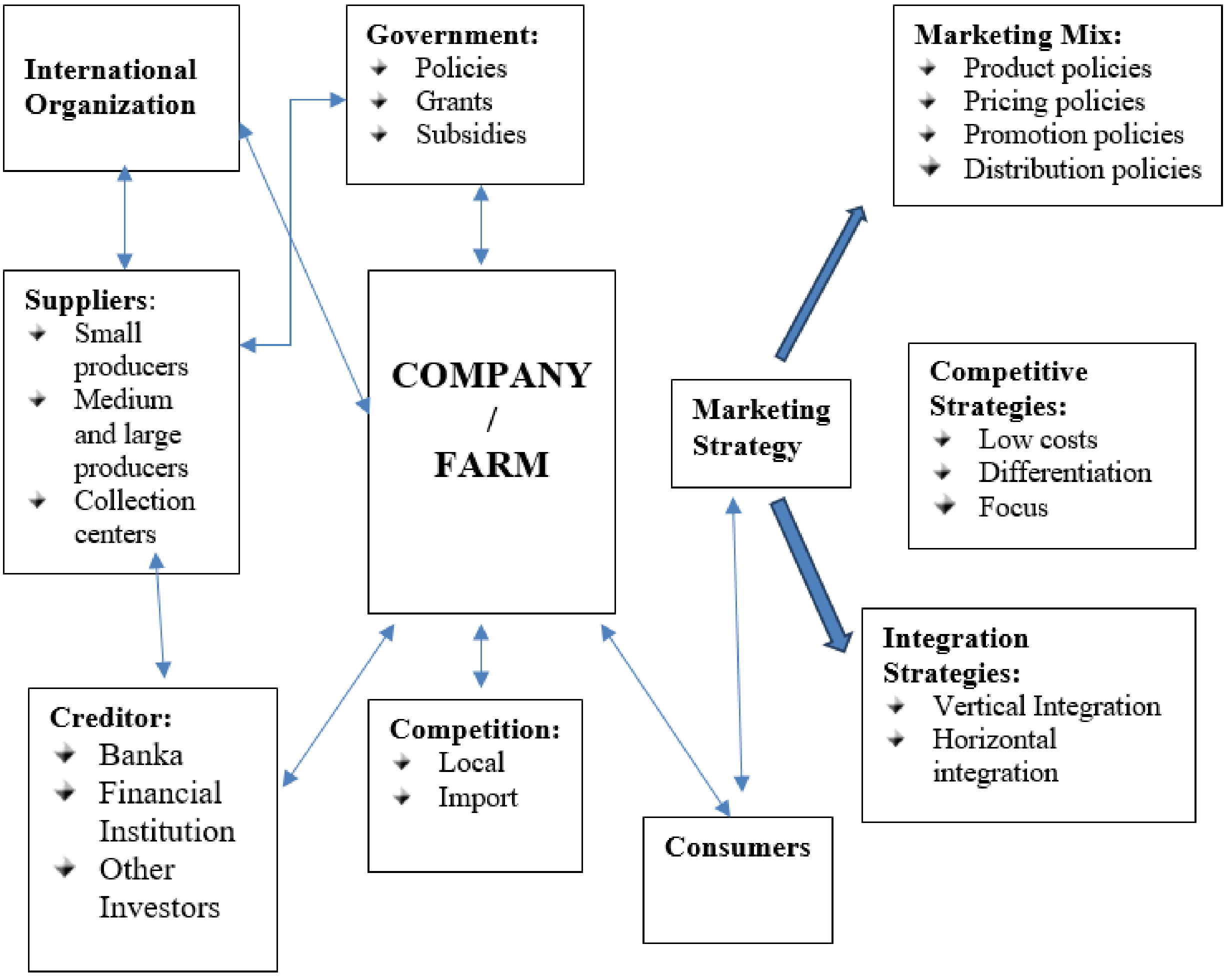

Fig. 1. The proposed model for competitiveness
Source: Prepared by authors.

The agricultural company needs to analyze each interest group thoroughly because through a comprehensive and detailed analysis, as outlined below, can increase its competitiveness in the market, and, in this context, lead to market participation and higher sales through the sale of more products to existing customers and higher sales to new customers.

Suppliers are among the most significant interest groups including small producers, plantations and collection centers (Kotler, Kartajaya, and Setiawan, 2021) [6]. **The competitors** area group of interest to which the company requires the utmost attention. Close competitors (vendors) and distant competitors (importers) are direct competitors that significantly affect the company's competitiveness, market share and overall sales. The marketing department or the designated individual within the enterprise must consistently analyze the market dynamics related to the competition and, in particular, their products (quality, type, packaging), competition prices for the same or similar products, promotional policies and distribution channels, and, above all, thoroughly analyze and understand the marketing strategies used by the competitors. This enables the company to stay ahead of the competition at all times, maintaining and increasing its competitiveness in the market (Vërçuni and Uldedaj, 2023) [11].

The consumer analysis requires the commitment of all company staff irrespective of their department or sector. The role of the marketing department or marketing manager is to design and implement a competitive marketing strategy that creates a better competitive and comparative advantage for the company over its competition. The marketing strategy proposed for the agricultural enterprise comprises three types of strategies: the marketing mix strategy, competitive strategies (Porter's generic strategies), and integration strategies. Actually, the strategy implementation phase does not mark the end of the strategic planning process as the achieved effects should be seen and measured through the strategy implementation control (Dieppe, 2020) [3].

CONCLUSIONS

Drawing upon the literature, the purpose and objectives presented, the methodology used in the paper, and the findings of the research, we can derive two types of conclusions: conclusions on the theoretical level, and conclusions on the practical level.

Conclusions on the theoretical level

-The globalization of the economy and the development of new markets coupled with global competition, pushed companies to be more careful in their marketing activities, a theory which also applies to manufacturing companies in the agri-food sector in Albania.

-The definition of objectives must be clear and understandable for all employees of the company, while simultaneously being realistic and achievable within defined time frames.

Conclusions on the practical level

-Market analysis can succeed when there is consumer confidence. The growth of this trust creates conditions for retaining existing customers and attracting new customers. To achieve this, experts from the marketing field are needed. The findings lead to the conclusion that there is a very good correlation between these two elements.

-Customer trust means repeated purchases from existing customers and increase in the number of customers, thereby affecting the increase in company's profits. This has been proven to be accurate also for the companies that are part of this study and in line with the proven hypothesis related to these variables.

-A large part of the respondents agrees with the conclusion that the price reduction can differentiate them more easily in the market from their competitors, in fact, 83% of them confirm the question with positive answers.

-The majority, approximately 78% of the respondents are of the opinion that the industry where they operate is very profitable.

-Most of the respondents have not yet established a sustainable supply chain due to not concluding contracts with suppliers in advance.

-Agri-food producers agree that there is strong, but genuine, competition in the market.

-The respondents are of the opinion that the combination of **product, quality** and **reasonable price,** is the formula for success in the market.

-The fight between international and domestic competition, according to respondents, is conducted through the lower prices offered by competitors from abroad.

-Marketing research/market analysis is conducted both by internal staff and by outsourcing specialized marketing agencies externally.

-The marketing tools used by small and medium-sized enterprises are mainly social media and direct marketing, while large businesses use more television and radio as forms of promotion.

-A small part of businesses does zone pricing, while the vast majority do not.

Recommendations

-The sustainable development of the enterprise in the market requires meticulous implementation of business strategies. Implementation is a critical moment for any enterprise. Marketing managers must find the easiest possible techniques to put into practice the strategy designed to achieve the company's goals. As most of the companies, part of this study, do not have marketing experts, it is recommended that they hire experts from the field of marketing, while the companies that stand better financially, form the marketing department within their companies.

-As most of the strategic decisions in the surveyed companies are made by the owners or finance managers and less by the marketing managers, it is recommended that these companies base their strategic planning on a coordination between the marketing department and other departments in the company. For companies that do not have a marketing department, it is advised hire marketing experts or outsource experts for temporary work.

Recommendations for producers/ processors

The manufacturing companies for agri-food products, as part of this study, have to some extent integrated elements of the marketing mix, in particular promotion and distribution channels, however have deficiencies related to the price and product differentiation. Another shortcoming that has been observed in these businesses is the use of insufficient or, more precisely, poor knowledge of marketing strategies.

The reduction of cost price can be achieved through various strategies which, according to surveys, can affect the increase of competitiveness in the market, the increase of consumer confidence and ultimately lead to the replacement of imports with local products.

The strategies that can be implemented by the producers, according to the sectors, would be:

• *Vertical integration strategy (up-down), and Vertical integration strategy (down-up).*

The strategy of vertical integration is highly suitable for most agricultural producers in Albania

-Milk processors can implement this strategy by establishing advance agreements with farmers ensuring a regular supply of milk and guarantee them the price for milk, which would ensure stability in supply and reduce the risk of running for fresh milk through different collection points.

-Processors of soft drinks derived from trees and processors of vegetables can also adopt this strategy, entering into advance agreements with farmers, plantation owners for regular supply of raw materials, alternatively buy or borrow property and plant their own trees and vegetables for cost reduction.

-Producers/processors of alcoholic beverages can minimize costs by planting grape vines on leased plantations or by pre-arranging with farmers who own the plantations and cover the costs of the raw material as compensation for the lower price for the grapes.

-Production and processing of flour products - the same can benefit from suppliers by buying wheat seed from them for planting, securing favorable prices from the outset.

-For edible oil processors it is advised to consider agreements with Albanian farmers to plant sunflowers, pay for the seeds and establishing long-term agreement for the supply of raw materials.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

PECULIARITIES OF INHERITANCE AND TRANSGRESSIVE VARIABILITY OF GRAIN NUMBER IN INTRASPECIFIC HYBRIDISATION OF WINTER BREAD WHEAT

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Abstract

In 2018-2020, the peculiarities of inheritance of grain number of the main spike in F_1 and transgressive variability in F_2 populations were studied in intraspecific hybridisation of early, medium early and medium late winter wheat (Triticum aestivum L.) varieties. It was found that in 97.5% of the hybrids the inheritance of grain number was based on positive superdominance with modification of phenotypic dominance (hp) depending on the selected hybridisation pairs and the year conditions. The excess of the extreme maximum grain number of the main spike over the parental forms in 18 (2019) and 14 (2020) F_2 populations of 20 crossing combinations with a positive degree of transgression (Td = 4.3-60.0%) and the frequency of breeding valuable recombinants (Tf = 3.3-66.7%) were studied. Positive correlations (r = 0.932; r = 0.977) between the positive degree and the frequency of transgressive recombinants were found to be very strong and close to functional correlations (r = 0.932; r = 0.977). The inclusion of varieties of different vegetation periods in hybridisation contributes to the formation of F_2 populations with the possibility of selecting economically valuable recombinants by the number of grains per main ear.

Key words: *soft winter wheat, number of grains, inheritance in F_1, degree and frequency of transgressions in F_2*

INTRODUCTION

The world's population has reached almost 7.8 billion people and is expected to reach 10 billion by 2050, requiring a significant increase in the amount of food, mainly cereals [24].
Worldwide and in Ukraine, winter wheat (*Triticum aestivum L.*) is one of the most widespread and productive crops [23, 6, 27].
Ukraine is one of the main wheat producers and exporters playing a important role in assuring food security and this is why grain yield need to be increased using high potential hybrids [8]. At the same time, production growth is severely constrained by agro-climatic resources. Under these conditions, predicting changes in wheat yields is important for maintaining global food security [29, 19]. To increase production potential and respond to climate change in a timely manner, increasing resistance to biotic and abiotic environmental factors should remain a priority for wheat genetic improvement [14].
The increase in grain yield and quality is largely due to the effectiveness of wheat breeding. This is achieved through the development and introduction of new varieties that produce high and stable grain yields under stressful growing conditions [3]. Only by cultivating winter wheat varieties that combine high yields with adaptability, can highly productive wheat agrophytocenoses be formed [12, 22].
In modern times, intraspecific hybridisation remains the primary method of generating genetic diversity in wheat [4, 16]. Under

certain conditions, first-generation hybrids may exhibit heterosis, which results in increased adaptability, productivity, viability, and stress resistance compared to their parental forms. It is important to note that this phenomenon only occurs when there is sufficient recombination of parental components [15]. The success of hybridisation relies on selecting appropriate parental pairs for crossing. Knowledge of the variability patterns of economically valuable traits that determine productivity enhances the efficiency of selecting initial forms for crossing and further selecting valuable genotypes in hybrid populations [21].

Improving the efficiency of the breeding process and creating new varieties that meet the required production parameters largely depend on the diversity and study of the source material [13].

The importance of a comprehensive study of the source material has been highlighted by many scientists [9, 16, 22]. The breeding charter experience demonstrates that in numerous instances, changes in breeding are linked to a diverse array of source material [10].

The growth and development of winter wheat are determined by the physiological functions of the genotype and the interaction of the plant organism with the environment. This is primarily due to the dynamics of meteorological conditions and the impact of stress factors of the year. Wheat goes through generative phases during its development, which determine plant productivity [18].

The number of grains in the ear is a crucial element in the structure of wheat yield. It is formed during the IV-IX stages of organogenesis and is determined by pollen fertility during fertilisation [1, 20]. The processes that occur are determined by the genotype and weather conditions during flowering, as well as their interaction. Therefore, the study of grain formation in the ear of hybrids and their descendants has become widely used in wheat breeding practice to increase its adaptive and productive potential [5].

The number of grains in the ear depends on the ear's genetic potential for productivity. The realization of this potential is conditioned by the genotype's reaction to environmental conditions during the formation of the ear, spikelets, flowers, and fertilization [17].

Therefore, it is important to investigate the influence of parental forms and meteorological conditions on the number of grains in the main spike of F1 and F2 populations. This trait is commonly used as a marker by breeders during the selection process to create new source material and wheat varieties, making it a crucial area of research.

The research aimed to determine the characteristics of grain number formation and inheritance in the main ear of F_1 and transgressive variability in F_2 populations resulting from intraspecific hybridisation of early, medium early, medium late, and late winter wheat varieties.

MATERIALS AND METHODS

In 2018-2020, the Research Center of Bila Tserkva National Agrarian University conducted a study on 36 cross combinations in their experimental field. The parental components of hybridisation included early maturing varieties such as Mironovskaya early ripening (Mir. early), Kolchuga and Belotserkovskaya semi-dwarf (B.Ts. s/d.). For mid-early varieties Zolotokolosa (Zolotokol.), Chernyava, and Shchedra niva were used. For medium ripening varieties, Antonovka, Vidrada, Yednist and Stolichna were used. Finally, for medium-late ripening varieties Dobirna and Vdalawere used.Seeds of the original forms, F_1 and F_2 populations, were sown using a manual sowing machine in the following order: mother form, hybrid (F_2 populations), male form. Biometric analysis of the studied material was conducted using an average sample of 25 plants in triplicate [28].

Agricultural technology is commonly used for growing soft winter wheat in the Forest-Steppe region of Ukraine. Its predecessor was mustard for grain.

The arithmetic mean (x) and its error ($\overline{x} \pm S\overline{x}$) were used to estimate the number of grains from the main spike. The range (*min-max*) and coefficient of variation were used to determine the variability (*V, %*) [7]. The coefficient of variation determines the level of variability. If V is less than 10%, the variability is considered insignificant. If V is greater than 10% but less than 20%, the variability is medium. If the coefficient of variation exceeds 20%, the variability is significant.

To determine the degree of phenotypic dominance (hp) the following was used method Griffing (1950) [11]. The data obtained were classified according to Beil & Atkins (1965) [2], positive dominance (heterosis) *hp*>+1; partial positive dominance +0.5 <*hp* ≤ + 1; intermediate inheritance –0.5 ≤ *hp* ≤ +0.5; partial negative inheritance–1 ≤ *hp*< –0.5; negative dominance (depression) –*hp*< –1.

The degree (Td) and frequency (Tf) of positive transgression in F_2 populations were determined by the following method Vasylkivskyi & Kochmarskyi (2016) [26].

Statistical parameters, in particular, correlation coefficients (r) and determination coefficients (r^2_{xy}) were calculated using the Statistica 12.0 software. When determining the strength of the relationship between the traits, the scale r < 0.3 was used: weak relationship between the traits, 0.3 < r < 0.5 – moderate, 0.5 < r < 0.7 – significant, 0.7 < r < 0.9 – strong, r > 0.9 – very strong, close to functional.

RESULTS AND DISCUSSIONS

During the sowing period (last decade of September), the meteorological conditions in 2017-2019 were favourable for the simultaneous germination and growth of soft winter wheat in autumn. The amount of precipitation during the autumn growing season exceeded the long-term average indicators in 2017 (124.1 mm) and 2019 (147.4 mm), and was slightly lower in 2018 (70.3 mm) at 82.5 mm (2018) (Fig. 1).

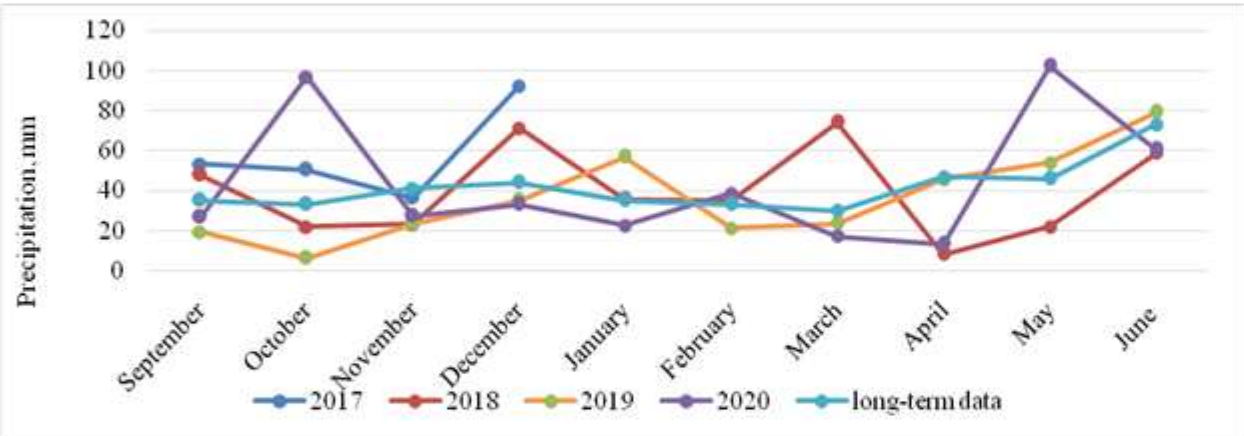

Fig. 1. Distribution of precipitations in 2017-2020, mm
Source: The Bila Tserkva meteorological station [25].

