IMPROVEMENT OF EARLY WARNING SYSTEMS

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ОПТИМИЗИРАНЕ НА СИСТЕМИТЕ ЗА РАННО ПРЕДУПРЕЖДЕНИЕ

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***Abstract**: The aim of this article is to describe the general methodology of early warning systems. The common disaster monitoring system was analyzed, and the construction system of disaster information management system was discussed particularly. This paper addresses traditional views of early warning systems and what is needed to turn them into efficient, people-centred systems.*

Key words: EARLY WARNING SYSTEMS, DISASTER INFORMATION, NATURAL HAZARDS, GEOINFORMATION TECHNOLOGY, REMOTE SENSING SYSTEM.

1. Introduction

Natural and technological disasters and events monitoring are an important part of national security which set the task of solving some basic problems like stabilization and surroundings improvement, liquidation and prevention of regional ecologic crises. This imposes the need for developing a national system for monitoring, enabling operative solving of tasks connected with prevention and action during crises and consequences avoidance. Also, analyzing the stability of the functional structure of natural systems and making short-term prognosis.

The use of advanced tools for computation and modelling of natural hazards can be combined with a Geographic Information System (GIS) that has the capability of decision support and advanced visualization to produce models, that will represent the risks of natural hazards and man-made disasters in the form of risk maps, where the risks are categorized and quantified [Ivanov M., Yankov Y., 2016 b]. Very large amounts of data can be processed, quantified and displayed on digital maps, allowing decision makers to assess the situation rapidly and take appropriate actions. Furthermore, these processes can be automated, enabling near real time access to the risk maps. This can greatly help decision makers with the emergency measures and mitigation in most of the cases.

The role of science and research linked to early warning and crises management (EW and CM) is very specific. The roles of both are looked upon as practical activities only. For many years there have been a limit mainly for realization of inhabitants' needs for help in crises situations. Later the efforts expanded and concentrated on the readiness of population in dangerous areas for a specific type of disaster in those regions. New technologies and a dedicated scientific research have been accepted too slowly, and it took a long time before they were treated as a means to significantly change the quality of assistance provided to disaster risk reduction.

This paper aims at adding concepts and ideas about how often neglected geoinformatics and cartography can contribute to the improvement of the quality and results of disaster risk reduction.

To understand the characteristics of disasters and our potential to handle them, is one of the key topics in thinking for ways to improve EW and CM decision making process. There are five major characteristics of disasters that make them difficult to overcome:

1. *Disasters are large, rapid-onset incidents relative to the size and resources of an affected jurisdiction.*

If pre-accident data is available, geospatial analysis can provide important insight into the nature and extent of changes wrought by disasters.

2. *Disasters are uncertain with respect to both their occurence, and their outcomes.*

This uncertainty arises because hazards that present a threat of disaster are hard to identify, the causal relationship between hazards and disaster events is poorly understood and risks are hard to measure – that is, it is difficult to specify what kind of damage is possible, how much damage is possible, and how likely it is that a gven type and severity of damage will occur.

Geospatial models can help predict the locations, footprints, times and duration of events, and the damage they may cause, so that jurisdiction can be better prepared for them.

3. *Risks and benefits are difficult to assess and compare.*

Disasters present emergency planners, emergency managers and policy makers with countervailing pressures. On the one hand, it is important to minimize the exposure of populations and infrastructure to hazards; on the other, people want to build and live in scenic, but hazard-prone areas and often oppose government regulation. What is more, various levels of government cannot keep the balance between providing reliéf to the victims of disasters and the need or desire to avoid encouraging risk accepting behaviour, etc.

Geospatial data and tools are invaluable in making the necessary assessments of the geographic distribution of risk and in estimating the quality of each assessment.

4. *Disasters are dynamic events.*

Disasters evolve as they progress, and they change in response to human actions and natural forces. This makes it imperative that response strategies be flexible and argues for the value of analysis in helping responders understand and adapt to the changing conditions they face. Managing these phenomena can thus bet the highly technical endeavor requiring specialized expertise for both policy development and policy implementation. [Ivanov M., Yankov Y., 2016 a].

