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SUPPORT SYSTEM FOR MANAGEMENT DECISION-MAKING BY HEADS OF HYDROLOGICAL EMERGENCY SITUATIONS LIQUIDATION USING GEO-INFORMATION TECHNOLOGIES

The main purpose of the article is to create a management decision-making support system for the head of emergency liquidation of hydrological origin, which includes the use of geoinformation technology tools, in particular the ArcGIS software complex.

Keywords: *civil protection, sustainable development, data visualization, catchment basins, ArcGIS software.*

Introduction

When natural emergencies occur, special attention is paid to monitoring and observing changes in the environment and the course of events in real time. In order to respond in time to all changes and possibly predict the future situation, the head of emergency response must know and use a wide range of tools, one of which is a geographic information system (GIS).

Information about the state of the environment plays an important role when making management decisions both in the field of environmental protection, liquidation of the consequences of emergency situations, and in the fields of management of spatially distributed man-made objects (urban economy, transport, energy, etc.).

It is necessary to take into account the potential effect of the surrounding natural environment, which can harm water management facilities and other technological process;

- take into account changes in the state of the environment in order to avoid accidents caused by natural factors;
- to implement the management policy in such a way as to minimally harm the natural environment.

In order to make really optimal decisions, you need not just up-to-date information, but it is needed quickly and, most importantly, in a form that is convenient for decision-making. A huge amount of data, which is accumulated and constantly updated in the field of environmental monitoring and natural cadastre data management, should be organized, systematized and structured as much as possible to ensure its processing and presentation of the result in the form that will be most convenient for decision-making. At the same time, the data processing experience accumulated in the world should be widely taken into account.

World experience has proven that the best way to present, store and process information that has a spatial component (geographic reference) is geoinformation systems.

The use of GIS makes it easier to monitor and observe the situation and, according, make management decisions regarding the occurrence of additional risks for the population and territories. This tool is especially effective in large-scale emergencies such as floods, forest fires and earthquakes.

The current hydrological state of rivers and their environmental quality in Ukraine is not satisfactory. This applies to places that are constantly affected by anthropogenic influence in the form of discharge of sewage and return water, as well as natural runoff from polluted areas and agricultural fields and plots. Taking certain measures to regulate this impact and manage the existing situation in order to improve the carrying capacity, improve the quality of surface waters and bring them into compliance with regulations is becoming imperative. Similar measures and management decision-making should be scientifically based and optimal in the spectrum of all possible solutions.

In addition, in order to ensure the convenient access of the head of liquidation emergency situation to the monitoring data, it is necessary to create an information system to support management decision-making using geoinformation technologies, which are the optimal way of presenting hydrological and environmental information.

Methods and materials

The issue of improving support for management decision-making by emergency response managers has always been, is, and will be relevant.

In the article [1] emphasizes the importance of decision-making in the process of prevention, localization and liquidation of the consequences of emergency situations of various nature. The strategy proposed by the authors, based on formal approaches, will improve the quality and speed of decision-making when planning preventive measures and eliminating the consequences of disasters. In the future, the authors plan to develop this strategy to create an intelligent decision support system for civil protection officials. However, as the authors themselves note, this strategy is theoretical and formal, which entails certain difficulties in implementing it in practice in real emergency situations.

The articles [2, 3] describe management decision-making strategies from the perspective of the socio-psychological aspect in emergency situations. The authors prove that decision-making by a group of people is psychologically easier than making managerial decisions by one person, especially when it comes to risks to other people's lives. As a way of facilitating such decision-making, the authors see the receipt of a wide range of information by the manager of emergency liquidation, which will provide an opportunity to get a comprehensive overview of the event and make the right decision. This proves that our proposed support system for management decision-making by emergency management managers will be useful in practical activities.

The study [4] presents an innovative scenario-response analysis framework for emergency management during construction safety accidents. This approach offers a local risk analysis at a specific facility with a local emergency event and is not applicable to large-scale emergency situations.

In the article [5], the authors propose a management decision-making strategy based on the example of systemic and periodically occurring events. However, emergency situations of hydrological origin are not always systemic and occur seasonally, but in different territories. The authors of the work [6, 7] apply an improved, using intuitionistic fuzzy sets and analysis of the regime and consequences of risk failure, the above-described strategy for decision-making in earthquake mitigation. As expected, the described strategy targets systemic and periodic emergencies such as earthquakes, but will not be effective for flooding situations.

In Ukraine, the problems of management decision-making were considered in a number of articles. Thus, in the article [8], the authors propose the creation of an effective information and analytical subsystem for managing the processes of prevention and localization of the consequences of emergency situations. However, the authors do not provide practical testing or at least simulation of application in real events, so it can be concluded that this subsystem was not used in real emergency situations or their models.

