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INFORMATION SYSTEMS AND DISASTER RISK MANAGEMENT

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Abstract

Disaster risk management is nowadays hard to imagine without appropriate information systems that facilitate the decision-making process in phases before, during, and after the disaster. In the face of disasters, decision makers must look at and analyze various information on hazard characteristics such as nature, power, intensity, while on the other hand they must take timely measures to achieve a short-term and long-term recovery of the community from the consequences of such events. Certainly, the spatial dimension of disasters has a decisive importance in terms of rapid addressing the resulting consequences and preventing the further spread of harmful effects of various disasters. In the paper, the authors describe the existing information systems, their characteristics and ways of applying in the process of disaster risk management. In addition, special attention is paid to the description and the way of using geographic information systems as well as remote detection and satellite recording. Also, the role and significance of social media systems and interactive simulation and visulation for modern disaster risk management are examined.

***Keywords**: disaster, risk, management, information systems, GIS.*

1. INTRODUCTION

In the process of disaster risk management, which is increasingly more frequent and disruptive, people have continuously improved their tactics and techniques of mitigating or preventing them. Not long ago, people around the world began to realize that the national reference values of the countries are more endangered by the consequences of natural disasters than conventional wars. Excessive use of advanced technologies and production processes multiply the problem by affecting climate change that coexists with the risk of disasters (Cvetković & Jakovljević, 2017). In the interaction of extreme dangerous events and increasingly vulnerable societies, it is necessary to develop risk management models to mitigate the emergence of disasters. Disaster risk management involves a systematic process of using administrative decisions, organization, operational skills, and capacity to implement policies, strategies and capacities of society and the community to address and reduce the effects of natural disasters as well as related ecological and technological disasters. This includes structural and non-structural measures for avoidance (prevention) or limitation (mitigation and preparedness) of negative effects of disasters. The aim of management is to reduce the risk of disasters, and this relates to the conceptual framework of the elements considered, with the possibility of reducing the vulnerability and risk of disasters in the wider context of sustainable development (Nations, 2004).

Establishing and using information systems in the disaster risk management process is a crucial step without which today's decision-making is unimaginable. An emergency management information system is a decision support system that integrates all phases of emergency management and response (Kwan & Lee, 2005). In dealing with disasters, decision makers must look at and analyze various information on hazard characteristics - nature, strength, intensity, etc., while on the other side they must take measures to achieve a short-term and long-term recovery of the community. Certainly, the spatial dimension of disasters has a decisive significance in rapid addressing the resulting consequences and preventing the further spread of harmful effects of various disasters. In addition to the spatial dimension, disasters as very complex events also include inputs such as wind speed, roughness of the surface, air temperature, flow of currents and geographical features (Pine, 2008). Thereby, it is important to point out that physical characteristics influence on the consequences and they are included in the hazard models presented in the form of mathematical algorithms or formulas. Certainly, for the use of such models it is very important to look at its characteristics and data that are necessary for its functioning. Certain models, such as HAZUS-MH, have technical documentation that provides users with the necessary data.

Starting from the destructive consequences of numerous disasters and their suddenness, decision makers increasingly rely on the use of earth observation and geographic information systems that are a powerful tool in the risk management process. With the help of such tools, and all benefits offered by information systems, it is possible to mitigate the consequences of disasters in a timely and effective manner. From the local to the regional level, risk management is largely conditioned by spatial data on the emergence and spread of hazards, obstacles encountered, affected area, etc. The main goals of developing information systems are (Marko, Marjan, & Vlada, 2010): shortening the response time, that is, the response of organizational systems and better decision making, that is, acting; continuous data collection, data processing which provides information on all the essential performances of the system, condition, deadlines, costs, quality, results, reliability, etc.; ensuring the complete "history" of the system being monitored for the purpose of analyzing and forecasting the state of the system in the future. The basic principles on which the information system is based should be: data and/or information that are entered into the system only once where they are generated or where they are collected; requests for data and information that are set up to those who keep storage, which eliminates the classic reporting method by level; minimizing manual work on documentation; timely informing all management levels in accordance with their needs; elementary data processing, thereby avoiding the possibility of "refined" reporting; permanent data storage, as long as they are actual, and the ability to evaluate the efficiency of the system and its elements (Marko et al., 2010).