On 20.11 (2017), 12.11 (2018) and 21.11 (2019), the vegetative growth of soft winter wheat ceased, which aided in the successful hardening of the plants. Winter precipitation exceeded the long-term average of 112 mm in 2017/2018 (247.2 mm) and 2018/2019 (172.2 mm), and was slightly lower in 2019/2020 (97.3 mm).

The temperature regime during the winter months also contributed to the successful overwintering of the plants (Fig. 2).

Following the resumption of the growing season in 2018 on 4th April, the temperature regime was characterised by elevated values, which accelerated the growth and development of soft winter wheat. In April, the average monthly temperature was 13.3°C, significantly higher than the long-term average of 8.4°C.

However, the amount of precipitation was significantly below the normal 47 mm, with only 8.1 mm recorded.

The vegetation of soft winter wheat during the recovery period (02.03.2019 - 28.02.2020) occurred over the course of a month, with low average monthly temperatures gradually increasing.

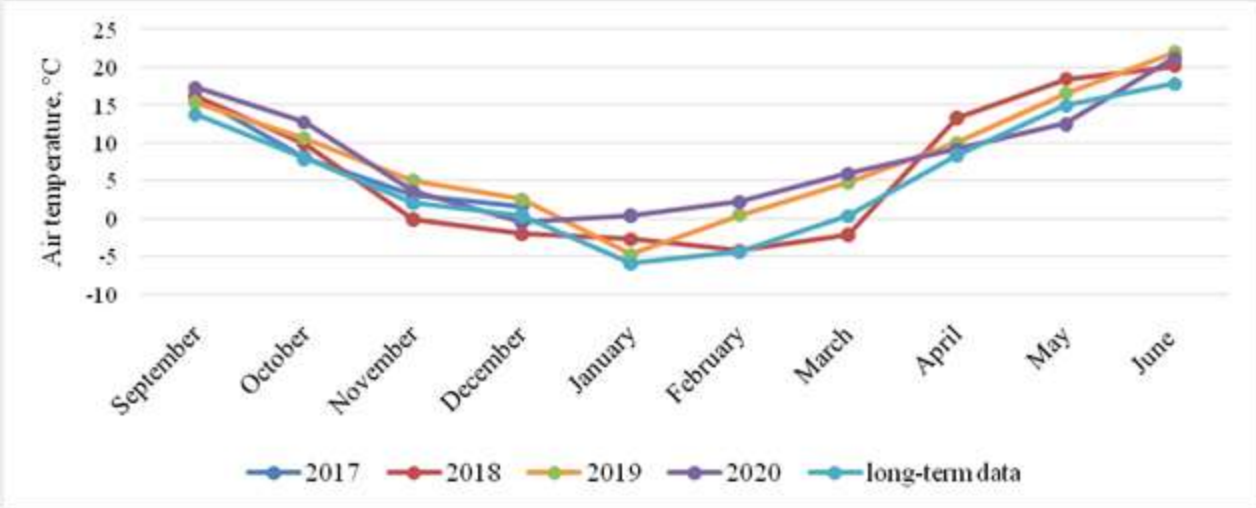

Fig. 2. Temperature regime in 2017-2020, ºC
Source: The Bila Tserkva meteorological station [25].

The precipitation levels in March and the first two decades of April 2019 were significantly lower than the long-term average of 61 mm, with only 23.4 mm and 14.2 mm respectively. In 2020, the precipitation level was even lower, with only 22.7 mm over the same period. However, in the third ten-day period of April 2019, the moisture supply of wheat plants improved with 31.3 mm of precipitation. In contrast, in 2020, the precipitation level was only 7.7 mm, which was lower than the long-term average of 16 mm. The average monthly air temperature in April was 1.6°C above normal in 2019 and 0.8°C in 2020.

In May 2018, the average air temperature was 18.4°C, which exceeded the long-term average of 14.9°C. However, in May 2019, the temperature dropped to 16.6°C, and in 2020 it was even lower at 12.5°C. The amount of precipitation during this period was also noteworthy. In 2019 and 2020, the precipitation exceeded the norm of 46.0 mm, with 54.0 mm and 102.3 mm respectively. In contrast, in 2018, the precipitation was only 22.8 mm.

The meteorological conditions during the research years were characterised by contrasting temperature and precipitation distribution.

These conditions significantly influenced the formation of the number of grains in the main ear of winter wheat. This allowed for a comprehensive assessment of the experimental material.

During the research period, the parental forms were differentiated by the number of grains in the main spike. According to the international classifier of the genus *Triticum* (1986), in 2019, only the medium-early variety Chernyava had more than 55 grains in the ear.A large number of grains of group II (43-55 pcs.) was formed by the medium-late variety Dobirna in 2019 and 2020. Meanwhile, the varieties Mironovskaya early ripening, Kolchuga (early ripe group), Zolotokolosa, Stolichna and Vdalawere observed to have a high number of grains group I (36-42 pcs.) from 2018 to 2020. In 2018 and 2019 the early-ripening variety Belotserkovskaya semi-dwarf had a large number of grains in group I, while in 2020, it had a large number of grains in group II. Similarly, in 2019, the mid-ripening variety Yednist had a large number of grains in group II (Table 1).

In 2018 the average number of grains per genotype (41.4) was significantly exceeded only by the mid-early variety Chernyava (+13.0).

The average number of grains (42.0) in 2019 was significantly higher than the average number of grains (42.0) in 2019 which was significantly higher than Chernyava (+17.0), Yednist (+2.1) and Dobirna (+1.8).

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

Table 1. Statistical parameters of the manifestation and variability of the number of grains of the main ear

Variety	2018				2019				2020			
	(x ± S x), pcs.	Lim (pcs.)		V,%	(x ± S x), pcs.	Lim (pcs.)		V,%	(x ± S x), pcs.	Lim (pcs.)		V,%
		min	max			min	max			min	max	
early ripening												
Mir. early.	39.1±0.82	28	55	18.1	39.8±1.60	28	55	20.1	42.3±2.09	30	56	19.2
B.Ts. s/d	37.7±0.91	25	60	18.9	39.5±1.64	27	60	18.6	49.5±1.42	39	58	11.1
Kolchuga	41.8±0.93	21	60	21.4	38.4±1.83	21	60	23.2	38.4±1.68	29	50	16.9
mid-early												
Zolotokolosa	42.4±1.29	26	70	26.3	39.8±2.36	26	65	29.7	37.9±2.14	25	62	21.9
Chernyava	54.4±1.30	34	82	20.7	59.0±2.21	37	82	18.7	52.1±2.71	30	69	20.2
medium-ripening												
Antonovka	41.1±0.94	27	57	19.7	40.6±1.73	28	55	21.3	42.7±1.84	32	57	16.7
Vidrada	37.2±0.73	27	51	17.1	37.6±1.35	27	49	18.0	35.9±2.38	20	51	25.7
Yednist	40.8±1.01	23	67	21.5	44.1±1.88	27	67	21.3	34.1±1.53	27	51	17.3
Stolichna	40.5±0.83	27	58	17.9	38.9±1.37	27	54	17.6	39.0±1.89	30	59	18.1
medium late												
Vdala	39.9±1.00	26	59	21.6	40.7±1.68	26	58	20.7	39.8±2.08	30	57	20.3
Dobirna	40.7±1.15	26	60	24.6	43.8±1.81	29	60	20.6	47.7±2.76	32	70	22.4
LSD (P≤0.05)	1.96	–			1.34	–			1.68	–		

Source: Authors own results.

In 2018-2020 intra-varietal variability in the number of grains of the main spikelet by the coefficient of variation varied from medium to significant. The average coefficient of variation was observed in the early-ripening variety Belotserkovskaya semi-dwarf (11.1-18.9%) and the mid-ripening variety Stolichna (17.6-18.1%) (Table 2).

Table 2. Number of grains, degree of phenotypic dominance, degree and frequency of positive transgressions by number of grains

Crossing combinations	F_1, 2018				F_2, 2019				
	(x ± S x), pcs.	Lim (pcs.)		h_p	(x ± S x), pcs.	Lim (pcs.)		Td, %	Tf, %
		min	max			min	max		
Mir. early/B.Ts. s/d.	63.5±2.95	45	82	35.9	59.2±1.56	43	81	35.0	33.3
Mir. early/Kolchuga	59.5±2.46	39	76	14.1	62.4±1.68	46	81	35.0	53.3
B.Ts. s/d./ Kolchuga	55.6±2.90	44	66	7.7	52.2±1.53	39	72	20.0	16.7
Mir. early/Zolotokol.	63.8±2.19	48	78	14.9	62.4±2.25	42	84	29.2	30.0
Mir. early/ Chernyava	64.9±3.46	59	73	2.4	61.2±1.76	46	89	21.7	26.4
B.Ts. s/d./Zolotokol.	60.2±8.58	29	77	9.0	55.7±1.64	42	72	10.8	16.7
B.Ts. s/d./ Chernyava	76.5±8.23	66	101	3.6	56.7±1.29	44	69	-	-
Kolchuga/ Chernyava	53.6±3.87	39	68	0.9	50.9±1.53	31	64	-	-
Mir. early/Antonovka	53.6±2.50	39	71	13.5	60.6±2.07	40	88	60.0	66.7
Mir. early /Yednist	64.2±3.03	55	73	28.5	53.0±2.57	30	89	32.8	13.3
B.Ts. s/d./ Antonovka	60.1±1.81	43	78	12.2	63.6±1.82	49	83	38.3	50.0
B.Ts. s/d./ Yednist	69.0±4.15	53	91	19.2	66.8±2.42	43	94	25.4	41.4
B.Ts. s/d./ Vidrada	55.4±2.38	38	71	71.8	57.1±1.62	41	75	25.0	33.3
Kolchuga /Antonovka	62.6±3.19	46	79	60.4	60.8±1.63	46	82	36.7	43.3
Kolchuga / Yednist	49.0±2.66	34	68	15.4	67.0±1.44	41	71	6.0	6.7
Kolchuga / Vidrada	51.0±2.99	36	74	5.0	56.4±2.65	32	86	43.3	37.0
Kolchuga / Stolichna	64.8±2.20	53	77	36.4	59.9±1.78	43	83	38.3	40.0
Mir. early / Vdala	69.1±2.35	61	78	74.0	59.2±2.22	42	91	56.9	50.0
Mir. early / Dobirna	63.1±2.85	41	84	29.0	58.7±2.26	41	84	40.0	35.7
B.Ts. s/d./ Dobirna	58.2±2.25	45	75	12.7	56.9±1.74	35	72	20.0	40.0

Source: Authors own results.

Significant variation (20.3-29.7 %) in 2018-2020 was found in medium-late varieties and medium-early Zolotokolosa.

The number of grains of the studied hybrids in 2018 was determined at the level of 49.0-76.5 pcs. and with the exception of Kolchuga/Chornyava, significantly exceeded the indicators of the original parental forms (Table 2).

In 2018 the number of grains on the main spike was higher than the F_1 average (60.9 pcs.) in the following varieties: Belotserkovskaya semi-dwarf /Chernyava (76.5 pcs.), Mironovskaya early ripening/Vdala (69.1

pcs.), Belotserkovskaya semi-dwarf /Ednist (69.0 pcs.), Mironovskaya early ripening/Chernyava (64.9 pcs.), and Kolchuga/Stolichna (64.8 pcs.).

Mironovskaya early ripening yielded the highest number of fruits per plant with an average of 64.2 pieces, followed by Zolotokolosa with 63.8 pieces, Belotserkovskaya semi-dwarf with 63.5 pieces, and Dobirna with 63.1 pieces. Kolchuga and Antonovka had the lowest yield with an average of 62.6 pieces per plant. Based on the data obtained, it can be concluded that most F_1 hybrids produce a large number of grains when crossed with a parental form that has the ability to produce a large or very large number of grains.

With the exception of the Belotserkovskaya semi-dwarf/Zolotokolosa hybrid, which showed partial positive dominance (hp = 0.9) all other hybrids exhibited positive superdominance in determining the number of grains per main ear (hp = 3.6–74.0).

In 2019, the hybrid F_2 populations under study exhibited a significant increase in grain number. In most cases, both the average and maximum values exceeded those of the parental forms, except for Belotserkovskaya semi-dwarf / Chernyava and Kolchuga/ Chernyava. The percentage of positive transgressions in the number of grains in the studied F_2 populations ranged from 6.0% to 60.0% with a recombinant frequency of 6.7% to 66.7%.

High levels of transgression and frequency of economically valuable recombinants were observed in the populations: Belotserkovskaya semi-dwarf / Dobirna (Td = 20.0%; Tf = 40.0%); Belotserkovskaya semi-dwarf / Yednist (Td = 25.4%; Tf = 41.1%); Belotserkovskaya semi-dwarf / Vidrada (Td = 25.0%; Tf = 33. 3 %); Mironovskaya early ripening / Zolotokolosa (Td = 29.2 %; Tf = 30.0 %); Mironovskaya early ripening / Belotserkovskaya semi-dwarf (Td = 35.0 %; Tf = 33.0 %); Mironovskaya early ripening / Kolchuga (Td = 35. 0 %; Tf = 53.3 %); Kolchuga / Antonovka (Td = 36.7 %; Tf = 43.3 %); Kolchuga / Stolichna (Td = 38.3 %; Tf = 40.0 %); Belotserkovskaya semi-dwarf / Antonivka (Td = 38.3 %; Tf = 50.0 %); Mironovskaya early ripening / Dobirna (Td = 40. 0 %; Tf = 35.7 %); Kolchuga / Vidrada (Td = 43.3 %; Tf= 37.0 %); Mironovskaya early ripening / Vdala (Td = 56.9 %; Tf = 50.0 %); Mironovskaya early ripening / Antonovka (Td = 60.0 %; Tf = 66.7 %).

The study found that crossing combinations with a larger number of grains in F1 resulted in higher rates of positive recombinants. Strong positive correlations (r = 0.932±0.035) were observed between the degree and frequency of transgressive recombinants, with a coefficient of determination $r^2_{xy} = 0.869$.

When hybridising different early maturity varieties, the average number of grains in the F1 generation was slightly higher in 2019 (63.6) compared to 2018, with a range of 53.0-72.7 grains (Table 3). It is worth noting that the parental forms also had the highest average number of grains in 2019.

Hybridization was used to determine which varieties exceeded the F1 average (63.6 grains) indicator. The following combinations produced higher yields: Mironovskaya early ripening/Zolotokolosa (72.7), Belotserkovskaya semi-dwarf/Antonivka (69.3), Kolchuga/Antonovka (69.2), Mironovskaya early ripening/Dobirna (69.1), and Belotserkovskaya semi-dwarf/Kolchuga (67).

These hybrids include Mironovskaya early ripening/Vdala (67.5 pcs), Mironovskaya early ripening/Chernyava (67.0 pcs), Mironovskaya early ripening/Antonovka (65.7 pcs), Belotserkovskaya semi-dwarf/Dobirna (64.9 pcs.), and Belotserkovskaya semi-dwarf / Vidrada (63.7 pcs.).

In 2019, the average F_1 values of five hybrids selected based on the number of grains in 2018 were exceeded. It indicates a successful selection of hybridization parent pairs.

Analysing the indicators of the degree of phenotypic dominance of F1 in 2019, it was found that all the obtained hybrids determined the number of grains per main ear by positive superdominance (hp = 1.1-1644.0).

Table 3. Number of grains, degree of phenotypic dominance, degree and frequency of positive transgressions by number of grains

Crossing combinations	F_1, 2019				F_2, 2020				
	(x ± Sx), pcs.	Lim (pcs.)		h_p	(x ± Sx), pcs.	Lim (pcs.)		Td, %	Tf, %
		min	max			min	max		
Mir. early/B.Ts. s/d.	61.8±3.43	48	75	147.7	50.9±1.63	32	71	22.4	20.0
Mir. early/Kolchuga	61.3±3.36	53	76	31.7	47.3±2.09	18	64	14.3	17.2
B.Ts. s/d./ Kolchuga	67.8±2.39	64	74	52.5	50.4±1.22	34	62	6.9	13.3
Mir. early/Zolotokol.	72.7±2.85	51	86	1644.0	49.9±1.43	39	68	9.7	10.0
Mir. early/ Chernyava	67.0±3.08	59	85	1.8	56.3±2.47	39	85	23.2	16.7
B.Ts. s/d./Zolotokol.	59.2±2.49	42	76	130.3	53.3±1.48	35	69	11.3	13.3
B.Ts. s/d./ Chernyava	60.2±3.07	50	73	1.1	40.8±1.72	31	59	-	-
Kolchuga/ Chernyava	60.8±3.33	54	69	1.2	39.3±1.16	28	58	-	-
Mir. early/Antonovka	65.7±3.17	40	94	63.8	44.6±1.09	35	56	-	-
Mir. early /Yednist	62.0±3.77	40	93	9.3	50.1±1.28	39	70	25.0	16.7
B.Ts. s/d./ Antonovka	69.3±2.26	50	81	53.2	45.2±1.35	30	65	12.1	6.7
B.Ts. s/d./ Yednist	58.3±3.05	40	67	7.2	42.1±0.96	28	51	-	-
B.Ts. s/d./ Vidrada	63.7±1.54	54	72	26.5	41.5±1.07	30	52	-	-
Kolchuga /Antonovka	69.2±3.39	53	87	27.0	47.3±1.55	28	65	14.0	6.7
Kolchuga / Yednist	55.9±3.61	38	76	5.1	52.9±1.28	40	67	31.4	53.3
Kolchuga / Vidrada	53.0±2.57	35	72	37.5	43.2±1.08	28	55	7.8	6.7
Kolchuga / Stolichna	62.9±3.84	38	89	97.0	51.7±1.55	35	72	22.0	16.7
Mir. early / Vdala	67.5±3.28	50	86	60.6	60.5±1.59	46	74	29.8	56.7
Mir. early / Dobirna	69.1±3.98	59	87	13.7	50.1±1.46	35	69	-	-
B.Ts. s/d./ Dobirna	64.9±3.80	40	80	10.8	50.6±1.54	33	73	4.3	3.3

Source: Authors own results.