In the articles [9, 10], the authors consider the possibilities of standardizing management decision-making for various emergency situations, but the authors themselves agree that the more specialized the management decision-making system is in accordance with a specific emergency situation, the higher efficiency of the liquidation manager's work of this emergency.

In the work [11] developed a new methodology based on a Bayesian network and influence diagram for risk management and decision-making in marine oil spill accidents. A case study of marine oil spill accident due to subsea oil pipeline leak is used to illustrate the methodology. The example of this methodology clearly shows how the specialization of the methodology affects the effectiveness of final decision-making.

In the paper [12], the authors describe a method called the "Evacuation Diagram" to support risk-based evacuation planning and decision-making. This makes it possible to effectively plan the evacuation of the population in large-scale emergency situations, such as flooding. However, evacuation is only a part of the general powers of the manager of liquidation of an emergency situation, and in a flooding situation, the management decision-making system requires a comprehensive approach.

In the work [13] considers a comprehensive set of information collection such as expert opinions, statistical data and analysis of various social, technical, institutional, cultural, infrastructural and environmental factors that contribute to the occurrence of floods. The authors tested the idea on the flooding that occurred in Pakistan in 2010 and concluded that if there was sufficient information about the emergency situation, the number of victims could be reduced several times, due to the creation of engineering and technical measures of civil protection. On the basis of this, we conclude that the idea of creating a flood database as part of an information system to support management decision-making by managers of liquidation of emergency situations of hydrological origin will be extremely useful.

The study [14] first established a comprehensive flood resilience assessment system for cities with the entire disaster cycle, covering flood resilience, flood coping and recovery capacity, and post-flood adaptation capacity. This system has been practically applied and is constantly supplemented according to the recommendations of experts. However, this system does not yet take into account non-urban areas, such as agricultural lands, nature reserves, recreational areas, etc., which have other important aspects from the point of view of preventing and eliminating an emergency of hydrological origin.

In the works [15, 16] describe and analyze the priorities of various available innovative solutions that have sufficient potential to be useful and used in practice. One of the conclusions that the authors declare is that the use of GIS technologies today is a vital tool in making management decisions, especially for the head of liquidation of an emergency situation of hydrological origin.

The authors of the works [17, 18] investigate various emergency situations, such as the spread of forest fires and the stress-deformed state of the soil with the help of GIS tools and their effectiveness in decision-making, regarding the elimination of these situations, which may also be useful for use in the support system for management decision-making by heads of hydrological emergency liquidation.

In the articles [19, 20] explore the application of GIS technologies for modeling and decision-making in the event of flooding of territories. The authors note that this tool can be used not only for graphic visualization, but also for planning the allocation of resources, personnel and technical means of protection. These articles describe only the component of the application of GIS technologies and do not show its complex application with other measures, but emphasize its necessity.

In the work [21], the authors proposed the theoretical aspects of the conceptual model for managing portfolios of flooding projects, which will help in making effective management decisions. However, practical application is not described in this article. In the articles [22, 23], the authors already present practical ways of using the proposed management model with the application of GIS technologies on real examples of the territory of Ukraine. However, the authors note that for more effective and faster work of the proposed model, it is necessary to create an information system to support management decision-making, which will provide a full range of opportunities to the head of emergency response when responding to an hydrological emergency.

The article [24] considers the relevance of using a complex of terrestrial hydrological, radioecological, and modern remote methods in the process of monitoring studies of territories that are difficult to access, swampy, and largely radionuclide-contaminated. The main idea of the article is to indicate the widely used spectrum of GIS technologies, including for radiation-contaminated territories, which should be taken into account in further research.

It is advisable to combine all the above-described aspects and tools into an information system, which will enable the head of emergency response to use current data and forecasting results developed by GIS technology tools.

In the work [25], the authors present the development of a new interpretive framework for the analysis of risk management strategies in organizations, which will make it possible to assess sustainability through risk assessment in the perspective of sustainable development goals. This model is a good solution for organizations and companies, but from the point of view of responding to hydrological emergency situations, a new specialized system must be developed.

In articles [26, 27], the authors of the study consider collaborative electronic development based on public opinion and expert knowledge. To improve efficiency, they propose a multi-phase model of collaborative emergency decision-making based on knowledge and opinion, which combines social media data representing public opinion with expert knowledge and experience. In addition, the authors applied a real flood case in South China in 2020 to test the proposed model. This methodology is extremely interesting and practically tested, however, in Ukrainian realities, when emergency situations of flooding occur in remote mountainous areas and the density of the population using social networks in these territories is small, since the average age of the inhabitants of the villages is 45 years. The question of the feasibility of taking this factor into account arises, especial when making management decisions.