2. GEOGRAPHIC INFORMATION SYSTEMS AND DISASTER RISK MANAGEMENT

The rapid development of technologies has greatly eased the process of disaster management and in the 1990s, relatively powerful and networked desktop computing systems have become an integral part of the disaster management operation (Stephenson & Anderson, 1997). Drabek (1991) pointed to a rather widespread use of computers based on decision system support in the US, especially during the damage assessment stage. Geographic information systems on the one hand and remote detection and satellite recording on the other hand represent the fundamental components of hazard research that create opportunities and improve new scientific approaches (Tobin & Montz, 2004). In hazard and disaster studies, the application of GIS started in the early 1990s, after Hurricane Andrew in 1992 (Hodgson & Palm, 1992). After better understanding of the potential of geographic information systems for disaster risk reduction, they started to be used for a number of purposes: allocation of public assistance, management of the area affected by disaster, mapping damaged and demolished homes, showing path and direction for hazard spreading, recording important points, risk mapping, etc.

In the literature, there are different definitions of geographic information systems that reflect the perspective of the author who defines them. However, there is also a traditional definition according to which the geographic information system (GIS) is a computer system for the collection, processing, transmission, archiving and analysis of data with geographical references (Čekerevac, Anđelić, Glumac, & Dragović, 2010). In addition, it can be said that GIS consists of four interactive subsystems: subsystem for entering that performs the conversion of maps and other spatial data into digital form (the so-called digitalization of data is performed); subsystem for storing and calling data; subsystem for analysis; and output subsystem for making maps, tables, and for providing answers to asked queries (Maguire, 1991). The analysis of natural hazards implies a professional combining the use of geographic information systems, ecological modeling and remotely detected datasets (Pine, 2008).

In recent years, the use of GIS by disaster researchers and decision makers has become increasingly popular and they are starting to use it in all phases of the disaster management cycle (Curtis & Mills, 2009). Penton and Overton (2007) used satellite images and certain models for modeling the volume and depth of floods in the complex river system in Australia (Penton & Overton, 2007). It particularly should be noted that for certain hazards such as tropical cyclones and forest fires, satellites are the main source of information collection and monitoring. On the other hand, in a number of hazards, certain network cells that measure specific measurable characteristics can be used. For certain hazards, information reflection methods are used in different parts of the electromagnetic spectrum obtained from different groups of optical and infrared area. Thus, satellites can be used to map events and sequential flood phases, such as duration, depth of flooding and direction of the current (Smith, 1997). Geomorphological information can be obtained using optical (landsat, spot, aster) and microwave (ers, radarsat) data (Marcus & Fonstad, 2008). Surely, there are many factors that interfere with the use of certain optical data, such as the presence of clouds and dense vegetation. Thermal sensors can provide data for mapping forest fires or destroyed areas (Giglio & Kendall, 2001). In order for geographic information systems to function, it is necessary to establish appropriate hazard databases. Such databases should cover the dangers of high probability and low intensity, but also those of low probability and high intensity in order to create scenarios for the most likely and most significant events. For this reason, it is also important to carry out a large number of archival research in order to obtain information from the past, in addition to measurement, observation and mapping. For example, in China, an analysis of extreme precipitation was made based on data obtained on the basis of historical documents for the past 1500 years (Zheng, Wang, Ge, Man, & Zhang, 2006). Also, through participatory mapping and geographic information systems, with the help of local community participation in data production and spatial decision making, it is possible to create hazard lists (Westen, 2013). According to Pine (2008), spatial data is intended to be viewed on maps and geographic information systems allow interactive changing of such maps in order to reveal information from the landscape in various ways. With the help of such systems, different spatial layers can be added: where people live, transport routes, quarantine areas, key facilities or infrastructure, etc. Also, the aforementioned author points out that the presentation of the results of hazard analysis and the use of spatial analysis and mapping tools help the local community to: identify patterns in complex datasets or multiple datasets of related data; find meaning in large datasets; considering that local geospatial objects change over time; considering that geospatial objects may be similar, or to cross more often, in smaller geographical proportions; provide means of communicating complex information without oversimplification of data; provide managers of first responders at local, state or regional level with critical information on the nature of the hazards and their potential impacts. Stoimenov, Stanimirović, Milosavljević, and Živković (2012) point out that GIS can, with the appropriate spatial data base: enable mapping, search of geo-data and other basic GIS functions; provide a visual representation of the obtained data about the objects/buildings that are potentially endangered; provide information about the nearest fire, police stations, and emergency medical teams; provide information on existing water system installations, electricity network, telecommunication cables, road network, etc.

