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573942-EPP-1-2016-1-RS-EPPKA2-CBHE-JP

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Disaster Risk Management in the Western Balkans

A comprehensive approach on technical and economic perspectives

Editors
Dr Elona Pojani
Dr Julinda Keçi

eBOOK

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Publisher: University of Novi Sad, Faculty of Technical Sciences,

Novi Sad, Trg Dositeja Obradovića 6, Serbia

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Proofreaders:
Dr Igor Džolev, University of Novi Sad, Serbia
Dr Linda Makovicka Osvaldova, Dr Miroslava Vandaličkova
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CIP - Каталогизација у публикацији
Библиотеке Матице српске, Нови Сад

504.4:005.334(082)

DISASTER risk management in the Western Balkans [Elektronski izvor] : a comprehensive approach on technical and economic perspectives / editors Elona Pojani, Julinda Keçi. - Novi Sad : Faculty of Technical Sciences, 2020. - 1 elektronski optički disk (CD-ROM) ; 12 cm

Nasl. sa naslovnog ekrana. - Bibliografija uz svaki rad.

ISBN 978-86-6022-269-7

a) Елементарне непогоде - Управљање ризиком - Зборници

COBISS.SR-ID 17038857

Graphic design: Futura doo, Novi Sad

Printing: Futura doo, Novi Sad

Circulation: 300

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PREFACE AND OVERVIEW

Natural and man-made disasters - floods, landslides, earthquakes, storm winds, hail, drought, wildfires and building fires are on the rise in the last decades in the Western Balkans (WB). Human casualties, extensive damages to the urban areas, negative impact on the environment and further weakening of the regional economy are amongst indicators of increasing vulnerability. Preliminary surveys, done by WB project partners, have revealed a shortage of skills and an unstructured/informal learning method in the field of Disaster Risk Management (DRM). Knowledge and skills of the existing staff in this area (state administration, public institutions and companies) are based on the education acquired from other engineering disciplines. These competences, knowledge and skills are insufficient to solve the growing problems in the field of Disaster Risk Management. Moreover, the lack of safety culture in society in general is notable.

Decision No 1313/2013/EU on a Union Civil Protection Mechanism, in view of the significant increase in the numbers and severity of natural and man-made disasters in recent years and in a situation where future disasters will be more extreme and more complex with far-reaching and longer-term consequences as a result, in particular, of climate change and the potential interaction between several natural and technological hazards, emphasize an integrated approach to disaster management as increasingly important. Prevention is of key importance for protection against disasters and requires further action as called for in the European Parliament Resolution, entitled a "Community approach on the prevention of natural and manmade disasters". Reaching the prevention objectives and carrying out prevention actions, improving the disaster risk knowledge base and facilitating the sharing of knowledge, best practices and information, were defined as the first ranked action to take.

Education and training (ET 2020) lie at the heart of the Europe 2020 strategy to exit the recession and establish the foundations for future knowledge-based growth and social cohesion. The same goal is promoted in multiple EU documents, such as European and Mediterranean Major Hazards Agreement (EUR-OPA), South East Europe 2020 Strategy – Jobs and Prosperity in the European Perspective (SEE 2020 Strategy) and Supporting growth and jobs – an agenda for the modernization of Europe's higher education systems COM(2011).

The above mentioned are common objectives and goals both for EU and WB Region, considering the on-going European integration process in the Balkans. Common regional needs to improve the resilience of the region to hazards are recognized:

- the need for human resources – experts, competent to operate in prevention, reaction and recovery phases of the catastrophic events and solve engineering problems in the field of disaster risk management, and
- the need to educate competitive experts, able to create sustainable financial plans for disaster preparedness and preventive measures, according to regional economy recourses.

This book offers a practical approach to disaster risk management, focusing on one hotspot area of Europe in relation to disaster risk – the Balkans. Both technical perspective and economic perspective on the issue are addressed. The team of authors include experts working in the field of disaster risk management in Albania, Serbia and Bosnia-Herzegovina.

A comprehensive overview of different aspects of disaster risk management, enriched with specific case studies from the Balkan area will be offered. Concepts of risk and vulnerability, the systems that exist to manage hazard risk, stakeholder involvement, specific risk assessment for different kinds of disasters and finally description and implementation of financial strategies for disaster risk management are some of the key topics addressed in the book.

The book is organized in three parts. Part I sets the scene and introduce basic concepts of disaster and risks seen from the social, legal, economic, environmental, political and technical perspective (SLEEPT). Part II explores the nature of disaster risk management, with a focus on technical perspective, including flood risk assessment, earthquake risk assessment, fire risk assessment and fire safety, risk assessment on landscape perspective, as well as the application of service-oriented GIS in risk assessment. Two original research papers are also included in this part, focusing on risk assessment on landscape perspective and fire resistance. Part III focuses on economical exposure and financial capacities in case of disasters, risk transfer mechanisms- insurance, reinsurance, CAT bonds, and other ex-ante and ex-post instruments for DRM.

The knowledge in the field of Disaster Risk Management offered by this book would provide bases for building a resilient society.

The Editors

Acknowledgements

The editors of this book would like to express their appreciation to the Knowledge FOr Resilient soCiEty (K-FORCE) project partners, for their assistance and support. We are also grateful to the authors who contributed their research work to this publication.

Section I

Setting the Scene

IDENTIFICATION AND DEFINITION OF RISK, THREATS AND DISASTERS

Branko Babić

1. INTRODUCTION

It is believed that the risk originated in the Middle Ages, and it was taken over from the Italian and French speaking areas, from the French word *risique* and Italian *rissiko*. Risk is used in a variety of meanings, and it originally implied the danger that ships were threatened by from the rocks. Later it related to the danger, the exposure to danger, daring feat, a job or a wager that is linked to the danger of decay, the deviation in the work whose effect diminished its result, loss or damage suffered [1]. Linguistically, it is a potential danger to people and material goods. On the technical side, it is the likelihood of human casualties, injuries or trauma, as well as the loss of material goods or other values. The definition from the aspect of insurance is interesting: *"Risk is the possibility of occurrence of an uncertain event that does not depend on the exclusive will of the interested persons and whose insurance is permitted by law, public order and morality."* From the aspect of VrSi, risk "is a combination of the probability that a disaster will occur within a certain period of time and with certain negative consequences" [2]. Risk is also defined as the likelihood of injury, illness or damage to the health of an employee due to danger (circumstance or condition that could endanger health or cause injury to an employee) or dangerous occurrence - a dangerous event or process that occurs (or which may occur) and which causes a danger to life, human health and the environment [2]. That is why the term risk is processed and defined by many laws which will further be discussed.

This chapter is dedicated to the discussion of different definition on risk and disasters as well as their use and application in legislation. The first part will offer a literature review on the former and the remaining of the chapter will summarize the use of such definitions across Serbian Laws on civil security and disaster risk management.

2. DEFINITIONS OF DISASTER

Research on disasters involves usually interdisciplinary study, with the focus on social and sociological constructions in particular. The definition of most researchers is that a disaster is *any event* that creates significant harmful consequences (endangering safety) – implying that it refers to events from a natural environment (floods, earthquakes, strong storms, etc.), technological and war events (Dombrowsky, 1989). Over time, with the development of definitions, the consequences of terrorism could be studied as disasters. In the definition of disaster most scientists place emphasis on the breakdown of the normal (regular) state of the social system (disruption of basic or most of the basic functions of society, or the "regular" state of security) *as causes* rather than the event itself or the causes of events [4].

Many scientists provide their views of disasters. Thus, Fritz (Fritz, 1961) sees a disaster as a threatening event that affects the functioning (disruption) of all society or some of its parts, with the emphasis on "the basic functions of society being disrupted." Fischer (Fischer, 1998) points out that sociologists are actually studying the changes in the state of society in conditions of endangering security resulting from a disaster. Sjoberg (Sjoberg 1962)

characterizes disaster as “a rare, relatively sudden and largely unexpected disruption of the normal (regular) state of the social system”, due to a previous threatening event that is not subject to social control. Kreps (Kreps, 1998) defines a disaster as “an unusual threatening event” that creates disruption of the normal state of the social system and physical damage. Porfiriev (Porfiriev, 1998) also sees disaster as an event that destabilizes a social system, initiated by a disturbance of normal functioning, which requires intervention to restore stability (a regular, preferable state of security). Drabek (Drabek, 2006) defines disaster as an unusual social problem, with other unusual social problems that are not disasters. Quarantelli (Quarantelli, 2005) states that the definition of disaster must contain, but also separate, *conditions, characteristics and consequences*, and defines disaster in the context of the needs and possibilities of a community to deal with it, as a *crisis situation in which needs have surpassed possibilities* [4].
The UN International Strategy for Disaster Risk Reduction ((UN-ISDR United Nations – International Strategy for Disaster Risk Reduction)) identified disaster as: “A serious disruption in the functioning of a community or society that is causing a widespread human, material, economic or environmental losses that exceed the possibilities of the affected community and the inability to deal with it with their own resources "(UN-ISDR, 2009).
In Germany, the term catastrophe (*katastrophe*) is used. This term implies a sudden and progressive event whose effect on people and material values is so destructive that emergency services and the affected community are unable to properly respond to it due to lack of forces and resources and are forced to react by introducing extraordinary measures, while asking the neighbouring and wider community for help (Kurt et al., 2006).

3. DEFINITIONS OF RISK

Typically, **risk** is considered to be every situation, that is, the state of a particular system, which, with a certain probability, can cause a change in quality, or loss of the system [5]. There are numerous criteria for specification and division of risk. Bearing in mind the speed of change in the state of the system, risk is classified as: *cumulative risks*, characterized by slow development, slow degradation processes and gradual change in the behaviour of the system; or *accidental risks*, characterized by high speed of development, fast deregulation processes, high speed of parameter change and rapid changes in the output characteristics of the system. It is difficult to define risk in a unique way because it depends on how an individual understands the concept of risk and what their occupation is. As there are numerous definitions of risk, there are numerous criteria for its division.
The basic criteria for division of risk (for example in insurance) are according to:

- measurement possibilities (objective and subjective),
- outcome (pure and speculative-work risks),
- influence (general-fundamental and individual-specific risks),
- variability (static and dynamic risks).

Pure risks represent risks that may result in harmful events, and can be:

- technical risks (fires, damage to machinery, devices and installations, etc.),
- risks of natural disasters (earthquakes, floods, etc.),
- human factor risks (intentional work mistakes, ignorance, negligence, violent behaviour, etc.),
- ecological risks (pollution of soil, air and water),
- political risks (social crises, demonstrations, wars, terrorism), and finally,

- biological risks (influenza epidemic, etc.).

People, property, rights of obligations are exposed to spatial and temporal risks. At the core of the risk is uncertainty, which is a term used in the field of probability and statistics. There are three basic concepts of probability:

- **classical concept** - there is a final set of all outcomes of a random event, all outcomes are excluded and equally probable,
- **statistical concept** or an empirical concept - a sufficiently large number of repetitions of an event in unchanged conditions is required,
- **subjective concept** - the degree of faith that a logically consistent person has in the realization of a given event.

In general, there are two basic approaches to risk assessment:

- **objective** risk assessment, where all factors influencing its occurrence are measurable and can be identified and quantified,
- **subjective** risk assessment, where the factors that lead to the occurrence of risk can be difficult to quantify and measure with exact mathematical methods.

4. THE CONCEPT OF CHALLENGE, RISK AND THREAT TO SECURITY

Challenges, risks and threats to security are concepts that are at the basis for defining all other concepts in a modern security concept. These concepts are, in essence, the core of all terms related to security breaches, and therefore VrSi [6].

Challenges are possible forms of endangering the stability and sovereignty of a country and the identity of an individual and a society. They contain numerous, multidimensional forms of threats: military, political, economic, societal and of ecological security spectrum. The nature of the challenges in relation to the survival of a country and society is initially neutral. However, a challenge need to be addressed and its evolvement defines what kind of situation a country is dealing with. If the goal that needs to be achieved and realized would improve the state of a country and society than we are dealing with a positive situation. Otherwise if a risk and threat that come out of the challenge and whose degree and concentration are more direct and harmful to the security object is identified, than we are dealing with a negative situation. Challenges are the most common forms of endangerment and they also contain risks and threats.

Risks are indirect form of jeopardizing the sovereignty and identity of countries and societies that are manifested through more specific and limited forms of military, political, economic, societal and ecological sectors and bring them to a state of greater danger than challenges. Risks usually refer to a negative situation, threatening and endangering the survival of a country and society, but there is also the possibility of avoiding these risks, with a favourable solution and outcome for the security facility. The concept of risk in a broader sense also includes the notion of danger. In insurance, the concept of risk implies a guaranteed risk of certain possible dangers, for example, fire, accidents, etc. In lexical meaning, it signifies *daring feat, gambling, the possibility of death, exposure to accidents, ruin, loss,* and follows, to a greater or lesser extent, every human activity. ***Risk is the danger, possibility or likelihood of damage or loss, exposure to danger, involving the perception of the response to this probability***. Risk is a possibility, a certain degree of probability of occurrence of an event or action with unfavorable consequences, where the removal or reduction depends on the level of knowledge about the phenomenon in which it is contained [7]. Risk can be qualified and quantified by analysis. Namely, risk analysis is the process of systemic research of factors that influence the results when assigning the probability of the occurrence of future states. In doing so, systematic risk factor research involves classifying them into those that are encompassed by the environment, function, and structure of the subject of the analysis. In terms of VrSi, risk is considered to be any situation that, with a certain probability, can initiate an unsuspected quality change, i.e. loss of system. Risk is a measure of probability and consequences of the occurrence of danger, a sudden event that causes damage or injury, therefore, always causes loss.

Threats are direct forms of endangering countries and societies, one kind of pressure by which damage or some evil deed is to be inflicted from a position of force, in order to force the object of threat to make certain concessions. Threats have clear and certain forms of threatening such as war, economic sanctions, or terrorist attacks, and carry a negative value for the survival of a country and society. They are the ultimate, most immediate manifestation of risks and threats. In the broadest sense, threat represents a conscious intention of causing damage to a person, property or right, in order to compel the object of threat to fulfil the imposed behavior.

Referring to the security of the Republic of Serbia [6], for the purpose of combining these elements, we can argue that challenges, risks and threats have a complex character, and with similar content, scope and intensity can be manifested at global, regional and national levels. Of the 22 listed risks, the most interesting risk is "*The consequences of natural disasters and technical and technological accidents"*, as well as endangering the environment and the health of citizens due to radiological, chemical and biological contamination. Technological accidents pose a significant risk, in which the effects of hazardous substances can affect not only the territory of the Republic of Serbia but also the neighboring countries. The environment is additionally endangered by high risk facilities in the countries of the region, as well as economic facilities with technology that does not meet international environmental standards.

The specificity of these security challenges, risks and threats is based on the possibility of their timely detection and preventive action. Challenges, risks and threats to security at global, regional and national levels are constantly being duplicated and their character, intensity and forms of manifestation are changing.