Having analyzed the above, it can be concluded that for effective management decision-making in liquidation of hydrological emergency situations, it is necessary to collect information, constantly update it, involve employees of other services, such as water management, environmental, information-analytical, logistics to collect and analyze the requested information. In addition, it is necessary to use the tools of GIS technologies, which will undoubtedly help in making effective management decisions. And all this can be combined into one information system to support management decision-making, which will be constantly improved and filled with relevant information.

Results and discussion

A complex of technologies for creation support system for management decision-making by heads of hydrological emergency situations liquidation (SSMD HHEL) should cover a wide range of tasks:

- monitoring of water resources and forecasting the development of the situation;
- analysis of flooding risks and other hydrological hazards;
- prompt alerting and informing the population about the danger by means of local alert systems;
- coordination of actions between rescue units;
- making decisions about evacuation and resettlement of the population;
- planning and allocation of resources to eliminate the consequences of emergency situations;
- damage assessment and planning of further restoration activities;
- determination of risk zones for the spread of an emergency situation based on geodata;
- ensuring the safety of personnel and the population during an emergency;

- monitoring the state of infrastructure facilities;

- construction of engineering and technical structures of civil protection and implementation of measures to protect territories from an emergency situation.

Solving all these tasks requires an integrated approach, that is, taking into account many factors, collecting and updating a large amount of diverse information about water bodies, water users, and hydrometeorological conditions; formation of certain predictive information. This causes a number of problems of an organizational, regulatory, methodological and financial nature, as well as problems related to the choice of optimal methods and technologies for presenting, storing and processing this information.

However, in accordance with the tasks of the head of hydrological emergency liquidation, in order to make management decisions, the system must be able to handle data not only about water resources, but also about other natural resources, about sources of their pollution and dangers that not only directly pollute natural waters with sewage, and are potentially dangerous objects (landfills for waste disposal sites, critical infrastructure objects, etc.).

Therefore, it is important to develop a decision-making support system with a bank of ecological, water management and cadastral information about the water fund, water and other natural resources, the use of water resources, the qualitative and quantitative state of water, existing engineering and technical structures of civil protection, statistical historical data on flooding in the studied territory with ordering, systematization and structuring of information into a single system, which would become the basis for solving the problems of assessment, forecasting, monitoring of the state of water and liquidation of flooding in catchment basins and for managing crisis situations in them.

SSMD HHEL must satisfy a number of requirements:

1. Ensure comprehensive monitoring of the state of the environment and sources of its pollution with the unification of indicators lists and geographic objects-locations of sample sampling. For this, a single model of the hydrographic network should be created, which would combine all available data of the water fund on the rivers and reservoirs of the basin and information about them in the data management systems for monitoring the state of water and data on water use (special water use).

2. Provide constant updating (updating) of system data from other information systems in an automated mode, which, firstly, will ensure the constant relevance of data, secondly, will require a minimum of time for system support, and thirdly, will allow to constantly check the correctness of data imported from one system based on data analysis from another.

3. Provide information support for decision-making according to both basin and administrative principles of management. That is, the input, processing and output of information should be carried out according to the criteria formed by both the first and second principles. And this, in turn, ensures the ease of use of the system both for basin management of water resources and for the head of hydrological emergency liquidation.

4. Provide the possibility of exporting information into common formats. Databases — in XML (for transferring data to other Ukrainian or pan-European systems), MS Excel (for further data processing, preparing reports with numerical information), MS Word (for generating text reports). Maps — into graphic files (BMP, JPG, PNG, etc.).

5. To perform basic functions, do not require the purchase of licenses for professional geoinformation software, which will allow the system to be easily distributed to an unlimited number of users who will enter input data and use the system's analytical reports to make decisions. To work with the system, it should be enough for computers traditional for Ukrainian institutions: MS Windows XP and MS Office.

The authors have developed an algorithm for creating a support system for management decision-making by heads of hydrological emergency situations liquidation, which meet all the above requirements. The main idea is the technology of spatially oriented data presentation, which is based on the following principles:

1) monitoring of pollution sources is carried out in complex with changes in the state of the environment that they cause;

2) the basis of the water ecosystem — the hydrographic model — is identified based on the data of the main systems of nationwide monitoring of the state of the environment and sources of its pollution;

3) all monitoring objects are linked to geographical maps using a unified approach;

4) all data in the system is systematized according to a single approach and connected with all others.

The main principle of the author's system, which determines its name, is that all data on real physical objects (rivers, reservoirs, forests, monitoring posts, water intakes) are tied to a geographical map, and all other data (sampling locations samples, civil protection engineering facilities and auxiliary data) are spatially and informationally and logically linked to them.

Systems created on the basis of this technology integrate all available information about environmental objects and anthropogenic influence on them, allow to identify trends and causes of changes in the state of the environment, ways to reduce anthropogenic load on the environment, violations of environmental and fire safety requirements and the culprits of this , produce optimal solutions for integrated management of the state of the environment, etc.