In particular, geospatial data and tools can help incident managers to visualize the event over time, track the activities of responders, and predict the outcomes of various courses of action.

5. *Disasters are relatively rare.*

Most communities experience few, if any, disasters during the average time in office of a political official or the average time of residence of a citizen. More obvious and immediately pressing public service concerns displace disaster preparedness as a priority. Specialized capabilities, such as geospatial data and tools are especially vulnerable to budget cuts and resource realocation.

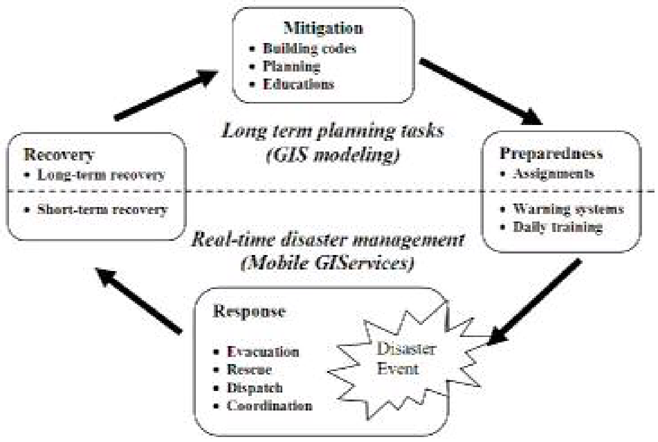

Fig. 1 The role of geoinformation technologies in early warning and crises management.

2. Basics of early warning systems.

The essence of early warning, as a stage of a crisis reaction, is giving timely and effective information for coming and immediate threat of disasters to a definite group of people – authorities, reaction forces and population [Nedevski D., 2010].

Warning is a process of collecting and exchanging information between command and control operatives for possible events, on the basis of which an immediate preparation of reaction forces commences [8].

The main objective of early warning is to limit the risk of threat of coming disasters, get control of the current situation and reduce the consequences.

The essence of early warning lies in revealing the earliest indications for emerging disasters on time and notifying the government and army forces in order to make a decision for protecting the citizens [Defense solution, 2016]. This makes the early warning systems (EWS) an important tool in national security conception and a real basis for crisis prevention.

In broader sense, the EWS embrace some chain processes:

- disaster monitoring;
- building a system of parameters and criteria for giving an account of the processes connected with the formation and growth of crisis situations;
- creating a system of preventive actions, which may avoid intensification of some crisis processes;
- working out a reliable and effective mechanism for population defense.

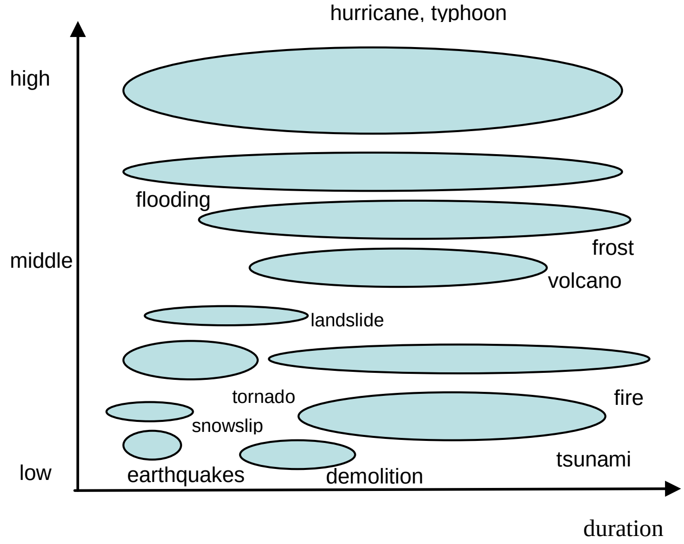

Fig. 2 Interdependence between opportunities for early warning and disaster duration.

Early Warning System tasks:

- To provide a comprehensive technological framework for practical hazards mitigation efforts.
- To consolidate the efforts of government agencies and disaster management communities involved in order to promote systematically the hazard mitigation research.
- To integrate hazard-related research results and transfer them to feasible procedures so that they can be implemented effectively.
- To develop appropriate methodologies for potential analysis, risk assessment and scenario simulation of natural hazards.