5. RISKS IN LEGAL DOCUMENTS IN THE REPUBLIC OF SERBIA

Concluding this chapter, in the following paragraphs we have summarized the use of the terms risk, challenge and threat in different Laws dealing with security, environmental protection and emergency management in the republic of Serbia. This is done to demonstrate how the terms are included in legal documents for the purposes of law enforcement and discipline, enabling readers to understand the relationship between theory and its application. Risk area is defined by many laws, and being familiar with them contributes to preventive action and reduction of the risk to the population, material and cultural goods and the environment.

1. Law on Disaster Risk Reduction and Emergency Management [2] defines the following related terms: *disaster, natural disaster, technical and technological accident, emergency event, danger, disaster risk reduction, risk management.*

In relation to the last one, the following definitions are included:

- ***risk assessment*** is the determination of the nature and degree of risk of potential danger, conditions of endangerment and consequences which could endanger the life and health of people, the environment and material and cultural goods;
- ***reducing the risk of disasters*** is a policy that is being established and that is guided in order to prevent new and reduce existing risks through the implementation of integrated and inclusive economic, social, educational, normative, health, cultural, technological, political and institutional measures that strengthen resilience and preparedness of a community to respond and alleviate the consequences of the resulting disasters, thereby strengthening the resilience of the community;
- ***risk management*** is a set of measures and activities that are implemented in order to implement disaster risk reduction policy as well as administrative, operational and organizational skills and capacity for their implementation;
- ***risk treatment*** is a way of dealing with the identified, very high risk, in terms of determining activities for undertaking preventive measures for risk reduction, i.e. preparing for readiness and training of forces and agents for reacting to protect and rescue from a certain danger and is undertaken on basis of disaster risk assessment.

2. Law on Safety and Health at Work [3] regulates the implementation and improvement of safety and health at work of persons involved in work processes, as well as persons encountered in the workplace, in order to prevent injuries at work, occupational diseases and diseases related to work. Some terms used in the law include: risk, risk assessment, workplace position with increased risk, etc.

3. Water law [8] regulates the legal status of waters, integral water management, water facilities management and water land management, sources and method of financing water activities, monitoring the implementation of this law, and other issues important for water management. Some terms used in the law address the issues of pollution, floods, hazardous substances, environmental objectives, risk management for water resources, and flood risk assessment.

Managing the risks of harmful effects of water includes:

- making a preliminary flood risk assessment,
- development and implementation of flood risk management plans,
- general and operational plans for protection from floods,
- implementation of regular and emergency protection from floods,
- implementation of protection from ice on water courses and
- protection against erosion and torrents.

Preliminary assessment of the flood risk is made by the Ministry for the Territory of the Republic of Serbia, which contains:

- charts of water areas in the appropriate scale, with the boundaries of the sub-basins entered, showing the topography and the manner of land use;
- a description of floods from the past that had more significant harmful effects on human health, the environment, cultural heritage and economic activities and the likelihood of occurrence of similar events in the future, which could have similar consequences;
- assessment of the potential harmful effects of future floods on human health, the environment, cultural heritage and economic activities, taking into account topographic, hydrological and geomorphological characteristics and the status of

watercourses, including flood areas, the effect of existing flood protection facilities, position of settlements and industrial zones, long-term development plans and climate change from impacts on the occurrence of floods.

Review and, if necessary, revision of the preliminary risk assessment of floods, shall be carried out by the Ministry after the expiration of six years from the date of its production. The Minister shall establish a methodology for the preparation of a preliminary risk assessment of floods.

A map of vulnerability and a flood risk map are developed for flood areas where there are significant flood risks. The flood risk map contains data on the boundaries of the flood area for floods of different return periods, depth or water level and, if necessary, speed or water flow. The flood risk map contains information on the possible harmful effects of floods on human health, the environment, cultural heritage, economic activity and other information of importance for managing the risk of floods. The map of vulnerability and the map of the flood risk is made by a public water supply company.

The Flood Risk Management Plan provides risk management by reducing the potential harmful effects of floods on human health, the environment, cultural heritage and economic activity. The plan is developed on the basis of a map of vulnerability and flood risk maps, according to the methodology that contains:

- the objectives of flood risk management and measures for their achievement,
- priorities and manner of implementation of the flood risk management plan,
- competent legal entities and funds needed for the implementation of the risk management plan from floods,
- a way of aligning with the water management plan and involving the public.

4. The Law on Fire Protection [9] regulates the system of fire protection, rights and obligations of state authorities, autonomous province authorities and bodies of JLS, companies, other legal and natural persons, organization of fire service, supervision over the implementation of this law and other issues of importance for the fire protection system. Terms related to fire safety are defined in the law, such as: fire, explosion, accident, and rescue.

The owner or user of business, industrial and public buildings, blocks and underground garages and facilities in the third category of fire threat and building assemblies, or building councils in residential buildings, shall issue Fire protection rules that include:

- organization of technological processes in such a way that the risk of outbreaks and spreading of the fire is removed, and that in case of its outburst, a safe evacuation of people and property and its spread is prevented;
- fire protection depending on the purpose of the facility with the required number of persons qualified for fire safety activities;
- adoption of the Evacuation Plan and instructions for handling in case of fire;
- the manner of training employees for the implementation of fire protection.

The technical documentation for the previous works must contain the fire protection requirements prescribed by the fire risk assessment, in accordance with the law, the regulations passed on the basis of the law and the technical regulations and standards to which these regulations are referred.

5. The Law on Environmental Protection [10] regulates an integral environmental protection system that ensures the realization of the human right to life and development in a healthy environment and a balanced relationship between economic development and the environment in the Republic of Serbia. The term risk and its definition in the context of environmental protection is also included in the Law.

6. The Law on the Transport of Dangerous Goods [11] regulates the powers of state authorities and specialized organizations in the transport of dangerous goods, the special conditions under which the transport of dangerous goods is carried out, the manner of transporting dangerous goods, procedures in case of emergency events in the transport of dangerous goods and supervision of the execution of this law in road, rail, air and water transport.
The danger of occurrence of consequences in the transport of dangerous goods due to the non-application of the ratified international agreements, laws and by-laws adopted pursuant to this Law is classified into three categories:

- category I danger is the danger to a person's life or environmental pollution with consequences whose elimination is time-consuming and costly;
- category II danger is the risk of serious bodily injury to a person or significant environmental pollution and environmental pollution in a larger area;
- category III danger is the danger of causing a slight bodily injury to a person or a slight environmental pollution.

Some terms used within the law context of have the following meaning:

- ***emergency event*** is an event in which the transport of a dangerous goods has been interrupted or stopped because the dangerous goods have been released or because there is a possibility of releasing the dangerous goods;
- ***dangerous goods*** are substances, objects or waste that, according to fulfilled conditions, are classified as hazardous goods;
- ***transport of dangerous goods*** between the sender and the recipient includes: loading and transport from the dispatch to the point of departure, the retention of dangerous goods in the vehicle, the tank and container caused by traffic conditions before, during and after transport, as well as for transportation for the purpose of changing the type of traffic or means of transport and temporary disposal and unloading of dangerous goods;
- ***participant in the transport of dangerous goods*** is a company, other legal entity or an entrepreneur who is: sender, carrier, recipient, loader, packer, filler, user of container tank or portable tank, transport organizer and transporter service provider in changing the mode of transport in transport of dangerous goods.

7. The Law on Protection against Ionizing Radiation and on Nuclear Safety [12] prescribes measures for protecting human life and health and protecting the environment against the harmful effects of ionizing radiation and nuclear safety measures in all procedures related to nuclear activities and regulates the conditions for carrying out activities with sources of ionizing radiation and nuclear materials, as well as radioactive waste management. Terms such as accident, decontamination, protection, exposure, safety and risk are used and defined in the law in the context of Ionizing Radiation and on Nuclear Safety. Protection against ionizing radiation in radiation activities, nuclear activities and radioactive waste management is based on the principle of ***justification of the application*** -

the conditions and the permissibility of performing existing and future radiation activities, nuclear activities and radioactive waste management activities also determine the prices according to the economic, social and other benefits which their performance provides to society in relation to the radiation risks that may arise from their performance, taking into account the best available data on their efficiency or consequences.

8. The Law on Protection against Non-Ionizing Radiation [13] regulates the conditions and measures for protecting human health and environmental protection against the harmful effects of non-ionizing radiation in the use of non-ionizing radiation sources.

9. The defense strategy of the Republic of Serbia [14] is the basic strategic document that directs the engagement of defense resources and the development of normative, doctrinal and organizational solutions of the defense system of the Republic of Serbia. The Defense Strategy specifically analyzes the security environment and identifies challenges, risks and threats to the defense. The strategy defines the challenges, risks and threats to the defense of the Republic of Serbia which have a complex character. Special attention should be paid to natural disasters and chemical, biological, nuclear, technical and technological accidents that are a permanent security threat for the Republic of Serbia, its population, material assets and the environment. The negative consequences of these phenomena can affect and threaten the territories of neighbouring countries, and can also extend from the territory of neighbouring countries to the Republic of Serbia and jeopardize its territory and population.

SUMMARY

This chapter serves as an introduction to the book dealing with disaster risk management and its technical and economic dimensions. Therefore, a summary of key terms used in the books, such as risk and disasters, is an essential premise for the following chapters. The chapter summarized the definitions of risk and disaster across literature, and also showed how these terms are used and included in the safety and risk management Laws in the Republic of Serbia. Understanding each definition and the distinction between the terms used in the area of disaster risk management is very important not only for researchers working and studying the field of disaster risk management, but also for the broader population, in order for it to be prepared and adequately trained in case of a threating event.

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DISASTERS, POVERTY AND DEVELOPMENT

Elona Pojani

1. INTRODUCTION

Disasters have a major impact on the living conditions, economic performance and environmental assets and services of affected countries or regions. These have been principally conditioned by the increases in population and assets exposed to adverse natural events, a trend likely to worsen with growing urbanization, environmental degradation and expected increase in the number and intensity of hydro-meteorological events resulting from climate change [6]. It is recognized that disasters can have widespread impacts, causing not only harm and damage to lives, buildings and infrastructure, but also impairing economic activity, with potential cascading and global effects. Consequences may be long term and may even irreversibly affect economic and social structures and the environment.

This chapter will give a comprehensive overview of disaster impacts, focusing mostly on the relationship between disasters and economic development. The first part of the chapter will focus on the relationship between disasters and poverty, by trying to convert the effect of disasters into macroeconomic indicators. The second of the chapter will deal with community and individual behavior in case of disaster and consequences they face in relation to the overall macroeconomic impacts. This part will focus mostly on the theory of risk behavior and the way it applies in case of disaster events. The third part will offer a short overview of the concept of resilience, particularly focusing on economic resilience. Finally, a case study about climate change action in Albania will be introduced, focusing on the response to climate change based on three levels, international, national and community.

2. DISASTER AND POVERTY

Disasters affect the economy in any country they occur, and no apparent relation have been observed between economic development and exposure to natural hazards [15]. Based on data from the Karlsruhe Institute of Technology in April 2016, it is evaluated that the economic damage caused worldwide as a result of natural disasters from 1900 to 2015 is over $7 trillion. Floods are the main cause for economic and human losses, according to the findings from the 35,000 natural disaster databases in over 115 years, accounting for about 60% of the damage caused by disasters. Since 1960, storms and hurricanes have replaced the floods as the most devastating force that struck buildings and infrastructure. It cannot yet be determined whether this is due to climate change (The Karlsruhe Technological Entity 2016). Meanwhile, in terms of human loss, according to the study, 8 million people have died throughout this time frame from disasters such as earthquakes, volcanoes, droughts, fires, etc.. Earthquakes are estimated to cause nearly 30% of the deaths, or about 2.3 million human lives lost during the 115-year period. However, in comparison with the population of the globe in general, which is on the rise, deaths from catastrophes, with the exception of Africa, are declining throughout the world (Figure 1).

In absolute monetary terms, over the last 20-year, the USA recorded the biggest losses (US$ 945 billion), reflecting high asset values as well as frequent events. China, by comparison, suffered a significantly higher number of disasters than the USA (577 against 482), but lower total losses (US$ 492 billion) [4]. Comparing continents, Asia, as the continent with the highest population and land mass, has the most disasters, fatalities, and people affected. In relation to the population, the death rate is highest in Africa [15].

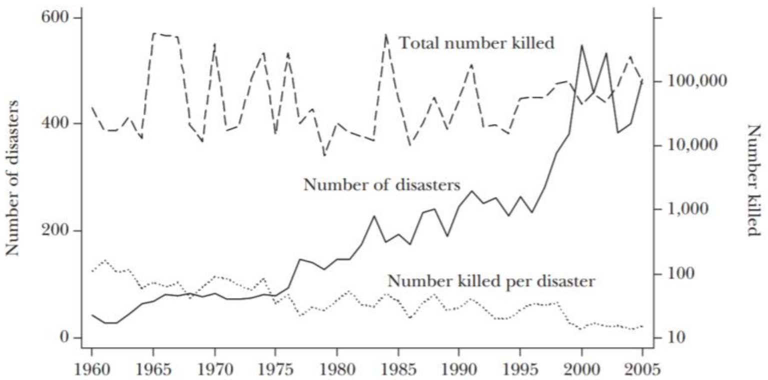

Figure 1. People affected by disasters [15].

Between the 1950s and 1990s, the cost of natural disasters increased 15 times. Disasters in the 1990s caused an economic loss estimated at an average of $ 66 billion a year (in 2002 prices). In 1998-2017 disaster-hit countries also reported direct economic losses valued at US$ 2,908 billion, of which climate-related disasters caused US$ 2,245 billion or 77% of the total. This is up from 68% (US$ 895 billion) of losses (US$ 1,313 billion) reported between 1978 and 1997. Overall, reported losses from extreme weather events rose by 151% between these two 20-year periods. In 2017, according to the Natural Catastrophe loss data: NatCatService | Munich Re, total losses from world natural disasters accounted for $ 330 billion, compared to $ 184 billion in 2016. The year's losses resulted from 710 events, compared to 780 events in 2016.

While upper income and lower income countries have the same chance of being hit by a disaster event, in high income countries the means to cope with a disaster have improved over time, making a highly exposed area less vulnerable to disaster impacts [15]. It is in fact demonstrated that, disaster impact is much more serious in developing countries and emerging economies [7]. This is due to many factors, including the infrastructure conditions, lower building standards, absent or poor incentives for mitigation, and underdevelopment of private markets which do not provide catastrophe insurance for homeowners and small businesses, and greater constraints on government resources available to cope with disasters. Moreover, developing countries face further constrains when trying to develop disaster risk management strategies which would alter disaster impacts. This is also because of the mentality present in these countries. This includes the mentality of governments which often develop short run strategies corresponding to the election cycle, the mentality of the private sector which develop its activity focused on short term profit, without taking into account any damages imposed to the environment and infrastructure, and the mentality of the population which do not consider insurance as a risk protection technique ([11], [7], [5]). Although capital losses might be smaller in absolute terms when compared to those in developed countries, their relative weight and overall impact tend to be very significant, even affecting sustainability [6].