In 2020, 14 out of 20 F_2 populations exhibited a positive degree (4.3-31.4%) with a frequency of upcrossing of breeding valuable recombinants ranging from 3.3% to 56.7%. With the exception of Belotserkovskaya semi-dwarf/Chernyava, Kolchuga/Chernyava, as well as Mironovskaya early ripening/Antonovka, Belotserkovskaya semi-dwarf/Yednist, Belotserkovskaya semi-dwarf/Vidrada, Mironovskaya early ripening /Dobirna, the majority of populations exceeded the corresponding values of the parental forms in terms of the extreme maximum number of grains.

In 2019, high indicators of the degree and frequency of transgressions were noted in the populations of Mironovskaya early ripening/Vdala (Td = 29.8%; Tf = 56.7%), Mironovskaya early ripening/Belotserkovskaya semi-dwarf (Td = 22.4%; Tf = 20.0%) and Kolchuga/Yednist (Td = 31.4%; Tf = 53.3%).

In 2020, a study found very strong positive correlations (r = 0.977±0.036) between the degree and frequency of transgressions. The study also established a coefficient of determination (r^2_{xy} = 0.955) to measure these correlations objectively.

CONCLUSIONS

In crossing combinations where one of the components is a parental form capable of producing a large number of grains, most F_1 forms a large number of grains. It is important to note that this statement is based on objective evidence and does not contain any subjective evaluations.

In hybridisation of early, medium early, medium late varieties of winter bread wheat, the inheritance of the number of grains on the main spike in F1 was predominantly positive dominance (97.5%), with variations in the phenotypic dominance index depending on the crossing components and meteorological conditions of the year.

In most F_2 populations, higher rates of positive recombinants were observed in crossing combinations that produced a larger number of grains in F_1.

The involvement of varieties with different vegetation periods in hybridisation contributes to the formation of F_2 populations, allowing for the selection of economically valuable recombinants based on the number of grains per main ear.

In 32 out of 40 F_2 populations in 2019 and 2020, the number of grains per main ear showed a positive degree of transgression (Td= 4.3-60.0%) with a recombinant frequency of 3.3-66.7%. Strong positive correlations (r = 0.932; r = 0.977) were found between the positive degree and the frequency of transgressive recombinants, indicating a close to functional relationship (r = 0.932; r = 0.977).

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

DIRECTIONS FOR ACHIEVING SUSTAINABLE DEVELOPMENT OF THE PRODUCTION POTENTIAL OF THE RUSSIAN AGRO-FOOD COMPLEX

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Abstract

In the international food market at the global level, one of the major task and strategic goal of any country is to sustain technologically and financially food security. The goal of this research work is to quantify the reserves for increasing agricultural production and to set up the directions for its sustainability. The study emphasized the opinions of foreign and Russian scientists who were dealing with the sustainability of rural areas. The dynamics of the pace of agricultural development in leading foreign countries is empirically studied, and the trends in innovative development are substantiated. The directions for sustainable growth of production potential are improved taking into account environmental factors: development of innovation and investment mechanisms to stimulate the introduction of digital technologies in agricultural production, development of scientific and educational centers to build up digital competencies, formation of a system of package solutions ready for implementation in agricultural production of digital technologies. For evaluating the efficiency of the presented activities, there were used specific indicators. The criteria reflecting the efficiency of the implementation of digital technologies regard the degree of their distribution, the increase of crop yields, the reduction and optimization of the production costs related to farm inputs. The practical value of the results is in the development of a strategy for sustainable development of rural areas.

Key words**:** *sustainability, development, agro-food complex, industry approach, state support measures, foreign experience, legal framework*

INTRODUCTION

In modern geopolitical conditions, the sustainable development of the rural areas is a driver for ensuring the country's independence [5]. Intensive implementation of innovative and digital products in agricultural production stimulates sustainable development [33]. Research on sustainable development is presented in the works of N. Schaller, who proposes a systems approach [31]. According to F. Menalled, the most important condition for ensuring and increasing the quality of life is the synthesis of economic and environmental efficiency, as well as the study of climate problems [4, 24].
The concept of the American economist J. Elkington is based on a triune approach to sustainable development, according to which three most important elements of corporate sustainability (3P) are identified - People, Planet, Profit, reflecting the assessment of sustainability in various dimensions. The goal-setting basis of the proposed triple benefit strategy is the spillover effects of benefit for business representatives, consumers and society as a whole [11,12].
Studying the functioning of individual organizations, Stoneham, G., Chaudhri, V., Ha, A., Strappazzon substantiated the need to adapt business strategies to the tasks of sustainable development of regions, taking into account possible risks [32].
The rationale for models and scenarios of balanced ecological, economic and social development is reflected in the works of Placet [26].
The UN has developed Sustainable Development Goals, which are implemented at the national and supranational levels in accordance with existing governance mechanisms [3, 27].

In particular, O. V. Gonova emphasizes the need to assess and diagnose sustainable development of the agro-food complex. A set of methods of simulation and economic-mathematical modeling is proposed as an assessment and forecasting tool for sustainable development. Russian scientists Medyanik N.V., Cherednichenko O.A., Dovgotko N.A. are researching the directions of monitoring the goals of sustainable development [15, 23].

According to the research results, in order to achieve sustainable Russian business, state stimulation and support are necessary.

To assure a better life quality for the rural population and the preservation of the natural systems regarding biodiversity and the beauty of the landscapes is the main goal to carry out by any country.

For rural areas, the main goal-setting principles remain improving the quality of life of the population and maintaining an acceptable state of natural systems [10].

Similar ideas have been sustained by [2, 17] in their research studies.

In this context, the paper aimed to assess the resources destined to sustain the increase of agricultural production and establish the efficient framework and the major directions for a sustainable production development.

MATERIALS AND METHODS

This study is based on a large number of information sources including publications such as: books and articles on the topic, and updated data for the main studied indicators which are going to be analyzed.

Also, classical methods and procedures specific to similar studies used by various scientific personalities and experts in the field were adopted in this research as well.

From a methodological point of view, there were utilized various well known tools like: monographic description, analysis, synthesis, critical evaluation of the others' opinions, logical structure of the ideas and results, comparisons, analogies, illustrative items for a better understanding of the phenomena.

Sustainable development of agriculture and rural areas requires a brainstorming, a 'spring'' of new ideas and solutions from the greatest scientific personalities which have to enlarge the knowledge wealth in the field.

More than this, following the experience accumulated by the EU, one of the top players in the world agriculture and agri-food trade, other countries could use this model adapted to their local conditions regarding land, human, and financial capital to cover the economical and social requirements for a sustainable development which preserves the environment quality.

RESULTS AND DISCUSSIONS

The global sustainable development goals are related to solving multifaceted problems, including overcoming hunger, mitigating dramatic climate change and significantly reducing greenhouse gas emissions. UN experts noted significant difficulties in implementing the goals at the national level:

in 2022, about 30% of the world's population was undernourished; there was a very high concentration of greenhouse gases; high risks of extinction of flora and fauna species remained. In many countries, the income gap between small and medium-sized farmers has not been overcome. Based on selected data, experts determined that the average annual income of small agricultural businesses is 40-50% lower.

In Russia, specialists from the Federal Statistics Service monitor and evaluate targets and indicators for achieving sustainable development. According to their assessment, in 2010-2021, greenhouse gas emissions per unit of GDP decreased by almost 3 times, which is due to the use of energy-saving and material-saving technologies. At the industry and regional levels, plans for adaptation to climate change are being developed [34].

Many countries around the world are not fully achieving the goal of promoting sustainable economic growth. In 2022, global output slowed from 5.3% in 2021 to 2.2% in 2022.

The growth rates of agriculture in some countries are shown in Figure 1.

The European Union has strict environmental standards. In the period under review, Russia achieved the highest growth rates, especially in crop production and food production, which indicates a successful solution to the problem of food security.

The growth rates of livestock production (116.9%) were also higher than those of individual European countries.

The development of agricultural production should be coordinated taking into account the principles of sustainable development [30].

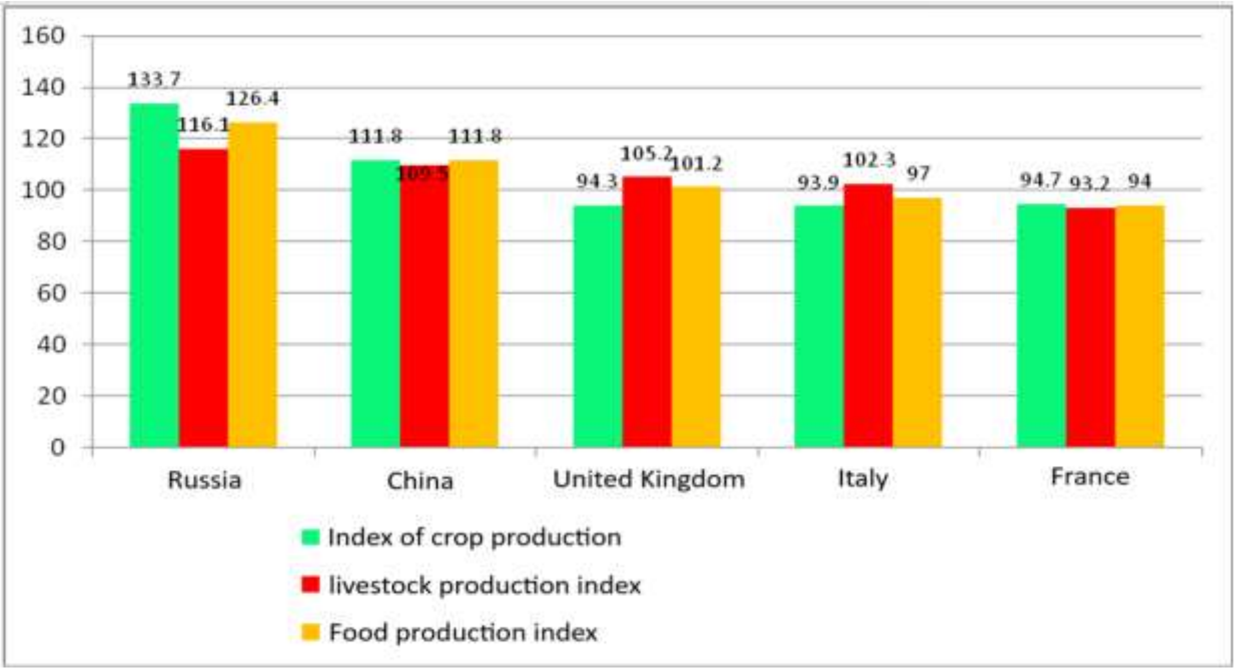

Fig. 1. Indices of production of agricultural products (2022 in % of 2004-2006)
Source: Own calculations based on data [18,19, 22].

Significant growth is expected to be achieved due to innovative factors that allow for effective resource substitution and increase the productivity of production factors [6, 8]. Fig. 2 shows the indices of total factor productivity of agriculture. different countries. The calculation of these indices is based on the assessment of the contribution of labor and capital factors to production using the production function method [35].

According to research by Russian scientists, in 2021 Russia ranked second in the world in terms of factor productivity.

In the analyzed period, the processes of scaling up the agricultural business in certain branches of animal husbandry [7].

For example, precision farming technologies are used mainly in large and medium-sized agricultural organizations, which helps to increase yields by about 20%.

With strict compliance with the technology requirements, production costs can be reduced by 10 - 50%. The use of nanotechnology and intelligent biosensors in precision farming allows for timely diagnosis of soil conditions to assess compliance with environmental standards [16, 29].

In greenhouse vegetable growing, an important innovative solution is the use of satellite control to organize production [9].

High rates of production of modern agricultural technologies, especially agro-biotechnology, predetermine the possibilities of Russia's positioning in world markets [1].

The main condition for cost optimization is the development of domestic selection. In Italy - organic production; in Germany - precision farming and plant protection. Innovative projects to create artificial soils, greenhouses using sea water are being implemented in the agriculture of African countries. For Russia, trends in selection technologies and precision farming will retain their significance in the short term. Promising technologies that have not received sufficient distribution include bioinformatics, bioengineering and genomics [13].

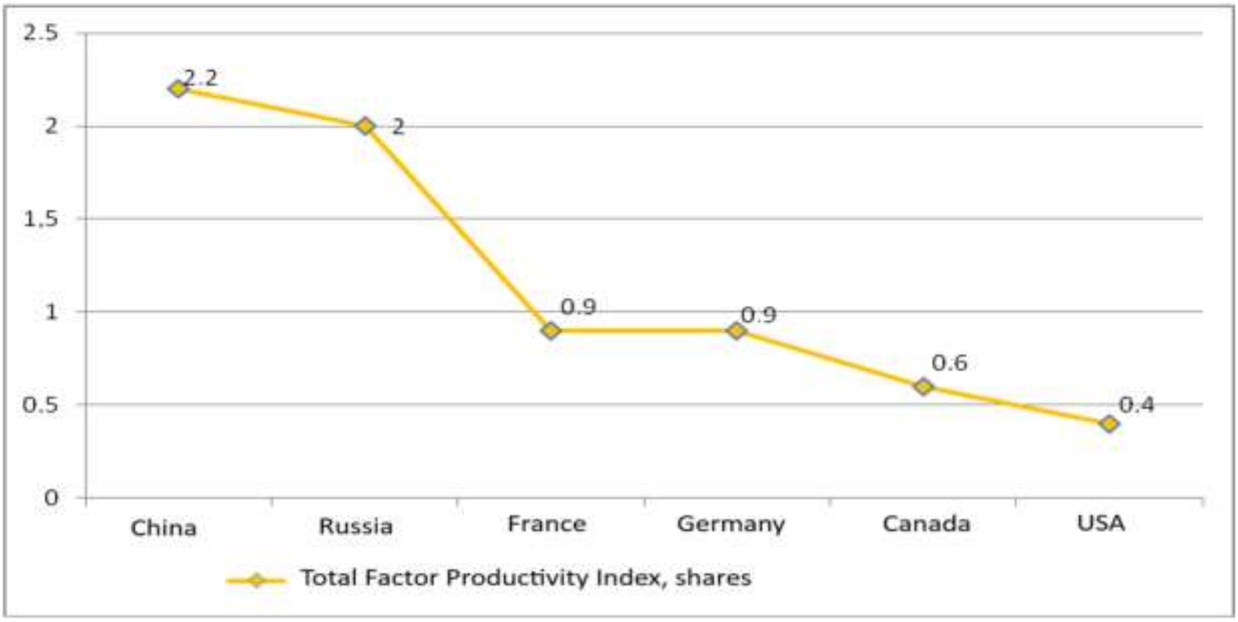

Fig. 2. Total factor productivity indices in agriculture of individual countries (2021 in % of 2000)
Source: Own calculations based on data [21] .

In animal husbandry, the main trends in scientific and technological development in the medium term are defined as aerospace digital technologies in pasture livestock farming, organic livestock farming, genomic assessment of livestock genetic resources, production of agro-food products and feed mixtures with specified quality characteristics [14].

The study proposes to take into account the principles of forming an innovative and ecological profile with the substantiation of the system of evaluation indicators. It is substantiated that the criteria for the effectiveness of the introduction of digital technologies are the degree of their distribution, the growth of crop yields, the minimization of the costs of economic resources, the coefficient of the optimization of the cost of production.

When developing mechanisms for sustainable development of rural areas, both national goals and regional and sectoral characteristics should be taken into account.

The introduction of new technologies in selection and seed production will ensure technological independence in the Russian agro-food sector. Therefore, the most important indicator is the indicator of import substitution of new plant varieties and animal breeds.

The authors share the point of view on the need to adapt individual elements of the Common Agricultural Policy of the European Union to the Russian conditions of functioning of the agro-food complex. Important attention should be paid to environmental protection standards called to sustain the green economic growth for the future [10, 28].

Only based on the knowledge economy and the principles of inclusive development the future of the novel sustainable growth could be attained and provided to the next generations [20, 25].

No doubt, the long and positive EU experience which led to high economic, social and environment performance, is model that any country would like to follow.

The EU healthy vision for its future economic grown and social well-being is founded on an effective management in solving problems in close connection with a firm response to diminish the negative impact of climate change, to increase the capacity of resilience, and to implement the Green Deal by 2050.

In Russia, there are similar problems agriculture and rural areas are facing and to solve them a transfer of positive EU experience could be beneficial for setting up new strategies of development called to assure the sustainable growth under the environment conservation.

CONCLUSIONS

The new strategy of the development of agriculture and rural areas has to take into account the own local conditions and to quantify the influences of various factors (geographical, demographical, economical, social, environmental etc).

