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RISK MANAGEMENT OF NATURAL DISASTERS: CONCEPTS AND METHODS

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Abstract

Every day, people are exposed to a variety of risks ranging from small and insignificant to larger ones, such as natural disasters. The concept of risk has been a topic of interest for researchers from different disciplines in the past fifty years. For these reasons, there are many definitions of risk which reflect a scientific discipline itself from which they originated. Managing risks of natural disasters is very complex and conditioned by the existence of well-defined and elaborated management model that will allow efficient and prompt elimination of consequences. Certainly, understanding of the perception of risk is essential for the management prosess. Namely, individuals diferently perceive risks of natural disasters due to their demographic, socio-economic and psychological characteristics. Thereby, there are various methods of risk evaluation, which are conditioned by scientific-disciplinary approach, origin and size of risks.

Starting from the multi-dimensionality of risks of natural disasters, authors firstly analyze the theoretical determination of risk through the lens of different disciplines and perspectives with special emphasis on the types of risks. In addition, special attention is given to consideration of the risk management process through generally accepted models, methods and

methodology of risk assessment in Serbia. Also, the paper gives an overview of the most important approaches to risks of natural disasters in social sciences.

Keywords: *disaster; risks; management; concepts and methods.*

1. Introduction

Identification of hazards is the first step in the process of risk management. Such a process involves a description of the community, specific information about the nature and characteristics of hazards [1]. It examines the potential of a hazard to cause harm to life or damage to property and environment. This process takes advantage of the use of ecological modeling to characterize the risks and impacts of disasters. It comes to clarification of the scale of disaster that may pose a threat to human, built and natural environment. Object of identification and characterization of hazards is to describe the hazards that could hit a community or organization [2]. It provides the basis for future steps in the process of hazard analysis. He suggests that it is necessary first to examine in detail the local community through a multidisciplinary approach and subsequently to categorize hazards in groups according to type. Hazard in one category can lead to secondary hazard included in the other category. Heavy rains can cause floods and lead to a chemical spill or an avalanche. Comprehensive historical data about all hazards are crucial in understanding what hazards have affected the community in the past and likelihood to be repeated in the future. In Pin's opinion [2] risk analysis is an assessment of

the probability and severity of consequences based on the history of the past accidents, local experience and best available technological information. He suggests that the risk analysis provides an assessment of: the probability of disasters based on a history of the current conditions and considerations of all unusual environmental conditions (e.g., areas in the flood plains), or probability of multiple accidents, such as a hurricane with tornadoes (e.g. risks of floods, or fires); the severity of consequences of human injury that can happen (acute, delayed, and/or chronic health consequences), number of possible injuries or fatalities and the associated high risk groups; the severity of consequences to critical facilities (e.g., hospitals, fire departments, police departments, communications centers); severity of consequences to property damage (temporary, reversible, permanent); and severity of consequences of damage to the environment (reversible, permanent).

2. Theoretical determination of risk

The term "risk" is derived from the Chinese word "Wei Ji:" which implicitly suggests to a combination of "hazard" and "opportunity" [1, 3, 4, 5, 6]. Risk and concept of risk management have always been the subject of multiple definitions, and are often mistaken or confused with other terms such as risk identification, risk assessment, risk analysis and communication of the risk. Risk, as a basic term for risk management, has different meanings in different disciplines such as medicine, finance, security, safety, and so on. The literature also mentions three main issues related to risk [7]: What can go wrong?; How likely is something like this to happen?; What are the consequences if this happens? First question, what can go wrong relates to

possible scenarios of events, "risk scenarios". The second question relates to the examination of the likelihood of such scenarios, while the third question focuses on the possible consequences of such scenarios. Meaning of the word "risk" is conditioned by a variety of cultural and ethnic characteristics. For example, Arabic "risq" refers to everything that is given by the God, and it can not be learnt something from that [8]. In Latin "risicum" describes a specific scenario faced by a sailor in efforts to avoid dangerous reefs. Almost always it is used with negative meaning [9]. Copola points out that among managers who deal with risks there is no generally accepted and universal definition of the risk of emergency situations [10, 11]. Barton [12] considers the concept of risk through the aspects of perception and information on risks, risk assessment and risk management. Slović and Veber [13] suggest that the risk can be considered as: Risk; Probability; Consequence; and Threat. Tiwari [14] points out that the concept of risk of emergency situations is critical for risk perception and is determined as the complexity of the interactions between hazard, exposure and vulnerability. Risk, which is a latent hazard of natural origin such as cyclone, turns into a disaster that creates vulnerability. Damage and losses from emergency situations depend on the degree of exposure to social elements and their vulnerability. The risk of emergency situations is a multifaceted, because the existence of risk of emergency situations requires all three components - hazard, vulnerability and exposure [1]. Kardona [15] considers the risk as potential direct or indirect losses for social subjects or systems. Consequently, he points out that the risk can be expressed in form of a mathematical equation of the probability of economic, social or environmental consequences in a given