The main task of EWS is to establish a system for observation, control, analysis and prognosis, which keeps a close watch on treats, providing the incoming information on time and taking measures for prevention of potential events.

It is well known [Nedevski D., 2010; Spatial analysis, 2016], that the opportunities for early warning depend on the basic physical parameters of disasters. Meteorological events are the easiest for prognosis and the hardest (some even not possible - earthquakes) are geological threats – fig. 2.

3. Possible structure of early warning systems.

Early warning system contributes to reduction of economic loses and disaster risk for population by providing information that ensures protection to sociality, individuals, critical infrastructure and private property. The pre-emptive information gives an opportunity for fast reaction at the very beginning of a disaster. Good integration between EWS, evaluation and management of risk and action planning is a starting point for the real process of defense and prevention, reduction of human loses and economic damages.

After analyzing the objectives, principles, characteristics, main tasks and EWS requirements, a functional structure for the

EWS can be suggested. The elements which must be included in the system are:

- agencies and resources for obtaining information, monitoring and processing;
- risk identification and evaluation;
- creating a methodology for evaluation of critical infrastructure;
- zoning the territory according to risk factors;
- designing models for engagement in advance;
- modeling decisions for reaction in possible disasters;
- communication system for information in defense mode.

After integrating these specifications in the national early warning system and creating a known information picture, it is possible to:

- coordinate all activities of the special structures and businesses for preventive and remedial measures;
- interact with similar systems in other countries.

4. GIS functions in early warning systems.

Geographic Information System (GIS) is a collection of applications whose tasks include (collaborating with other systems) gathering geographic data, store and process spatio–temporal data (geo-data) and share the derived geographic knowledge with the users and other applications. Some of the most important routine applications of GIS are spatial analysis, digital elevation model (DEM) analysis such as line of sight and slope computations, watershed and viewshed analysis, etc. GIS has became quite an important tool for geospatial sciences and has gone beyond typical tasks of mapping to performing complex spatio-temporal analysis and operations. The number of users relying upon Decision and Support Systems (DSS) built upon GIS has increased as a result of the availability of a very high resolution satellite imagery and integration of spatial data and analyses with GIS packages which now satisfy the needs of many and is not only used for specialized operations.

As in many GIS applications, the geodata differs from grid and vector data. The **grid data** in the form of digital topographic maps and remote sensing data serves as a better overview of the emergency situation. Depending on the emergency site (urban or rural regions) different maps, like city or regional maps, aerial photos and satellite images are used to visualize the emergency location. For viewing this maps and images, standard-tools for clipping, panning and zooming are integrated into a combined system.

The GIS analysis in EWS is based on a **vector dataset** which includes, beside other data, geocoded addresses and the street network. Operation areas of the public safety organisations, water bodies and lines and point of interest (POI) like locations of rescue teams, SOS telephones and hydrants are used for the cartographic visualisation of the emergency area. In any case, it is important for a successful emergency aid all data to be up to date.

The main GIS functionality of PSS is a function that uses **geocoded addresses**. This function is required in order to enable localization of the emergency site. The addresses are usually organised in a dataset, which include the necessary geographic information, e.g. coordinates. In addition to this function, the emergency location can be entered via the name of the street or ordinary geographical coordinates.

The second important GIS function is the **network analysis**. In the network analysis the shortest or the fastest way between the position of the emergency forces and the emergency site is calculated. This function uses miscellaneous parameters, such as one-way-streets and turn restrictions. Applications designed for ambulances use the function of the “travelling salesman problem” for calculating the cheapest way between the location of the patients and the health care centres (hospitals, foster homes, medical specialists). The acquired routes are then shown on the cartographic visualisation tool and sent as GPS-coordinates or as a textual list of directions to the emergency vehicles.