The strategic objectives have to be realistic and to be accompanied by measures and tools called to sustain the attainment of the goals.

The results of this study emphasized the conceptual aspects of foreign and Russian agricultural scientists having the most significant achievements regarding the research of sustainable development of agriculture and rural zones.

The dynamics of the pace of agricultural development in leading foreign countries is empirically studied, and the trends in innovative development are substantiated.

The directions for sustainable growth of production potential must be improved taking into consideration the need of innovation and investments, the benefits of the digital era which offer efficient tools for agriculture modernization and automatization for an increased productivity, the new digital technologies will changes job structure and sustain a new orientation in the field of education and scientific research as fields producing economic and social progress. Educational centers based on the new technologies applied in teaching and learning process are called to build up digital competencies, and to create a system of package solutions ready for implementation of digital technologies in agricultural production.

This study substantiated that the criteria for the effectiveness of the introduction of digital technologies, the degree of their distribution, the growth of productivity, the minimization of the production expenses.

Knowledge economy and the principles of inclusive development must be involved in the process for assuring the sustainable growth.

The new strategies for the development of Russian agriculture must be positively influenced by EU experience in solving problems management for assuring an economic sustainable growth, a better living standard to the population and a high quality of the environmental factors.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY ON THE POSITION OF AGRICULTURE AMONG THE BIOECONOMY SECTORS IN THE EUROPEAN UNION

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Abstract

This paper provides a detailed analysis of the position of agriculture among the bioeconomy sectors in the European Union and Romania, focusing on the recent period. It explores the National Competitiveness Strategy 2015-2020, which identified 10 economic sectors, including the 5 considered part of the bioeconomy. Using Eurostat statistical data and processing them through SPSS software, indicators such as minimum, maximum, mean and standard deviation were calculated to highlight the evolution of this sector. In the EU, the bioeconomy generated around 17.2 million jobs and €664 billion in value added in 2020, with an increasing trend in value-added and a decreasing trend in jobs. Sectors with high potential, such as food, agriculture and wood products, have seen significant added value. Romania is presented as having a high potential to develop the bioeconomy, based on the diversity of natural resources. The bioeconomy has been found to have a significant presence in primary sectors such as agriculture and the food industry and can contribute to sustainable growth and job creation in the private sector. Agriculture is considered an important pillar of the bioeconomy ecosystem, by providing added value and creating employment opportunities. As of 2020, across the EU-27, the agriculture sector represented a high share of the value added in the bioeconomy, supporting the efforts to sustainable development and the efficient utilization of biological resources on European scale.

Key words**:** *bioeconomy, added value, labour productivity, strategies, Romania*

INTRODUCTION

The bioeconomy is an innovative approach to economic development, encompassing fundamental principles such as sustainability, efficient resource use and circularity. In the European context, the bioeconomy is becoming increasingly present in scientific research as the impact of climate change becomes more evident and significant in terms of human activity. The bioeconomy is linked to concepts such as the green economy and the circular economy, and their interactions are particularly highlighted in the relationship between the bioeconomy and the circular economy [2, 12, 13].

The bioeconomy is based on the responsible use of biological resources and processes in the environment to create goods, energy and services [11]. It focuses on the sustainable use of resources such as plants, animals, micro-organisms and marine resources in various fields such as sustainable agriculture and forestry, food industry, renewable energy or medicine. The aim is to develop products and solutions that reduce environmental impacts and support economic development [14].

The concept of bioeconomy is closely connected to the objective of reducing the dependency on mineral resources, while providing value-added goods, including food, feed, fiber, industrial and health products, through the sustainable utilization of the locally available biological resources (Socaciu, 2014) [19] .

Bioeconomy is characterized as an environmentally friendly and sustainable economic sector, bringing positive benefits for economic development by creating new employment opportunities and expanding the business environment. It can be presented as a key element in the process of reducing the economic gap between the countries of Central and Eastern Europe and those of the Western continent.

Authors Bălan E.M. and Cismas L. (2022), have conducted a study on the analysis of the CEE grouping according to specific bioeconomy indicators, highlighting similarities or discrepancies between these countries [3].

Research by Rozon T. (2020), highlights structural differences between EU national bioeconomies, accentuated over time, with reference to the apparent level of labour productivity [17].

The establishment of bioeconomy governance frameworks at both regional and national levels is an important step in the transformation of bioeconomy within those contexts [6, 15]. Participatory design of the financial support and regulatory mechanisms is helpful in overcoming bottlenecks that may arise during setting the scene for the bioeconomy sector. Employing the method of hierarchical cluster analysis, a group of researchers evaluated the progress towards bioeconomy of EU member states. Having in mind the sectors engaged in biomass production and conversion, the study has highlighted a visible progress in the bioeconomy, highlighting the performance of Belgium and Denmark [9].

The European Union aims for a circular bioeconomy, so that biological resources are used as efficiently as possible to reduce waste. This process involves transforming biological materials into different products [18]. The European Union's bioeconomy strategy includes several objectives, such as reducing dependence on finite resources, promoting high-performance technologies and innovation, creating jobs and sustainable economic growth. It also aims to protect the environment, and combat climate change through better management of natural resources [14, 1].

In agriculture, the bioeconomy involves the adoption of practices that can harness biological resources, and soil fertility, moving towards reducing the use of chemicals, thus ensuring efficient and sustainable production in the long term [5, 20]. Bioeconomy in agriculture also promotes the efficient use of resources such as water, energy and agricultural inputs to maximize production and reduce losses [7, 4]. Responsible waste management in agriculture involves recycling of nutrients to maintain a sustainable resource cycle [20].

This paper aimed to present the current state of the bioeconomy at European level and in Romania, as well as an evolution of this sector for the period 2008-2020.

MATERIALS AND METHODS

The data was analysed according to the economic sectors that fall under bioeconomy umbrella, that were previously identified in National Strategy for Research, Development, and Innovation 2014-2020, as follows: agriculture, forestry, fisheries and aquaculture, biopharmaceuticals, and biotechnologies.

The statistical data analysed were taken from the europa.eu database and regard the following indicators: number of persons employed, value-added and apparent labour productivity. For a more detailed study, descriptive indices such as minimum, maximum, period mean and standard deviation were calculated using SPSS. These calculated indicators highlighted the periods of growth and decline of this sector, thus providing an overview at European and national level.

RESULTS AND DISCUSSIONS

At European level, in 2020, the bioeconomy sector provided jobs for around 17.2 million people and added an estimated €664 billion in value, according to the latest estimates. For the year 2020, the European Commission reports showed that the bioeconomy sector provided a share of 8.72% of the total workforce employed in the EU-27. More than half of the employed individuals in bioeconomy, totalling 8.7 billion people, were engaged in agriculture. a share of 27% of the workforce (4.6 billion people), were employed in the food, beverage, and tobacco industries. At the bottom were the sectors of topical interest at European level, bioelectricity and liquid biofuels with 0.2% of total EU-27 employees.

Between 2008 and 2020, there was a decrease of 15.3% in the share of employees within the bioeconomy sector. This decline was evident across various sectors of the bioeconomy as follows: agriculture 23.4%, bio-based textiles 35.64%, fishing and Aquaculture 7.88%, forestry 2%, paper sector 5%, wood products and furniture sector 17.9%.

It is interesting to be noted that the bio-based electricity sector has experienced significant expansion. During the analyzed period, the number of employees registered a substantial increase, being 3 times higher in 2020 (36.7 thousand people) than in 2008 (11.8 thousand people)

Table 1. Descriptive statistics on the number of persons employed in agriculture and other bioeconomy sectors in the period 2008-2020 at EU-27 level (thousands of persons)

Specification	Minimum	Maximum	Mean	Std. Deviation
Agriculture	8,703.00	11,358.00	9,973.8462	869.46898
Bio_based_chemicals_pharmaceuticals_plastics_and_rubber	365.00	473.00	400.6923	37.40184
Bio_based_electricity	12.00	37.00	22.4615	8.03757
Bio_based_textiles	724.00	1125.00	844.6923	103.84314
Fishing_aquaculture	156.00	190.00	170.3846	8.51017
Food_beverage_tobacco	4,137.00	4,657.00	4,324.3846	181.06837
Forestry	494.00	529.00	515.6154	9.81953
Liquid_biofuels	15.00	27.00	21.3846	3.84141
Paper	581.00	650.00	603.6923	21.27355
Wood_products_furniture	1,288.00	1,618.00	1,359.6154	92.50904
Total_employed_people	17,163.00	20,267.00	18,236.538	927.55005

Source: SPSS's own representation based on europa.eu data [8].

At Member State level, the number of people employed varied in the proportions of the population employed in the bioeconomy sector. Figure 1 shaows that the highest shares are observed in Poland (14.11%), Romania (12.72%), Germany (12.19%), Italy (10.88%), and France (10.10%). At the opposite side, Luxembourg, Malta, and Estonia have the lowest shares, each below 0.3%.

Several Member States stand out for some specific sectors within the bioeconomy:

-Romania, Italy and France lead in agriculture.

-Germany, France and Poland have a high number of employees in the food, beverage and tobacco sectors

-France, Germany and Poland in wood products and furniture.

These findings highlight the varying degrees of engagement in the bioeconomy across different Member States, reflecting diverse economic structures and priorities within the EU-27.

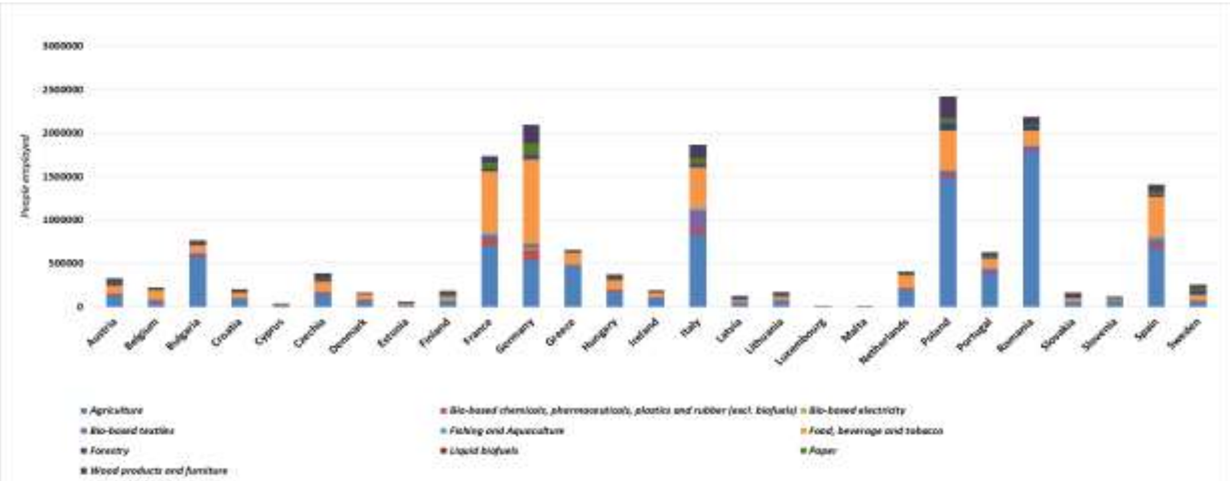

Fig.1. Number of persons employed in the bioeconomy sector, by EU-27 Member State, 2020

Source: Own processing based on europa.eu data [8].

Regarding the value added, it was found that during the period under study it increased by 29.53% in 2020 compared to 2008. The only sector that saw a decrease in value-added was Bio-based textiles, by 13.2% in 2020 compared to 2008. The largest increases were observed in the Liquid biofuels (by 161.33%) and Bio-based electricity (by 198.23%) sectors.

The minimum value added recorded at EU-27 level was €474.3 billion in 2009, the maximum was €667.23 billion in 2019, and the average for the period analysed was €566.10 billion. The highest values of value added were seen in the following sectors of the bioeconomy: food,_beverage,_tobacco (with a maximum of 237.53 billion euros in 2019), agriculture (with a period maximum of 192 billion euros in 2019) and wood_products_furniture (with a maximum of 50.67 billion euros in 2020).

Table 2. Descriptive statistics on value added in agriculture and other bioeconomy sectors in the EU-27, 2008-2020 (€ billion)

Specification	Minimum	Maximum	Mean	Std. Deviation
Agriculture	**138.85**	**192.00**	**171.1377**	**15.62835**
Bio_based_chemicals_pharmaceuticals_plastics_and_rubber	42.60	79.30	53.7823	12.70180
Bio_based_electricity	2.22	6.63	4.1223	1.23210
Bio_based_textiles	20.01	25.65	22.4731	1.58715
Fishing_aquaculture	5.29	6.36	5.7446	.34650
Food_beverage_tobacco	174.78	237.53	199.9138	22.88892
Forestry	16.90	26.74	23.2608	2.83703
Liquid_biofuels	1.41	3.88	2.7185	.85228
Paper	33.89	48.15	40.3846	4.56845
Wood_products_furniture	37.71	50.67	42.5685	4.43280
Total_value_added	**474.30**	**667.23**	**566.1062**	**62.84825**

Source: SPSS's own representation based on europa.eu data [8].

At Member State level, in 2020, the highest value added was recorded by Germany, France, Italy and Spain with shares in total value added of 19.16% (€125.4 billion), 15.44% (€101.06 billion), 13.7% (€89.65 billion) and 10.47% (€68.51 billion) respectively. In 2020, the following countries with high value added values in the sectors with the highest shares of value added stood out:

-France, Italy and Spain in agriculture with values of 32.8 billion Euro, 30.5 billion Euro and 30.1 billion Euro.

-Germany, France and Italy, for the food, beverage and tobacco sectors with a value of EUR 53.3 billion, EUR 43.7 billion and EUR 27.9 billion, respectively.

-For bio-based chemicals, pharmaceuticals, plastics, and rubber (excluding biofuels), Germany holds the top position with a value of 16.8 billion Euros. France follows with 8.6 billion Euros, and Italy with 7.1 billion Euros.

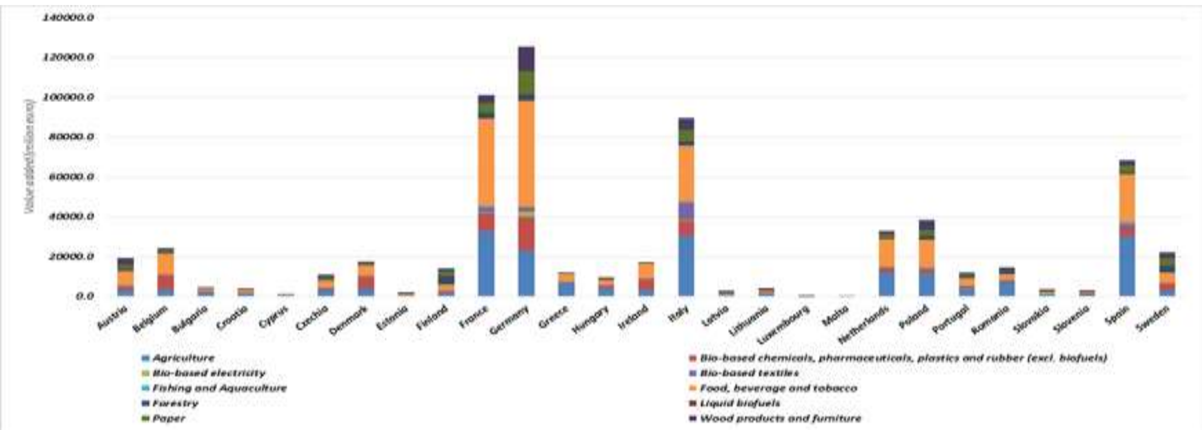

Fig. 2. Distribution of value added by country in the bioeconomy sector of the EU-27 in 2020
Source: Own processing based on europa.eu data [8].

The apparent productivity of the labour force in the bioeconomy sector, in 2020, at the EU-27 level, was EUR 38,100 per employee, representing an increase of 36.1% compared to the 2008 value (28 000 euros per employed person).

Within Figure 3 you can see a distribution of the apparent productivity of labour at the EU-

27 Member State level by the value recorded by each category of the business sector. Three distinct levels of apparent labour productivity can be highlighted: Less than 25,000 euros per employee, II. Between 25,001 and 50,000 euros for each employee and III. More than 50,001 euros per employed person. Apparent labour productivity in the Member States has shown significant variations, some of which are above the EU-27 average for each sector.

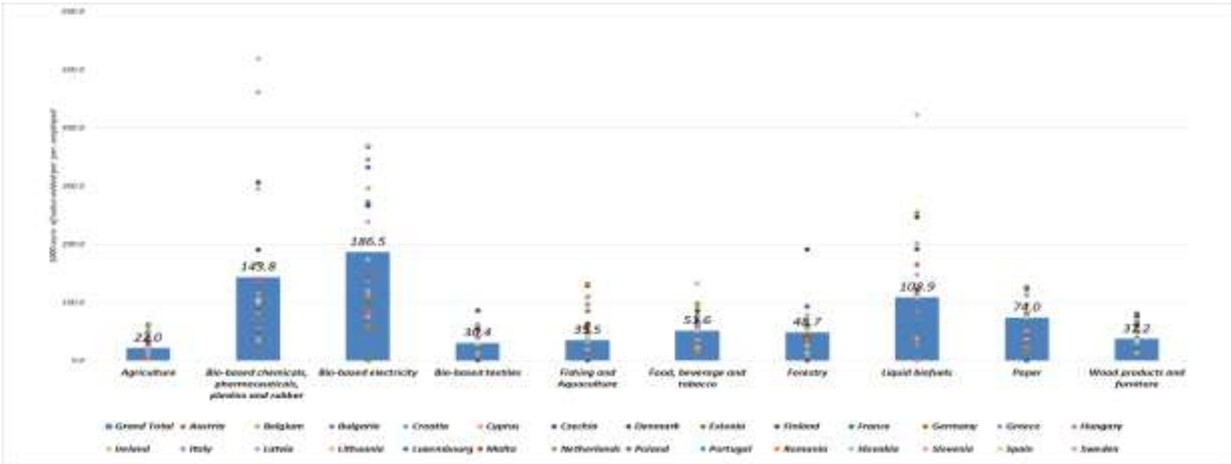

Fig. 3. Apparent Labour productivity in agriculture and other bioeconomy sectors in the EU-27 in 2020
Source: Own processing based on europa.eu data [8].

