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REPUBLIC OF SERBIA NATURAL AND OTHER DISASTER RISK ASSESSMENT – METHODOLOGY[1]

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Abstract: One of the most serious challenges of modern society is the lack of awareness of the presence of various dangers and possibilities of influencing them. Each community takes various measures and activities to assess the degree of their vulnerability tending to a state free from danger. As the most complex part, risk assessment requires a systematic approach to identifying and analyzing hazards based on the application of appropriate criteria for calculating the level of risk presented in this paper. Each risk assessment methodology must be adapted to the context of risk assessment. For this reason, the methodology for risk assessment of natural and other disasters is an attempt to establish basic requirements and criteria for risk assessment in the field of emergency management. Due to the complexity and unpredictability of natural and technological hazards that threaten people, material resources and the environment, risk assessment methodology includes risk mapping and assessment of combinations of risks – multi-risk, as well as a cross-border dimension of risk.

Keywords: emergencies, natural disasters, other disasters, risk assessment, risk maps, multi-risk, cross-border dimension of risk.

1. Introduction

Although occurring randomly and often unexpectedly, natural and other disasters are a contemporary phenomenon in the economic and social development. Their dynamics is more and more influenced by natural, as well as anthropogenic influences mostly reflected in climate change and its effects on the environment. Multiplication of these influences and interactions by natural factors in the years and decades to come create much difficulty in predicting the formation and development of events called natural and other disasters.

The statistical data in Serbia show insufficient capacity of the society to respond to the present challenges, risks and threats in an adequate way, which results in material and non-material damage, both at the level of commercial entities and at the level of the state. First of all, loss of human life is unrecoverable. According to the data of the Ministry of Interior of the Republic of Serbia, 700 persons were killed in various disasters such as fires, technological accidents, explosions etc. in the course of 2009, which was coupled with considerable material damage. These accidents, including natural disasters, caused damages of over one billion and four hundred million EUR.

Material losses are by all means important, but all the more important is the non-material loss, in terms of creating a bad image with all the related consequences, detrimental to

1 Natural and other disaster risk assessment methodology presented in this document was conceived while drafting the Guidelines on the methodology for producing vulnerability assessments and emergency protection and rescue plans, drafted by the Emergency Management Sector of the MoI RS together with the representatives of eminent national institutions dealing with risk assessment.

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commercial entities, but even more harmful to the state. At the national level, bad reputation and insecurity perceptions bring unfavourable political and economic consequences, both at the national and international level. In such circumstances potential foreign investors lose interest in investing in Serbia, whereby opportunities are lost for securing new work posts and economic growth. As far as they require an organized response with the view to their prevention and removal of the related harmful consequences, natural and other disasters are emergency situations the effects of which on people, goods and environment are difficult to predict. However, it is widely accepted that emergency prevention or preparedness is a prerequisite for the reduction of harmful consequences.

Risk assessment, as an important element of emergency risk management, is an integral part of the body of measures taken in emergency prediction and prevention, as well as of human planned and systematic attempts to face them in an organized manner. In contemporary practice and scientific and technical literature different methodological risk assessment approaches are used, all having a common goal and that is to gain an exact and methodological insight into the possible occurrence of undesirable phenomena, to take organized social action and thus reduce the uncertainty of occurrence of undesirable consequences. Unfortunately, uncertainty will always exist to the extent in which negative environmental influences increase, and human capacity to control them will mostly depend on Man's good will, first of all not to provoke them and to reduce antrophogenic influences, but also to tackle them the very moment he realizes the scope of their destruction effects.

A methodological approach to risk assessment presented in this text is the first attempt to provide, on the basis of theoretical background and best practice contained in the international, European and national standards in this area, a complex picture of risk assessment in the contemporary security environment.

2. Emergencies and preventive attributes of risk assessment

Most theoreticians and practitioners agree that emergencies are situations that do not happen regularly, i.e. that require additional resources and efforts to handle them and return to the "normal state". However, different approaches, in terms of the capacity to respond to these situations with existing resources of an organization or system, are to blame for difficulties and inconsistencies in the interpretation of the term "emergency".

There are attempts in literature to solve the problem of methodological definition of this term by distinguishing it from similar terms such as: crisis, catastrophe, extraordinary situation, etc. An *emergency* is not yet a crisis, although it makes extraordinary requests to traditional entities. In such situations, emergency services (police, firemen, ambulance, etc.) are able to respond with their traditional assets. Contrary to *crises* which are vague in their character and dimensions, emergencies are mostly tackled in routine operational procedures in the framework of the existing capacities of an organization or community. A somewhat different definition of ***emergencies*** can be found in the Law on Emergency Situations of the Republic of Serbia (Law on E/S, 2009), which defines it as a state in which risks and threats or consequences of catastrophes, emergencies and other hazards are of such gravity and intensity for the population, environment and material goods, that their formation or consequences are not possible to prevent or remove by regular action of the competent authorities and services, which is why it is necessary to use special measures, forces and equipment for their mitigation and removal, in an enhanced work regime.