The **cartographic visualisation** of emergency sites is another important function of EWS. It is usually presented on a digital map which can be completed with tactical symbols, simple drawings and labels. With the help of GPS transmitters, the current position of the vehicles is acquired and visualised with symbols on the map. In additional layers, buildings with high exposure like hospitals, schools, hotels, etc. can be displayed on the map or retrieved from special building databases.

Other GIS functions included in the graphic display of EWS are the measurement of routes and surfaces and the query of specific emergency data. Additionally to the described GIS functions, some applications also enable a simulation of atmospheric **dispersion of hazardous materials**. The dispersion models are standard calculation models with experience values. The result of the dispersion model (a polygon) is combined with other geodata, like geocoded addresses to warn the affected population.

Maps for disaster risk assessment combine international, regional and local data provided by various services, agencies, and organizations. The data gathered from various numerous sources as geographic database; topographic maps; thematic maps; disaster management plan; seismic hazard information; geological information; building stock information; demographic and social information; business / communications / industry information; infrastructure information; statistical data, etc. is heterogenic and its use for the disaster risk evaluation and crisis management is not easy. Therefore, the data should be integrated and presented in the most appropriate way to assist specific tasks of participants in all stages of disaster risk management. In order all the data to be integrated and presented on the maps it should be standardized and managed according to the main aspects of data harmonization following Directive recommendation [8]:

− Georeferencing the information into a uniform reference system;

− Standardizing attribute structure;

− Standardizing object classification;

− Standardizing level of detail;

− Unifying cartographic visualization.

Disaster risk evaluation encompasses rather heterogeneous information data sets. The integration of these data in a uniform data base requires a lot of multi- and inter-disciplinary efforts. Calibration and verification of the data sets and methods used is important to continue, in order to proceed further with the comparative analysis of the available maps and the consequent risk evaluation in GIS environment. It is also necessary to have compatible vector maps and/or digitized raster maps with proper spatial resolution at disposal. It would be useful and interesting to perform risk evaluations with different available maps, thereby some beneficial inferences and recommendations in terms of sensitivity of the final risk evaluation with regard to different input data sets could be performed.

The geographic information system for EWS needs is intended for providing with geospatial information all elements of national security system in joint tasks implementation.

The main object of GIS is to create an effective spatial data infrastructure for a crisis management system, based on current and perspective information and geo-information technologies, [MC 296/1 NATO Geospatial Policy, 2006.] and satisfy world standards.

The specification of an early warning process imposes the following basic requirements on GIS:

- collecting initial digital geo-information data from different institutions and organizations;
- entry and storage of geo-information data in information bases; updating geo-data through monitoring systems and remote sensing;
- improvement of service quality and quickness, assisting government in making decisions, concerning the processes taking place in a definite territory;
- exchange of data between information bases of a particular system;
- analyses and prognoses of geo-information data and submitting the results.

5. Conclusion

Disaster reduction measures should be based on continuous assessment of vulnerability and hazards, including a vulnerability /hazard analysis and monitoring/. The geoinformation is essential for almost all disaster risk management cycle integrating all data sets in a information system. Spatial data information, as core subjects in disaster prevention and emergency management, should be reliable, timely and in digital form to be processed in a powerful GIS. The use of GIS software for data analysis and representation alongside with different techniques for data processing can reduce the uncertainty, and serve as a catalyzing agent for information acquisition and distribution. Advanced IT technologies, as base of a spatial data infrastructure, foster the process of spatial information analysis, which can be used as a valuable source in all phases of disaster risk management.

Advisable decisions for action in case of disasters depend on: preliminary preparation of a system for extraction of geospatial information; organizational structures; elements and functional relations. Spatial identification of the changes of geophysical parameters of natural events is a complex process including GIS, remote sensing and data processing.

The cartographic products, the spatial modeling of the terrain, the geographic analysis, the semantic generalization of geo-data are a base for the formation of a spatial-oriented scheme for global application in crisis management.

GIS unifies traditional operation with database, like request and statistical analysis, visualization advantages and spatial analysis which maps offer. These opportunities distinguish GIS from other information systems and give a unique opportunity for using them in a broad spectrum of tasks, connected with analyses and prognoses of events and processes.

6. Literature

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