Of the 40 worst catastrophes in terms of the number of victims in 1970- 2001, 39 occurred in developing countries [7]. A 2013 study states that disaster losses in developing nations amount to $862 billion, which is still considered under-estimate [10]. The United Nations Development Programme (UNDP) calculates that while only 11% of those people exposed to droughts, earthquakes, floods and windstorms live in low-development countries, they account for 53% of the people who lose their lives [16]. These devastating events affect millions of people around the world, causing deaths and injuries and destroying homes and livelihoods. In addition, inequality is even greater than available losses data suggest because of under-reporting by low income countries [4]. While high income countries reported losses from 53% of disasters between 1998 and 2017, low income countries only reported them from 13% of disasters. No losses data are therefore available for nearly 87% of disasters in low income countries.

In conclusion, all published data demonstrate that while absolute economic losses might be concentrated in high income countries, the human cost of disasters falls overwhelmingly on low and lower-middle income countries. This burden is expected to rise, especially under the conditions of a changing climate change, which, as shown before, is increasing the frequency and severity of extreme weather events.

3. MACROECONOMIC RISK OF NATURAL DISASTERS

Economic impacts of a disaster are usually grouped into three categories: direct, indirect, and macroeconomic effects (Figure 1). Direct economic damages are mostly the immediate damages or destruction of assets or “stocks”, due to the event per se. The effects can be divided up into those to the private and public economic sectors. Direct damages have indirect impacts on the “flow” of goods and services. These are referred to as indirect economic losses that occur as a consequence of physical destruction affecting households and firms. Most important indirect economic impacts include: diminished production/service due to interruption of economic activity; increased prices due to interruption of economic activity leading to reduction of household income; increased costs as a consequence of destroying roads, e.g. due to detours for distributing goods or going to work; loss or reduction of wages due to business interruption. It should be kept in mind that the social and environmental consequences also have economic repercussions. The reverse is also true, since loss of business and livelihoods can affect human health and well-being. Finally, macroeconomic impacts also arise in case of disasters. The disaster will affect different sectors in varying degrees and thus will be reflected in the macroeconomic performance of the country’s economy [14].

Unfortunately, there are no preliminary models for assessing the marginal consequences of a disaster, but the overall consequences are determined by a complex set of factors, including the country's economic situation before the event, the amount of damages caused, the extent of the disaster, the time at which it occurs, the nature of the phenomenon, the reaction of the institutions, the reconstruction phase, the level of debt before the event, and so on.

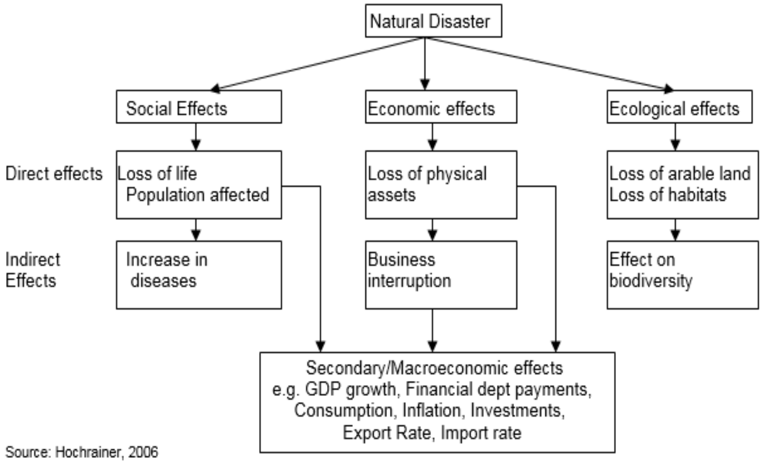

Figure 2. Relationship between the effects of the natural disasters and macroeconomic indicators

The fact that the GDP is negatively affected by disasters is generally accepted throughout the literature. Because of the loss of capital and also of the various factors of a country's previous economic situation, different chain effects may be observed in relation to GDP performance, measured either at the level of growth or in absolute terms (Figure 3). First, GDP can return to its predicted level, which means that the disaster in the long run has had no effect on macroeconomic factors. Second, GDP may rise above its forecasted level, which means that the event had positive effects on the country's macroeconomic performance. This happens when the public sector is able to efficiently use reconstruction funds, resulting in long term prosperity. Thirdly, GDP may rise but again be below its forecasted level, which means that the disaster has had long-term negative effects on macroeconomic factors [3]. What determines the long run behavior of the GDP is the ability of the public sector to cope with the event and the efficiency of its economic resilience mechanisms.

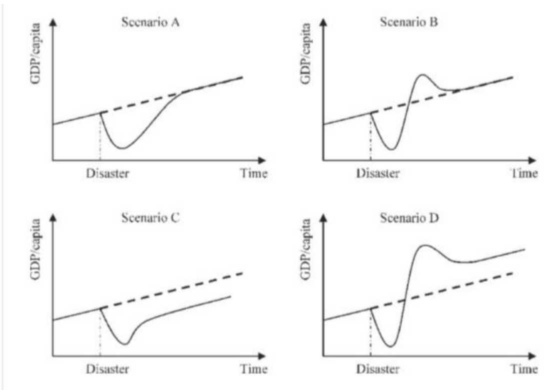

Figure 3. Scenarios of GDP after a disaster event [3]

A disaster event would affect different sectors of the economy in different extent [8]. The agricultural sector's level of growth would be negatively affected in the catastrophe year, especially due to hydro-meteorological risks, but after one or two years it returns to its previous level. In the service sector, growth rates are negatively affected in the disaster year. Growth rates of the export sector are negatively affected in the year of the event. Although it appears that in the years immediately following the catastrophe the average growth rates are higher, which is difficult to explain, no clear trends in this sector can be observed in the long run, although usually a negative rather than positive trend is observed in this period. The import growth rate is positively affected by events of this kind in the year that they occur. In the medium term, the growth rate reached the level of the pre-event period, and for the long run no general conclusions can be drawn. However, an interpretation of these outcomes may be that, during the first and second year after the disaster, imports are higher due to external aid, and later, as these aid decreases, import growth rates also decrease. Government spending in the event year decreases. Later, after one to two years, the average growth rate of government spending increases due to reconstruction of the area and public and private sector funding efforts. Overall, in the long run, government spending stagnates below pre-crisis levels, which may be explained by government's fiscal problems due to lost of funding. Table 1 illustrates some potential impacts of a disaster event on macroeconomic indicators.

Table 1
Potential impacts of a disaster event to macroeconomic indicators [8]

Macroeconomic Indicator	**Expected change**
GDP	Immediately drop in GDP growth in the year of the event Rise in GDP growth in the year after the event Slowdown in second and/or third year
Agricultural sector	Significant fall in production
Manufacture Sector	Decrease in activity due to disruption of transportation, reduced production capacities
Service Sector	Decrease in activity due to disruption of transportation and payment system
Exports of goods	Reduction in the rate of growth in the year of the event In the year after, return to the previous levels In subsequent years continuation of the year after
Imports of Goods	Considerable increase in the rate of growth in the event year A return to pre-disaster level a year after In subsequent years a further drop, possibly caused by reducing incomes
Gross Formation of Fixed Capital	Sharp increase in the year following the disaster
Inflation rate	Short increase caused by the disruption of production and distribution and increasing transportation costs
Public financing	Worsening of deficit due to a shortfall in tax revenues and increase of public expenditures
Trade balance	Deficit due to decrease in exports and an increase in imports, associated with the decline in production capacities and strong public and private investments for reconstruction

The assessment of the macroeconomic risk of a country from a natural disaster will help develop the main strategies for risk management. Assessing the macroeconomic impacts involves taking a different perspective and estimating the aggregate impacts on economic variables like gross domestic product (GDP), consumption and inflation due to the effects of disasters, as well as due to the reallocation of government resources to relief and reconstruction efforts [5]. Figure 4 represents a macroeconomic risk management approach, according to this relationship.

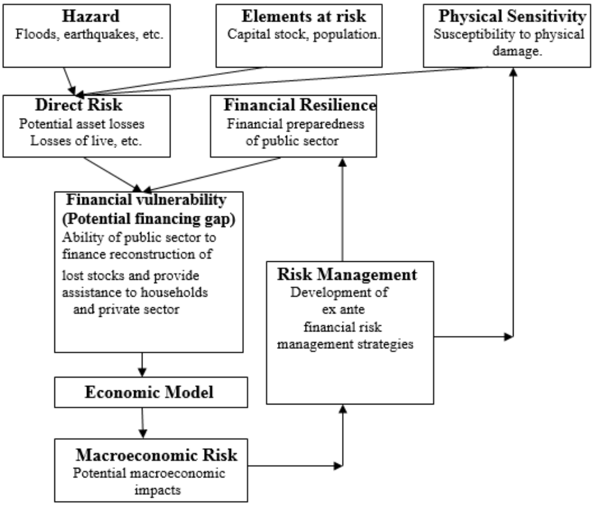

Figure 4. Macroeconomic risk management approach [8]

4. BUILDING RESILIENCE IN CASE OF DISASTERS

The ability of the public sector to respond to the event is determined by several factors. This ability is often referred to as economic resilience [2]. The economic resilience is conditioned by all the possible internal and external resources available to the government to respond to the event. Access to these resources has limitations and costs that must be taken into account depending on the macroeconomic and financial conditions of the country. The availability of the following options in case of a disaster event determines the economic resilience level:

- The insurance and reinsurance payments;
- The reserve funds for disasters that the country has available during the evaluation year;
- The funds that may be received as an aid and donations, public or private, national or international;
- The possible value of new taxes that the country could issue and collect in case of disasters;
- The margin for budgetary reallocations of the country, which usually corresponds to the margin of discretion expenses available to the government;
- The feasible value of external credit that the country could obtain from multilateral organisms and in the external capital market;
- And, the internal credit the country may obtain from commercial and, at times, the Central Bank, signifying immediate liquidity.

The public sector has in most of the cases the responsibility to bear the cost of damages caused by a disaster, acting as insurers of last resort [2]. In particular, the government plays a key role in loss financing after a disaster in developing and emerging-economy countries, and even in high-income countries. According to Hochrainer [8], post disaster government assistance can be seen as one of the most important arrangements of non-market risk transfer. Governments have principally four possibilities to ease their financial burden in the context of natural disaster losses: first, they can continue as before and recover from the effects of a disaster event as best they can, using available resources; second, they can eliminate the risk, e.g. by locating infrastructure out of hazard prone areas; third, they can reduce the risk (mitigation), e.g. by retrofitting existing facilities and the last and fourth option is to transfer risk to other levels [1].

Governments generally have access to various sources of financing following a disaster. These sources can be categorized as ex-post and ex-ante financing instruments.

Ex-post instruments are sources that do not require advance planning. This includes budget reallocation, domestic credit, external credit, tax increase, and donor assistance. Often the public sector relies on such ex post financial means, where international assistance has been especially important. Even though funding from donors and international development banks can be an important part of government catastrophe risk management strategy, over-reliance on this approach has often been the cause of the lack of economic incentives for countries to engage in proactive disaster risk management [7].

Ex-ante risk financing instruments require pro-active advance planning and include reserves or calamity funds, budget contingencies, contingent debt facility and risk transfer mechanisms. These practices are considered a crucial part of disaster financial planning. In this respect, risk transfer instruments are of major importance and much emphasized in academic literature, financial strategies and international institution's recommendation, especially as a mean of risk management that should be considered and implemented in developing countries ([7], [9]).

Households, businesses and governments can transfer their catastrophic risk by insurance and/or reinsurance. According to Linnerooth-Bayer and Mechler [12] insurance and other risk-transfer instruments are justified by the concept of risk aversion. In addition to reducing direct and indirect losses, insurance provides economic security. For businesses, insurance removes risks from balance sheets, meaning that higher-profit and higher-risk activities can be pursued. For governments, insurance assures timely assistance and recovery, which can attract more investment to the country [13].

In addition to traditional insurance and reinsurance, there is emerging interest in other alternative risk transfer instruments, e.g. catastrophe bonds and weather derivatives. Weather derivatives are index based, e.g., physical indicators such as rainfall measured at a specific location are used to define trigger events. Weather derivatives and index-based insurance are seen now as promising risk transfer instruments for the developing and emerging economy countries, especially in the agriculture sector [17]. Catastrophe bonds emerged as instruments primarily for re-insurers; however, there are also governmental efforts in some countries (e.g. Mexico) to transfer their risk with this instrument [8].

Finally, inter-temporal risk spreading is another approach for risk management. At the household level risk spreading over time can be achieved in the form of savings. On the country level, governments can establish catastrophe reserve funds, usually financed by taxes, which are depleted only in the case of a disaster event. Contingent credit arrangements allow borrowing money after an event, whereas the post-event annuity payments are smaller in comparison to a regular credit. Borrowing is also a kind of inter-temporal risk spreading of losses, because payments will be made in the future. A contingent credit is a mixture of saving and borrowing [8].

A comprehensive approach to disaster risk management should emphasize both ex ante measures (prior to a hazard) and ex-post activities. Keipi and Tyson [9] give a comprehensive list of the instruments that can be used by governments as ex ante and ex post sources (Figure 7).

***Ex* ante Sources**[a)]		***Ex post* Sources**
Instruments without risk transfer Nonreimbursable resources ? Calamity funds ? Reserve funds or diversion of national budgetary resources ? Development and social funds Reimbursable resources ? Contingent credits ? Development and social funds	*Instruments with risk transfer* ? Insurance and reinsurance with damage coverage based on real losses ? Insurance and reinsurance with parametric activation of payments ? Catastrophe bonds with damage coverage based on real losses ? Catastrophe bonds with parametric activation of payments	Nonreimbursable resources ? Emergency donations ? Taxes Reimbursable resources ? Emergency credits (for example the IDB's Emergency Reconstruction Mechanism) ? Reconstruction loans ? Reformulation of existing loans

Figure 5. Classification of Disaster financing mechanisms [9]

Finally, as the frequency of disaster events is expected to increase with the increasing risk of climate change, exposure of businesses, infrastructure, assets and economies to disaster risk will be even more serious. The inexorable increase in disaster loss over the past 50 years underscores the fact that ad hoc action may no longer be adequate. The rising frequency and costs caused by natural hazards call for more action to reduce disaster risk. A more proactive approach is urgent, starting with a better understanding of the sources of risk, the systematic consideration of risks in development planning, and the development of financial protection mechanisms. Understanding how to involve the private sector in responding to these risks – or encouraging them to take advantage of the new business opportunities that may arise from changing climate conditions – is crucial to catalyze greater investment in activities that increase countries, businesses, and communities' resilience.

SUMMARY

This chapter offered a discussion about disaster risk and development. First a general overview of impacts of disasters on both developed and developing countries has been presented. This part emphasized that while disaster events can occur in any country, their impact on economic development is much serious in developing countries. Several reasons for this were discussed. A theoretical review regarding the macroeconomic risk of natural disasters and some approaches and instruments for financing the risk of these disasters was presented in the next part. Later, a discussion on resilience and ways to achieve resilience at both government, community and household level is presented. The chapter emphasized the importance for both government, business sector and households to consider disaster risk management strategies, and to consider threats and opportunities that may arise from changing climate conditions.