Many authors state that the question of perception is very important for delineation of these unspecific terms. While a big fire, grave traffic accident is only an emergency for one social group or geographic community, for those affected by it this may be a big crisis or catastrophe. Normative definition and perception of an event denoted as emergency are a framework in which roles and participation of different actors and their resources are identified, with the view to preventing such situations or responding to them in an efficient manner, which is the basis of emergency management process.

Emergency management may be defined as a process that identifies potential events that have a negative effect on an organization or community and provides a framework for capacity building in response to that event. Emergency management *requires an urgent and higly structured response* (UNEP, 1988). In practice, however, these two requirements presuppose *a comparable level of decision-making among different higly structured organizations and agencies,* which is most often not the case, especially if the levels of decision-making are different. Procedures that are standard for an emergency service are usually extraordinary for a company. If response to a fire (as an emergency) requires more than the capacities of an affected organization allow, other services are included in the intervention. There are numerous variations: a fire catching dangerous chemicals, exlosives, fire set by a mentally disordered person who threatens to kill people in the building caught by fire or firemen, etc. Furthermore, a highly structured response requires harmonized procedures of public and private services.

Our paper focuses on emergency prediction in order to take adequate measures and prepare people for their occurrence and consequences. The quality of decisions and effectiveness of measures will depend on correct prediction. The degree of prediction is not the same in different emergencies. This is why it is important to define here natural and other disasters, i.e. list the emergencies which are the subject of our methodology approach. According to the Law on Emergency Situations, *a natural disaster* is an event of hidrometeorological, geological or biological origin, caused by an action of natural forces such as: earthquake, flood, torrential flood, storm, heavy rains, atmospheric discharge, hail, drought, landslides, blizzards, snow drifts and avalanche, extreme air temperatures, accumulation of ice in the waterway, disease epidemics, cattle disease epidemics and pests, and other large-scale natural phenomena which may harm human health and life or cause grave damage.

Other accidents in terms of this methodology include technical and technological hazards and terrorist attacks, one of the major attributes of these hazards being the intensity of consequences thus created. In the Law on Emergency Situations a *technical-technological accident or incident* is defined as a sudden and uncontrolled event or a sequence of events which could not be controlled while managing equipment and handling dangerous substances in the production, use, transport, trade, processing, storage and disposal, such as fire, explosion, accident, traffic accident in road, river, railway and air traffic, accident in mines and tunnels, interruption of the operation of cable-supported transport systems, destruction of dams, accidents in electrical power, oil and gas plants, accident in handling radioactive and nuclear substances; and the consequences of which threaten the lives and safety of people, goods and environment.

In all their aspects, emergencies are extremely complex in their causes, development, form of manifestation and intensity of impacts and threats for protected values. The biggest problem and the most complex task in emergency management are to assess the risks of their formation and development. From the very moment of receiving information sufficient for assessment of the relevant measures there is a time deficit for their implementation. This leads to a paradox of emergency situations: while expecting to receive authentic information sufficient for decision making, an organization

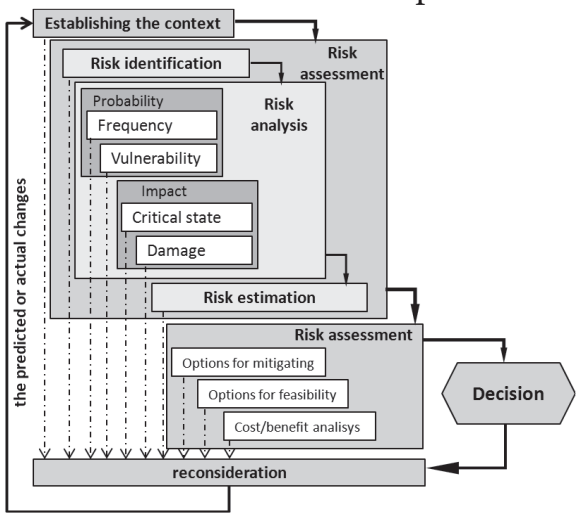
suffers losses because of the unexpected change and cannot take planned measures aimed at solving the newly arisen problems. Therefore, *in the initial stages of potential hazard, general measures are recommended, aimed at increasing strategic flexibility of the organization*. By receiving specific information, measures for removing the hazard or consequences in question become specific as well. However, all these measures cannot make up for the deficiencies occurring due to a bad risk assessment, and this assessment is essential for emergency management in all the stages. Risk assessment allows for decision making based on the facts and in real time. Namely, risk assessment identifies all potential hazards in one area, analyzes their impacts according to time, space and consequences and enables decision making on the measures for tackling the risk.