At the national level, in 2020, the bioeconomy sector provided more than 2 million jobs, representing 25.7% of the national labour force. The added value recorded was EUR 14.55 billion.

Statistics show that 81% of the employees in the bioeconomy sector were from agriculture (1.77 milions pers.). The food, beverage and tobacco industry accounting for 8.3% of the labor force in the bioeconomy sector in Romania (180 thousand pers.). The difference of 10% of the total employed persons was divided between the remaining sectors. The lowest shares were recorded in the bioelectricity and liquid biofuels sectors (below 0.04%) (Figure 3).

Table 3. Descriptive statistics on the number of persons employed in agriculture and other bioeconomy sectors in Romania, 2008-2020 (thousands of persons)

Specification	Minimum	Maximum	Mean	Std. Deviation
Agriculture	**1,772,600.00**	**2,844,400.00**	**2,325,076.92**	**383,279.3**
Forestry	42,900.00	61,800.00	52,092.31	5,686.455
Fishing and Aquaculture	1,600.00	4,700.00	2,530.77	817.9085
Food, beverage and tobacco	180,996.00	208,537.00	187,944.00	7,098.798
Bio-based textiles	60,827.48	132,630.06	91,786.66	17,621.47
Wood products and furniture	90,007.62	129,549.98	99,988.03	9,662.041
Paper	11,748.37	14,961.97	13,362.88	1,108.681
Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)	12,236.97	15,328.65	13,655.63	880.0555
Liquid biofuels	792.83	1,152.49	1,025.99	114.0385
Bio-based electricity	5.61	294.75	169.82	102.622
Total_employed_people	**2.189,092.86**	**3,407,238.51**	**2,787,633.01**	**409,051.2**

Source: SPSS's own representation based on europa.eu data [8].

In Table 3 can we see descriptive statistics on the number of employees in different sectors of the bioeconomy, the maximum, minimum and average value for the period 2008-2020. The data presented show a persistent decline in the number of people employed in the agricultural, food, beverage and tobacco sectors during the period under review.

The maximum number of employees being recorded in 2008 at 2.8 million persons, i.e.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

208 thousand persons, and the minimum in 2020 at 1.77 million persons, i.e. 180 thousand persons. During the period under review, there was a significant increase in the number of employees in the biochemical, pharmaceutical, plastics and rubber sectors and the bioelectricity sector. Beginning with a minimum of 12.2 thousand individuals (equivalent to 6 pers.) in 2009, the workforce in these sectors reached a peak of 15.3 thousand people (or 254 individuals) in 2019.

In contrast, the value added in Romania's bioeconomy sector exhibited a fluctuating trajectory between 2008 and 2020. The minimum value added was recorded in 2010 (10.282 million euros) and the maximum in 2019 (15.37 million euros).

Regarding the distribution of added value by sectors of the bioeconomy, it could be noted that the highest weights were in agriculture, forestry and in the food, beverage and tobacco sectors, with weights of 48.3%, 12.9% and 18.8%, respectively. The lowest share was recorded by the paper, liquid biofuels and bio-bio-based electricity based electricity sectors.

Table 4. Descriptive statistics on value added in agriculture and other bioeconomy sectors in Romania, 2008-2020 (thousands of euros)

Specification	Minimum	Maximum	Mean	Std. Deviation
Agriculture	**5,668.00**	**8,771.00**	**6,976.4615**	**965.02725**
Forestry_	393.00	1,880.00	937.0000	428.40401
Fishing_and_aquaculture	12.00	304.00	126.6154	95.49567
Food_beverage_and_tabacco	1,581.00	2,848.00	2,234.0000	341.27799
Bio_based_textiles	541.00	754.00	630.5385	62.94126
Food_beverage_tobacco	746.00	1,233.00	952.6923	138.69053
Paper_	142.00	295.00	213.3077	57.75867
Bio_based_chemicals_pharmaceuticals_	213.00	474.00	339.5385	80.74715
Liquid_biofuels	4.00	29.00	15.0769	7.93160
Bio_based_electricity	.00	15.00	9.2308	5.71772
Total_value_added	**10,282.00**	**15,372.00**	**12,434.1538**	**1,623.48862**

Source: SPSS's own representation based on europa.eu data [8].

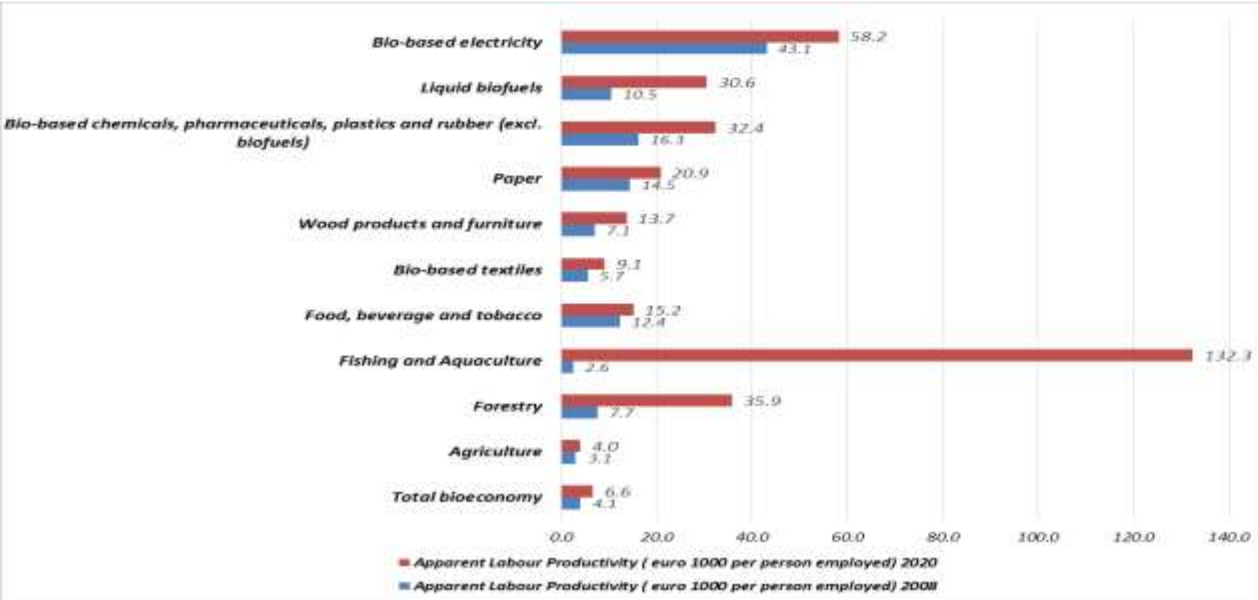

Fig. 4. Apparent Labour productivity in agriculture and other bioeconomy sectors in Romania in the period 2008-2020
Source: Own processing based on europa.eu data [8].

The highest values of value added were recorded in 2019 for most sectors of the bioeconomy, which showed low values during 2010-2012. The Bio-based electricity sector presented the lowest values of value added, with the maximum recorded being 15 thousand euros two years in a row in 2019 and 2020. Apparent labour productivity recorded at national level followed an increasing trend, in 2020 it was 62.3% higher than in 2008. In 2020, the apparent productivity within the bio-based sector equated to only 30% of the average European level. When examining specific sectors, Figure 2 shows a number of significant increases in apparent productivity in areas such as fisheries and aquaculture, forestry, liquid biofuels and bio-based chemicals, pharmaceuticals, plastics and rubber (excluding biofuels).

For instance, the agricultural sector saw a considerable 28.6% increase in apparent productivity in 2020 compared to 2008.

Although Romania does not present a dedicated strategy for the bioeconomy, this concern is reflected in the National Strategy for Research, Development and Innovation 2014-2020. This Strategy highlights the potential of the bioeconomy at the national level by focusing on key sectors: agriculture, forestry, aquaculture and fisheries [16]. At regional level, a limited number of dedicated strategies have been identified, with regions planning for the period 2021-2027 to publish regional strategies and introduce specific measures on the bioeconomy [10].

CONCLUSIONS

Bioeconomy covers a wide range of traditional economic sectors. These sectors present a high potential in terms of innovation given the continuous development that has occurred in recent years. At European level, the bioeconomy generated around 17.2 million jobs and an estimated added value of €664 billion in 2020, with the trend over time being one of increasing added value and decreasing employment. A high potential in the bioeconomy is presented by the food_beverage_tobacco, agriculture and wood_products_furniture sectors with an added value of more than 50 billion Euro in 2020. Romania presents a high potential for the development of the bioeconomy due to the diversity of its natural resources. Primary sectors such as agriculture and food and tobacco are predominantly bioeconomic at the national level. These sectors can help to support sustainable growth through the transfer of knowledge and technology, and the generation of private sector labour.

In the period 2008-2020, the number of employees in the bioeconomy at the national level decreased, and the added value has increased. In 2020, in Romania were registered 2.2 million employees in the bioeconomy, representing 12.72% of the total employed population in the EU-27. The value added was EUR 14.55 billion. Apparent labor productivity increased from €4,100 per employee in 2008 to €6,600 in 2020.

A number of EU Member States have developed national bioeconomy strategies with the aim of achieving a coherent vision, appropriate policies and adequate financial instruments for the development of this sector. The bioeconomy is supported and promoted by the European Union through research and implementation of sustainable solutions, but also through the allocation of funds through the HORIZON 2020 (€3.8 billion) and Horizon Europe 2021-2027 (€10 billion) programs. Agriculture holds a central and crucial position within bioeconomic fields, representing an essential element in this global approach. The contribution to the added value in the economy at the level of the European Union in terms of agriculture, in 2020, was high, the share being 48.3% of the total value. As a key sector, agriculture not only ensures food security and creates employment opportunities, but also serves as an essential foundation for the development of other branches of the bioeconomy.

In contrast, sectors such as bioelectricity and liquid biofuels recorded lower proportions of value added compared to agriculture, indicating significant variation in their contribution to the bioeconomy. These data underline not only the relevance of agriculture at the local level in Romania, but also at the European level, highlighting the diversity and interconnectedness of the bioeconomic sectors.

ACKNOWLEDGEMENTS

The present research is part of the Project ADER 22.1.4 "Research on the development of technical-economic solutions for the creation of value chains in the agri-food sector in view of the transition to the circular bioeconomy" of the Research Institute for Agricultural Economics and Rural Development (ICEADR Bucharest).

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ANALYSIS OF ORGANIZATIONAL MODEL PREFERENCES OF FRESH FRUIT AND VEGETABLE PRODUCERS: A CASE STUDY IN TÜRKİYE

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Abstract

The main purpose of this study is to analyze the organizational tendencies and factors affecting the organizational preferences of fresh fruit and vegetable producers in Izmir province, Türkiye. In study, data from 155 producers were compiled with proportional sampling. A five-point Likert scale was used to evaluate the factors that producers consider important regarding agricultural organization, their preferences and tendencies, and their opinions and expectations. In the study, Analytical Hierarchy Process (AHP) was used to reveal the organization model preferences of the producers according to various criteria. According to the study results, the average age and education period of producers are 49.12 and 7.86 years, respectively. 63.87% of the producers are currently partners in any agricultural cooperative. The most important expectations of producers from cooperatives are the managers must have honest and moral values, create solidarity and unity among the producers, be based on the democratic management approach, and not allow unfair gain and corruption. The most effective criterion for producers' choice of organizational model is price advantage. This criterion is followed by input supply, risk reduction, technical training and consultancy and marketing opportunity in order of importance. When producer decisions are evaluated according to the selection criteria among alternative organizational models; it has been determined that the first choices of producers are cooperatives, followed by individual farms, companies and producer unions, respectively. 76.77% of the producers stated that they could become partners if a Fresh Fruit and Vegetable Cooperative was established in the region.

Key words: *agricultural organization, producer organizations, cooperative, producer movement, social innovation*

INTRODUCTION

Cooperatives: it is a major factor in reducing the number of intermediaries between the producer and the consumer. For every good that reaches the consumer from the producer, values such as profit, wage, interest, and rent, which are production factors, are added at every stage of the distribution channel, and the more the good changes hands until it reaches the end consumer, the more its cost increases, thus the higher the price reflected to the consumer [28].

In Türkiye, due to the characteristics of agricultural production and the small-scale nature of farms, the desired production and income increase in agriculture cannot be achieved [49]. However, due to the scattered settlements in rural areas, the length of the producer-consumer chain, lack of adequate storage conditions and inadequate organization among producers, producers cannot compete with the prices. In Türkiye, producers need to establish their own organizations to be rewarded for their labour by producing marketable products of high quality and in accordance with standards [6]. Effective organization of producers is also very important to increase production, income, and welfare in the agricultural sector [37].

Fruit and vegetable farms in Türkiye do not have any influence on price formation. A small part of the production is subject to export. For this reason, applicable policies are needed that will enable small producers to come together under organizations (unions, cooperatives, etc.) where they can come together and become stronger. There are currently 29 Fresh Fruit and Vegetable Cooperatives in Türkiye, and these cooperatives have a total of 2,953 partners

[31]. In addition, there are four Fresh Fruit and Vegetable Exporters Associations in Türkiye. When we look at the problems experienced despite existing cooperatives and unions, it is seen that cooperatives and unions cannot take a sufficiently active role in production and marketing [39, 52].

Many studies have been conducted in different countries around the world on the marketing effectiveness of agricultural organizations for fresh fruits and vegetables and the satisfaction level of producers with the activities of these organizations [23, 47, 48, 30, 15, 11, 1, 38, 16, 34, 4, 9, 32].

When the study conducted in Türkiye is examined, in some of them, the organizational tendencies of the producers were analyzed [26, 25, 49, 2, 22, 24, 14, 27, 21, 35]. Some of them revealed the contributions of the organization in agricultural product marketing [53, 29, 18, 7, 13, 12, 17, 43, 46]. However, there is a need to conduct research on producer organization in different regions in order to ensure efficiency in fresh fruit and vegetable marketing, reduce the number of intermediaries, and increase producer income.

According to 2022 data, Izmir province constitutes 3.9% (28,150 ha) of Türkiye's total vegetable production area (717,680 ha) and ranks 8th among the provinces. It constitutes 4.2% (153,411 ha) of fruit production areas (3.67 million ha) and ranks 7th [50]. From the perspective of producer organization, there are a total of 289 cooperatives operating for agricultural purposes in Izmir, including 162 Agricultural Development Cooperatives, 82 Irrigation Cooperatives, and 45 Aquaculture Cooperatives [31]. Research to be conducted in Izmir province can reveal the problems faced by fresh fruit and vegetable producers in marketing, as well as make important contributions to determining the organizational tendencies and organizational preferences of producers.

The main purpose of this study is to analyze the organizational tendencies and factors affecting the organizational preferences of fresh fruit and vegetable producers in Izmir province, Türkiye.

MATERIALS AND METHODS

The data that constitutes the main material of the study was obtained by face-to-face survey method from producers producing fresh fruits and vegetables in Bayindir, Bergama, Kemalpasa, Ödemis, Tire and Torbali districts of Izmir province. Apart from this, data published by relevant institutions and the results of previous research on the subject were also used.

It was planned to include the districts where fruit and vegetable production is intense in Izmir province within the scope of the research. According to the data of the Izmir Provincial Directorate of the Ministry of Agriculture and Forestry, approximately 65% of the total vegetable production area and approximately 53% of the total fruit production area in Izmir province are located in Bayindir, Bergama, Kemalpasa, Ödemis, Tire and Torbali districts. Therefore, these six districts were included in the scope of the research.

It was decided that it would be appropriate to include three neighbourhoods producing fruit and vegetables from each district within the scope of the research. In this way; Tulum, Atalan and Yeniköy neighbourhoods from Torbali district; Kizilcaavlu, Yolüstü and Demircili neighbourhoods from Ödemis district; Yeniciftlik, Eskioba and Akkoyunlu neighbourhoods from Tire district, Göcbeyli, Bölcek and Pinarköy neighbourhoods from Bergama district; Tokatbasi, Karaveliler and Balcilar neighbourhoods from Bayindir district; Bagyurdu, Ören and Yigitler neighbourhoods from Kemalpasa district were included in the scope of the research.

In the light of the data received from the District Directorates of the Ministry of Agriculture and Forestry, the total number of producers registered in the Farmer Registration System in these neighbourhoods was determined as 2,188. However, in the study, it was decided that it would be appropriate to include some of the producer through the sampling method. For this purpose, the following proportional sample size formula was used [33]. It is seen that this formula has been used in many previous similar studies [19, 3, 14, 35, 21].

$$n = \frac{Np(1-p)}{(N-1)\sigma^2{}_{px} + p(1-p)}$$
....(1)

where:
n = Sample size
N = Total number of producers
p = Proportion of producers producing vegetables and/or fruits (0.5 was taken for maximum sample size)
σ^2px = Variance.

In the study, calculations were made based on a 99% confidence interval and a 10% margin of error, and the sample size was determined as 155. In determining the number of producers to be interviewed in each neighbourhood, the shares of the neighbourhoods in the total number of producers were taken as basis.