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STAKEHOLDERS IN DISASTER RISK MANAGEMENT AND DECISION MAKING

Dorina Koçi, Mariola Kapidani

1. INTRODUCTION

The identification and analysis of stakeholders' impact on disaster risk management are an important step of implementing sustainable strategies and plans in this field. As a general explanation, the involvement of stakeholders in disaster risk management requires the proper identification of individuals, institutions or organizations that can influence the goals and objectives of Disaster Risk Management, by playing a crucial role in the phases pre and post disaster occurrence. Different stakeholders such as: government, community, individuals, academia, NGO's and the private sector, are important pillars of increasing disaster resilience. The partnership between several stakeholders improves the DRM measures by creating a broader network of contributors, exchanging relevant information, creating a link between government and the community needs, combining efforts and resources to reach substantial results. However, this approach must address the incorporation of legal framework improvement and strengthening of policies in the disaster risk system with the institutional development and financial resource budgeting. An institutional framework accompanied by appropriate policies and decentralized authority and resource allocations is essential for sound disaster risk reduction actions [32].

This chapter is organized as follows. First a definition on stakeholders is given, by emphasizing their approaches to the process of disaster risk management. Then the role of different stakeholders is analyzed, including the role of central and local government units, NGOs and international institutions, financial institutions and private sector. Finally, a case study on the role and involvement of stakeholders in Albania is offered.

2. STAKEHOLDERS DEFINITION AND THEIR APPROACHES TO MANAGING DISASTERS

In the context of Disaster Risk Management, a stakeholder can be described as any entity that can affect and be affected by disaster management. According to UNISDR[1] there are different actors that play an important role in the disaster management process such as, National and local governments, NGOs, Academia, Regional institutions, Corporation, Media and last but not the least, Communities, especially the most vulnerable ones.

Harrison et al. [16] claimed that stakeholder theory should take in consideration the decision makers' roles, their decisions and who takes advantage of the outcomes of those decisions. According to Freeman [15] and Savage et al. [30], stakeholders have an interest in the actions of an organization, and they have the ability to influence it or they can be affected by the achievement of the organization's objectives. Stakeholders experience or anticipate experiencing the harm and benefits of an organization [12]. A latest definition describes the

1 United Nations International Strategy for Disaster Reduction

stakeholder as someone who has input in decision making as well as who benefits from the results of decision makings [27].

Stakeholders have two different approaches toward natural disaster management, noted as proactive and reactive approaches [25]. The criteria used to divide the stakeholder approaches in these two groups is determined by the kind of DRM activities undertaken by them and the time when these activities are undertaken. The stakeholders react in a pro-active manner when they plan and conduct activities before the natural disaster happens, such as mitigation and preparedness. These activities aim to tranquilize the adverse impacts of natural disasters effectively. From the other side, if stakeholders’ activities have to do with responses and recovery, they are embracing a reactive approach.

Even though the attitude of stakeholders toward natural disaster management is recognized by two different approaches, most studies conclude that the stakeholders tend to resolve by reactive approaches the problems arisen by natural disaster [6], [7]. Brilly and Polic [7] considered stakeholders' approach to provide an integrated flood mitigation decision making process in a Slovenian case. Bosher et al. [6] concluded that there is a need to address proactively the weaknesses in maintaining the built environment from a range of disasters. They also emphasized that there is a lack of evidence for construction stakeholders in playing an active role in mitigating flood risk.

Both national and local authorities in almost all Western Balkan countries are becoming more aware of the need to develop long-term risk reduction approaches, with a multi-stakeholder participation approach. However, as suggested from previous studies, local government units in Albania, Bosnia and Herzegovina, Kosovo and Macedonia lack sufficient knowledge about disaster risks and vulnerabilities of their communities as well as appropriate disaster risk reduction measures and risk assessment programs at the local level, particularly for smaller communities. In other words, the disaster response and planning capacity at municipal levels could be enhanced. At present, Albania is working towards the inclusion of disaster risk reduction in the legal and institutional framework and transitioning from a reactive to a more proactive disaster risk reduction orientated approach [13].

3. THE ROLE OF THE GOVERNMENT

Disaster risk management is an important issue for achieving sustainable development of cities, taking into account the fast growing of urban areas and the fast population expansion. Making cities resilient is a complex task, which requires the collaborative efforts of various stakeholders, including decision makers, community groups, private sector, financial institutions, international organizations, civil society and academia. Disaster risk management and prevention depends on wider social and political conditions that affect the ability of governments and civil organizations in this process, such as capacity planning, regulatory, institutional environment, chains of responsibility and interaction with stakeholders [29]. However, it is the responsibility of the governmental institutions, both at the national and local level, to address the appropriate implementation of disaster risk reduction measures and resilience programs, to achieve relevant outcomes. The government structures, in all levels of governments, are the ones that should integrate the disaster risk management activities with the community planning and recourse capability assessment [32].

Government's role in disaster risk management is linked to fundamental services and infrastructure facilities provision, financial support and implementation of the right measures to prevent, prepare, mitigate and recover from the impacts of disasters. Institutional mechanisms are crucial to monitor the implementation of these disaster risk management measures, and to coordinate the action plans and prompt response to disaster situations. Major objectives of the government institutions are firstly directed toward the achievement of citizens' wellbeing and protecting their life quality. Within these objectives, government role is to provide the necessary logistic support, including actions such as rescue, relief and resilience in case of major disasters. Building the right communication network and financial links between different stakeholders is important to enhance the response and recovery actions, but also the earlier phases of disaster risk management measures such as preparedness and prevention. The coordination of stakeholder contribution in disaster risk management is a further responsibility of the government institution in charge, in order to encourage their participation in decision making and to avoid overlapping of tasks between different parties.

The basic steps to be undertaken by the government related to disaster risk management, is the regulation of the legislation and policy instruments, to properly address authority alignment, resource allocation, responsibility lines and enforcement of regulations in specific matters. Disaster resilience may be improved by giving priorities to disaster risk assessment and establishing an effective emergency response mechanism. In terms of disaster resilience, the effective programs require national DRM strategies combined with law enforcement on land use regulations and building codes. Another important factor in proper disaster risk management programs, is taking into consideration strengthening of human resources. Building resilience requires the equipment of individuals, communities and organizations with a practical approach and the necessary knowledge on DRM. National and local governments should provide training programs, designed for the broad participation of non-governmental organizations, disaster management authorities, international donor organizations, private sector, civil defense divisions, and the community. A training program that is designed to combine different stakeholder groups, intends to better address the issue by identifying strengths and weaknesses and complementing the disaster risk topic with experiences and knowledge of different approaches. Lastly, the practical training programs provided by the government should include research institution collaboration and the university programs outcomes to contribute to the disaster risk management knowledge at broader levels.

Several studies reveal that disaster management requires effective community-based strategies which include programs and measures to prevent and mitigate disaster effects. Following this argument, in recent years, research in disaster risk management is focused in the local government units. According to a UNDP study: "the active commitment and leadership of a local government is important for the implementation of any local disaster risk reduction measures to deal with different stakeholders and multiple layers of government". It is argued that national disaster risk reduction measures will fail to succeed when communities and stakeholders are not integrated and properly engaged in the disaster risk management operations, even if the early warning system measures are adopted. Disaster risk management at the local governmental level is considered more effective since the natural disaster occurrences are local in nature. Moreover, local government units and communities are in the closest position to respond and mitigate, as well as rehabilitation of the territories within the disaster risk management practices. To conclude this argument, there is evidence that a decentralized risk management system, where local actors are assigned relevant functions, creates a very effective environment for disaster risk reduction in the region [5].

According to Pal and Shaw [26] local government plays a key role in implementing disaster risk initiatives, identifying four main aspects: coordinating disaster risk reduction strategies in multi-stakeholder platforms; creating a link between the local community concerns and government priorities, by engaging citizens and DRM decision making; implementing the appropriate mechanisms and techniques for disaster risk reduction; strengthening institutional capacities and practices for local disaster risk management. Another role of local government is to cultivate prevention and preparedness by raising awareness of community on natural disasters and enhancing the inclusion of citizens in DRM. Local government inclusion in disaster risk management is based on the reciprocal support from the central government, in terms of financial and technical support, and also in the institutionalization of the framework regulations. Despite their important role, in many cases the local government units are not equipped with sufficient knowledge and financial tools in performing appropriate disaster risk reduction practices, which increases the importance of inclusion of donors and partner organizations in the process. In this context, in order to accomplish the objective of broader stakeholder participation in disaster risk management, several local actors may be involved of both the public and private sectors, by identifying the specific links and contributors to the process.

Disaster risk management should be regulated by adequate laws and specific programs should be incorporated in the budgetary system. The role of national government is to instruct and support local authorities to prepare and respond, especially in the case of large-scale disasters. The system of measures and response requires the decentralization of power in disaster risk management, including aspects of administrative competences, financial capacity and policy implementation.

UNISDR has addressed the role of local government units in disaster risk management, by identifying sound practice for institutional coordination in aspects of: a) effective preparedness, early warning and response; b) training, education and public awareness; c) building regulations and land use planning; d) multi-hazard risk assessment at regional level; e) environmental protection and strengthening ecosystems; e) recovery and reconstruction. Another important aspect of local government role in DRM is linked to involvement of citizens and all prior stakeholders in decision-making, in order to ensure the effective implementation of disaster risk reduction measures [19]. Coordinating efforts in terms of knowledge, information, financial resources, and human resources is perceived as the essential approach to effective disaster risk management, at local level and further at a larger scale. Given the importance of disaster risk at the local level, it is important to address the challenges that local institutions face in terms of infrastructure capacity, expertise in risk assessment, financial capacity and decentralized authority in decision making [2]. In many countries, a reformation of the existing disaster risk management system might be required, to increase the competencies of local government units in locally addressing DRM measures and their implementation.

Finally, regarding financial resources, the current legislation in several western Balkan countries, defines the state budget as the primary financial resource for civil emergency planning and crisis management. Local government units receive financial support from the central government for civil protection work, but they also use some of their income and fundraise through donations.

4. INTERNATIONAL ORGANIZATIONS AND DONORS' ASSISTANCE

When assessing stakeholders’ role in disaster risk management, the role of international organizations, local NGO-s and donors’ assistance is identified as crucial in disaster emergency relief. This argument relies on the complementary role that non-governmental organizations play in pre and post disaster actions to support the government measures. Support offered includes shelter, emergency food supplies, counseling, trains the volunteers, providing language assistance, providing transportation and logistics support. NGOs work together with the government and other agencies to provide relief services, promote recovery, and reduce stress of disaster victims. Their contribution is also notable in prior phases of disaster risk management, such as strengthening the community preparedness and promoting disaster risk reduction awareness, in line with the national programs.

In recent years, an increased integration of international organizations contributes to national or local disaster risk management strategies has been evident, with an important role in community disaster prevention and reduction. Partner organizations' assistance is relevant, especially in those communities with high vulnerability to natural hazards that lack sufficient capacity, resources and knowledge of local institutions to plan and manage local disaster risks [31]. International organizations cooperate with the national governments in different countries in terms of specifying policy guidelines, enhancing the legislative framework, and implementing the disaster risk community-based programs nationally as well as locally. Another role of non-governmental organizations is in promoting the participation of local communities in disaster risk management decision making. Working closely to the vulnerable communities, they have an advantage in enhancing preparedness and mitigation by encouraging communities' participation in disaster risk reduction programs [20]. In this aspect, linking the local communities to local governments is considered an important assistance of partner organizations to assure the sustainability of disaster risk reduction measures. Closeness to communities, including the phases during and post disaster occurrence, puts the nongovernmental organizations at favorable position for data collection in terms of risk assessment and ex post loss information. The information disclosure is often provided in the form of risk assessment reports, in cooperation with research institutes or other organizations. The contribution is also of high importance in terms of financial budgeting of preparedness, trainings, and risk assessment programs that are provided from the assistance of donors and international organizations that operate in the field of disaster risk. According to UNDP [31], participation of international nongovernmental organizations in DRM programs is significant for combining resources and expertise, especially in encouraging cross-border and cross-sectoral risk management.

In Western Balkan countries, several international and local organizations operate in the disaster risk management programs and humanitarian aid in emergency crisis. The active donors in supporting disaster risk management projects in Western Balkan, include organizations and programs such as: the European Commission (through IPA), World Bank (WB), GFDRR (The Global Facility for Disaster Reduction and Recovery), United Nations International Strategy for Disaster Reduction (UNISDR), United Nations Development Programme (UNDP), Organization for Security and Co-operation in Europe (OSCE), World Meteorological Organization (WMO), and bilateral donors such as the Italian Cooperation, the Swiss Cooperation, DANIDA, USAID, JICA and others. Enhancing regional institutional capacity and coordination with regard to disaster risk reduction and adaptation to climate change is an important objective of international organization's contribution to DRM. Another important task is related to the improvement of regional risk assessment and mapping capacities in Western Balkan. This active participation is achieved through initiatives such as Europe Re and the South Eastern Europe and Caucasus Catastrophe Risk Insurance Facility (UNISDR). A wide range of local nongovernmental organizations also contribute to the disaster risk reduction initiatives, in cooperation with government programs and research institutions in terms of risk assessment and also in increasing public awareness.

5. THE PRIVATE SECTOR AND ITS ROLE AS A STAKEHOLDER IN DRM

The private sector comprises the major part of the economy of a country and own the major part of the real estate, representing in this case the major source of potential losses from disasters. The first aim of a business is to maximize its profit. From this point of view, it would be expected for businesses to take disaster risk management actions that are in line and enhance this primary objective.

There are four major categories of co-benefits from DRM investment to the private sector. Rose provides some examples for each category [28]:

1. Benefits to the business undertaking the investments
   - Improved business image (from being a "good citizen")
   - Improved credit rating (from increased stability)
   - Improved ability to deal with multiple hazards (from business continuity planning)
2. Benefits to other businesses in the supply chain or geographic vicinity
   - Increased supply-chain stability (from business continuity)
   - Reduction in contagion effects (from lower likelihood of fire spreading or falling debris)
3. Benefits to the general business climate
   - Reduced uncertainty (through lowering the likelihood of disaster loses)
   - Increased economic stability (from business continuity)
   - Increased economic growth (from business continuity)
   - Contributions to technological progress (from embodied technological improvements)
4. Benefits to society
   - Improved health and education (from employee-related measures)
   - Improved environment (from more prudent use of resources)

Business investment in disaster risk management, creates benefits not only for the business itself, but in a broader context, the benefits are linked to the economy as a whole. In other words, businesses are able to create positive externalities. For example, a fire protection system that is installed in a business building, may protect also the other surrounding buildings and the community as well. However, the private sector has lagged behind with the investment in disaster risk management, since most investment in DRM is actually made by the public sector [28]. This is also caused by the gaps that exist in terms of arrangements that could further facilitate its involvement. For example, the role of business in disaster relief and recovery is largely ad hoc and not formalized into response and recovery plans [18].

An effective implementation of government intervention to manage disaster risk can be achieved by establishing partnerships with the private sector and in particular the insurance industry. Especially in the developing countries this service requires the support through government subsidies, government regulations and re-insurance. Following the pro-active approach for transferring the risk it is evident that insurance presence is required. In fact, the role of insurance in DRM is very important. In the major agricultural insurance regions (e.g. in North America, parts of the EU) it has been proven that only an insurance system supported by the government is able to provide for sustainable market [11].