The basis of risk management, with risk assessment as its integral part, is taking measures aimed at elimination of the causes of occurrence and/or minimization of the effect of a high-risk event, as well as measures for ensuring minimum loss and removal of consequences if the events in question do happen. Literature contains different definitions of risk management (Guide 73, 2004). However, the goal of the entire process of risk management is to obtain adequate information for making a correct, timely and realistic decision. Decision making is a result of risk management process and is determined by three elements: certainty, risk and uncertainty. As we make progress from uncertainty, through risk – the existence of a specific degree of probability of the event in question – to certainty, potential damages decrease. The essence of a correct risk management is to reduce the possibility (probability) of occurrence of a harmful event and the intensity of its impact. Accordingly, the process of risk management is both an input and output of the decision making process. In a decision making process it is crucial to understand how to shift from a risky to a less risky plan and how to reduce expenses without hampering the goals of an organization.

3. Conceptual framework, requirements and criteria for natural and other disasters risk assessment

Risk assessment is an integral part of the risk management process. It is a comprehensive process of identifying potential hazards, risk analysis and assessment (Chart 1).

Chart 1: Risk assessment process



Source: SRPS A.L2.003:2010, Social security – risk assessment in protecting persons, property and business

As the chart shows, risk assessment is a comprehensive process of risk identification, analysis and evaluation (SRPS A.L2.003, 2010). It includes the process of identifying the internal and external hazards and vulnerabilities, identifying the probability of occurrence of an event with an increase of such threats and vulnerabilities, defining the key functions required for continous activity of the organization, defining risk control where it is required for reducing the exposure and evaluation of the cost of such a control.

In order for an organization to be able to make an effective risk assessment, it must previously define the context of the assessment. In particular, risk assessment at the national level is a specific challenge from different aspects. The reason for this is that a risk assessment must include the use of logical and systematic methods for: communication and consultation during the process; establishment of an organizational context for identification, analysis and assessment of risks related to any activity, product, function or process and adequate reporting and archiving in connection with the results of the assessment. When the assessment is finished, the organization should perform a risk management.

As these are multi-disciplinary activities performed in a long-term period and continuously, several conditions should be fulfilled:

1. Appoint a body or person in charge of coordination of the assessment process;
2. Due to workload and the need to recruit experts, it is essential to set up working groups, consisting of experts in specific types of potential dangers, and to include in them the representatives of various interest groups and establish different levels of responsibility (republic, regional and municipal);
3. The representatives of the interest groups must have a unique approach related to risk assessment, and the support in handling the highest risks (Doebeling, 2009).

3.1 Requirements for natural and other disaster risk assessment

Entities that are to make a risk assessment in the national context are: republic, province, local government and commercial societies (Law on E/S, 2009). The efficiency in producing a risk assessment will depend on the fulfillment of legal conditions for doing business and the presence of a skilled professional qualified for performing the tasks of risk assessment. Compliance with the legal conditions of doing business and the capacity of the entity in question will depend on the fulfillment of requirements of all legal regulations related to the field of an entity's activity. Other conditions also need to be fulfilled in order to initiate the risk assessment process: insurance in case of damage incurred during risk assessment, possession of an adequate information support, use of all sources which have the necessary and quality information related to assessment and use of scientific and other knowledge about potential hazards (Kuljba, arhipova, 1998).

In view of the specific geographic position of the Republic of Serbia and its environment, and based on the existing knowledge and information held by expert organizations, natural and other disasters posing a potential threat to the Republic of Serbia may be divided into: natural and technical/technological (Štrbac, 2009). In the process of risk assessment every potential hazard should be analyzed, regardless of the current degree of threat to an organization.

3.2 Risk assessment criteria

The process of risk assessment is continuous and constant in all the stages of emergency management. In order to be effective and sustainable, risk assessment should be integrated at all levels of the protection and rescue system and supported by the relevant authorities (Guide 73, 2004). The methodology for risk assessment in the protection from natural and other disasters is specialized for this area and includes a comprehensive group of criteria according to which the protection and rescue agents compare an identified state at a site against defined parameters. This means that the organization processes each individual hazard in accordance with the requirements and criteria prescribed in this methodology.

The criteria for risk assessment in this methodology have been grouped in the following manner: criteria for identification and preliminary analysis of potential hazards, such as earthquakes, landslides, landslips and erosions; floods, storm winds; hail; blizzards, snow drifts and icing conditions; drought; epidemics; epizootic diseases; fires and explosions; technical–technological accidents and terroristic attacks and nuclear or radiation accidents; probability criterion; impacts criterion; risk level criterion; risk category criterion; risk priority criterion; risk mitigation options criterion; feasibility options criterion; cost-benefit analysis criterion; residual risk criterion and multi-risk criterion.