The study was found ethically appropriate with the decision of Ege University Scientific Research and Publication Ethics Committee numbered E-157153. The survey form prepared to collect data included questions to determine the socio-economic characteristics and activity results of producers, questions to determine their perspective on agricultural organization, organizational tendencies, and preferences. The producers to be interviewed in the neighbourhoods were determined using the random numbers table. During the survey studies, the aims of the study and how they can benefit from the results were explained to each producer. The research was based on the 2021 production period. Research surveys were conducted in January-March 2022.

During the data analysis phase, it was planned to first group the producers according to land size in order to make comparisons. Producers are divided into three groups according to land size. Producers with land size of 5 hectares or less formed the first group (58 producers), producers with land size between 5.1-10 hectares formed the second group (42 producers), and producers with land size of 10.1 hectares and larger (55 producers) formed the third group.

First of all, the socio-economic characteristics of the producers are revealed. At this stage; The age of the producers, their education level, household size, land size and use, labor force availability and use and capital availability were examined. Then, the views and expectations of the producers on their level of agricultural organization, their perspective on agricultural organization, their organizational tendencies, preferences and the factors affecting this are revealed.

Likert scale was used to evaluate the producers' knowledge levels regarding agricultural organization, the factors they consider important, their preferences and tendencies, and their opinions and expectations. According to the Likert scale, the expressions in the attitude scale were evaluated on a 5-point scale [10].

In the research, Analytical Hierarchy Process (AHP) was used to reveal the organization model preferences of the producers according to various criteria. Using AHP, it was determined which criteria were given priority and at what level. AHS was developed by Thomas L. Saaty in 1977. In its most general definition, the technique provides a structural approach in determining multiple criteria and importance levels [41]. AHP is a powerful and easy-to-understand methodology that allows groups and individuals to combine and use qualitative and quantitative factors in the decision-making process [40]. AHP uses a hierarchical model consisting of objective, criteria/sub-criteria and importance levels matrices for each problem and is built on three basic principles. These are [42] creating hierarchies, determining superiorities, and ensuring logical and numerical consistency.

The stages of the AHP method can be listed as follows; defining the problem, determining the criteria, presenting the alternatives, drawing a hierarchical tree diagram, determining the criterion importance levels, scoring the alternatives according to each criterion, obtaining the multi-criteria score of each alternative, comparing the overall scores and selecting the best alternative by ranking [51].

A 9-point scoring scale is used in AHS [41]. The larger the scale, the more accuracy and precision in valuation increases. The pairwise comparison matrix of different criteria is expressed as follows. Here, n criteria are listed in rows and columns, up to i=1,2,..,n, and up to j=1,2,..,n, creating the comparison matrix. The wi/wj term in the matrix is used to achieve the goal in the comparison matrix. criterion j. It expresses how important it is than the criterion [41].

In the mathematical modelling of AHP, matrix consistency should be calculated by finding the relative importance levels of the alternatives/criteria evaluated. For a comparison matrix to be consistent, the largest eigenvalue (λmax) must be equal to the matrix size (n) [41, 42]. To calculate the relative importance of the criteria, a “column vector” is created by averaging each row. By normalizing the created column vector, the "relative importance vector" is obtained. Each row in the matrix is multiplied by the relative importance vector to obtain the weighted importance vector. Another vector is then calculated by dividing each element of this vector by the corresponding element in the relative importance vector. As a result, the arithmetic mean of this vector gives the largest eigenvalue, “λmax”. Then, the accuracy of the result is checked by calculating the consistency indicator and consistency rate as follows.

Consistency Indicator (CI) = (λmax–n)/(n-1) ....(2)

If it is a Random Indicator (RI), the consistency rate is presented as follows.

Consistency Rate (CR) = CI/RI ....(3)

Consistency rate can be used in the evaluation stages of the decision maker based on every criterion and is an important concept in terms of the quality and validity of the final decision. The AHP method provides more confidence than other multi-criteria decision-making methods as it allows consistency to be tested. For the decision matrix to be consistent, $CR<0.10$ is required. The closer the CR is to zero, the more consistent the comparison results will be [5].

In the study, it was also tested statistically whether there was a difference between the groups. Chi-square test was applied in comparisons regarding the data obtained by counting. For continuous variables, first the Kolmogorov-Smirnov test and the normal distribution test were applied. Analysis of variance was used for normally distributed variables, and the Kruskal-Wallis’s test was used for non-normally distributed variables [36].

RESULTS AND DISCUSSIONS

Socio-Economic Characteristics of Producers

Some socio-economic characteristics of the producers are presented in Table 1. The age of the producers varies between 24-72 and the average is 49.12. Education periods vary between 5-15 years and the average is 7.86 years. It is seen that the producers in the third group are older and the producers in the same group have longer education periods. However, the difference between the groups in terms of the education period of the producers is not statistically significant ($p>0.05$). The agricultural experience of producers varies between 6-42 years. The average experience period was determined as 22.15 years.

The total population of the farms examined is 586, and the average household size is 3.78 persons. The average population is larger in the farms in the first group. While calculating the family labour potential, the population was first converted into male labour unit (MLU) and then into male labour day (MLD) with the approach that they can work 300 days a year [18, 35]. The average family labour potential in farms was determined as 2.25 MLU.

The land size in farms varies between 0.9-52 hectares. The average land size is 11.38 hectares.

The average number of parcels was found to be 4.58, and the average parcel size was 2.48 hectares.

As the farm size increases, the average parcel size also increases. On average, 62.41% of the total land of the farms consists of owned lands, 25.97% consists of rented lands, and 11.61% consists of jointly operated lands.

Land assets constitute 91.94% of the total active capital in farms. When the distribution of active capital according to items is examined; it is seen that soil assets have a significant share (68.13%), followed by building assets (20.11%) and tools-machinery assets (4.88%). However, it was determined that 70.50% of the liabilities consisted of equity capital.

Table 1. Some socio-economic characteristics of producers

Characteristics	**Farm groups**			
	1.Group (≤5 ha)	2.Group (5.1-10ha)	3.Group (≥10.1ha)	General
Age of producer	49.28	48.55	49.38	49.12
Education period of producer (year)	7.71	7.64	8.18	7.86
Agricultural experience of producer (year)	22.26	22.14	22.05	22.15
Household size	3.92	3.77	3.65	3.78
Family labour potential (MLU)	2.34	2.24	2.17	2.25
Land size (ha)	3.09	8.30	22.46	11.38
Average parcel size (ha)	1.17	1.99	3.24	2.48
Property land rate (%)	77.45	56.66	61.85	62.41
Equity rate (%)	77.10	69.00	69.66	70.50

Source: Results of this study.

Producers' Perspectives on Organization and Their Organization Levels

There is a Chamber of Agriculture in all six districts included in the research. All producers are members of the Chamber of Agriculture. Apart from this, it has been determined that producers are partners in some agricultural cooperatives, members of some breeders' unions for breeding purposes and some producers' unions (Table 2). 63.87% of the producers are currently partners in any agricultural cooperative.

Table 2. Agricultural organizations of which producers are members

Organizations		Farm groups			
		1.Group (≤5 ha)	2.Group (5.1-10 ha)	3.Group (≥10.1 ha)	General
Chamber of Agriculture		58	42	55	155
Agricultural Cooperatives		38	26	35	99
Breeder Unions	Breeding Cattle Breeders Unions	11	10	12	33
	Bee Breeders Unions	2	3	4	9
Producer Unions	Milk Producers Unions	10	9	11	30
	Fruit Seedling Producers Unions	3	4	3	10
	Vegetable Seedling Producer Unions	2	1	2	5

Source: Results of this study.

50.32% of the producers are partners in Agricultural Development Cooperatives and 27.74% in Agricultural Credit Cooperatives. The partnership period of producers in cooperatives varies between 3-18 years, the average period is 12.65 years. In a study conducted in Izmir province, Türkiye, the average partnership period of producers in a cooperative was calculated as 17.23 years [3]. In a study conducted in seven different provinces of Türkiye, the partnership period of producers in the cooperative was determined as 13 years [45]. In a study conducted on cooperative partners in Balikesir, Bursa and Canakkale provinces of Türkiye, the partnership period of producers in the cooperative was determined as 17.02 years [19]. In a study conducted in Isparta province, Türkiye the duration of cooperative partnership; it was determined that it varies between 1-10 years in 49.2% of the producers and between 11-20 years in 40.2% [20].

When producers were asked about the advantages of organization, the most important advantage was; they stated that the partners should meet their in-kind and cash needs and act as intermediaries in the supply of inputs (Table 3).

When producers were asked about their basic expectations from cooperatives, their most important expectations were; it has been determined that the managers have honest and morality values, create solidarity and unity among the producers, are based on the democratic management approach and do not allow unfair gain and corruption (Table 4).

Table 3. Producers' views on the advantages of agricultural organizations*

Advantages	Farm groups			
	1.Group (≤5 ha)	2.Group (5.1-10 ha)	3.Group (≥10.1 ha)	General
It provides the in-kind and cash needs of the partners	4.03	3.98	4.00	4.01
It supports producers in marketing.	3.31	3.26	3.16	3.25
They are more democratic organizations.	2.16	2.12	2.31	2.20
It is an advantage for partners to know each other.	2.59	2.50	2.49	2.53
Participation in management and studies is greater.	2.50	2.40	2.40	2.44
The work can be done cheaper and faster.	2.88	2.64	2.51	2.68
It acts as an intermediary in the supply of input.	3.64	3.55	3.45	3.55
Provides technical information and support to producers.	2.97	2.83	2.76	2.86
It ensures increased production and quality.	3.14	3.17	3.11	3.14
It encourages the production of natural products.	2.76	2.64	2.49	2.63
It makes the region known.	2.91	2.79	2.69	2.80
It supports rural development.	3.24	3.17	3.07	3.16

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this study.

Table 4. Basic expectations of producers from cooperatives*

Expectations	Farm groups			
	1.Group (≤5 ha)	2.Group (5.1-10 ha)	3.Group (≥10.1 ha)	General
Creating solidarity and unity among producers	4.33	4.36	4.33	4.34
Encouraging volunteer participation	4.21	4.31	4.35	4.28
Demonstrating an open and transparent management approach	4.17	4.17	4.15	4.16
Being sensitive to social responsibilities	4.26	4.50	4.20	4.30
Based on democratic management approach	4.22	4.38	4.42	4.34
To act independently	4.19	4.24	4.24	4.22
Creating a positive impact in the region	4.33	4.33	4.33	4.33
Managers must have honesty and moral values	4.38	4.40	4.42	4.40
Creating a fair and reliable environment	4.28	4.14	4.17	4.17
Having an audit and control system	4.14	4.02	4.05	4.05
Not giving opportunity to unfair gain and corruption	4.21	4.40	4.34	4.34
General assemblies work in harmony	3.90	4.07	4.03	4.03
Giving importance to social goals as well as economic goals	3.98	4.10	4.11	4.11

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this study.

In research conducted in Van province, Türkiye, the most important expectations of producers were to increase income, market partners' products and provide input at low prices [49].

When producers were asked about their satisfaction levels with cooperatives, they stated that the most important activity expected from the cooperative was marketing, that they recommended other producers to become partners in the cooperative, and that they supported the creation of a common machinery park in the region (Table 5).

In a study conducted in seven different provinces of Türkiye, it was determined that 70.2% of the partners were satisfied and successful with the cooperative, while 29.8% were dissatisfied and found it unsuccessful [44]. In a study conducted in Edirne province, Türkiye, it was found that 81.5% of the partners considered the product purchasing activities of the cooperatives effective and that they were satisfied [8].

Producers who are not cooperative partners specified that the main factors which affect their non-membership are: managers who do

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

not act honestly and morally, no audit and control system in cooperatives, cooperatives have no influence in the region and that they are not successful (Table 6).

Table 5. Opinions of producers regarding their satisfaction with cooperatives*

Opinions	Farm groups			
	1.Group (≤5 ha)	2.Group (5.1-10 ha)	3.Group (≥10.1 ha)	General
The cooperative in which I am a partner creates benefits	3.02	3.12	3.07	3.06
Cooperative partnership makes my work easier.	3.60	3.62	3.58	3.60
The cooperative raises my standard of living.	3.02	3.17	3.11	3.09
I recommend other producers to become partners in the cooperative.	3.83	3.93	4.00	3.92
I have read the articles of association of the cooperative.	3.10	3.17	3.11	3.12
I attend cooperative general assemblies.	3.19	3.14	3.00	3.11
I speak at the general assemblies I attend.	3.22	3.14	3.00	3.12
There is no favoritism in cooperatives.	3.43	3.62	3.69	3.57
I can take part in cooperative management.	3.02	3.14	3.11	3.08
The most important activity expected from the cooperative is marketing.	3.93	4.10	3.96	3.99
The most important problem of cooperatives is lack of capital.	3.66	3.29	3.44	3.48
I support the creation of a common machinery park in the region.	3.81	3.88	3.87	3.85

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this study.

Table 6. Factors affecting producers not becoming partners in cooperatives*

Factors	Farm groups			
	1.Group (≤5 ha)	2.Group (5.1-10 ha)	3.Group (≥10.1 ha)	General
There is no suitable cooperative in my region where I can become a partner.	2.95	3.07	3.13	3.05
It is difficult to become a partner in the cooperative, there are many transactions	3.64	3.36	3.38	3.47
I do not have the capital I can allocate for the cooperative.	3.34	3.86	3.78	3.64
I don't trust people easily	4.17	4.14	4.15	4.15
Cooperative cannot enable us to act together	4.05	3.64	3.71	3.82
Cooperatives have no impact in the region, I do not find them successful.	4.26	4.50	4.60	4.45
Managers do not act honestly and ethically	4.21	4.79	4.73	4.55
There is no open and transparent management in cooperatives	4.17	4.14	4.15	4.15
I can already sell my products at a higher price	4.17	4.14	4.15	4.15
Agricultural support is already insufficient, and I do not benefit from it.	3.90	3.00	2.96	3.32
There is no supervision and control system in cooperatives	4.28	4.57	4.58	4.46
I don't have any land anyway; I produce by renting.	2.05	2.00	1.87	1.97

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this study.

In a study conducted in seven different provinces of Türkiye, the most important factors affecting producers' participation in cooperatives are it was determined as increasing the economic power by acting together and benefiting from the product sales guarantee [44].

Organizational Model Preferences of Producers According to Various Criteria

In the research, producers' organizational model preferences in terms of cooperative, individual farm, company, and producer union; Priority preferences were analyzed with Analytical Hierarchy Process (AHP) in terms of price advantage, input supply, risk reduction, marketing opportunity and technical training and consultancy services.

Table 7 shows the relative importance values and consistency level calculations of the criteria. In pairwise comparisons, the inconsistency shown by the person making the judgments in the evaluation is expressed as the consistency ratio. While the inconsistency is acceptable below a certain rate (10%), when it exceeds this rate, the decision maker may be asked to reconsider the pairwise comparison judgments. From the findings, it can be stated that the inconsistency contained in the judgments in the pairwise comparison matrix is at an acceptable level. The relative importance values obtained for the criteria are meaningful and interpretable. In this case, the most effective criterion in terms of organizational model preference is price advantage (0.3657). This criterion is followed by input supply (0.2055), risk reduction (0.1739), technical training and consultancy (0.1607) and marketing opportunity (0.0942) in order of importance.

When producer decisions are evaluated according to the selection criteria among alternative organizational models; it is seen that the first choices of producers in terms of price, cost, input supply, risk reduction, technical training and marketing supports are cooperatives, and this organization model is followed by individual farm, companies, and producer unions, respectively (Tables 8, 9,10, 11 and 12).

Table 7. Relative importance values of criteria and consistency level calculations

Normalized values						**Relative importance weights**	**Consistency level**			
Criteria	Price advantage	Input supply	Reduce risk	Technical training and consultancy	Marketing opportunity		aij.wj	aij.wj/wi	CI	CR
Price advantage	0.4014	0.7103	0.4002	0.2144	0.1019	**0.3657**	2.5801	7.0562	0.6009	0.5365
Input supply	0.0816	0.1444	0.3815	0.2579	0.1621	**0.2055**	1.6459	8.0093		
Reduce risk	0.1270	0.0479	0.1266	0.4519	0.1163	**0.1739**	1.5968	9.1799		
Technical training and consultancy	0.1265	0.0378	0.0189	0.0675	0.5528	**0.1607**	1.1340	7.0564		
Marketing opportunity	0.2635	0.0596	0.0728	0.0082	0.0669	**0.0942**	0.5386	5.7170		
Total	**2.4910**	**6.9259**	**7.8992**	**14.8056**	**14.9463**		λmax	7.403		

Source: Results of this study.

Table 8. Evaluation of options in terms of price advantage

Normalized values					Relative importance weights	Arrangement
Options	Cooperative	Individual farm	Company	Producer union		
Cooperative	0.5837	0.7658	0.4114	0.2845	**0.5113**	1
Individual farm	0.1238	0.1624	0.4630	0.3242	**0.2684**	2
Company	0.1455	0.0360	0.1025	0.3196	**0.1509**	3
Producer union	0.1471	0.0359	0.0230	0.0717	**0.0694**	4

Source: Results of this study.

Table 9. Evaluation of options in terms of input supply

Normalized values					Relative importance weights	Arrangement
Options	Cooperative	Individual farm	Company	Producer union		
Cooperative	0.5671	0.7666	0.3672	0.2516	**0.4881**	1
Individual farm	0.1240	0.1676	0.5125	0.3474	**0.2879**	2
Company	0.1539	0.0326	0.0997	0.3323	**0.1546**	3
Producer union	0.1550	0.0332	0.0206	0.0688	**0.0694**	4

Source: Results of this study.

Table 10. Evaluating options to reduce risk

Normalized values					Relative importance weights	Arrangement
Options	Cooperative	Individual farm	Company	Producer union		
Cooperative	0.5937	0.7608	0.4364	0.3106	**0.5254**	1
Individual farm	0.1266	0.1622	0.4377	0.3053	**0.2580**	2
Company	0.1384	0.0377	0.1017	0.3101	**0.1470**	3
Producer union	0.1414	0.0393	0.0243	0.0740	**0.0697**	4

Source: Results of this study.