The emergence of geographic information systems has rapidly raised the researcher's ability to examine, in a systemic way, the spatial characteristics of hazards, as well as their impact on endangering people. In the integration with such a system, special data such as aerial photographs after disasters can be collected to see changes in topography and geography generated during such an event (Cutter, 2002). The local population has a wealth of important information that can be used to model risks. Therefore, the integration of geographic information systems and such hazard information is of great importance. Unfortunately, such integration is still in its initial phase and a large number of generated information from hazard projects is not taken into account for participatory mapping. Rautela (2005) shows that the sources of information about depths of floods, intensities and damages are most often generated in the local community (Rautela, 2005). The US Environmental Protection Agency used GIS to mark the locations of toxic chemicals in eight countries to show that spills are the largest in densely populated areas. On that occasion, it was found that the spread of hazardous industrial sites occurred primarily in the areas inhabited by the population with lower incomes and by minority groups of the population who had already lived before buildings and roads were built (Smith & Petley, 2009; Stockwell, Sorensen, Eckert, & Carreras, 1993).

Various examples of the use of geographic information systems are mentioned in the literature: Emmi and Horton (1993) show a method based on the use of geographic information systems for the assessment of seismic risk and material damage and which is used to plan a proactive community response; Mejia-Navarro and Garcia (1996) demonstrated a geographic information system that is suitable for assessing the range of geological hazards identified by the support systems for planning purposes; Dymon (1999) described how this information system can be used to calculate the level of damage of the wind wave before the Hurricane Fran reached the coast of North Carolina in 1996; Smith and Petley (2009) point out that the first responders in America use geographic information system support to identify areas that need to be evacuated when an upcoming storm is expected; geographic information systems as an addition to statistical analyzes and mathematical models represent the tools most commonly used in spatial analysis and their use is appropriate before, during and after the hazard investigation; they promote the development of standardized protocols in relation to exposure to hazards and data that can be electronically stored, merged and disseminated electronically (Challenges & Opportunities, 2006); using state-of-the-art approaches through the geographic information system and remote-based technologies, LandScan Global has developed a population census model that provides the best solution to the problems related to population census data available to the whole world and the continental United States. LandScan Global represents the “population in the neighborhood” in the area of 1 kilometer and as such is 2,400 times more accurate than the previous standard (Bhaduri, Bright, Coleman, & Dobson, 2002); geographic information system provides a tool for understanding certain risks and many hazard modeling programs are associated with GIS tools to show risk zones or identify areas of population and infrastructure (roads, bridges, utility pipelines or industrial areas) at risk (Pine, 2008); it can be used as a tool for customizing data for use in model output presentation and for completing analytical processes in model result presentation (Tran, Shaw, Chantry, & Norton, 2009).

The use of satellites for remote detection purposes provides a basic platform for disaster risk management. Earth observation via satellites contributes greatly to improving the preparedness of countries for disaster response, but also ensuring communication when critical infrastructures are destroyed or damaged. For example, for years, hurricanes have been detected using geostationary satellites that provide global coverage between 50°N and 50°S in half-hour intervals. In addition, such repetitions enable a close monitoring of the storm, and consequently, no cyclone can now be formed without any detection (Smith & Petley, 2009). Surely, very high resolution satellites usually capture every area every few days. However, the problem lies in the fact that the instruments are of an optical character, which means they can not neutralize the clouds. Radar instruments can do it, but data of the resolutions are often too poor to be used to analyze short-term estimates of the damage. While on the other hand, high resolution data is much more expensive. By using differences in spectral labels for different types of floods - standing water, flooded crops, areas where flooding is in decline, flood mapping can be successfully carried out. In addition, the topographic information necessary for danger zone mapping can be provided by instruments such as SPOT and ERS satellites.