Identification and preliminary analysis of potential hazards

Identification of potential hazards is performed by a skilled professional, using the known data of an expert organization and service and collecting the field data. The size of potential hazards are identified in the following manner: size 1 – **minimal** hazard; size 2 – **small** hazard; size 3 – **medium** hazard; size 4 – **considerable** hazard and size 5 – **maximum** hazard.

Preliminary analysis of potential hazards allows for the identification of a specific hazard in a given area, and then measuring the degree of risk, from the aspect of vulnerability of the protected assets, in comparison with other hazards (ISO 31000, 2009). Upon finalization of the preliminary analysis, the entity in question ranks potential hazards according to sizes from minimum to maximum. Based on the scale of potential hazards, the entity makes a decision on the urgency to implement measures for reduction of the potential hazard. The decision on urgent action regarding the maximum potential hazard must not disregard other potential hazards with lower degree of danger. The results of a preliminary analysis of potential hazards are risk analysis input results (SRPS A.L2.003, 2010). The entity performs a preliminary analysis of potential hazards on the basis of the results obtained by comparing the actual situation in a given area against the prescribed criteria according to the groups of dangers. The criteria, broken down by groups of hazards, are based on the following information: (NFPA 1600, 2010)

Earthquakes

1. A planned monitoring document;
2. Identification, early warning and alert system;
3. Monitoring and record system;
4. Density of population and size of animal stocks;
5. Possibility of occurrence of other hazards.

Landslides, landslips and erosions
1. Parameters and the nature of landslide, landslip and erosion area;
2. Surface and characteristics of the affected area;
3. Density of population;
4. Density of infrastructure and commercial entities;
5. Possibility of occurrence of other hazards.

Floods
1. The cause and nature of flood;
2. The existence of a flood protection system;
3. The nature and density of population and the size of animal stocks, the quantity of cultural heritage and other goods;
4. Possibility of occurrence of other hazards.

Storm winds
1. Characteristics of the area;
2. Intensity of storm winds, direction of blowing;
3. Density of infrastructure and commercial entities;
4. Possibility of occurrence of other hazards.

Hail
1. Characteristics of the hail phenomena;
2. Areas affected by hail;
3. Directions of arrival of hail clouds;
4. Characteristics of critical surfaces and facilities;
5. Vulnerability of agricultural crops to hail, especially in specific phenophases;
6. The existence of an active hail protection;
7. Possibility of occurrence of other hazards.

Blizzards, snowdrifts and icing conditions
1. Affected areas;
2. Time of occurrence and duration of hazard;
3. Activities affected by the hazard;
4. Possibility of occurrence of other hazards.

Droughts
1. Classification of the intensity of drought by SPI and the related impacts;
2. Time of occurrence and duration of hazard;
3. The surface and characteristics of the affected area;
4. Irrigation capacities;
5. Possibility of occurrence of other hazards.

Epidemics
1. Area affected by an epidemics without correlation with other phenomena;
2. Types of epidemics;

3. Sanitary state of the facilities and infrastructure installations;
4. Health and other capacities for use in caring for, accommodation, transport and other;
5. Possibility of occurrence of other hazards – analyze the possibility of increase of harmful effects on the protected assets due to a concurrent occurrence of other hazards.

Epizootic diseases

1. Parameters and the nature of hazard;
2. Surface and characteristics of the affected area;
3. Density of animal stocks,
4. Existence of an epizootic protection system;
5. Possibility of occurrence of other hazards.

Fires and explosions

1. Cause and characteristics of fires and explosions;
2. Existence of a fire protection system;
3. The density of population, size of animal stocks, proximity of cultural heritage and other goods;
4. Possibility of occurrence of other hazards.

Technical/technological accidents and terrorist attacks

1. Position and characteristics of the territory;
2. Transportation infrastructure;
3. The state of facilities, tools and equipment;
4. Existence of a protection and rescue system;
5. Possibility of occurrence of other hazards.

Nuclear and/or radiation accidents

1. Position and characteristics of the territory;
2. Transportation infrastructure;
3. State of the facilities for nuclear and radiation protection;
4. Existence of a protection and rescue system;
5. Possibility of occurrence of other hazards.

Risk analysis

Upon completion of a preliminary analysis of potential hazards, an organization or entity performs risk analysis for identified potential hazards. Risk analysis results in determination of risk levels. Risk analysis is a process aimed at understanding the nature of risk and determining the level of risk. For each risk and risk scenario identified in the previous stage, the risk analysis makes a detailed (if possible quantitative) assessment of the probability of their occurrence and the degree of potential influence (SRPS A.L2.003, 2010).