A generalized algorithm for creating a support system for management decision-making by heads of hydrological emergency situations liquidation in the form of a block diagram is shown in Figure 1.

Figure 1 – Generalized algorithm for creating a support system for management decision-making by head of hydrological emergency liquidation

The generalized algorithm for creating an information system is as follows:

Stage 1. Arrangement and systematization of data. All input data is collected, systematized and classified in a certain way.

I. Due to the need to take into account the history of changes.

1. Static — characterized by the value of a variable that is relevant at the moment, as a rule, these are passport data about environmental objects.

2. Dynamic — characterized by an array of values at different points in time, as a rule, these are data on the state of the environment.

3. Annual static data — characterized by the value of a variable that is relevant in the current year, but the data may change from year to year, as a rule, these are data on sources of pollution.

In general, all static data can be considered as annual static data, since completely unchanged data almost does not exist.

II. By object type.

1. Reference data on environmental objects (static data).

2. Reference data on water use and sources of basin pollution (annual static data).

3. Data on environmental quality indicators (dynamic data).

4. Data on water quantity indicators (dynamic data).

5. Reference data on quality indicators, quantity indicators, their limit values of various types, types of characteristics of environmental objects and sources of pollution (static data).

6. Metrological data (data on measurement methods, measuring equipment and measurement errors) — specific information that, only in some subjects of the state monitoring system, necessarily accompanies each measured value and is entered into a computer database.

7. Data on other objects of the basin (static data) — data that may be needed during decision-making (data on the population of each settlement in the region, engineering and technical facilities of civil protection, data on elements of the road network, pipelines, etc.).

III. By spatial distribution of data.

1. Spatially concentrated data (values of indicators of the quality or quantity of water in a creation or monitoring post) — for their maintenance, it is optimal to use database management systems (MS Access, Oracle, MySQL, etc.).

2. Spatially distributed data with a geographical reference (elevations of the terrain, coordinates and contours of rivers, cities, forests, etc.) — for their management, it is optimal to use geoinformation systems (ArcGIS, Mapinfo, etc.).

3. Topological data (hydrographic network with monitoring objects, sources of pollution and other objects) — interconnected spatially oriented data in the

form of a graph model, for their management it is optimal to use geographic information systems (ArcGIS, Panorama, etc.).

Stage 2. Structuring of information. A single basin model of all data on basin objects is formed. Basic principles:

1) all geographic objects of the system must have certain numerical or textual characteristics, all data must necessarily be associated with certain geographic objects;

2) maximum data connectivity — each group of data should be connected to another, mainly through hydrographic network objects.

Since it is impossible and impractical to enter all information about environmental objects in the form of specific numerical or text indicators, it is possible to characterize any geographical object with arbitrary graphic materials in the most popular formats: text (doc, pdf, txt), numerical (xls — MS Excel format), hypertext (htm — Internet web pages), graphics (bmp, jpg, png). In the form of specific values of indicators in the database, it is advisable to submit only that information from which it may be necessary to select and filter data in the future, and all other information will already be used as additional data about the found object. This approach to data management ensures speed and convenience of updating various information about a large number of objects.

If certain data do not have a precise geographical reference, for example, the species composition of fish in a river, then reference is made to the entire object as a whole — to the river, to the reservoir, or, in extreme cases, to the administrative region or the pool as a whole. In the event that only the geographic location of the object is known, but none of its characteristics are yet known (a small pond, a water source, a forest plot, etc.), then it is possible to enter at least the proper name of the object and information materials about it in the above formats.

If there is a complex system of water objects, pollution sources or water management objects in the basin, a separate model of connections is created for them, which will allow tracking all the relationships and interactions between them.

Stage 3. Spatial orientation of all data relative to the topological network of water resources.

A single topological object is created - the hydrographic network of the basin. The main requirements for it:

1. In places where the river is represented by planar objects (wide channel, channel reservoirs), the middle of the fairway is laid or a conditional line of the averaged river current is laid, along which the main flow of pollution moves, from the source of the river to the mouth, bypassing the islands, this is the route as a linear object and becomes an element of the hydrographic network.

2. All canals or other man-made objects and their separate sections can be elements of the hydrographic network only if it is necessary to ensure the integrity of the network (when a separate section of the river has turned into a channel and without the involvement of this section the network will be broken). A condition for the integrity of the hydrographic network is the physical possibility of laying a route from the source of any tributary of the highest order to the mouth of the main river. The exception is cases when a section of a particular river "goes underground", then this river is not an element of the network. Any water bodies that do not contribute to hydrographic integrity networks (canals, water pipelines crossing rivers) are considered extraneous are not added to the network itself.

3. Along the entire course of the river from the source to the point of confluence with another river (or sea), each river is represented topologically by a single linear object by connecting lines between reservoirs and lines conventionally drawn along these reservoirs or planar (wide) sections of rivers. To distinguish the rivers created in this way from the rivers that are mapped according to the standards for electronic maps, we will refer to them as "meta-rivers" (author's term).