Table 11. Evaluation of options in terms of technical training and consultancy services

Normalized values					Relative importance weights	Arrangement
Options	Cooperative	Individual farm	Company	Producer union		
Cooperative	0.3306	0.4748	0.7381	0.6045	**0.5370**	1
Individual farm	0.2562	0.4053	0.1726	0.1413	**0.2438**	2
Company	0.3437	0.0997	0.0425	0.1270	**0.1532**	3
Producer union	0.0695	0.0202	0.0468	0.1271	**0.0659**	4

Source: Results of this study.

Table 12. Evaluation of options in terms of marketing opportunities

Normalized values					Relative importance weights	Arrangement
Options	Cooperative	Individual farm	Company	Producer union		
Cooperative	0.5724	0.7846	0.3798	0.2592	**0.4990**	1
Individual farm	0.1105	0.1514	0.4927	0.3439	**0.2746**	2
Company	0.1570	0.0320	0.1042	0.3243	**0.1544**	3
Producer union	0.1601	0.0319	0.0233	0.0725	**0.0720**	4

Source: Results of this study.

When producer decisions are evaluated holistically among alternative organizational models, it is seen that the first choice of producers is cooperative, followed by individual business, company, and producer union, respectively (Table 13).

In a study conducted in seven different provinces of Türkiye, it was determined that the first choice of producers as an organizational model was cooperatives, the most important factor in terms of preferences was market guarantee, and the expectation of good prices came last [45].

Table 13. Holistic evaluation of results

Options	Criteria					Holistic importance	Arrangement
	Price advantage	Input supply	Reduce risk	Technical training and consultancy	Marketing opportunity		
Cooperative	0.5113	0.4881	0.5254	0.5370	0.4990	**0.5120**	**1**
Individual farm	0.2684	0.2879	0.2580	0.2438	0.2746	**0.2672**	**2**
Company	0.1509	0.1546	0.1470	0.1532	0.1544	**0.1517**	**3**
Producer union	0.0694	0.0694	0.0697	0.0659	0.0720	**0.0691**	**4**
Weighting	0.3657	0.2055	0.1739	0.1607	0.0942		

Source: Results of this study.

In a study conducted in Izmir province, Türkiye, it was determined that producers see cooperatives as the most important alternative in terms of the highest profit, lowest risk, and best marketing opportunity criteria to achieve success, and the most important criterion is the best marketing opportunity [3].

According to results of this study, 76.77% of the producers stated that they could become partners if a Fresh Fruit and Vegetable Cooperative was established in the region. In a study conducted on tomato producers in Mugla province, Türkiye, 88% of the producers stated that they could become partners in such a cooperative if it was established in the region [14]. In a study conducted in Manisa province, Türkiye, it was determined that 90.70% of the producers engaged in crop production were willing to become partners in an agricultural cooperative to be established in the region [35]. In a study conducted in Nigde province, Türkiye, it was determined that 74.11% of apple producers could become partners in a cooperative to be established in the region [21]. The most important reasons why producers want to become partners in the Fresh Fruit and Vegetable Cooperative are; marketing problems can be reduced by establishing a cooperative, input prices can be reduced by establishing a cooperative, and local products can be branded by establishing a cooperative. In research conducted on tomato producers in Mugla province, Türkiye, the most important reasons for wanting to become a partner in the cooperative are it has been determined that the marketing problem disappears and tomato production increases [14].

The most important expectations of producers from the Fresh Fruit and Vegetable Cooperative are product prices are higher, product prices are stable, product prices are paid on time and regularly. In a study conducted in Nigde province, Türkiye, it was determined that the most important expectations of apple producers if a cooperative was established in the region would be product marketing, technical information support and input support [21].

CONCLUSIONS

In this study, with the data compiled by survey method from 155 producers with proportional sampling in Izmir province, Türkiye, the perspectives of fresh fruit and vegetable producers on organization were evaluated, their organizational model preferences were analyzed, and their tendencies and expectations towards partnership in case of establishing a Fresh Fruit and Vegetable Cooperative in the region were revealed. According to producers, the most important problems encountered in growing fresh fruits and vegetables are low product prices, high input prices and the fight against diseases and pests. The suggestions that producers most agree with to reduce intermediaries in the marketing of fresh fruits and vegetables are increasing the number of food industry enterprises, ensuring the organization of producers, and establishing an inspection system for intermediaries.

The most effective criterion for producers' choice of organizational model is price advantage. This criterion is followed by input supply, risk reduction, technical training and consultancy and marketing opportunity in order of importance. When producer decisions are evaluated according to the selection criteria among alternative organizational models; it has been determined that producers' first choices are cooperatives. 63.87% of the producers are currently partners in any agricultural cooperative. However, 76.77% of the producers stated that they could become partners if a Fresh Fruit and Vegetable Cooperative was established in the region. The most important reasons why producers want to become partners in the Fresh Fruit and Vegetable Cooperative are; marketing problems can be reduced by establishing a cooperative, input prices can be reduced by establishing a cooperative, and local products can be branded by establishing a cooperative.

Producers mostly market the fresh fruits and vegetables they produce to traders and brokers. Other important channels are processors and exporters. Direct marketing is more limited. producers can generally obtain prices above cost. However, 93% of the producers in vegetable production and 94% of the producers in fruit production are not satisfied with the prices they get. Producers can achieve effectiveness in marketing by coming together in cooperatives. In this way, it will be possible to reduce the number of intermediaries between producers and consumers, producers will sell their products at affordable prices, and consumers will be able to buy products at affordable prices. Since a cooperative that can be established by producers, especially for marketing purposes, may also have a storage, processing, and distribution network, it may also be possible to provide employment opportunities in the region. In addition, the cooperative that can be established in this way can contribute to preventing short migration and attracting young people's interest in agriculture. The most important expectations of fresh fruit and vegetable producers from cooperatives are product marketing efficiency and obtaining high prices. Therefore, it may be useful to take Agricultural Development Cooperatives that are successful in marketing as an example during the establishment of a cooperative.

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Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ANALYSIS OF THE STRUCTURE OF INDONESIAN PALM OIL EXPORT COMPANIES

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Abstract

This study aims to reveal the complex structure of Indonesian palm oil export companies. Primary data were obtained from a survey of 15 palm oil export companies in Indonesia. The survey was conducted through in-depth interviews. The list of companies surveyed was obtained through the Indonesian Palm Oil Research Center (PPKS) with a purposive sampling method. Based on the research results, 13.13% of palm oil export companies are state-owned enterprises (PTPN), and 86.67% are limited liability companies (LLC). 80% of the companies are involved in production, 93% are involved in processing, storage, and packaging, and 100% sell products domestically and export. The survey results show that 93% of the companies have the Roundtable on Sustainable Palm Oil (RSPO) certification, which aims to ensure responsible, environmentally, and socially friendly palm oil production. 66% of the companies have received ISO certification, confirming the quality and efficiency of management systems following international standards. Based on the research results, 93% of companies export to China, 86% to India, 66% to the USA, and 60% to the Netherlands, Germany, Singapore, and Vietnam. Palm oil companies face various problems, such as climate issues, high fertilizer prices, export restriction policies by the government and importing countries, and negative campaigns by NGOs on palm oil. Solutions implemented by the company include careful planning of fertilization, management of raw material purchases, market diversification, active participation in industry associations, and compliance with national and global palm oil sustainability standards.

Key words**:** *palm oil, export, Indonesian company*

INTRODUCTION

Indonesia, renowned for its lush landscapes and abundant natural resources, is an eminent global player in the palm oil industry. Indonesia is the biggest palm oil producing and exporter country in the world [5, 6], with an area of 15.38 million hectares and a total palm oil production of 45.58 million tons in 2022, followed by Malaysia, with palm oil production of 19.20 million tons, Thailand 3.26 million tons, Colombia 1.76 million tons, and Nigeria 1.40 million tons. Indonesia has been exporting palm oil for 104 years (1919-2023) [2], making the palm oil industry an essential engine of economic growth for Indonesia [9] as it contributes significantly to foreign exchange earner, a provider of employment and a source of household income [7]. The industry plays a fundamental role in strengthening Indonesia's position in the global market.

The Indonesian palm oil sector, pivotal to the nation's economy [9], is characterized by a multifaceted structure encompassing many factors, including ownership models, governance practices, environmental sustainability, and supply chain management. However, as palm oil continues to face international scrutiny due to environmental and social concerns, the need to thoroughly analyze the structure of Indonesian palm oil export companies becomes even more compelling. These companies' structure is essential to their day-to-day operations and has profound implications for sustainability, environmental conservation, and responsible business practices.

This research seeks to uncover the complex structure of Indonesian palm oil export companies to provide deeper insight into the structure of palm oil export companies in Indonesia, including an understanding of company ownership composition, production and export activities, government regulations, company problems, and solutions, as well as identifying potential environmental and social impacts of the palm oil export industry.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

MATERIALS AND METHODS

The data used in this study are primary and secondary. Primary data is obtained from surveys conducted directly with companies that export palm oil in Indonesia. The survey was conducted through an in-depth interview. The survey was conducted from March to July 2023. The list of companies surveyed was obtained through the Indonesian Palm Oil Research Center (PPKS); the purposive sampling method was used due to time and resource constraints. This study involved 15 palm oil export companies in Indonesia. Secondary data were obtained from documents, publications, and year-end reports of Indonesian palm oil export companies and related agencies. The data obtained from this study were analyzed using basic statistical methods for comparative tables and interpretation.

RESULTS AND DISCUSSIONS

Demographic characteristics of company respondents

In this study, the characteristics of the surveyed company personnel are analyzed and presented in Table 1.

Based on the research results, 26% of the surveyed company staff are women, while 73% are men. 20% of the surveyed company respondents are 22-25 years old, 46% are 26-29, and 46% are 30-35.

20% of company respondents were single, while 80% were married.

Regarding education level, 100% of the company respondents surveyed are bachelors.

Based on their workplace position, the majority of respondents (46%) are supervisors.

26% were assistant managers, 20% were operators, and 6.6% were trainees.

Based on the length of service of respondents in the company, 46% have worked for 1-3 years and 4-6 years, and 6.6% have worked for more than 10 years.

Table 1. The demographic characteristics of company respondents

Gender	n	%
Female	4	26.67
Male	11	73.33
Total	15	100.00
Age	n	%
22-25	3	20.00
26-29	7	46.67
30-35	5	46.67
>36	-	-
Total	15	100.00
Marriage status	n	%
Not married	3	20.00
Married	12	80.00
Total	15	100.00
Education level	n	%
Elementary school	-	-
Junior high school	-	-
High school	-	-
Diploma	-	-
Bachelor	15	100.00
Master	-	-
Doctorate/PhD	-	-
Total	15	100.00
Position at work	n	%
Supervisor	7	46.67
Manager	-	-
Assistant manager	4	26.67
Company owner	-	-
Operator	3	20.00
Trainee	1	6.67
Total	15	100.00
Length of time working in the company	n	%
1-3 years	7	46.67
4-6 years	7	46.67
7-10 years	-	-
>10 years	1	6.67
Total	15	100.00

Source: Author`s data from the questionnaire survey.

Information on palm oil export companies

Based on the survey results in Table 2, 13.13% of palm oil export companies are state-owned enterprises (PTPN), and 86.67% are limited liability companies (LLC). PTPN is a State-Owned Plantation Enterprise (SOPE) under the direct supervision of the Indonesian government and has specific responsibilities in implementing government policies related to plantations and the environment. LLC is a form of company with limited shareholding. It has greater flexibility in its business management and less direct involvement of the government in the company's operations, except within the framework of applicable laws and regulations. Regarding company activities, 80% of the companies are involved in production, 93% are involved in processing, storage, and packaging, and 100% sell products domestically and export. In terms of production area (plantation), 80% of companies have their own production area, while 20% of companies do not have a production area. Based on the research, 93% of companies process oil palm in company-owned processing plants.

Regarding how long palm oil companies have been exporting, 20% of palm oil companies have been exporting for 11-15 years, and 80% of palm oil companies have been exporting for more than 20 years. Based on the survey results, 80% of the companies get their primary supply of palm oil from their own plantations (nucleus plantations) and plasma plantations. Nucleus plantations are plantation systems owned and managed by large companies. The company owns a large area of prime land for growing oil palm. This land is called the "core" or "core estate." The company usually uses its own labor to manage this core estate. The company is fully responsible for managing and investing in its core estate, including seed procurement, fertilization, maintenance, harvesting, and processing of the oil palm produce. At the same time, plasma oil palm plantations are plantation models that involve the participation of smallholders or farmer groups. In this system, the government or palm oil companies provide smallholders with a portion of their land. This land is called a "plasma estate." Plasma farmers are responsible for the management and maintenance of their own plantations. However, they can receive technical and capital assistance from the government or the parent company through agricultural guidance, fertilization, seed assistance, and access to palm oil processing facilities. Smallholders have contracts with companies to provide fresh fruit bunches (FFB). Moreover, 80% of the company sources its palm oil supply from partner companies, 66% from traders, and 33 % from independent smallholders. The supply purchased by the company from smallholders, intermediaries, and farmers is in the form of fresh fruit bunches (FFB) (Table 2).

Table 2. General information about palm oil export companies

Legal form of company	n	%
PTPN (State-owned plantation enterprise)	2	13.33
Regional company	-	-
State-owned enterprise	-	-
Public company	-	-
Limited liability company (LLC)	13	86.67
CV	-	-
Cooperative	-	-
Total	15	100.00
Company field of activity	n	%
Production	12	80.00
Processing	14	93.33
Storage	14	93.33
Packaging	14	93.33
Domestic marketing	15	100.00
Export	15	100.00
Own production area	n	%
Yes	12	80.00
No	3	20.00
Total	15	100.00
Palm oil processing method	n	%
Doing in own facility	14	93.33
Purchase in processed form	-	-
Using intermediaries	-	-
Facility ownership status	n	%
Owned	15	100.00
Lease	-	-
Partnership	-	-
Other	-	-
How long has the company been exporting	n	%
0-5 years	-	-
6-10 years	-	-
11-15 years	3	20.00
16-20 years	-	-
>20 years	12	80.00
Total	15	100.00
Product supply method	n	%
Own plantation (nucleus)	12	80.00
Plasma plantation	12	80.00
Partner of companies	12	80.00
Collector traders (Smallholder)	10	66.00
Farmers	5	33.33

Source: Author`s data from the questionnaire survey.

Palm oil companies, like other industrial companies, need access to capital markets and raise funds from investors by selling the company's shares to the public through an Initial Public Offering (IPO) or listing on the Indonesia Stock Exchange. Funding from an IPO can be used to finance business expansion, development of new oil palm plantations, expansion of production facilities, investment in technology and innovation, and debt reduction. In addition, joining the stock exchange raises a company's profile and improves its image and reputation in the market. Listed companies usually have easier access to business opportunities and strategic partnerships with other companies. It can help palm oil companies to develop more business opportunities and optimize company value [4]. Based on the survey results, 46% of palm oil companies conducted an IPO, and 53% of companies did not conduct an IPO (Table 3). Some companies said they would conduct an IPO the following year, and some companies were not interested in doing an IPO because they did not need fresh funds for expansion.

Table 3. Palm oil companies that conduct Initial Public Offering (IPO)

Palm oil export company joins Indonesia Stock Exchange	n	%
Yes	7	46.67
No	8	53.33
Total	15	100.00

Source: Author`s data from the questionnaire survey.

Certification is critical for palm oil export companies to demonstrate their commitment to environmental and social sustainable practices, quality, safety, and compliance with international standards. In addition, strong certification standards and ongoing verification are vital tools to assure buyers, consumers, and the general public that a company is implementing, executing, and fulfilling sustainable product production practices. Based on the survey results, 93% of companies are certified by Roundtable on Sustainable Palm Oil (RSPO). RSPO is an international body established in 2004 to regulate and promote sustainable palm oil production. RSPO members must fulfill the RSPO principles and criteria (P&C), a set of strict standards governing sustainable palm oil production. RSPO certification aims to ensure that palm oil production is carried out responsibly, environmentally, and socially friendly [10]. 66% of companies have received ISO (International Organization for Standardization) certification, which applies international standards to ensure that companies have efficient and high-quality management systems. This certification confirms that the company has complied with specific requirements set by the ISO standards. The types of ISO certification obtained by Indonesian palm oil export companies are ISO 9001, the Standard for Quality Management Systems. ISO 9001 focuses on improving the quality of products and services and managing efficient business processes. Its scope ranges from the management system of oil palm plantations, palm oil mills, palm kernel processing, and other supporting facilities. ISO 14001: Standard for Environmental Management Systems. ISO 14001 helps companies identify and reduce the environmental impacts of their operations. It covers the management system of oil palm plantations, palm oil mills, palm kernel processing, and other supporting facilities. Moreover, the last is ISO 45001: Standard for Occupational Health and Safety Management Systems [12]. It covers the management system of oil palm plantations, palm oil mills, palm kernel processing, and other supporting facilities (Table 4).

Table 4. Types of certifications held by export companies

Certifications held by the company	n	%
RSPO Certification	14	93.33
ISO Certification	10	66.67
HACCP Certification	5	33.33
ISCC Certification	8	53.33
Halal Certification	11	73.33
Kosher Certification	8	53.33
GMP Certification	7	46.67
PROPER Certification	5	33.33
BHRISC Certification	1	6.67
ISPO Certification	9	60.00
IFC Certification	1	6.67
SNI	5	33.33
PHPL Certification	1	6.67
OHSAS Certification	2	13.33
FSSC Certification	2	13.33
SMK/OHS Management System	3	20.00

Source: Author`s data from the questionnaire survey.