The most positive aspect of insurance service is the incentive for mitigation. In this context, lower insurance rates would have a spillover effect on disaster risk management, as far as lower rates make the insurance service less expensive and affordable to a larger group of people. Private insurance companies have their network of marketing and sales that can help other public insurance programs to operate effectively. Private companies sell disaster insurance policies on behalf of the disaster insurance state program or usually private insurance companies incorporate in their insurance policies also public security from disasters. In some cases, the private insurance companies may be shareholders in the disaster-related insurance program. As far as insurance companies sell other products, they are much more accessible to the public. Thereby, the public becomes even more aware about the insurance coverage and get more information about insurance.

The partnership between government and private insurance companies is also in the interest of the latter, because of some advantages on their part. On behalf of the public insurance program, private insurance companies sell policies and receive commissions. The government can make publicity through its agencies for the insurance service in general and particularly for property. Consequently, the private insurance companies may profit from this publicity without having any additional costs. If private insurance companies may link together their products with public disaster insurance, they can increase their market share.

6. FINANCIAL INTITUTIONS

Financial institutions are the key providers of financial products and services and together with financial markets are part of the financial industry that, itself, is a very important component of a country's economy. The role that financial services could play in managing disaster risk, has been subject of investigation from many researchers and international institutions [22], arguing that financial services may be an active tool of disaster risk reduction. Several disaster finances schemes have been mentioned, such as partnerships with NGO-s, insurance companies, local savings and credit institutions. According to Vellinga et al [33] financial services may play a significant role in managing risk that accompany climate change.

In many developing countries, the major part of financial and other resources for disaster risk reduction and adaptation activities comes from households - mainly through the use of their savings [34], which may take the form of cash money or a deposit in a commercial bank. Savings do not provide optimal risk coverage for very poor, due to factors such as erratic income flow and limitations in participating in effective financial management schemes [9]. Many households use the self-insurance mechanisms as a tool for risk management. Anyway, when using this kind of risk management tool, in case of a natural hazard, they do not transfer the risk to another party. Informal lending is also used as a disaster finance mechanism, even though interest rates in such schemes can vary from 30% to 120% [17]. Initiatives taken by governments and NGOs regarding the household risk finance, are based more on a general development perspective rather than a risk management perspective. As far as these initiatives point out the efforts for sustainable development, the threat of natural disasters may be under-evaluated. The micro-finance institutions cover the major part of the services for this category of community.

Microfinance has provided support over the years to people all over the world and has played an important role in creating resilience, particularly in developing countries. The term microfinance refers to the provision of financial services to low-income individuals, including the self-employed [21]. Microfinance targets the poor class of communities which often lacks access to proper livelihood activities [3]. In a broader context, microfinance is potentially an integral part of an overall disaster risk management strategy that reduces the financial vulnerability of individuals and households. Among the products and services provided by micro-finance institutions, micro-credits play the crucial role. The primary idea of micro-credits awarded the Nobel Prize for Peace to Mohamed Yunus[2] and the Grammen Bank in 2006. The clients of Micro-finance institutions are member of groups where each of them shares the responsibility of paying the principle and interest of small loans with others. Another main product offered by Micro-finance institutions (MIFs) are insurance policies, even though traditionally these institutions do not have the expertise in designing and providing insurance services. They have lacked resources on an actuarial basis for computing premiums and contributions. Micro-insurance provided by MFIs might not be always feasible because they have a smaller and possibly more homogeneous risk pool, and they lack reserves and reinsurance [34]. MFIs face high covariant risk when disasters affect all of the community groups with outstanding loans. In order to be successful in providing insurance, and also to reduce the variability in their portfolio, micro-finance institutions should reach a certain range in numbers of policies and clients. By seeking formal insurance and reinsurance partners, MFIs may be able to better transfer risk once scale is achieved [10].

There is a range of products designed for the provision of any benefits to individuals' voluntary savings, pre- and post- disasters rehabilitation loan and relief loans, etc. [1]. For example, Opportunity International[3] offers micro-insurance products that help such groups to better manage their risks and also benefit micro-credit operations by preventing loan default in the case of an unexpected event [34]. According to Mapfumo (2005), the loan from Opportunity International in Malawi are provided with a compulsory insurance component, the premium of which is added to the interest rate of the loan. This linkage between the two products reduces the risk of loan default in the event of a disaster, and the risk that the client has to assume the burden of yet another loan to cover the loss of assets and the original loan principal.

Research suggests different saving strategies for Micro Finance Institutions to help the affected communities in times of disasters, i.e. these institutions may allow voluntary withdrawal access and convenience in frequency and location of collection of the clients, which consequently, help clients accumulate larger balances. The variety of possible approaches reflects ambiguity regarding which product to offer in what kind of disaster stages, i.e. pre-disasters, or whether to let disasters strike the community and then launch a readily available product for relief, rehabilitation and reconstruction activities [8]. Savings products generally play a crucial role in helping clients overcome their losses and rehabilitate to their pre-disaster social position. Regarding the case of Bangladesh, however, the compulsory saving products offered by most Micro Finance Institutions show the provision of limited benefits to their clients because of difficulties in accumulating meaningful balances and meeting substantial demands for withdrawals. Despite the benefits of voluntary saving products in disaster protection of clients, some issues remain regarding the potential demand for voluntary savings and regulatory restrictions of MFIs [8].

7. CASE STUDY

7.1. Main Stakeholders, Roles and Responsibilities in Disaster Risk Reduction and Management in Albania

Albania is exposed to natural hazards, including those of hydro-meteorological and geological origins, such as earthquakes, floods, droughts, forest fires and landslides. The

[2] Mohamed Yunus is known as the "Father" of Microfinance

[3] www.opportunity.org

General Directorate for Civil Emergencies is responsible for undertaking national disaster risk assessments and coordinates with the line ministries and institutions that have responsibility for the respective sector risk analysis, development strategies and integrated planning. At the local level, the prefectures and municipalities are responsible for their own risk assessment and planning. Under the chairmanship of the mayor, the Commission on Planning and Responding with Civil Emergencies is established, and its main task is to coordinate all activities of the local government unit and voluntary organizations, responsible for planning and responding to emergencies.

Albania is working towards the inclusion of disaster risk reduction (DRR) in the legal and institutional framework and transitioning from a reactive to a more proactive DRR orientated approach. The Civil Protection System in Albania consists of permanent and temporary structures at national regional and local. Through these structures, each ministry, department or institution, has specific responsibilities, for all stages of the disaster risk management cycle. The Agency for Civil Emergencies is the key institution for disaster risk management and is best placed to enhance the inclusion of DRR in the existing legislation and management system.

Several private sector companies are called upon to provide humanitarian support, including mobile phone companies (e.g. AMC, Vodafone Albania, Plus), Tirana International Airport and so on. In addition, humanitarian non-governmental organizations (NGOs), such as the Red Cross Albania, provide humanitarian services.

At present, a multi-disciplinary, multi-sectoral and multi-stakeholder National Platform for DRR does not exist, in order to help advance a national commitment to reduce disaster risks. Although DRR is addressed and acknowledged in some policies, strategies and action plans, a systematic approach to the mainstreaming of DRR into sectoral and multi-sectoral plans has not yet been adopted. In the National Strategy for Disaster Risk Reduction 2014-2018, one priority action that has been outlined is the need to engage line ministries at a higher level around DRR, including the formalization of a multi-stakeholder National Platform for DRR, emphasizing the growing recognition around the need for effective DRR in Albania.

1.1. SWOT analysis[4]

SWOT analysis consists in assessing and balancing the strengths and weaknesses, gaps and opportunities of a system. As a methodical approach, it has a broad application to help decision-makers find the most appropriate solutions to a particular problem. A SWOT analysis of stakeholders' involvement in Albania is presented next.

Weaknesses & Threats

Albanian institutions engaged in Disaster Risk Reduction & Civil Protection (DRR&CP), conceptually and practically have adopted a "reactive" instead of "proactive" approach. Under these conditions they focus more on the reaction and less (or not at all) in other components such as "mitigation" of "prevention". Measures that are implemented are one of the main issues related to crisis management. DRR is not yet properly integrated into central, sectoral, and local policies.

There is also a gap between legal obligations and obligations assumed by line ministries or other institutions in relation to DRR & CP, while communication between them or General Directorate of Civil Emergencies continues to remain problematic.

There are a number of DRR & CP measures that result outdated or inadequate, such as: a) predictive techniques, b) environmental measures, c) training / awareness of disaster

[4] Retreived from: http://idmalbania.org/albanias-civil-protection-system-and-its-related-regional-cooperation/

prevention and protection, d) involvement of local communities and volunteers, e) market mechanisms (including the insurance market) to amortize and not allow for the increased impact of disasters. The lack of early warning systems (24 hours / 7 days) and the lack of disaster education (in all cycles) remain problematic.

Strengths & Opportunities

Albania has a legal framework and policies that, despite all the shortcomings, provide a basis for further improvements under the RRF & MC. The Natural Hazard Study undertaken in 2003 and the National Civil Emergency Plan 2004 provides important qualitative and quantitative (statistical) information on threats from disasters as well as on the roles and responsibilities of Albanian institutions. The government is showing a growing awareness on risk prevention measures, though there is much to be done to put them into practice.

The growing assessment from the highest decision-making disaster risk reduction (DRR) levels apart from being positive in itself, has also found support and sponsorship from international actors (World Bank) with programs of such as the strengthening of hydro-meteorological monitoring systems, the adoption of Euro-codes for construction, the introduction of insurance systems, etc.

Above all, it is worth noting that the disasters of recent years (mainly floods and fires) with all the damage (in the economy, but fortunately not in humans) have evidenced some capacity of Albanian institutions and population to cope in such situations. The lessons learned from them, as well as an increased ability of institutions to cooperate and support each other in response to emergencies, constitute a good basis for future challenges of this nature.

SUMMARY

This chapter offered a overview of stakeholders involved in the cycle of Disaster Risk Management. Two approached of their involvement were presented and analyzed: proactive and reactive approaches. Among stakeholders, the role of the government, financial institutions, international organizations, and private sector were analyzed. Finally, a SWOT analysis of stakeholder involvement in Albania was presented.

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DEVICE FOR RISK ASSESSMENT AND MANAGEMENT OF CATASTROPHIC EVENTS

Branko Babić

1. INTRODUCTION

Figure 1 illustrates the Disaster Management Cycle according to FAO [1].[5] It includes a number of phases, each of which requires a different range of response activities. Although there are six phases, they are often grouped together in three main categories: the pre-emergency phase, the emergency phase and the post-emergency phase. The pre-emergency phase includes prevention, mitigation and preparedness under the heading of risk reduction. In the emergency phase the response mechanisms are automated. The post-emergency phase includes recovery and development.

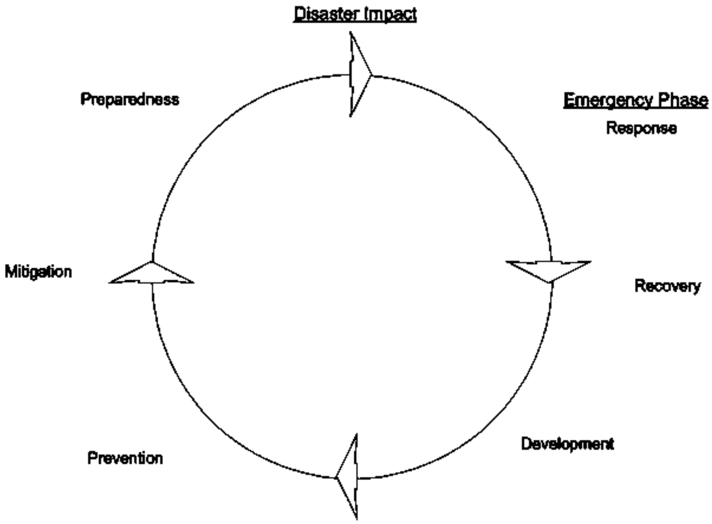

Figure 1. Disaster Risk Management Cycle according to FAO

Within the pre-emergency phase, a risk assessment process has to be developed. Figure 2 shows the overall **risk assessment process**. Risk assessment identifies sources of potential threats, examines possible consequences, needs and possibilities of implementing measures and tasks of protection and rescue from catastrophic events.

[5] Food and Agriculture Organization

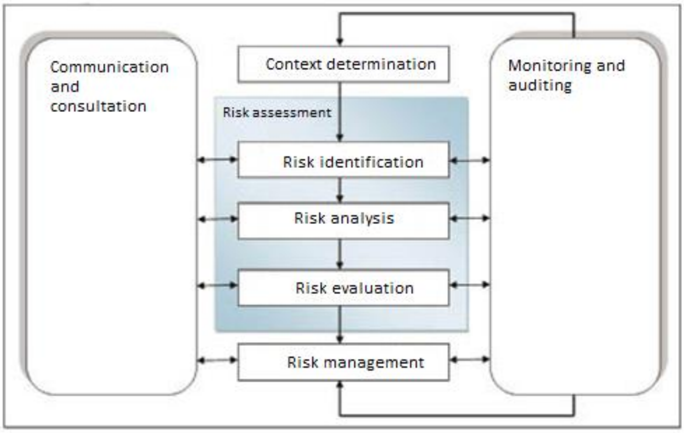

Figure 2. Risk Assessment Process in Risk Management

Risk assessment deals with the determination of the nature and degree of risk of potential dangers, conditions of vulnerability and consequences that could potentially jeopardize the lives and health of people, material assets and the environment. It is a process that involves identifying, analyzing and evaluating risks. The assessment should include the descriptions of all scenarios for each danger, the context in which the scenarios are being considered, the results of the risk calculation and the risk levels (risk matrix) and the cartographic presentation of all risks. In the end, risk assessment is performed by comparing the results of the risk analysis so that a clear picture is obtained as to whether the risk is acceptable or certain measures will be taken to reduce it. **Risk identification** is the process of finding, identifying, and describing risks. During this phase all scenarios are considered, and types of risks are defined, including location of risk, reasons of threat, and consequences on the protected values. **Risk analysis** is a process of understanding the nature of risk and determining the level of risk. The analysis is carried out to determine the probability and consequences for the protected values. **Risk evaluation** is the process of comparing risk analysis results with risk criteria to determine if the risk and/or its size can be tolerated. **Risk management (risk treatment)** is a process that is implemented to modify - reduce risk. In that sense, the necessary analysis is carried out on measures for the reduction or elimination of risks that could endanger or leave certain consequences on the protected values, as well as the need for building of capacity for response.

While this is the theoretical background behind the activities performed in the pre-emergency phase, their application in different contexts differ. Therefore, we thought is useful to show in this chapter a demonstration on how the risk assessment is carried out in the Republic of Serbia for the purposes of serving to the overall management activities in case of disasters. This will be done by reviewing, summarizing and analyzing key national documents for Disaster Risk Management in Serbia, such as Emergency Plans and Rescue Plans, instruction and methodology documents, as well as other legal documents, such as the Law on Disaster Risk Reduction and Emergency Management. Therefore, the remaining of the chapter will analyze the definitions used in the Serbian Emergency Laws, the components of the system of disaster risk management, and the methodology applied when preparing these documents.