4. All meta-rivers must flow into other meta-rivers. Exceptions are tributaries that go underground, and the main tributary of the basin, which flows into a river of a larger basin or into the sea. It is important that the meta-rivers that flow into reservoirs should continue to the line of the meta-river of this reservoir, imitating the path of pollution migration through the hydrographic network.

5. The network created in this way should enable the formation of relative coordinate systems (linear coordinates) along each watercourse, when any point is specified only by the distance from the mouth or from the source of the river.

6. If the basin is transboundary, and the system is created only for the part located in Ukraine, then for each transboundary river, the length of the section of the river located on the other side of the border should be estimated - this will allow measuring the distance along the entire course of the river.

7. The following information resources should be used to create a hydrographic network:

- geographical maps of the region (both electronic and paper);

- the system 2-TP "Vodgosp", which contains information about rivers-objects of water use in the form of the mileage of the confluence of all rivers into others and further into the main river and into the sea;

- data of the water fund of the basin, where such information about each river is especially important (where it flows, its length, and whether it is a left or right tributary).

The biggest difficulties that arise in this case:

1. The error in calculating the coordinates of the confluence of rivers 2-TP "Vodhosp" is due to the manual method of calculating these values, changes in the water management development of the regions (individual sections of the rivers have turned into canals or channel reservoirs, which no longer makes it possible to use distance data), accuracy up to 1-2 km and the lack of information about which tributary the river is (left or right) relative to the main one, because in a section of 1-2 km two rivers flow into the river from two sides at the same time;

2. Different names of rivers in different information resources are mainly related to differences in the translation of names from Ukrainian to foreign languages and vice versa;

3. Errors in the data itself, when in one of the guides it is indicated that the river is 50 km long, and in another that the Nameless stream flows into it at the 63rd kilometer;

4. Geographical maps become outdated and also need to be updated after carrying out hydromelioration works, construction or modernization of water management structures or after powerful floods that can change the riverbeds in the region.

The authors have accumulated a lot of experience and developed a complex of algorithms and techniques that allow identifying the basic model of the hydrographic network in the first approximation by 80-96% based on the analysis of only the above-mentioned information resources for the given region. At the same time, a geographical map of Ukraine on a scale of 1:200,000 is taken as a basis, individual areas are specified on the basis of a known paper map of Ukraine on a scale of 1:100,000 and updated using the international web system of satellite maps of Google Earth.

In the second approximation (with the involvement of experts), all data and objects on the map are refined, and the identification result is brought to 100%.

Lists of rivers in each of the above systems are brought into line with the identified basic model of the hydrographic network.

The result of the work is the presence of:

- geographic electronic vector map with identified river names and ID codes assigned to them;

- the list of rivers of the 2-TP "Vodhosp" system, to which all data on water use of the basin are linked informationally and logically and in which its ID code on the GIS map is determined for each river;

- the list of rivers of the water fund of the basin, to which all data of the cadastre of natural resources of the basin are informationally and logically linked and in which its ID code on the GIS map is determined for each river.

All this allows you to connect all the data of the water and other resources cadastre with the data on water use and the map of the region, which lays the foundation for the complex analytical processing of all these data as a whole.

Stage 4. Selection of conventional designations of geographical objects on the map.

This stage is particularly important, since a correctly selected system of conditional markings allows better perception, and therefore analysis, of information.

The following methods and technologies were used to create the systems themselves:

- during the construction and optimization of models of the structure of information systems and their components — the unified modeling language of the structure of complex systems (UML) and author's approaches to their optimization according to many criteria;

- during the search for optimal options for the implementation of system reports that are automatically built — a sequencing device for the synthesis of technical systems of automatic control, adapted by the authors to information systems;

- during the synthesis of the software code of information systems - the technology and methods of object-oriented programming, as well as the VBA programming language;

- for the formation of forms, means of analytical processing and system reports — methods of the theory of relational databases and the SQL language;

- for data exchange with other information systems — XML technology; network technologies and information protection technologies were also used.

For each geographic object of the systems, a geoinformation model has been developed that describes the orientation of the object in space and relative to other geographic objects and the structure of data about this object, their relationship with data about other objects of ecosystems related.

Optimization of each model was carried out in accordance with the rules of database normalization and taking into account the peculiarities of data management of these objects by environmental institutions and departments. Methods of identifying the parameters of these models in practice, including in an automated way, using data on other geographical objects and data from departmental information systems, have been developed. Special attention is paid to the construction of models of network objects (a hydrographic system based on a graph model) and to the establishment of topological unity and information links of this model with models of other geographic objects (monitoring network, sources of pollution, built engineering and technical facilities of civil protection, etc.) , which opens much greater prospects for data analysis and making scientifically based management decisions than working with data in isolation.