Risk analysis is based on quantitative data (UNEP, 1998):

- of the assessment of probability of occurrence of an event or potential hazard, and if

possible, on a historical sequence of events of a similar scale, on available statistical data relevant for the analysis, which may be helpful to observe the tendencies of growth of potential hazards (e.g., due to climate change) and in case of a lack of historical data on the exposure in time of a protected asset to a potential hazard;

- of the assessment of the level of influence, produced in a quantitative form.

The assessment should be as objective as possible and should recognize uncertainty in the underlying evidence.

Probability criterion

Probability (P) is a combination of the frequency of a harmful event and vulnerability with regard to the potential hazard (Table 1), (SRPS A.L2.003, 2010). Probability grading is done in the following way: 1 - impossible, 2 - improbable, 3 - probable, 4 - almost certain and 5 - certain.

Probability is determined according to the following pattern: P= **F # V**..... (1)

Frequency (F) implies repetition of a specific harmful event in time or exposure of a protected asset to a specific potential hazard in a specific time unit (SRPS A.L2.003, 2010). Frequency is used in two forms, as follows:

F_1 – frequency of recorded harmful events and

F_2 – frequency of unrecorded harmful events.

An entity will grade frequency (F_1) in the following manner: 1-very rarely, 2-occasionally, 3-frequently, 4-prevalently and 5-very frequently. Grading of frequency (F_2) is done in the following manner: 1 – negligible, 2 - occasional, 3 – long-lasting, 4 - prevalent and 5 – permanent.

VULNERABILITY		very high	high	medium	low	very low
FREQUENCY		1	2	3	4	5
very rarely	1	3	2	1	1	1
occasionally	2	4	3	2	2	1
frequently	3	5	4	3	2	2
prevalently	4	5	4	3	3	3
constantly	5	5	5	4	3	3

Table 1: Probability matrix

Vulnerability (V) is the existing state of protection of entities, i.e. vulnerability of an entity to potential hazards. Grading of vulnerability of an entity is done in the following manner: 1 – very high, 2 - high, 3 – medium, 4 - low and 5 – very low.

Impact criterion

Impacts (I) are effects of a harmful event on the protected assets of an entity, and are manifested as the degree of loss (damage) in relation to a critical protected asset (Table 2), (SRPS A.L2.003, 2010):

Grading of the impacts is done in the following manner: 1 - minimum; 2 – low-scale; 3 - moderate; 4 – serious and 5 – maximum.

Impacts are measured according to the following fomula: I = **D # C** ..... (2)

CRITICAL STATE		**very high**	**high**	**medium**	**low**	**very low**
DAMAGE		1	2	3	4	5
minimum	**1**	3	2	1	1	1
low-scale	**2**	4	3	2	2	1
moderate	**3**	5	4	3	2	2
serious	**4**	5	4	3	3	3
maximum	**5**	5	5	4	3	3

Table 2: Impacts matrix

Damage (D) is the measure of harm to protected assets.

The entity in question grades damage in the following manner: 1 - very small; 2 - small; 3 - medium; 4 - large and 5 - very large.

Critical state (K) is the measure of the value or importance of a protected asset, or the degree of vulnerability of the entity to the effects of a harmful event.

The entity in question grades critical state in the following manner: 1 - extreme; 2 - serious; 3 - medium; 4 - moderate and 5 - minimum.

Risk level criterion

Risk level is the product of the degree of probability and the degree of impacts (SRPS A.L2.003, 2010), (Table 3). An entity in question determines the risk level according to the following formula:

RL = P x I ..... (3)

IMPACTS		**Minimum**	**Low-scale**	**Moderate**	**Serious**	**Maximum (disastrous)**
PROBABILITY		1	2	3	4	5
impossible	**1**	1	2	3	4	5
improbable	**2**	2	4	6	8	10
probable	**3**	3	6	9	12	15
almost certain	**4**	4	8	12	16	20
certain	**5**	5	10	15	20	25

Table 3: Risk level matrix

Risk level determined according to this method may range from minimum 1 to maximum 25.

Risk evaluation

Risk evaluation is the process of comparing the results of risk analysis with risk criteria in order to establish if the risk and/or its measure(s) are acceptable or tolerable (ISO 31000, 2009). Risk criteria are reference points for determination of the importance

of risk. Risk criteria may imply expenses and benefits, legal requirements, socio-economic and ecological factors, issues related to stakeholders, etc. Risk evaluation is used in order to decide on the importance of risk and whether every special risk should be considered and managed. For the purposes of risk evaluation, the entity classifies risks into categories and then decides which risks are acceptable and which are not.

Risk category criterion

The entity in question classifies risks into categories, ranging from the lowest (first) to the highest (fifth) (SRPS A.L2.003, 2010).