2. RISK ASSESSMENT AND MANAGEMENT OF CATASTROPHIC EVENTS IN THE REPUBLIC OF SERBIA

2.1. Definitions

The Act on Disaster Risk Reduction and Emergency Management regulates the reduction of risk of disaster, prevention and the strengthening of the resilience and readiness of individuals and communities to respond to the consequences of disasters, protection and rescue of people, material, cultural and other goods (hereinafter: protected values), rights and obligations to protect and rescue entities (hereinafter: entities) and other issues of relevance to the organization and functioning of the disaster risk reduction and emergency management system [2]. The Law defines the following terms:

- disaster constitutes a natural disaster or a technical and technological accident whose consequences endanger the safety of protected values or the environment on a larger scale and whose occurrence or consequences cannot be prevented or remedied by regular activities of competent authorities and services;
- risk management is a set of measures and activities that are undertaken in order to implement disaster risk reduction policy as well as administrative operational and organizational skills and capacity for their implementation;
- entities of special significance for protection and rescue are companies and other legal entities performing activities and disposing of resources of particular importance for protection and rescue, which have been proclaimed to the entities of special importance by an appropriate decision of the competent authority;
- emergency management includes the coordination and management of entities and forces of the protection and rescue system in order to organize response to disasters and rapid recovery.

2.2. Disaster Risk Reduction and Emergency Management System

The Disaster Risk Reduction and Emergency Management System is an integrated form of management and organization of entities of this system in the implementation of preventive and operational measures and the execution of tasks of protection and rescue of people and goods from the consequences of disasters. It is a basic measure to reduce the risk of disaster, intended for the identification, regular assessment and disaster risk monitoring, reduction of the effects of factors that cause or increase disaster risks, planned land use and the appropriate technical and other measures undertaken [2]. Investing in prevention and reduction of disaster risks is a special task of all entities of the protection and rescue system.

The entities of the disaster risk reduction and emergency management system are the state administration bodies, autonomous province authorities and local self-government units, public services, companies and other legal entities and entrepreneurs, civil society organizations, educational institutions and scientific research organizations, public agencies and others who participate in the identification of measures and activities of importance for risk reduction and emergency management [2].

The forces of the disaster risk reduction and emergency management system are emergency staffs, civil protection units, fire brigade units, Service 112, Police, Serbian Armed Forces, Serbian Red Cross, Mountain Rescue Service, Fire Brigade of Serbia, Radio Amateur Federation of Serbia, trustees, i.e. deputies of civil protection officers, citizens, associations of citizens and organizations whose activity is of particular interest for the development and functioning of the system [2].

The disaster risk assessment identifies the type, character and origin of certain risks from the occurrence of disasters, the degree of vulnerability, the factors that cause them, or increase the degree of possible danger, the consequences that may affect the protected values, the performance of public services and economic activities. Disaster risk assessment is prepared and adopted by the Republic of Serbia, autonomous province, local self-government unit, entities of special importance for protection and rescue, except associations and clubs; companies, health institutions other than pharmacies; preschool and school institutions and faculties for all facilities in which children are staying, or facilities in which teaching takes place; social welfare institutions for facilities which are used by users [2].

Based on the Assessment, a ***Disaster Risk Reduction Plan*** is drawn up which determines, based on an assessment of individual risks, specific preventive, organizational, technical, financial, normative, supervisory, educational and other measures and activities that oblige competent state authorities and other entities to undertake in the future in order to reduce the risk of disasters and mitigate their consequences. The Disaster Risk Reduction Plan is developed for the territory of the Republic of Serbia (National Disaster Risk Reduction Plan), autonomous regions (Provincial Disaster Risk Reduction Plan) and local self-government unit (local disaster risk reduction plan) [2].

The plan for protection and rescue provides plans for measures and activities for prevention and mitigation of consequences of disasters, forces and resources of the entities of the disaster risk reduction and emergency management system, their organized and coordinated engagement and operation in emergency situations in order to protect and save the protected values and provide basic living conditions [2].

The Guidance on the Methodology for assessing the vulnerability from natural and other disasters and Plans for protection and rescue in emergency situations [3], establish unique criteria for the development of the Risk Assessment and the Protection and Rescue Plan.

2.3. Risk assessment at the national, provincial, local self-government units and companies and other legal entities level

Elements of Risk Assessment for System Entities are given in the following Table 1.

Table 1
General and special part of the risk assessment

<table>
<tr><th></th><th>The Republic of Serbia</th><th>Autonomous Province</th><th>Local self-government unit</th><th>Companies and other legal entities</th></tr>
<tr><td>INTRODUCTION</td><td colspan="4">7 elements
1.1. Decision on the participants
1.2. Method of estimation and hazard assessment
1.3. The way of monitoring the situation on the ground
1.4. Updating the assessment
1.5. Communication and consultation
1.6. Determining the context
1.7. Risk monitoring</td></tr>
<tr><td rowspan="2">GENERAL PART</td><td colspan="3">1. Position and characteristics of the territory
1) Geographical position
2) Hydrographical characteristics
3)Meteor.-climate characteristics
4)Demographic characteristics
5)Agriculture
6) Material and KD and protected natural assets</td><td>General information on PD

9 pieces of information</td></tr>
<tr><td colspan="4">2. Facilities and other infrastructure of special significance</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">1) Electricity infrastructure
2) Telecommunication infrastructure
3) Traffic infrastructure
4) Health and social protection
5) Water management infrastructure
6) Supplying the population with food
7) Finance
8) Production and storage of hazardous substances
9) State administration bodies and emergency services
10) National monuments and values
11) Science and education.</td><td colspan="2">1) Electricity infrastructure
2) Traffic infrastructure
3) Health and social. protection
4) Water management infrastructure
5) Supplying the population with food
6) Authorities of the autonomous province, local self-government and emergency services</td></tr>
<tr><td rowspan="4">SPECIAL PART</td><td colspan="5">1. Identification of danger from natural and other disasters</td></tr>
<tr><td>13 dangers</td><td>11 dangers</td><td colspan="2">minimum 3 dangers</td><td>minimum 3 dangers</td></tr>
<tr><td colspan="5">2. Developing the scenario
1) the most likely unwanted event
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<tr><td colspan="5">3. Creating a Threat Assessment
3.1. Protected values 3.2. Probability assessment
3.3. Assessment of consequences 3.4. Level of risk
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<tr><td>CONCLUSION</td><td colspan="5"></td></tr>
</table>

Identification of danger is done for the whole territory for which the Risk Assessment is carried out. Identification process identifies the parts of the territory that are threatened by some danger. The map of the territory presents some risks-dangers and parts of the territory that are more or less threaten by this danger. Based on the identified dangers, the possible development of the event-scenario of the accident, the intensity and the analysis of the consequences for the danger is determined. Some identified dangers are: 1) Earthquakes; 2) Landslides and erosion; 3) Floods; 4) Extreme weather events; 5) Lack of drinking water; 6) Epidemics and pandemics; 7) Plant diseases; 8) Animal diseases; 9) Fires and explosions, fires in the open; 10) Technical and technological accidents; 11) Nuclear and radiological accidents; 12) The status of nuclear facilities as well as facilities for protection against nuclear and/or radiation accidents; 13) The danger of a terrorist attack is viewed through an assessment of the consequences of terrorism.

2.4. Development of scenarios

Development of scenarios for any danger is a process that brings together (combine) all professional resources from specific fields, which by their engagement give professional contribution to the development of a quality and objective scenario. Analogously to the national level, the selection of scenarios for the provincial level, as well as for the level of local self-government units is done. The selected scenario must be displayed on maps (maps of exposure to population and the environment, property, critical infrastructure, business facilities and protected areas). The required content of the scenario is shown in Table 2.

Table 2
Content of the scenario

Parameter	General questions
Working group Danger	• Name of the danger • Composition of the working group • Description of danger
Occurrence	• Venue?
Spatial dimension	• The affected area?
Intensity	• Intensity of the event?
Time	• Time of occurrence? (part of the day, day, month and year) • Cause if it is known?
Course	• The time course of the development of events and what is included?
Duration	• Duration and indicate a direct impact on the protected values?
Early announcement	• Is this event expected?
Preparedness	• Is the population prepared? • Are the state authorities prepared to respond to the event?
Influence	• What protected values are affected and what are the consequences? • Number of vulnerable populations in the affected zone? • Influence on critical infrastructure?
Generating other dangers	• Multirisk
Reference incidents	• Have there been similar events in the past and when? (probability and consequences)
Informing the public	• Is the public informed timely and precisely?
Future information	• What else is important for the scenario that has not been covered?

The scenario is designed for two types of events:

- ***the most probable unwanted event*** is an event that is reliably known to occur frequently, that the conditions in which it arises suit its occurrence and that it is realistic to expect that it can endanger the lives and health of people in a certain area and cause material damage.
- ***unwanted event with the most severe possible consequences*** is an event that rarely occurs in a certain area, and in case of its occurrence, has such an intensity that its consequences are catastrophic for all protected values.

2.5. Development of risk assessment

An assessment is a set of risk assessments expressed in risk-based scenarios that may cause consequences in the territory or part of the territory of the Republic of Serbia. The assessment identifies sources of potential threats, examines possible consequences, needs and possibilities of implementing measures and tasks of protection and rescue from catastrophic events in relation to the protected values of the society (Table 3).

Table 3
Protected values

Protected values	**Criteria**
People's lives and health	The total number of people affected by some process (dead, injured, diseased, evacuated, displaced - others without an apartment/house, taken care of and sheltered)
Economics / Ecology	Total material damage
Social stability	1. Total material damage on facilities and infrastructure of special significance (critical infrastructure); 2. Total material damage to institutions/buildings of public social significance

Table 4 shows three different approaches in assessing the probability of events: a) expert assessment (qualitative), b) probability forecasts (probability), and c) use of past events data (Frequency). The choice of one of these approaches depends on the availability of previous records, data, resources and experts. Probability refers to an event with harmful consequence.

Table 4
Table for expressing probability

Category	**Probability or frequency**			
	(a) Qualitative	(b) Probability	(c) Frequency	Chosen
1	Negligible	< 1 %	1 event in 100 years or less often	
2	Small	1 - 5 %	1 event in 20 to 100 years	
3	Medium	6 - 50 %	1 event in 2 to 20 years	
4	Large	51- 98 %	1 event in 1 to 2 years	
5	Extremely large	> 98 %	1 event a year or more often	

Consequences are the effect of a harmful event on human life and health, economy/ecology and social stability, and are manifested through the size of loss (damage). Tables 5, 6, 7a, 7b show the criteria and classification of consequences respectively for each field.

Table 5
Table for expressing consequences for human health and life

Consequences for human health and live			
Category	Magnitude of consequences	Criterion	Chosen
1	Minimal	<50	
2	Small	50-200	
3	Moderate	201-500	
4	Serious	501-1500	
5	Catastrophic	>1500	
Note: Total number of people affected by some kind of danger (dead, injured, sick, evacuated, displaced - others without an apartment/house, taken care of and sheltered).			

Table 6
Table for expressing consequences for the economy / ecology

Consequences for the economy / ecology			
Category	Magnitude of consequences	Criterion	Chosen
1	Minimal	whose amount exceeds 1% of the budget	
2	Small	whose amount exceeds 3% of the budget	
3	Moderate	whose amount exceeds 5% of the budget	
4	Serious	whose amount exceeds 10% of the budget	
5	Catastrophic	whose amount exceeds 15% of the budget	

Table 7a
Tables for expressing consequences for social stability - total material damage on critical infrastructure

Consequences for social stability - total material damage on critical infrastructure			
Category	Magnitude of consequences	Criterion	Chosen
1	Minimal	<1% of the budget	
2	Small	1-3% of the budget	
3	Moderate	3-5% of the budget	
4	Serious	5-10% of the budget	
5	Catastrophic	>10% of the budget	

Table 7b
Tables for expressing consequences for social stability - total material damage to institutions/buildings of public social significance

Consequences for social stability - total material damage to institutions/buildings of public social significance			
Category	Magnitude of consequences	Criterion	Chosen
1	Minimal	<0.5% of the budget	
2	Small	0.5-1% of the budget	
3	Moderate	1-3% of the budget	
4	Serious	3-5% of the budget	
5	Catastrophic	>5% of the budget	

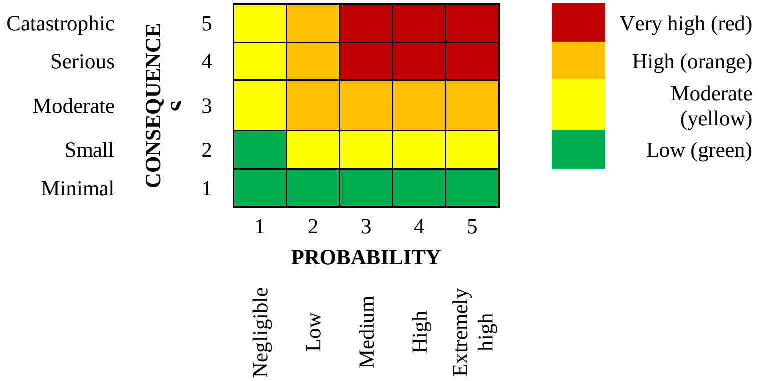
Finally, end-users need to decide what constitutes a very high, high, moderate or low risk (table 8). The purpose of risk assessment is to prepare the basis for deciding on the importance of individual risks, or whether the specific risk will be accepted, or some measures will be undertaken to reduce it. After carrying out risk analysis (understanding of the nature of risk and determining the level of risk), the evaluation of risk follows.

Table 8
Levels and acceptability of risk

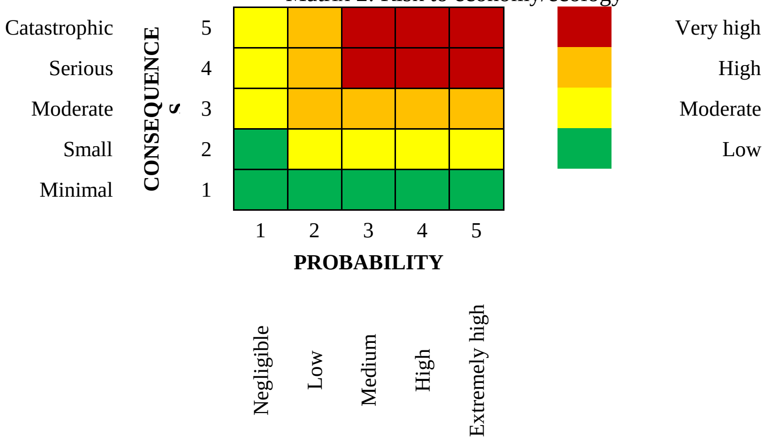
(red)	Very high (red)	Unacceptable	A very high and high levels of risk require risk treatment, in order to reduce to the level of acceptability (Chapter 3.7, "Risk Treatment". A moderate risk may mean the need to take some actions. Low risk can mean that no action is taken.
(orange)	High (orange)	Unacceptable	
(yellow)	Moderate (yellow)	Acceptable	
(green)	Low (green)	Acceptable	

The results of the scenarios (consequences and probabilities) are combined in a risk matrix. The risk matrix consists of two axes, axis of consequence and probability axis. Each axis has five values, giving a matrix of 25 fields. Those 25 fields are divided into four risk categories: low, moderate, high and very high risk. The overall risk is determined by the mean value of all risk values in relation to the life and health of people- Matrix 1, economy/ecology- Matrix 2, social stability- Matrix 3. (Example: if the mean value is 4.4, the risk level is 4, and if the mean value is 4.5 the risk level is 5).