When applying this technology, it is important to take into account the regional characteristics of each basin system, as well as the information systems and collected data that are already in use in that basin.

Creating exactly the same systems for any river basin is inefficient. Systems should only use uniform approaches to data entry and processing, interface, concepts to facilitate the work of emergency managers.

The visualized results of each stage of the algorithm for creating a support system for management decision-making by heads of liquidation of emergency situations of hydrological origin are shown in Figure 2.

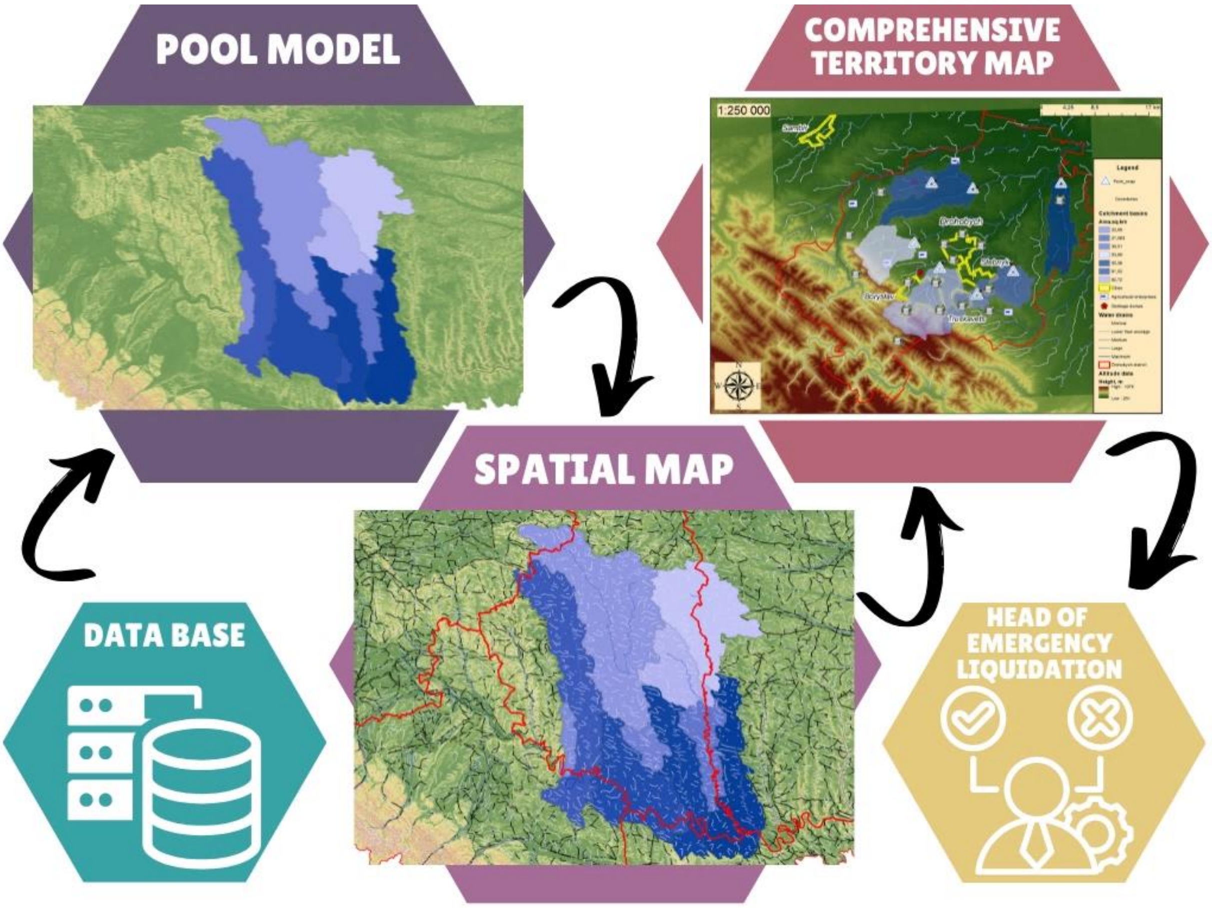

Figure 2 – Visualized results of each stage of the algorithm for creating a support system for management decision-making by heads of hydrological emergency situations liquidation

The SSMD HHEL information system for management decision-making by heads of liquidation of hydrological emergency situations will allow to significantly increase the manageability and organization of the management process of liquidation of this type of emergency situations and monitoring of changes in the environment reduce the time for collecting and preparing information and improve its quality.

The SSMD HHEL information system will be used in the internal network of the State Emergency Service of Ukraine. The system will consist of server software for managing a data bank about the river basin and a software complex of automated workplaces (AW) of employees of water management departments and relevant departments of the State Emergency Service of Ukraine.