Risk acceptability criterion

Based on the list of acceptable and unacceptable risks, the entity defines the list of priorities. Risks with the highest degree of risk are given priority. In determining which risks will be managed first, the entity should pay attention to potential low-level risks and the possitility of their becoming high level risks (due to risk management measures) requiring priority treatment.

Risk treatment

By treating unacceptable risks, i.e. by taking over various planned measures, an entity reduces risk levels to the acceptable ones. The entity then makes a risk treatment plan, including in principle: activity, implementing agency, time of implementation, partners and manner of reporting.

Mitigation option criterion

In order to reduce the levels of risk from negative impacts of a potential hazard, the entity takes one or a combination of the following measures (SRPS A.L2.003, 2010):

a) Risk avoidance – Risk avoidance strategy is used in risk treatment to replace the initiated activities with the alternative ones, without undermining the projected goals.

b*) Reducing risk by changing the procedure* – By applying the strategy of risk reduction the entity revises the manner – procedure of implementation of critical activities without undermining the projected goals.

c) Probability reduction – Reduction of the probability of occurrence of a potential hazard is used in risk treatment and includes measures aimed at reducing the frequency of occurrence or time exposure of a protected asset, as well as introduction of a new or enhancing the existing system of protection of the critical elements.

d) Reduction of impacts – The strategy of reducing the possibile impacts of potential hazards includes taking measures of protection of the protected assets from possible damage on the basis of the knowledge of the characteristics of the protected values and elements of the system of the entity and based on the reduction of vulnerability to a potential hazard.

e) Risk retention or accepteance – The strategy of risk retention implies to retain in the process of operation all activities or events which do not pose an immediate threat with an unacceptable risk level. Such potential hazards must be kept under control and the entity must take adequate measures so that the risk level does not become

unacceptable. An entity shall accept a risk only when there is a justifiable reason for that in terms of interest.

Risk treatment measures are built in the risk treatment plans, and actions are coordinated with all the stakeholders.

Feasibility options criterion

At each stage of risk assessment each risk treatment measure that an entity finds operational for a specific harmful event should be considered, and it should be checked if a measure is acceptable from the point of view of: conformity with the business policy of the entity or legal restrictions; the price of change of a product (service).

Technical bodies of an entity perform the analysis of feasibiliy options. In the process of establishing feasibility options for implementation of risk treatment measures, the entity applies the acknowledged and legally defined methods (SRPS A.L2.003, 2010).

Cost-benefit analysis criterion

Having finally established risk treatment measures, implemented risk reduction or mitigation measures and evaluated if there is unacceptable residual risk, by using the risk assessment criteria from this methodology, en entity performs analysis and identifies the magnitude of acute expenses of further treatment, in accordance with all general and special characteristics of an observed potential hazard. The cost-benefit analysis is performed by the technical service of the entity, by aplying the acknowledged and legally defined methods.

If the analysis shows indicators contrary to the interest gained by risk treatment, the risk should be considered unacceptable (SRPS A.L2.003, 2010).

3.3 Residual risk criterion

At the end of the risk assessment process, i.e. unacceptable risk treatment, an entity should identify if there is residual risk, i.e. risk which remains unacceptable even after the treatment measures have been taken. Each residual risk that remains upon taking risk treatment measures should be evaluated by using the criteria for risk assessment prescribed in this methodology. If residual risk does not fulfill these criteria the entity should take other risk treatment measures. After the implementation and verification of the specific risk treatment measures, the entity should decide if general residual risk in an area is acceptable, by using acceptability evaluation (SRPS A.L2.003, 2010).

4. Maps and registers of natural and other disaster risks

4.1 Risk maps

Maps are important instruments showing information about potential hazards, vulnerability and risks in the area of natural and other disasters and thus supporting the process of risk assessment and overall risk control strategy. Maps help towards setting the priorities related to risk reduction strategies. Maps also have an important role in ensuring that all the stakeholders in the risk assessment process have the same

information on the hazards and threats, as well as in conveying the results of risk assessment to the interested stakeholders (ISO 22300, 2007). Finally risk mapping is useful in a broader context of land use and visibility of vulnerability assessment results as well as in planning and use of threat response forces. Producing risk maps is a complex job. They are usually one of the results of risk analysis and a follow-up of the process of mapping potential hazards and vulnerability in a given area.

By means of risk maps, an entity shows the space and spatial distribution of the protected assets, risk sources, distribution zones, protection and rescue facilities, facilities that may cause a risk or multi-risks, the position of the neighbouring countries with critical infrastructure, etc. In general, topographic charts of different scale are used for showing the results of risk mapping. Besides topographic charts, in order to show specific topics, specialized agencies also use tematic maps (hydrometeorological, seismic, etc.) (NFPA 1600, 2010). On risk maps (charts) specific potential hazards may be shown for the purpose of a more detailed representation of risks or groups of specific hazards or all potential hazards in a given area.