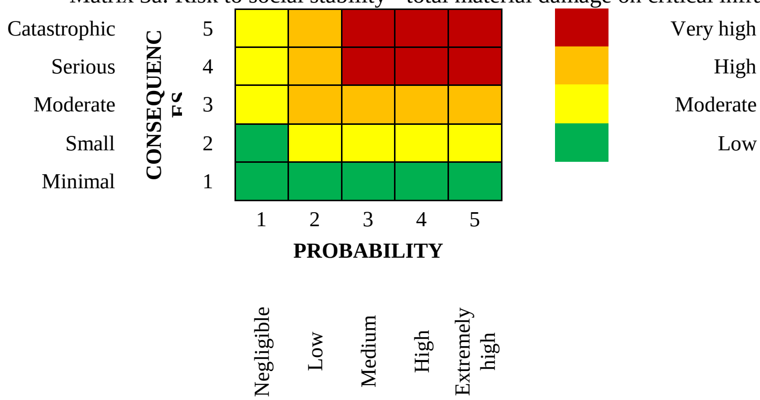
Matrix 1: Risk to human life and health



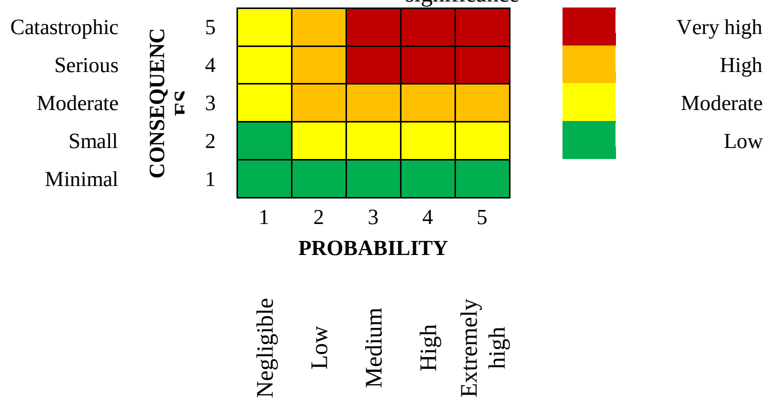
Matrix 2: Risk to economy/ecology



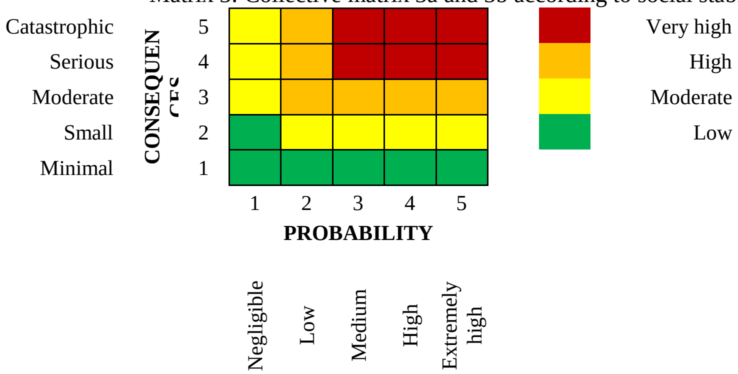
Matrix 3a: Risk to social stability - total material damage on critical infrastructure



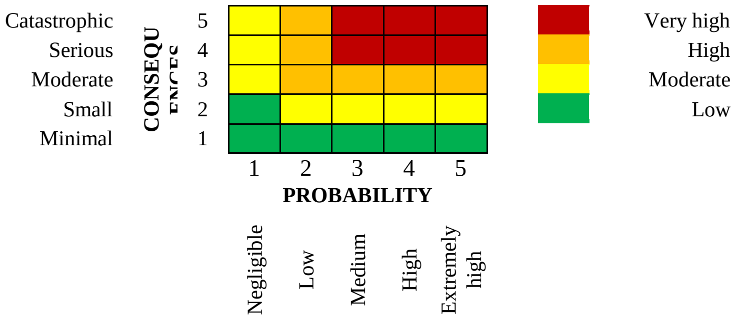
Matrix 3b: The risk to social stability-total material damage to institutions/buildings of public social significance



Matrix 3: Collective matrix 3a and 3b according to social stability



Matrix 4: Overall risk



2.6. Determining the combination of risk – multirisk

In the risk assessment process, the possibility that certain dangers do not individually affect the protected values is taken into account.

If it is noticed that any particular risk has a higher likelihood of occurrence or possible consequences for the protected values, and if it can bring multiplication of harmful events, or an increase in the final consequences, due to a combination of potential dangers, it is approached by prioritizing treatment of such risk, by engaging all necessary resources.
Multirisk represents a combination of two or more potential dangers, if:

- they are occurring at the same time or are occurring consecutively,
- they depend on one another or because they are caused by the same event or event trigger/trigger,
- they represent a threat to the same elements (harmful/exposed elements) without chronological coincidence.

Simultaneous potential dangers are also referred to as accompanying events, demolishing effects, domino effects or the effect of waterfalls. For example, an earthquake can cause an explosion of a gas pipeline, an industrial accident can cause a fire. Therefore, overview of multirisk examines the interdependence of several potential dangers and risks.
Any event or potential danger may trigger a greater number of following potential dangers, each of which may be considered individually. The probability of occurrence of each of these events is, of course, closely related to the probability of occurrence of the next event or the previous trigger event. The consequence assessment therefore has to take into account the cumulative impact of all the different effects that occur simultaneously or immediately one after the other. Also, different dangers should be considered, which will not occur at the same time, but still affect the protected values.
Such approaches to multirisks are important in all geographical areas subject to the negative consequences of several types of potential dangers. In this situation, focusing exclusively on the impact of only one specific potential hazard could even result in an increase in vulnerability with respect to another type of potential danger.
Each risk assessment must include possible reinforcement of the consequences due to interaction with other potential dangers. One risk can be increased as a result of another potential danger, or because some other type of event has significantly altered the system's vulnerability.
The basic guideline for making conclusions on the impact of multirisks should be the impact of potential dangers on the protected values, first considering each individual danger, and then the common impact.

2.7. Risk treatment

By treating unacceptable risks, or by undertaking various planning measures, the level of risk is reduced to an acceptable level. Risk treatment, in principle, contains: risk, activity, carrier of the activity, time of realization, associates in realization of activities, time and manner of reporting.
Measures are taken in the area of prevention and response, in order to reduce the level of risk from the effects of negative consequences, identified potential dangers or a combination of dangers.

1. Prevention

1.1. strategies, normative arrangements, plans
1.2. early warning system
1.3. spatial planning and legalization of facilities

2. Reacting

2.1. state of preparedness for response capacity

2.2. the preparedness of capacity of the fire-fighting and rescue units
2.3. the preparedness of capacity of the civil protection units
2.4. databases and bases for civil protection planning purposes
2.5. the ability of entities of particular significance for protection and rescue
2.6. state of mobility of the connection
All relevant risk assessment information is recorded in order to create a risk database in Table 9.

Table 9
Characteristics of potential dangers

Characteristics of potential hazards

Subject:____

This annex presents the characteristics of dangers by which an entity describes the identified potential danger for archiving and creating a database on dangers and risks.

No.	**Characteristic of potential danger**		**Potential danger SPECIFIC NAME OF THE DANGER**	**Remark**
1	2	3	4	5
1.	Initial state	Time of identification		
2.		Entity, organization/ organizational part		
3.		Macro location		
4.		Micro location		
5.		Endangered protected values		
6.		Engaged forces		
7.		Initial measures undertaken		
8.		Assessed consequences for protected values		
9.		Existing protection measures		
10.	Final state	Time of exposure to danger		
11.		Risk level		
12.		Affected protected values		
13.		Consequences for protected values		
14.		Measures undertaken		
15.		The effect of measures undertaken		
16.		Interaction with other dangers		

2.8. Production of risk maps

Risk maps are produced for the purposes of the Assessment. Risk maps are an important risk-mapping tool for the whole area, both for each individual risk and for overall risk. Maps help all participants involved in the Evaluation to facilitate the presentation of the results of risk matrix and to understand of the level of risk, as well as to visualize the state of risk, for the needs of making adequate decisions.
The modes of production, criteria and other elements necessary for production of maps within the geographic information system are coordinated by the Emergency Situations Division in accordance with the needs of each individual risk.
Risk maps show the space and spatial distribution of protected values, sources of risk, distribution areas, protection and rescue facilities, facilities that can cause risk and multirisk,

the location of neighboring countries with critical infrastructure, the distribution of protection and rescue forces, etc.
To view these contents, it is necessary to use the following transparent topographic maps as well as the possibility of digital transparent-topographic maps (DTTM):

- Republic level: TTM 1: 300 000 or TTM 1: 500 000
- Landscape level: TTM 1: 300 000
- Municipal level: TM 1:50 000 or TM 1: 100 000.

All levels can use maps TM 1:25 000 and TM 1:50 000 for a more detailed display of individual content. To operate and tag content on maps, it is necessary to use the commonly accepted and regulated topographic and other signs (national coordinate system).
In addition to topographic maps, in order to display specific content, thematic maps are in use by specialized organizations (hydro meteorological, seismic, etc.). To indicate some potential dangers on the risk maps, the labels and abbreviations given in Table 9 are used.

SUMMARY

This chapter showed how the risk assessment process is conducted in the Republic of Serbia. While the theory behind disaster risk management defines actions and measures to be taken in each of the phases of DRM, its application in different contexts takes into account national circumstances, laws and regulation.
At the end of this review, by completing the risk assessment process, as well as the processing of all scenarios and expressing results, it is possible to compare results and to present them in common matrix. In relation to each risk, a review of the possibilities of improving the situation in the area of prevention and reaction is possible.

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Section II

Technical Perspective

FLOOD HAZARD AND RISK ASSESSMENT

Miriam Ndini

1. INTRODUCTION

Floods are a natural phenomenon, part of human existence, but they are amongst the most frequent and destructive type of disaster, causing significant damage and disrupting livelihoods.

The land occupied, from time to time, by floods – floodplains – is often a preferred place for human use and settling. During floods this causes economic losses. Floodplains provide amenities, risks and rewards. During this process there is also a diminution of natural resources and their functions. In the long term, the residents of the floodplain will be always the loser, meaning that the risk will exceed all the advantages obtained from settling on the floodplain.

In our days, it is a matter of fact that the flood risk is increasing. Climate change, in one hand, may result in increasing precipitation, increasing temperature and rainstorms may become more intense and all these processes may increase flood hazards. But without people there is no risk. It is debatable if this risk is because of the increase of the flood hazard probability where climate change is involved, or because the flood prone areas are nowadays more and more vulnerable because of the increased human activity, demographic and economic development, in these areas. The impact of floods in next decades could dramatically increase due to the ongoing socio-economic and climatic changes [1].

Developed countries with their experiences are offering successful practices and methods for flood risk management that can reduce this impact. The first step towards the flood risk management is the flood hazard and flood risk assessment. A well conducted flood hazard and risk assessments lead to a good flood risk management decision, such as land-use master planning, design of infrastructure, and emergency response preparation. The results of these studies are the preparation of flood hazard and risk maps [2]. Mapping the flood hazard means showing the probability and the magnitude of flood events over an area. A flood risk assessment map shows the potential consequences of that flood event in terms of affected population, assets and expected economic damages. Both these maps can increase preparedness, improve land use planning and management in flood prone areas. But in the same time a reliable and fast flood forecasting tools are crucial for developing effective emergency response strategies.

2. FLOOD HAZARD ASSESSMENT

The European Commission on EU Floods Directive 2007/60/EC defines ‘flood’ as “the temporary covering by water of land not normally covered by water” [3]. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude floods from sewerage systems”.

There are several different types of floods, categorized in different way according to their origin or consequences. Different types of floods can be recognized based on:

- Origin of the water (source)

- Geography of the receiving area
- Cause
- Speed of onset

The characteristics of these floods are different, and so are their consequences; their probability of occurrence differs too, and the risk they may pose is different.

Before a hazard assessment is carried out, it is necessary to determine which types of floods are dominant and catastrophic in the catchment area, because in practice the selection of hazard, and risk assessment methods applied vary depending on the type of flood.

To perform a flood risk management one must recognize the two parts of this process that are: flood risk analysis and assessment on one hand and risk mitigation. Assessing the risk of floods means to establish the risk from the flood event and where mitigation measures must take place.

A flood risk is defined as the product of hazard and the vulnerability [4]:

Flood Risk = (flood) hazard * vulnerability (of the society/ area)

The term "Hazard" means that floods potentially have harmful effects. The statistical characteristics of the flooding event includes the return period of the flood, extent and depth of inundation, and flow velocity. In the term "Vulnerability" refers to the exposure of people and assets which can be harmed by those floods and the susceptibility of the elements at risk facing flood damages [5].

This definition is adopted also in the [6]. Based on this definition, analysis must be carried out on meteorological, hydrological, and hydraulics on the catchment area, to define the hazard. But without exposure to a certain flooding depth, not even a very vulnerable society or area will be harmed, and so and estimation of flood impact must be done to define the vulnerability and at the end these two steps have to be combined for the final risk analysis [7]. If any one of these elements is zero, there is no flood risk. Another definition of risk is given as:

Flood Risk = probability (of the flood) * consequences [4]

The term risk refers as well to the probability, chance or likelihood and this is better reflected in this second definition, in which the probability of the flood(s) is specified.

To assess the flood hazard, all the past flood events as a process must be determined. The magnitude and the frequency of floods have to be determined as well. The result of this analysis must be available to the decision maker, people living in the area, planners, etc. To carry out an analysis for both hazard (Probabilities) and vulnerability (Consequences), there is a wide literature with a number of approaches and models applied for different scales from local [8] to global [9].

2.1. Probability of Flood event

Floods are not happening each year or each a certain period of time. Their magnitude is different also. Large floods occur rarer than medium or small floods. The goal of flood hazard assessment is to assess the probability that a specific flood will occur over periods of years. The probability of each size of flood can be described as the possibility that this flood will happen in any one year (its annual probability). It is important to realize that this is not the same as a recurrence interval. Probability is a measure of the likelihood that the flood event will occur. If the event is for sure to occur, the probability is 1.0; otherwise, the event will not occur, the probability is 0.0. "Occur" means the level of that particular flood will be reached or exceeded. The biggest losses in built-up areas come from catastrophic floods that are rare events, but floods of different size, intensity, have different chance of occurrence, probability. The differences in the chances of experiencing floods of different sizes lead to the concept of return period, which is the average period of time for a flood that equals or exceeds a given magnitude. The return period is also known as recurrence interval represented by the symbol T and expressed as a period of years. The larger the number of years in a recurrence interval, the smaller the chances of experiencing that flood in a particular year. It is important to note that the return period T, is a statistical concept representing the *average* period of time between two events of a given magnitude. A T-year flood is the flood intensity that has a probability of 1/T of being exceeded in a given year and is named the exceedance probability. This does not mean that the event occurs once every T years. For example, the exceedance probability of a 10-year flood (occurring or being exceeded) in any given year is, P = 1/T = 1/10 = 0.1 meaning that there is a 10 percent chance (probability) each year, for the flood to occur. In long term the level would be reached or exceeded on the average, once in 10 years. It is important to note that once a flood occurs, its chance of recurring for any given year remains the same [10].