period of time. Frosdik [16] states that an understanding of risks is filled with uncertainties and that the terms such as risk assessment, risk evaluation, and risk analysis are used interchangeably in the description of techniques and processes in risk management. He suggests that the risk is a subject of disagreement between scientists of natural and social sciences. Smit and Petli [17] state that the terms of hazard and risk are often interchanged and that risk is taken as a synonym for hazard, although risk along hazard includes additional elements. Thus, hazards should be seen as an event of natural (lithospheric, atmospheric, hydrospheric, biospheric, extraterrestrial) or technological origin that has the potential to inflict losses to the people, their property and the environment. Starting from such defined hazards, risks should be seen as the intensity or frequency of exposure of people, their property and the environment to just mentioned hazards. According to the International strategy for disaster risk reduction [18], risk represents the probability of adverse consequences or expected losses due to the interaction between the hazard and vulnerability in a given area in a given period of time. According to the same strategy the risk of disasters represents potential losses in disasters, in terms of human lives, health conditions, existence, property and services, which may occur in a given community or society for a specified future period. It should be noted that the risk of disasters includes different types of potential losses which are often difficult to quantify. On the other hand, with knowledge of the prevailing hazards and patterns of population and socio-economic development, disaster risks can be assessed and mapped, at least in broad terms. The strategy highlights the concept of extensive and intensive risk (extensive risk) that is a widespread risk

associated with the exposure of the population in different locations to repeated or continuous conditions of hazard, of low or moderate intensity, often extremely localized nature, which can lead to negative cumulative effects of disasters. Basically, such a risk is a characteristic of rural areas and urban bordering parts, where communities are subjected to repeated localized floods, landslides, storms or droughts, and are vulnerable to such phenomena. It is often associated with poverty, urbanization and environmental degradation. On the other hand, intensive risk is the risk associated with exposure of high concentrations of people and economic activities to events of intense hazards, which can lead to potentially catastrophic impacts of an accident with high mortality and loss of property.

3. Models and methods of risk assessment

In the literature on the risks, the most common is division of methods of risk assessment into quantitative and qualitative assessments. Quantitative methods focus mainly on physical vulnerability while many qualitative methods include some other aspects. The main characteristic of measuring physical vulnerability is its complexity. The measurement process can be achieved through the use of empirical or analytical methods [19]. Empirical methods are either based on data on the damage from historical events of hazards, or expert opinions. For events that are relatively common and widespread, it is possible to collect information on the extent of physical damage to buildings or infrastructure created after hazardous events. This method is particularly suitable for floods and earthquakes, which normally affect the same type of objects, and allow for the generation of sufficiently

large samples to make a correlation between the intensity of hazard (e.g., modified Mercalli intensity, acceleration of the earthquake, water depth, etc.) and the degree of damage. The result is either a matrix of probability of damage or a curve of vulnerability. In many situations, the expert opinion is the most likely option to gather information about the vulnerability, either because there are no prior information about the damage, there are not enough funds for the implementation of analytical methods or because the classification of facilities that has been used elsewhere does not reflect the local state of structures [20]. Such a method involves consulting the expert group, and providing their position about the vulnerability, for example, the percentage of damage they expect for a variety of structural types with varying intensity of hazard. Analytical methods study the behavior of objects and structures based on the engineering design criteria, by analyzing, for example, seismic loads and implementation of probability of failure, using the tests of physical models (e.g. shaking tables or wind tunnels), as well as techniques of computer simulation. Information on the intensity of hazards in analytical methods should be in more detail. For example, in the case of the earthquake, the analysis of the vulnerability of buildings requires geotechnical reports to determine the value of the effective peak acceleration coefficient, the effective peak acceleration coefficient associated with the speed and type of soil profile. The value of the spectral acceleration should be obtained, as well. One of the most commonly used tests is shaking table. This is a device for structural models of shaking or components of facilities, with a wide range of simulated movements of the earth, including reproductions of recorded earthquakes [21]. Qualitative risk assessment