The structural diagram of the SSMD HHEL information system includes:

- AW of employees of logistics units that carry out planning and coordination of the delivery of material resources and equipment for liquidation of the consequences of emergency situations, management of material reserves;

- AW of communication system operators to ensure stable communication between all divisions, support of operational communication and technical maintenance of the information system;

- AW of employees of the information and analytical department to collect, process and analyze data on emergency situations of a hydrological nature, as well as prepare reports to support decision-making by the head of emergency liquidation;

- AW of water management employees who monitor the hydrological situation and enter data on the river basin;
- AW of the State Emergency Service of Ukraine departments, which control and coordinate actions during the liquidation of emergency situations, as well as monitoring changes in the environment;
- AW of employees of environmental services monitoring the impact of the hydrological situation on the environment, collecting and analyzing environmental data.

For each AW there will be a separate interface and software toolkit for viewing, entering and exporting data from programs and databases, as well as toolkit for using and analyzing information from the data bank and GIS. The structural diagram of the SSMD HHEL information system is shown in Figure 3.

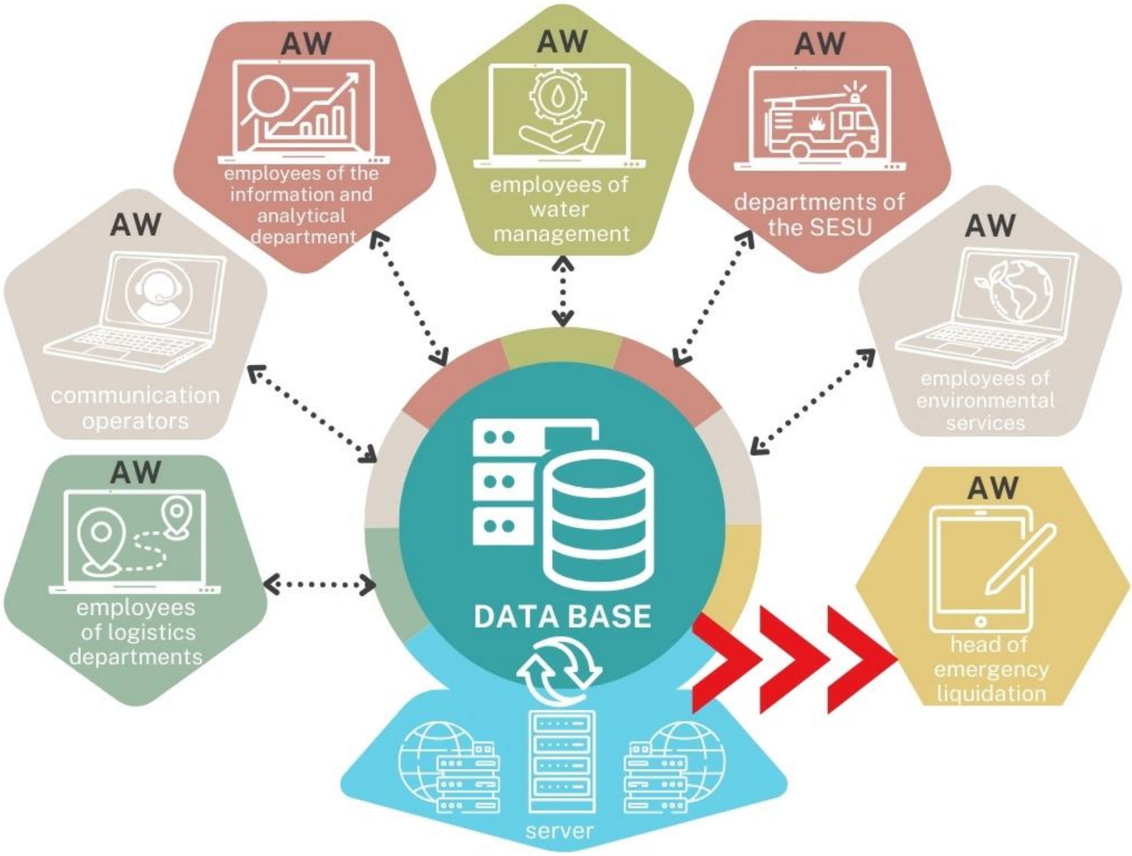

Figure 3 – Structural scheme of the information system

The data bank of the SSMD HHEL information system will be a set of separate databases designed for the accumulation and storage of information. With the implementation of this system, a single centralized data bank will begin to function, which will contain data from all necessary information environments used by employees of the State Emergency Service of Ukraine in their daily work, when analyzing the state of the environment and when making management decisions.

Conclusions

After analyzing scientific articles on the effectiveness of management decision-making in uncertain situations, the authors came to the conclusion that the best solution for the head of liquidation of an emergency situation of hydrological origin would be the creation of a management decision-making support system.