4.2 Risk register

Register of natural and other disaster risks is permanently produced in the process of risk assessment. An entity records all the data obtained or collected in the process of risk assessment. The records should be kept in hard copy or electronic versions for easy retrieval of data and creation of a database (UK Government, 2008).

In creating an efficient and comprehensive database, it is necessary to produce the relevant software that will provide an analysis of the entered data. Software solutions ensure high-speed analysis of data, visualization of data in real time and prediction of potential phenomena and events.

All vulnerability assessment results should be shown on electronic charts by using the geographic information system (GIS).

5. Multi-risk identification

In the process of risk assessment an entity takes into account the possibility that individual risks alone do not influence protected assets.

Multi – risk is a combination of two or more potential hazards generated from one potential hazard, taking into consideration the interactions of all potential hazards in all the situations:

- occurring simultaneously or consecutively, either because they are mutually dependant or because they are caused by a same event or a trigger event, or:
- posing a threat to the same elements under risk (vulnerable/exposed elements) without chronological coincidence.

Simultaneous potential hazards are also called side events, destructive effects, domino effects or waterfall effect (ISO TC223, 2007). The related examples are a landslide caused by flood, which was triggered by heavy rain, or an industrial accident which causes health problems, epidemics, etc.

Any event or a potential hazard may trigger a number of potential hazards, each of which may be considered separately. The probability of occurrence of each of these events is naturally closely linked to the probability of occurrence of a trigger event that preceded or followed. Assessment of the impacts must therefore take into consideration

the cumulative effect of all different potential hazards occurring simultaneously or consecutively (Keković et al, 2011).

Such multi-risk approaches are important in all the geographical areas prone to negative impacts of several types of potential hazards, as is the case of many parts of the Republic of Serbia. In this context, focusing only on one specific potential hazard could even result in increased vulnerability to another type of potential hazard (NFPA 1600, 2010). *For example, if an approval has been obtained for construction of a facility in a fertile valley, as its structure includes an elevated and high ground floor, this could result in a special vulnerability of the structure to the seizmic waves.*

A multi-risk approach requires a multi-hazard and multi-vulnerability perspective. Each risk assessment must include the possibly increased impacts due to an interaction with other potential hazards; in other words, one risk may be enhanced as a result of occurrence of another potential hazard, or else because another type of event has considerably modified the vulnerability of the system. The perspective of multi-vulnerability refers to the variety of exposed protected assets, e.g. of the population transport and infrastructure system, buildings, cultural heritage, etc. showing different types of vulnerability against different protected assets and requiring different capacities for prevention of potential hazards. Analyses of individual risks take into consideration the complexity of different sources of specific potential hazards (Kuljba, Arhipova, 1998).

Difficulties faced in combining the analysis of individual risks into one integrated picture of multi-risk must not impede drawing conclusions on multiplication or increase of impacts. Some difficulties arise from the fact that available data for different individual risks may refer to different time frames and to using different typologies of impacts, etc.

5.1 Multi risk scenario

Ideally, risk identification should take into account all possible potential hazards, the probability of their occurrence and their potential impacts on all the protected assets and the entity that performs the assessment should ensure the possibility to consider the combinations of all risks. Potential hazards may occur with different intensity and the quantum influence may be unstable, i.e. insufficiently related to the intensity of potential hazards, in other words, only based on specific probability (NFPA 1600). In reality, there are situations where one potential hazard triggers other potential hazards. The range of potential hazards to be considered, together with their impacts, side effects and influence are totally unlimited. Due to such complexity, risk identification usually includes a detailed presentation of a scenario of potential risk situations, which reduces the number of possibilities to several identified situations. Multi-risk scenario is a presentation of a situation in which one or more impacts of potential hazards would lead to considerable impacts posing a priority threat to protected assets (ISO 22300, 2007). In the next phase of designing a multi-risk scenario, it is necessary to analyze all the possible combinations that pose a threat, but also those that are not apparently hazardous. Risk scenarios are an authentic description of events that may be expected in the future. Scenario formation is mostly based on the past experience, but events and impacts that have not yet happened should also be taken into consideration. Scenarios are based on a coherent and internally consistent set of assumptions about the key relations and trigger forces. Therefore, it is essential that all the pieces of information which lead towards defining a scenario should be explicit in order to be able to analyze and update them (NFPA 1600, 2010). For a risk assessment at a high level of aggregation,

such as national risk assessment, a fundamental question is which scenarios will be chosen, as this will determine how useful the role of risk assessment will be in depicting the reality. In comparison to a wide range of situations (i.e. risks and their different degrees), which are likely to happen only a limited number of scenarios may be chosen.