methods are useful as an initial process to identify hazards and risks. They are also used when a supposed level of risk does not justify the time and effort to collect huge amounts of data required for quantitative risk assessment, and where the possibility of obtaining numerical data is limited [22]. The simplest form of the qualitative analysis of the risk is a combination of hazard maps with maps of risky elements of geographic information systems using a simple matrix of risks in which the classes are qualitatively defined [23]. This method is widely used, mainly at (inter)national or provincial level where quantitative variables are not available or it is necessary to generalize them. Qualitative approaches take into account a number of factors that have an impact on risk. These approaches are mainly based on the development of so-called risk index, as well as the use of multiple criteria of spatial evaluation.

4. Risk assessment methodology in Serbia

The disaster risk assessment methodology in the Republic of Serbia is determined by the Guidelines on the methodology for the development of assessment of vulnerability from for natural and other disasters and plans for protection and rescue in emergency situations [24]. According to these guidelines, the methodology was adopted in order to establish uniform criteria for making Assessment of increase in the quality and comparability of data and improvement of the databases on the risks of natural and other disasters on the territory of the Republic of Serbia. It contains an introduction, a general section and a special section. The aim of the

methodology is the development of Assessment of vulnerability to natural and other disasters. After completion of the preliminary analysis of potential natural and technological hazards, risk analysis is conducted. The objective of conducting risk analysis is the determination of the level of risk. Risk analysis is the process of understanding the nature of the risk and determining the level of risk. The analysis is performed after identification of risks in order to determine the probability and consequences for the protected. According to the guidelines, each of the indicated elements is defined in the following manner:

- Risk assessment is to determine the nature and degree of risk of potential hazard, condition of vulnerability and the consequences that could potentially endanger lives and health of people, property and the environment. This is a process that involves the identification, analysis and evaluation of risk. The assessment should include descriptions of all scenarios for each hazard, opted by working group, then the context in which they discussed scenarios, results of a calculation of risk and level of risk and cartographic representation of all risks. Finally, the working group evaluates risk, comparing the results of the risk analysis, which produces a clear picture of whether the risk is acceptable or requires taking adequate measures to mitigate it.
- Risk monitoring is an ongoing audit, control, critical observation or determination of status, in order to identify expected or required changes all the parameters on which the Assessment is based. Assessment is a document that requires constant upgrading and

updating. This is achieved by tracking the situation on the ground and recording all critical points (facilities, installations, river beds, plants, etc.) that is, the emergence of new factors that promote or induce a specific hazard. There is also continuous monitoring of scientific and professional achievements that may be used to upgrade and update the Assessment.

- Risk identification is the process of finding, recognizing and describing risks. This phase of the Assessment is implemented in the way that a working group and each subgroup consider all the scenarios and define what kinds of risk exist, where these may occur, why these occur and whether these can cause effects on the protected values.
- Risk evaluation is the process of comparing the results of a risk analysis and risk criteria, in order to determine whether the risk and/or its size can be tolerated. Risk treatment is a process which is carried out to modify - reduce the risk. In this sense, the necessary analysis is performed on taking measures to reduce or eliminate the risks which may compromise or produce certain consequences for the protected values, as well as on the need of capacity for response. Assessment of vulnerability at the national, provincial and local government levels consists of general and special parts.
- Risk treatment is a process which is carried out to modify - reduce the risk. In this sense, the necessary analysis is performed on taking measures to reduce or eliminate the risks which may compromise or

produce certain consequences for the protected values, as well as on the need of capacity for response.

Assessment of vulnerability at the national, provincial and local government levels consists of general and special part [24]. At the same time, for the level of the Republic of Serbia, autonomous provinces, and local authorities, General part is done according to the same content and is related to: position and characteristics of the territory (geographical position, hydrographic characteristics, meteorological-climate characteristics, demographic characteristics (number of inhabitants, sex structure, age structure, persons with disabilities), agriculture and material and cultural properties and protected natural resources and facilities, and other infrastructure of special importance (critical infrastructure).