The authors have developed a generalized algorithm for creating a management decision support system, which consists of four stages and includes the use of GIS technology tools, namely the use of the ArcGIS software complex, for more effective interpretation and forecasting of the possible spread of flooding. The article describes the methods and technologies used at each stage and visualizes the results of each of them, with the final result being a comprehensive map of the territories.

Optimization of each geoinformation model was carried out in accordance with the rules of normalization of databases and taking into account the peculiarities of data management of these objects by environmental institutions and departments. Methods of identifying the parameters of these models in practice, including in an automated way, using data on other geographical objects and data from departmental information systems, have been developed.

It has been proven that the application of each stage of the algorithm for the creation of a management decision-making support system by managers of hydrological emergency liquidation will lead to a more effective and faster response to changes that constantly occur when flooding occurs.

In addition, the authors developed a structural diagram of the information system for support system management decision-making by head of hydrological emergency liquidation, which will allow to increase the manageability and organization of the management process of liquidation of this type of emergency and monitoring of changes in the environment, significantly reduce the time for collecting and preparing information and improve its quality.

The SSMD HHEL information system will be used in the internal network of the State Emergency Service of Ukraine. The system will consist of server software for managing a data bank about the river basin and a software complex of automated workplaces of employees of water management departments and relevant departments of the State Emergency Service of Ukraine.

In the future, the authors plan to conduct a study of this system practically in the territories of the united territorial communities of the Lviv region in order to identify ways of its improvement.

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СИСТЕМА ПІДТРИМКИ ПРИЙНЯТТЯ УПРАВЛІНСЬКИХ РІШЕНЬ КЕРІВНИКАМИ ЛІКВІДАЦІЇ НАДЗВИЧАЙНИХ СИТУАЦІЙ ГІДРОЛОГІЧНОГО ПОХОДЖЕННЯ З ВИКОРИСТАННЯМ ГЕОІНФОРМАЦІЙНИХ ТЕХНОЛОГІЙ

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Основна мета статті створення системи підтримки прийняття управлінських рішень керівника ліквідації надзвичайної ситуації гідрологічного походження, що включає в себе застосування інструменту геоінформаційних технологій, зокрема програмного комплексу ArcGIS.

Авторами проаналізовано наукові статті, щодо ефективності прийняття управлінських рішень у невизначених ситуаціях і зроблено висновок, що найкращим рішенням для керівника ліквідації надзвичайної ситуації гідрологічного походження буде створення системи підтримки прийняття управлінських рішень з постійно оновлюваною базою даних. З урахуванням цього авторами розроблено узагальнений алгоритм створення системи підтримки прийняття управлінських рішень, що складається з чотирьох етапів та включає в себе застосування інструменту ГІС технологій для ефективнішої інтерпретації та прогнозування можливого поширення затоплення. Для кожного етапу описано методи та технології, що застосовуються і візуалізовано результати виконання кожного з них, з кінцевим результатом – комплексною картою територій. Доведено, що застосування кожного етапу алгоритму створення системи підтримки прийняття управлінських рішень керівниками ліквідації надзвичайних ситуацій гідрологічного походження призведе до ефективнішого та швидшого реагування на зміни, що постійно відбуваються при виникненні затоплень. Визначено, що під час застосування даної технології важливо враховувати регіональні особливості кожної басейнової системи, а також інформаційні системи та зібрані дані, які вже використовуються у цьому басейні.

У статті також розроблено структурну схему роботи інформаційної системи підтримки прийняття управлінських рішень керівниками ліквідації надзвичайних ситуацій гідрологічного походження, що дозволить підвищити керованість, організованість процесу управління ліквідацією такого типу надзвичайних ситуацій та моніторингу змін у навколишньому середовищі, значно зменшити підтримки прийняття управлінських рішень керівниками ліквідації надзвичайних ситуацій гідрологічного походження час на збір та підготовку інформації і підвищити її якість. Банк даних інформаційної системи підтримки прийняття управлінських рішень керівниками ліквідації надзвичайних ситуацій гідрологічного походження буде набором окремих баз даних, що призначені для накопичення і зберігання інформації інформаційної системи. З впровадженням даної системи почне функціонувати єдиний централізований банк даних, який міститиме у собі дані всіх необхідних інформаційних середовищ, що використовуються співробітниками ДСНС України у повсякденній роботі, при аналізі стану довкілля та при ухваленні управлінських рішень. Запропонована інформаційна система використовуватиметься у внутрішній мережі ДСНС України та складатиметься з серверного програмного забезпечення керування банком даних про басейн річки і програмного комплексу автоматизованих робочих місць співробітників відділів водного господарства та відповідних відділів ДСНС України.

Ключові слова: *цивільний захист, сталий розвиток, візуалізація даних, водозбірні басейни, програмне забезпечення ArcGIS.*