Many risky events may have a range of outcomes with different joint probabilities. Usually, smaller problems occur more frequently than disasters. Thus, there is a choice between the most frequent type of outcome and the most serious one, or another combination. In many cases it is appropriate to focus on the most serious outcome as it represents the biggest threat and is often of the most concern.

In some cases it may be appropriate to rank common problems and independent disasters as special risks. What is important is to use the probability relevant for the assessed impacts, and not the probability of an event as a whole.

6. Cross-border dimension of risk assessment

Many large-scale disasters have a considerable trans-border influence. Many real and potential hazards of the modern world, from remote areas, pose a threat to the main assets in the Republic of Serbia. The most known of these are nuclear facilities that exist in a closer or farther surroundings (Jakovljević, 2009).

Trans-boundary risk control depends on the cross-border exchange of information and therefore the data should be easy available and the neighbouring areas should also benefit from them. As successful as cross-border information exchange may be, it faces a number of challenges (Kuljba, Arhipova, 1998). Because of the very possibility of untimely exchange of information, it is essential to assess the possible impacts and risks from different potential hazards in the closer and farther surroundings of the Republic of Serbia.

Hazards that are typical for trans-boundary, even global effects, require a high level of communication among the states, national and international organizations. Communication does not mean a mere exchange of information, but is aimed at exchanging resources that will ensure prevention, timely response and recovery from the emergency impacts. The states take different measures intended for establishing such a communication, e.g. passing standards regulating the area of the risk management and early warning system, assessment of the response capacities, risk assessments, etc.

7. Conclusion

Emergencies, especially natural and other disasters, cause huge devastations and permanent consequences for people, their property, the environment, and also affect critical infrastructure. In terms of the number of deaths, material destruction and extraordinary expenses, the Republic of Serbia has suffered great losses as a result of various emergencies. In the previous couple of years it has used the emergency response forces and tools in a chaotic manner. Such a situation called for passing the relevant legal and sub-legal regulations related to drafting a natural and other disaster vulnerability assessment of the Republic of Serbia.

The vulnerability assessment, as a general act, gives many answers to questions related to degree of danger, manner of response, the size and distribution of response capacities and so on.

The most complex part of vulnerability assessment is natural and other disaster risk assessment. The first stage of risk assessment is a comprehensive inventory and

a thorough analysis of potential hazards in an area affected by natural and other hazards. In this phase the risk manager, in cooperation with experts for an observed area, performs a detailed analysis of the factors contributing to a potential danger. By their consideration, risk assessment and implementation of risk treatment measures, we have set the conditions for vulnerability prevention. The methodology for natural and other risk assessment in the Republic of Serbia has been conceived as a set of criteria and parameters, defined by expert organizations in charge of specific types of potential hazards, which allow for an integrated and precise interpretation and analysis of potential hazards. The ultimate goal is to define the type, quantity and distribution of the forces and tools required for an efficient emergency response, and to take prevention action, based on real indicators and eventually to evacuate the people and goods with the aim of protection and rescue.

A contemporary approach to emergency decision-making based on integrated risk assessment is an indicator of awareness rising in the community on the possible hazards and their impacts, on the necessity to develop plans for prevention or reduction of impacts and on economic use of the protection and rescue forces and capacities.

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PROCENA RIZIKA OD ELEMENTARNIH NEPOGODA I DRUGIH NESREĆA U REPUBLICI SRBIJI – METODOLOŠKI OSVRT

Rezime

Jedan od najozbiljnijih izazova savremenog društva jeste nedostatak svesti o prisustvu različitih opasnosti i mogućnostima uticaja na njih. U težnji ka stanju oslobođenom opasnosti svaka društvena zajednica preduzima razne mere i aktivnosti da proceni stepen svoje ugroženosti. Kao najsloženiji deo procene ugroženosti, procena rizika zahteva sistematičan pristup u identifikovanju i analizi opasnosti, zasnovan na primeni odgovarajućih kriterijuma za izračunavanje nivoa rizika prikazanih u ovom radu. Svaka metodologija za procenu rizika mora se prilagoditi kontekstu procene rizika. Iz tog razloga, metodologija za procenu rizika od elementarnih nepogoda i drugih nesreća predstavlja pokušaj da se uspostave osnovni zahtevi i kriterijumi za procenu rizika u sferi upravljanja u vanrednim situacijama. Zbog kompleksnosti i nepredvidivosti prirodnih i tehničko-tehnoloških opasnosti koje ugrožavaju ljude, materijalna dobra i životnu sredinu, metodologijom procene rizika je obuhvaćena i izrada mapa rizika, procena kombinacija rizika – multirizika, kao i prekogranična dimenzija rizika.