Special part of methodology refers to the identification of disaster hazards and is done for the entire territory for which the Assessment of vulnerability is conducted. Identification of hazards defines parts of the territory which are vulnerable to hazards. According to the guideline [24], a map of the territory shows certain risks of hazards and parts of the territory that are more or less endangered by these hazards. Based on identified hazards, we determine the possible development of event - accident scenario, intensity and analysis of results by hazards. In addition, among identified hazards, it is necessary to select only those hazards typical for a specific territory, and which represent input elements for making the Assessment. In addition to these data, the guideline gives directions for scenarios for any hazard which is a process that brings together (combines) all professional resources in certain areas, who with their engagement provide professional contribution to the development

of qualitative and objective Scenarios. Analogously to national level, scenarios are also selected at provincial level, as well as at the level of local authorities. The selected scenario must be shown on maps (maps of exposure of the population and the environment, property, critical infrastructure, commercial buildings and protected areas).

5. Disaster risk management

Risk management is a function that consists of several sub-functions that work together in order to inform decision-making at all levels of organizations and communities. The relationship between risk management and integrated management of natural disasters can be summarized in the following lines: establishing the context of risk is necessary only at the stage of mitigation of natural disasters; identification, analysis and evaluation of the risk are activities that are included in the stage of mitigation and preparation and do not contribute to the phase of response and recovery; risk treating may be associated with the phase of response of the protection and rescue system to consequences of natural disasters [25]. Domain of disaster management is the discipline and profession of applying science, technology, planning and management in order to cope with extreme events that can harm or kill large numbers of people, cause extensive damage to property and disrupt community life [26]. Such a perspective clearly explains what a disaster is and illustrates how research provides conceptual and practical tools for managers in the risk management process.

According to the international strategy for disaster risk reduction, risk management is a systematic approach and practice of managing uncertainty

to minimize potential damage and losses. According to the above-mentioned strategy, risk management includes risk assessment and analysis, implementation of strategies and specific actions to control, reduce and transfer risks. Organizations practice it significantly to reduce the risk when deciding on investments and to solve operational risks such as business interruption, impossibility of production process, environmental damaging, social impacts and damage from fire and natural disasters. Risk management is a fundamental problem for sectors such as water supply, energetics and agriculture whose production is directly affected by extreme weather and climate conditions.

Disaster risk management is defined as a systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and capacities of the society and community to cope with and mitigate the effects of natural disasters and related environmental and technological disasters. This includes all forms of activity, including the structural and nonstructural measures for avoiding (prevention) or restricting (mitigation and preparedness) adverse effects of a hazard [18]. Disaster risk management is aimed to reduce the risks of disasters, and it refers to a conceptual framework of contemplated elements with the possibility to reduce the fragility and the risk of disasters in the broader context of sustainable development [18]. In recent decades, there has been a change of focus from “disaster recovery and response” to “risk management and mitigation of the effects”. The change also relates to shift from an approach that is focused primarily on hazards as the main causal factor, and to reduction of risk by using physical protection measures, to an

approach that is focused on the vulnerability of communities and the ways to reduce the vulnerability through the implementation of preparedness and systems of early warning. Subsequently, capacities of local communities and local strategy to overcome disasters received more importance [27, 28]. Without proper risk management, risk management can not be imagined. Risk management is promoted by the International Strategy for Disaster Risk Reduction as "promoting and enhancing dialogue and cooperation among scientific communities and practitioners working on disaster risk reduction, encouraging partnerships between stakeholders, including those who work on the socio-economic dimensions of disaster risk reduction" [29]. Management depends on the level of political commitment (at international, national, regional and local levels) and the strength of institutions. Good management has been identified as a key area for successful and effectively viable disaster risk reduction [30]. One of the important processes in risk management is communication, which represents the interactive exchange of information on risks among risk assessors, managers, media, stake holders and the general public. An important component of all this is the visualization of risk. While the risk is generally spatially varying phenomenon, geographical information systems technology is now a standard tool in the production and presentation of risk information, as we have seen in the previous chapters [22].

6.Risk perception

Smith and Petli [17] point out that there are two main ways of risk perception - objective (statistical) and subjective perspective (observation).