3. SOCIAL MEDIA SYSTEMS AND INTERACTIVE SIMULATION AND VISULIATION FOR MODERN DISASTER RISK MANAGEMENT

Disaster risk management largely depends on new media technologies that have a major impact on reporting, which is critical to transmit certain information in a short period of time. Digital Television as one of the most important elements in reporting has many advantages (Valić Nedeljković & Pralica, 2013): Internet access and greater possibility of transmitting quality and important information to end users - viewers; access to databases and online information, the ability of consumers of disaster-sensitive information to track program-information contents that are exclusively directed to this target group; video on demand and partial video on demand - at the same time, several programs on crisis situations can be viewed, especially in cases of high risk and when the crisis is still ongoing; interactive news - the possibility of interactive communication between information consumers and media; crisis situations can also be followed by people with hearing impairment; for crisis reporting, the special convenience in digitization is a translation on demand. Before the Internet, the writing and sharing of educational materials on disasters was slow, limited in size and costly. Also, contacting various experts in this field to obtain detailed information on different segments of disasters was very difficult, especially since they were deployed in different parts of the world (Ovington, 2010: 35). However, today, thanks to the development of information technology, distribution of educational materials is very simple. This can be achieved by making websites, and by sending to email addresses. Today, a number of educational materials on disaster risk reduction can be found on the Internet. In November 2007, as a support to the Hjogo Framework for Action, the UNISDR Secretariat created a preventive website, called the “Knowledge Improvement Website” (http://www.preventionweb.net/english), sharing information on reducing disaster risk for professionals and the general public, local and global (UNISDR, 2007a).

Some examples of the application of simulations and the theory of mass servicing in the military field can also be useful for disaster studies: models of decontamination; evacuation of injured and diseased; reception a large number of refugees. In foreign literature, there are a lot of simulation applications in considering different types of emergency situations. Disaster simulations can be applied to a wide range of situations, such as natural disasters, prison riots, abductions and international conflicts (Boin, Kofman-Bos, & Overdik, 2006). However, these simulations are used for a limited number of goals. They are often used to illustrate the patterns and pathology of decision making in times of crisis. They have proven to be a very powerful tool for raising awareness among participants. Disasters are relatively rare events of great complexity and their unrepeatability and uniqueness limit the insight into the way of their occurring, and therefore the ability to study, prepare and train the people. That is why simulation training is an important, necessary and valuable tool in training future security managers. Certainly, the benefits of simulation training are multiple: they offer an almost perfect opportunity to get acquainted with all aspects of emergency management; represent a unique opportunity to gain an experience that can only be acquired in a real disaster; a good simulation generates the necessary awareness that extraordinary situations can indeed happen; it has an excellent educational character; can help to bridge the gap between theory and practice; if the simulation is repeated periodically in the same environment, it can take over the training function; raising the level of training and preparedness of students to perform future complex tasks in protection and rescue systems from local to national level.

4. CONCLUSION

Disaster risk management is a very complex process that incorporates a large number of elements and phases that are directly related to the characteristics of the disaster itself. That is why, with today's degree of scientific development, its functioning is unimaginable without certain information technologies that help decision makers to collect, analyze, display and understand specific spatial and temporal information. Lack of absolute prediction, intensity and destructive power alarmingly emphasize the need for a rapid decision-making process. The mentioned decision-making process in risk management, putting aside human errors, can be greatly enhanced by the use of fast information systems. The Geographic Information System improves the disaster risk management process in various ways. In the period prior to the occurrence of the disaster itself, the mentioned system can be used for planning activities, while during the disaster it can be used as a significant logistical support in the decision-making process. The advantages of using information systems in the disaster risk management process are multiple and they are reflected in the following: efficient and timely review of the overall situation on the ground, decision-making based on highly professional-operational information, improved coordination of short-term and long-term mitigation activities or elimination of consequences in the affected area by a disaster, improved communication in the field, better allocation of resources and assistance to affected citizens, etc. Surely, it is necessary to continue the development of information systems for the purposes of disaster risk management, because this can greatly overcome the catastrophic consequences caused by unprofessional and untimely decisions.

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