The Indonesian palm oil industry is essential to the Indonesian economy, and in order to maintain the stability of the national palm oil industry, associations are needed that aim to build and develop the Indonesian palm oil industry together. Joining an association allows companies to have a strong representation in the industry and speak with one voice in dealing with everyday problems, such as government regulations, trade policies, or environmental issues. Associations also provide access to the latest information and knowledge about the palm oil industry, including market trends, new technologies, research, and statistics, which can help companies make better business decisions. Joining an association opens up opportunities to expand business networks with other companies in the palm oil industry, which can help find partners, new customers, or cooperation opportunities. Based on the survey results in Table 5, 100% of companies join the Indonesian Palm Oil Association IPOA or GAPKI. IPOA is an association representing companies in the palm oil industry in Indonesia, and IPOA's primary purpose is to encourage and protect the interests of Indonesian sustainable palm oil industry as a source of prosperity [3]. 13% of palm oil companies are members of the Indonesian Corporate Secretary Association (ICSA) and the Indonesian Seed Association (Asbenindo). 20% of companies are members of the Forum of Communication for Oil Palm Seed Producers. 33% of companies joined the Indonesian Palm Oil Council (DMSI). DMSI aims to improve cooperation and coordination between business actors and facilitate the formulation of national palm oil regulations and policies that can bring business actors to compete, challenging in the international market while still paying attention to environmental sustainability (Table 5).

26% of companies join the Indonesian Biofuel Producers Association (APROBI) According to Sipayung (2023) [11], this association consists of biodiesel and bioethanol companies and forges partnerships with the government and other parties to optimize the use of biofuels in Indonesia. APROBI also seeks to explore new export destinations for biodiesel made from crude palm oil (CPO) by seeking support from relevant departments in destination countries. In addition, APROBI aims to ensure its members' readiness to implement the B35 program, which is a government program to increase the use of biodiesel blended with diesel fuel (Table 5).

Table 5. Export company membership in associations and partnerships

Membership in associations	n	%
Indonesian Palm Oil Association IPOA or GAPKI	15	100.00
Indonesia Corporate Secretary Association (ICSA)	2	13.33
Indonesian Seed Association (Asbenindo)	2	13.33
Forum of Communication for Oil Palm Seed Producers (FKPBKS)	3	20.00
Indonesian Palm Oil Council (DMSI)	5	33.33
Indonesian Issuers Association (AEI)	5	33.33
Indonesian Biofuel Producers Association (APROBI)	4	26.67
Indonesian Oleochemicals Producers Association (APOLIN)	5	33.33
Indonesian Association of Vegetable Oil Industries (GIMNI)	7	46.67
Global Agribusiness Alliance (GAA)	3	20.00
Food Industry Asia (FIA)	2	13.33
AVPN	2	13.33
Tropical Forest Alliance (TFA)	4	26.67
High Conservation Value Resource Network (HCVRN)	2	13.33
Consortium of Resource Experts (CORE)	1	6.67
Decent Rural Living Initiative (DRLI)	1	6.67
Earthqualizer	1	6.67
Fire Free Alliance (FFA)	4	26.67
International Finance Corporation (IFC)	1	6.67
Palm Oil Innovation Group (POIG)	1	6.67
Sustainable Landscapes Working Group	1	6.67
South East Asia Rainforest Research Partnership (SEARRP)	1	6.67
Radar Alerts for Detecting Deforestation (RADD)	1	6.67
Sustainability Assurance & Innovation Alliance (SUSTAIN)	3	20.00

Source: Author`s data from the questionnaire survey.

Information on palm oil export activities

Based on the survey results on export activities presented in Table 6, 86% of companies represent themselves in foreign markets, meaning that they directly and independently try to market, introduce and promote their products in international markets. Representing itself in foreign markets means companies take complete control of their marketing and promotion strategies in certain countries, such as by opening branch offices or corporate branches in destination countries, assigning sales and marketing teams in those countries, or using foreign channels own distribution and supply chain to spread products to overseas consumers. About 86% of the companies studied have overseas branch offices in Singapore, China, India, Germany, Spain, the Netherlands, America, Brazil, and others.

53% of companies use the services of importing companies to represent their products in foreign markets. Importing companies not only serve as intermediaries between producers or exporters in Indonesia and importers and distributors abroad, but they also play an essential role in facilitating trade flows, assisting the promotion of Indonesian products in foreign markets, and ensuring that imported products meet quality standards and regulatory requirements. 13% of companies use in-country intermediaries to represent their products in foreign markets. The domestic intermediaries used are companies engaged in marketing services for commodities produced by state-owned plantation companies (Table 6).

Based on the survey and interviews, the factor that most influence the image of palm oil products in sales is compliance with established standards, totaling 100%. The standards and requirements that Indonesian palm oil producers must comply with in foreign markets are essential because they not only affect the product image but can also affect the competitiveness and market access of palm oil at the global level. Export destination countries, especially the European Union, have strict regulations regarding sustainability and environmental issues. Meeting these standards will help ensure Indonesian palm oil is accepted in international markets and does not face trade barriers or rejection by consumers. The standards required by palm oil export companies today are sustainability certifications such as Roundtable on Sustainable Palm Oil (RSPO), Indonesian Sustainable Palm Oil (ISPO), International Organization for Standardization (ISO), Hazard Analysis and Critical Control Points (HACCP) and other relevant certifications. 66% of product sales image is influenced by image and reliability in the receiving country, 46% by packaging style, external appearance, and promotion activities, and 33% by brand and brand reliability (Table 6).

Based on the research results, the types of products exported by palm oil companies are 86% CPO and PKO. 53% of companies export oleochemicals, 46% biodiesel, 6.6% palm kernel meal (PKM) and seeds, 46% of companies export specialty fats and cooking oil, and 26% export shortening and margarine.

Based on the research results, 93% of companies export to China, 86% to India, 66% to the USA, and 60% to the Netherlands, Germany, Singapore, and Vietnam. 46% export to Spain and Italy, 40% to Brazil, 33% to Bangladesh, Pakistan, and the United Kingdom, and 20% to South Korea.

Table 6. Palm oil company export activity information part one

Ways of representation in overseas markets	n	%
Self-represented	13	86.67
Importing company	8	53.33
Overseas intermediary	-	-
Domestic intermediary	2	13.33
Factors that affect product image in sales.	n	%
Brand and brand reliability.	5	33.33
Compliance with standards	15	100.00
Packaging style and external appearance.	7	46.67
Image and reliability in the receiving country.	10	66.67
Logistics and coordination with buyers.	-	-
Promotion activities.	7	46.67
Types of products exported	n	%
Crude Palm Oil (CPO)	13	86.67
Paml Kernel Oil (PKO)	13	86.67
Oleochemical	8	53.33
Biodiesel	7	46.67
Palm Kernel Meal (PKM)	1	6.67
Seeds	1	6.67
Specialty Fats	7	46.67
Cooking oil	7	46.67
Shortening	4	26.67
Margarin	4	26.67
Main export destination countries	n	%
China	14	93.33
India	13	86.67
Netherlands	9	60.00
Spain	7	46.67
USA	10	66.67
United Kingdom	5	33.33
Jerman	9	60.00
South Korea	3	20.00
Bangladesh	5	33.33
Pakistan	5	33.33
Brazil	6	40.00
Singapore	9	60.00
Vietnam	9	60.00
Italia	7	46.67

Source: Author`s data from the questionnaire survey.

The company also exports palm oil to France, Kenya, Turkiye, Japan, Philippines, Cameroon, Peru, Papua New Guinea, Nigeria, Gabon, Russia, Kenya, Ivory Coast, and Ghana (Table 6).

Based on the research results, 100% of palm oil companies export palm oil products and their derivatives using sea transportation (Table 7). The average company studied has its cargo ship, dock, and port facilities in various strategic locations. Tank trucks will transport palm oil processed and stored in storage tanks from the mill to the port. Tank trucks are the most common mode of transportation used to transport palm oil from the mill to the port. Tank trucks are equipped with large-capacity tanks specifically designed to transport liquids such as palm oil. Based on the research results, the shipping terms most widely used by companies are FOB (Free on Board) and CIF (Cost, Insurance, and Freight). The choice between FOB and CIF depends on the agreement between the seller and the buyer and the specific needs of the export transaction.

Table 7. Palm oil company export activity information part two

Types of transportation channels used for export	n	%
Sea transportation	15	100.00
Land transportation	-	-
Air transportation	-	-
Shipping terms used in exports	n	%
FOB (Free on Board)	15	100.00
C&F (Cost and Freight)	-	-
CIF (Cost, Insurance and Freight)	15	100.00
Methods for finding buyers for the company	n	%
Through acquaintances or references	-	-
Through representative companies	-	-
Self-discovered import company	13	86.67
Through trade councils, export associations, governments and the like	8	53.33
Through overseas branches of the company	13	86.67
The buyer groups that companies target in exports:	n	%
Import companies	13	86.67
Agents	-	-
Company's own branch in destination country	13	86.67
Contract Type	n	%
Written	15	100.00
Oral	-	-
Written and Oral	-	-
Sales connection method in the company:	n	%
Short-term	15	100.00
Long-term	-	-
Short-term and long-term	-	-
None	-	-
Assessment of government incentives	n	%
Adequate	-	-
Insufficient	4	26.67
Inadequate	11	73.33

Source: Author`s data from the questionnaire survey.

As for how companies find buyers, 86% of import companies find them themselves (Table 7); importers search for companies through search engines, their country's embassy office, or trade directories specific to the palm oil industry. After finding a few potential companies, importers will visit the company's website to get more information about the products offered, production capacity, palm oil quality, and trade terms offered. 53% of companies find overseas buyers through trade councils, export associations, governments, and the like by utilizing institutions or organizations that have a role in facilitating and encouraging international trade activities. 86% of companies find buyers through company branches abroad (Table 7).

Based on the research results, 86% of the buyer groups the company targets in exports are import companies and the company's branches abroad. The type of purchase contract is 100% written. The purchase contract method is 100% short-term due to fluctuating palm oil prices and changing government policies. Short-term contracts allow the company to adjust prices according to changing market conditions more quickly. If palm oil prices increase suddenly, the company can adjust the selling price to earn higher profits.

Based on the research results, the government sets 100% of Indonesian palm oil export prices through the Ministry of Trade of Indonesia (Table 8). The Ministry of Trade once a month sets the benchmark export price (HPE), which is based on the international average price or FOB average price. It follows the Regulation of the Minister of Trade of the Republic of Indonesia No. 35/M-DAG/PER/12/2005 on the Determination of Export Benchmark Prices (HPE) for palm oil, CPO, and its derivative products. Palm oil companies will follow the export prices set by the Indonesian government. The method by which export companies obtain market information is 100% from government publications and exporter associations such as CPOPC and BPDPKS (Table 8). The Council of Palm Oil Producing Countries (CPOPC) is an intergovernmental organization of palm oil-producing countries that aims to promote, develop, and strengthen cooperation in palm oil cultivation and commodities among member countries. It currently consists of Indonesia-Malaysia as the world's largest palm oil producers [1]. 86% of companies rely on internal research institutes within their own company to obtain information about the market. 46% of companies get information about the market from government and industry publications in the countries where they export palm oil.

Table 8. Palm oil company export activity information part three

Export pricing methods within the company	n	%
Determined by the company itself	-	-
Buyers of the destination country collectively determine the price	-	-
Buyers individually determine the price	-	-
Company representative determines/suggests price	-	-
Government (Ministry of Trade)	15	100.00
Methods of obtaining market information	**n**	**%**
Representatives/distributors in the market	-	-
Government and industry publications in the market country	7	46.67
Government publications	15	100.00
Exporters' associations	15	100.00
Internal company market research	13	86.67
Market research company	-	-
Internet	-	-
Required ınformation on overseas markets	**n**	**%**
Product price	15	100.00
Product demand	15	100.00
Market size	15	100.00
Market structure	15	100.00
Country policy	15	100.00
Foreign policy of export destination	15	100.00
Competitor prices in other countries	4	26.67
Product quality	15	100.00
Shipping information	15	100.00
New potential market	15	100.00

Source: Author`s data from the questionnaire survey.

Information on export company problems and solutions

1.Climate problems. Unpredictable weather changes (extreme weather), including abnormally high rainfall or long dry spells, affect the productivity of palm oil products and hamper the global logistics supply chain. Solution: The company conducts strict infrastructure maintenance, meaning that the company tries to ensure that the facilities and amenities used in the harvesting process remain optimally functional and uninterrupted despite the abundance of rainy weather conditions. In addition, the company also conducts careful fertilization planning with a short time interval to ensure that plants still get the nutrients they need in unpredictable weather situations.

2.High fertilizer prices. Solution: The company uses processed fertilizer products produced through research and development conducted at the company's internal research center so as not to interfere with fertilization and crop maintenance. In facing the challenges of fertilizer prices and availability, a collaboration between companies, the government, and other stakeholders will be vital to finding sustainable solutions that positively impact the palm oil industry in Indonesia.

3.Fluctuations in raw material supply. That is, the purchase of fresh fruit bunches (FFB) from third parties has yet to be achieved. Solution: The company should have a clear and well-defined SOP for managing raw material purchases. These SOPs include conducting purchase requests, approval processes, supplier selection, supplier risk evaluation, stock availability monitoring, etc. With a structured SOP, the company can reduce the risk of raw material availability by ensuring that the purchasing process runs smoothly and is organized.

4.Global economic uncertainty. The palm oil industry has experienced the impact of global economic uncertainty caused by several factors, such as the trade war between the United States and China, the COVID-19 pandemic, and the conflict between Russia and Ukraine. Solution: Market diversification is one way to reduce dependence on markets affected by economic uncertainty is to look for alternative markets. Companies must actively seek new opportunities and develop markets in other countries, be it in Asia, Europe, or the Americas. In addition, implementing proper risk management strategies, including supply management, risk analysis, and reserve funds to deal with unexpected situations, can help mitigate the impact of global economic uncertainty.

5.Export restriction policy (DPO and DMO) by the government. Through the Ministry of Trade of Indonesia, the Indonesian government implemented a policy of limiting crude palm oil exports through Domestic Market Obligation (DMO) and Domestic Price

Obligation (DPO) to address the rising prices and scarcity of cooking oil in Indonesia. Palm oil exporters must fulfill a domestic supply of 20% of the company's export volume (DMO). The government also implemented a DPO policy set at IDR 9 300/kg for CPO and IDR 10 300/liter for olein [8]. The impact of these policies was that palm oil export volumes declined significantly, and the payment cycle for export product sales was constrained. In addition, the inconsistent implementation of the DMO and DPO policies has proven to hamper and reduce the competitiveness of the palm oil industry because it is based on policies that have been built for a long time. Palm oil companies and palm oil farmers have also experienced losses, namely difficulties in selling fresh fruit bunches (FFB) because many palm oil companies do not want to buy FFB from farmers because the stockpile tanks are full due to the absence of exports. Solutions: The company is actively involved in various palm oil organizations/associations. It works closely with industry stakeholders to provide positive input to the Indonesian government to create regulations conducive to the palm oil industry and other stakeholders domestically and internationally.

6.The government's implementation of export levy (PE) policies and export duty tariffs directly and materially affects the company's financial performance. The government determined the adjustment of export levies and export duty tariffs several times through the Minister of Finance Regulation of the Republic of Indonesia in 2022. Solutions: The company is actively involved in various palm oil organizations/associations. It works closely with industry stakeholders to provide positive inputs to the Government of Indonesia to create conducive regulations for the palm oil industry and other stakeholders domestically and internationally.

7.Regulatory changes by importing countries. Import tariffs, taxation, and other import restrictions imposed by importing countries affect the demand for CPO and its derivative products and encourage substitution for other vegetable oils. If the importing country bans imports of CPO from Indonesia, then other substitute products, which are taxed differently from CPO, such as soybean oil with lighter taxes, can negatively impact the competitiveness of CPO and its derivative products, which in turn impacts the demand and prices of products from Indonesian palm oil companies. Solution: Palm oil companies continue to follow changes in Indonesian and international government regulations and analyze the impact of these changes to make business decisions quickly and appropriately.

8.Negative campaign on palm oil by environmental and social NGOs. Negative campaigns by environmental and social NGOs against palm oil and boycotts of consumer products containing palm oil in some parts of the world have led to a low product image and public acceptance of palm oil products. Solution: to meet the sustainability challenges of palm oil products, Indonesian palm oil companies are actively participating in ISPO (Indonesian Sustainable Palm Oil) and RSPO (Roundtable on Sustainable Palm Oil) and conforming to global requirements such as No Deforestation, No Peat, No Exploitation (NDPE). ISPO is the national palm oil sustainability standard, while RSPO is a global standard that applies internationally. By complying with ISPO and RSPO standards and integrating NDPE requirements, companies can ensure that their palm oil products meet globally recognized high sustainability standards. In this way, palm oil can remain a product that contributes positively to the economy and environment without compromising long-term sustainability. In addition, the company provides education and socialization on the palm oil industry's sustainability practices.

CONCLUSIONS

This research provides valuable insights into the demographic characteristics of company personnel, the structure and practices of palm oil export companies, and their strategies for international market representation. It highlights the importance of compliance with sustainability standards, industry associations, and overseas branches in expanding market reach and ensuring a robust product image in sales. In addition, palm oil export companies are actively addressing various challenges, ranging from climate-related issues to regulatory changes and negative public perception. Collaboration, adherence to sustainability standards, and proactive engagement with government and industry associations are crucial in their strategies for problem-solving and maintaining the competitiveness and sustainability of the palm oil industry.

ACKNOWLEDGEMENTS

The authors would like to thank the palm oil export companies in Indonesia that participated in this study. This research received no specific grants from funding agencies in the public, commercial, or non-profit sectors.

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