At one extreme, an objective perception occurs when the risks are already scientifically evaluated in an impartial manner. All risks and their consequences are assumed to be accurately assessed without bias. At the other end of the scale is the subjective point of view of risk when an individual determines the level of risk based on their own experience, without any scientific validation of results. They also point out that the practitioner consciously strives to exclude all the emotional aspects related to personal preferences in order to achieve valid, reproducible results. Subjective assessment of the risks, on the other hand, is not the result of a formalized process and depends on the strength of the personal experience element. Hazard identification is to detect and accurately describe all sources of hazards and scenarios of their realization. The result of hazard identification is: prevention of adverse events; description of sources of hazards, risk factors, conditions of formation and development of adverse events; preliminary assessment of hazards and risks [1].

Citizens perceive risks differently and the perception of risk influences the decision making at individual, organizational and communal levels. Slović [31] points out that people respond to emergency situations that are perceived, and if these perceptions are wrong, then their actions are likely to be misdirected. Kirkwood [32] emphasizes that there is a distinction between objective and scientific evaluations of risks on the one hand, and public perception of the risks on the other. Wider and unprofessional public lacks of expertise to consider and understand comprehensively the risks of emergency situations. Researchers use established methodologies for risk assessment and are able to efficiently, impartially and objectively identify

and assess risks. This is why there is no overlap of subjective assessments of the risk of emergency situations hold by wider public and objective assessments alluded by experts. In their work, Fishof el al. [33] have noted that most experts believe that citizens are generally poorly informed about existing risks of emergency situations and that they often require "parental instructions" in order to protect themselves against the consequences of such events. Also, they point out that people are very different and we should avoid generalizations, as some tend to acceptance, and the others to avoidance of risk. Perceptions of risk can sometimes be misleading but rarely irrational and naive.

Lindel [34] found that the perception of risk is associated with the characteristics of hazards and perceived personal consequences that are on the other side associated with psychological predispositions of people. Miceli et al. [35] in the research results show that residents of Aosta, Italy are quite unprepared, and correlation and regression analysis indicated that disaster preparedness is positively correlated with the perception of risk. In fact, in their research "Disaster preparedness and flood risk perception: study in the Alpine valley in Italy" they conducted a quantitative research with an aim to test the preparedness of citizens to respond and flood risk perception. On that occasion, 400 adult respondents from nine local communities, who have been exposed to floods were interviewed using a structured interview. Interviewing was conducted through a computer telephone interviewing system. It is interesting to note that respondents were only adults who lived for the last 5 years in the area. They were asked about adopted sets of protection measures which enable them to prevent the negative effects of

floods. The flood risk perception is assessed using a one-dimensional scale that was developed by the authors themselves and that is approved. Respondents were asked to assess the probability of occurrence of different consequences and to express their feelings about floods. At the same time, socio-demographic data were collected.

Therefore, in order to citizens take certain measures of preparedness, they should be aware of natural hazards at local and national levels, believe that it is possible to reduce and cope with the resultant consequences. Citizens shall take such measures if they assume that natural disaster will bring them personally certain consequences, or guided by other considerations such as responsibility towards children or elderly parents [36, 37, 38]. Motivation for taking measures of preparedness is conditioned by the possession of a pet, the location and type of ownership of living facility. In the results of his research, Kapucu [39] points out that residents of Central Florida feel prepared to respond to hurricane (subjective perception), while objectively they are very unprepared for such events (objective perception).

7. Conclusion

Natural disasters pose a serious threat to the security of people and their property. Their unpredictability, intensity and polymorphous character are just a few of the characteristics that greatly complicate the management of risks of natural disasters. Risk management, viewed as a scientific discipline and a practical activity involves obtaining various information on the nature and type of hazard, level of probability of the event, development mode, operation of critical infrastructure and sometimes even involves

reliance on expert intuition. The quality of risk management influences on the ability to mitigate the effects of natural disasters. Timely findings about the possibilities of the occurrence of certain events of seismic, hydrological, biospheric or other origin can be critical for the timely response of social units. At the same time, informing the public about disasters is an important element in the management of disaster risks. The public is most able to protect themselves against the consequences of a disaster if they are informed that there is a hazard, and then educated about what they can do to minimize risks. That is why public education programs are one of the basic disaster mitigation measures. Surely, it can be said that every citizen has the right and obligation to be informed about any potential risks that exist in the local community where they live or work and it is necessary to enable efficient access to that information. The reality is that certain risks are associated with every aspect of our lives. Such risks can not be eliminated but can be assessed and managed in order to eliminate or minimize the consequences of disasters.

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