If the exceedance probability, P(Q) for a given discharge is known, it is possible to compute the probability for that particular discharge being exceeded at least once over any specific time period. This is referred to as hydrologic risk (R_H). The probability of exceedance of the 100-year event at least once, in a given 10-year period, is:

$$P\left(Q > Q_{100} \text{ at least once in 10 years}\right) = 1 - \left(1 - 0.01\right)^{10} = 0.095 \quad (1)$$

Even though rare, it is still possible, that another second "100-year floods" occur on the same given floodplain in the same year. But the probability is not one, since it is not guaranteed that the 100-year flood will occur in any of the 10 given years, but it is not zero, since it is not guaranteed that the 100-year flood will not occur in any of the 10-given year. However, the odds are never zero – even a very large flood, have always a very small chance of recurring every year.

The principal issue of the flood frequency analysis is the estimation of maximum flood discharges for different return periods. Flood hazard analysis estimate the flood intensity for a variety of exceedance probabilities, for example from 0.1 to 0.001. Estimation of T year maximum discharges can be done using the two most used methods:

- Statistical Discharge Frequency Analysis
- Rainfall-runoff modeling

While using Statistical Frequency Analysis the peak discharge, that passes a certain location during a flood, is assessed. But, using Rainfall-runoff models, not only the peak discharge but also a design hydrograph over a period of time is obtained as well.

2.1.1.Statistical Discharge Frequency Analysis

The goal of flood hazard assessment is to assess the probability that a specific flood will occur over periods of years. To use the Statistical approach a long records of river data, discharge measurements, must be available. The hydrological data needed for this analysis are the yearly maximum discharge of a river from a selected gage station for a very long period of time. Usually, in this analysis the highest recorded discharge from each year is used. So, if there are 25 years of existing daily discharge measurements for a particular station, then 25 discharge maxima data, referred to as annual discharge maxima, are used. After the series of maxima data is set up, the analyst fits several statistical distributions e.g.: log-normal, log-Pearson, or generalized extreme value, selecting that distribution that better fit to our data. A wide literature describes the tools to perform statistical analysis. For a

proper application and interpretation of statistical approach, great experience and specialized knowledge are needed.
A flood discharge so obtained is, in the most of cases, correct for the actual measurement station, or in the nearness but not if there are important tributaries or other discharge sources upstream or downstream of the station. Therefore, to properly estimate the flood discharge, a sort of measurement stations and the corresponding data analyzed over a river system must be available. In the situation where no discharge data are available, rainfall-runoff models referred as hydrologic models may adequately be used to convert extreme rainfall into flood discharge estimates and hydrographs.
Flood probabilities can change if the precipitation regime or the characteristics of the catchment area change. Complex modeling, considering climate changes, may be used to determine the future probabilities of floods [11].

1.1.2. Rainfall-runoff modeling

The discharge measurements are not always available. In many cases there are insufficient data for discharge frequency analysis and some time there are missing at all.
In these cases, an indirect method is used known as rainfall-runoff models. These models use the rainfall data and convert the extreme rainfall into design discharge and design hydrographs. So, a rainfall-runoff model depends on rainfall data availability, their quality and other information characterizing the watershed such as topographic maps or digital elevation models (DEMs), land cover and soil information, and the location and properties of river channels and other water bodies.
Nowadays there are many rainfall-runoff (RR) models available in scientific literature. To select the best one, it depends on a large number of factors, such as catchment properties and characteristics, data availability, temporal and spatial resolution, climatic conditions, knowledge level of the user, etc. Considering these factors, each RR model has its advantages and disadvantages. Because of the detailed analyses, the Rainfall-Runoff modeling is considered as the most accurate approach.
There are two classes of hydraulic models: ***Lumped*** models that consider the watershed as a single unit and the discharge estimated is applied to the watershed outlet. ***Distributed*** models use spatially varying data such as precipitation, infiltration, interception, interflow, infiltration, and base flow estimating discharge. Once a rainfall intensity of a given return period is estimated, it is assumed that, the resulting simulated discharge has the same return period [12].
As these models are based on rainfall data, these records must be of good quality and covering a sufficient long period to estimate the return periods that are required for the flood hazard analysis.

1.2. Delineation of flood prone area

After estimating the peak discharge for expected return period, this discharge has to be transformed into a flood water level (elevation), named ‘estimate flood stage’ and the area subject to this flooding must be delineated. Some approaches recommended in the literature are:

- using historic flood data and topographic maps;
- detailed engineering studies;
- hydraulic models.

The historical data on previous floods approach is used as information and must be combined with field surveys, satellite images and other available photos. Because the past cannot be the sole guide to the future, if possible, these approaches are combined, to produce more accurate results.
The floodplain is so delineated by the elevations corresponding to the flood profile. For that nowadays hydraulic models are successfully called “hydrodynamic models”. The selection of the right model is based on the availability of data regarding the river channel and the floodplain and the needs of the risk assessment. The output of such models is ‘flood extent map’. An example of a 100-year flood extent map is shown in Figure 1. These hydraulic models calculate not only the water level but the water velocity as well.

Figure 1. Flood extend map [12]

The most used models to delineate the flood area are:

- 1-Dimensional (1D) models that are simplified models. These models characterize the terrain using a set of cross sections and for each section perpendicular to it they compute the flow depth and velocity. These models are used in the areas where the flow direction is well described. The best-known 1D model is HEC-RAS from the U.S. Army Corps of Engineers. HEC-RAS is free to download at http://www.hec.usace.army.mil/software/hec-ras/.
- 2-Dimensional (2D) models that calculate the flow both parallel and non-parallel to the main flow. They can be used to model the areas of complex topography such as wider floodplains or broad estuaries but require high quality data and can require long computation times. Examples of 2D models include TELEMAC 2D, SOBEK 1D2D, and Flo2D. Because of their greater sophistication, most 2D models are not freely available. Decision about the land use must be taken upon these delineations.

2. VULNERABILITY ASSESSMENT OF THE BUILT ENVIRONMENT

The other component of flood risk is flood vulnerability. Here we focus only on one class of vulnerability: on physical vulnerability.
During floods, both humans and natural systems are affected. The vulnerability assessment is used to understand how a system, or a community will be affected by floods facing

property losses on how physical structures, houses or bridges could be damaged or destroyed, a business or service could face interruption. On this assessment factors that quantify the impact of floods on system or community must be defined to be used later for decision making process. The United Nations defines this factor as the 'index of human security'. For the same flood, in terms of intensity and exceedance probability, a more vulnerable area experiences higher flood loss. Vulnerability depends on the exposure, sensitivity, and adaptive capacity. Exposure refers to people, their activities and their properties, affected by a hazard. A risk assessment would require exposure information on the locations of the assets to be considered. The analysis of exposure is an overlay of hazard characteristics and of the characteristics of the area that is vulnerable to flooding. Depending on the risk assessment there are some receptors to be considered as people and property, but ecosystems receptors are considered as well.
After a flood hazard analysis and map hazard is defined, an exposure analysis is made to examine the economic assets and activities in the affected area by the flood: the number of people exposed, or the number and type of properties exposed to a flood hazard of a certain size [13].
Mapping is a central element of any assessment and exposure is an overlay of the hazard map with a geospatial map of all the assets on the flood hazard area. This resulting overlay maps are referred to as "risk maps". They can support spatial planning for flood risk mitigation and where other risk reduction measures should be targeted. Use of Geographic Information Systems (GIS) and Global Positioning Systems (GPS) and the mapping expertise is crucial on Risk assessment process.
The flood impact on structures is described by the so called "damage curves" or "damage functions" or "vulnerability functions" and is shown in the Figure 2. This is a relationship between damage and flood characteristics, usually the water depth.

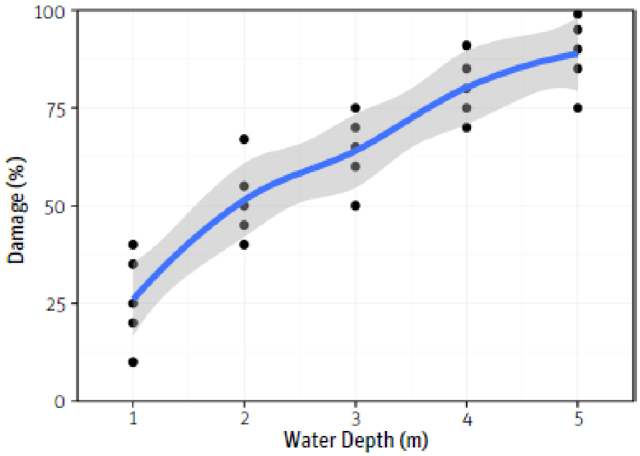

Figure 2. Flood damage curve [12]

3. FLOOD RISK ASSESSMENT

The flood risk is the combination of both the probability distribution of all possible floods and their likely consequences [14]. In hydrology the term risk is frequently limited to the

characterization of the hazard, but after the first step, flood hazard assessment, and second one, vulnerability assessment are completed, we can make an estimation of flood risk [4].
In the first step as explained above a statistical or rainfall-runoff model is used to estimate flood event for a set of exceedance probabilities. The second step is to convert it into flood elevations or stage, using a hydraulic model and after that mapping the floodplain area. The result of the vulnerability analysis is the determination of damages caused by different flood stages. Finally, in the risk analysis, the economic risk, represented by monetary damage for various exceedance probabilities, is calculated. This procedure can be used to estimate not only damages on the build environment, but also to estimate social, structural, or economic risks, as long as the different steps can be properly quantified.
In flood risk analysis damage scenarios are frequently given for a few scenarios for certain return intervals and discharges, respectively. Flood risk maps are based on the overlay of the vulnerability map and flood hazard maps for the defined flood scenarios (Q 50, Q 100, Q 1000).

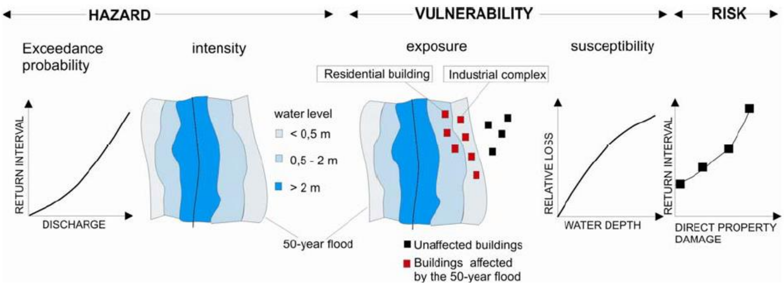

Figure 3. Flood risk as interaction of hazard (exceedance probability and intensity) and vulnerability (exposure and susceptibility) [15]

Flood risk is determined in terms of the flood risk definition which says that it is the synthesis of information on flood hazard and vulnerability of the model area (Figure 3). Flood risk maps thus present flooded classes of functional areas with corresponding acceptable risk along with flooded buildings within each flood scenario (Q 1000; Q 100; Q 50).
The consequences to the flood risk may be classified as direct and indirect. The direct flood consequences encompass the harms resulting from the first impact of flood with people, their property and the environment, for example, loss of human life, damage of the houses, economic assets, loss of agricultural crops and livestock, loss of cultural goods. Indirect consequences of flood are damages caused by disruption of economic activity and costs of emergency and other actions to be taken to prevent flood damage and other losses.
The risk analysis is very important for risk management. If we assess the economic effects of one flood, this doesn't help the flood management. What we must determine is the frequency of floods of various magnitudes that might occur and, accordingly, the measures to be considered and implemented for various probabilities.

4. CASE STUDY- FLOOD RISK MANAGEMENT PROCESS IN SHKODRA REGION[6]

4.1. Introduction /background

The Western Balkans are more and more exposed to the impact of climate change. A UNEP synthesis report [16], indicates that temperatures have risen in the region in the last 50 years. Every country in the West Balkan region has experienced warming, with this trend accelerating in the most recent decades. Meanwhile predicting the climate in mountainous regions is particularly difficult due to the complex topography, the consensus among the existing models predicts that the Western Balkans will experience substantial warming throughout the twenty- first century. Observed changes in precipitation in the last 50 years are not as pervasive or clear as the observed warming. Overall the region has received a decreasing amount of annual precipitation, with Albania and Macedonia being amongst the countries with the clearest downward trend. However, in winter, precipitation will increase in the mountains and the region in general. Flooding is predicted to become more frequent and more severe due to more precipitation in winter.

An assessment by the European Commission [17] concludes that historical flood data from the Western Balkans indeed suggests a more frequent occurrence of flood events, characterized by more extreme and more rapid increase in water levels, attributed to an uneven distribution of precipitation and torrential rain, and this particularly over the last decade.

Over the last decade several flood events have severely affected the Drin river basin. The most severe flood caused by the Drin River was the one in 2010, which had stark impacts on the society, environment and economy of the affected countries. It was characterized by more extreme and more rapid increase of water levels than was observed in previous events – which is in parts related to a changing climate.

4.2. Flood Risk in the study area

The study area for the flood risk management was located Shkodra region (Figure 4). It is characterized by the coastal floodplain of the rivers Drin and Buna, the surrounding mountains - foothills of the Albanian Alps - with heights up to more than 1,700 m and Shkodër Lake, a large inland lake which is shared between the two countries Albania and Montenegro, the biggest Balkan lake. Buna River at the south end of the lake is the only outflow discharging to the Adriatic Sea after joining with Drin River close to the city of Shkodër.

[6] Adapted from: Climate Change Adaptation in transboundary flood risk management, Western Balkans (CCAWB), GIZ, authored by Gerrit Bodenbender; Merita Meksi; Fationa Sinojmeri;

Figure 4. Albanian map and the study area.

The Drin-Buna Lowland is part of the extended trans-boundary Drin with the riparian countries Kosovo, Macedonia and Montenegro. The total catchment area of the basin is approximately 20,380 km² and it includes the Black Drin, White Drin and Buna River, as well as the Shkodër, Ohrid and Prespa lakes. Shkodra is the region of Albania that is among the most vulnerable areas, affected by two major geo-risks: floods and earthquakes.

The latest major floods occurred in January 2010, December 2010 and March 2013, April 2015, March 2018 resulting in high economic and environmental losses. The post-disaster analysis of the Shkodra region areas affected by the flood of 2010, conclude that 14,100 ha of land were flooded, and 4,600 houses were submerged. 12,150 people were evacuated, and the economic loss was estimated at ALL 2.5 billion (EUR 18 million). The flood of 2018 has covered in water 4800 ha of agricultural land, 160 affected houses, 40 fully flooded houses and 25 people evacuated.

4.3. Methodology

As part of the response to the upper mentioned flood events, the project "Climate Change Adaptation in transboundary flood risk management, Western Balkans" has supported Albanian government to prepare a comprehensive flood risk assessment and management plan (FRM) for the Lower Drini-Buna Basin, including options for flood risk mitigation measures. Even though Albania doesn't have it mandatory to fulfill the steps of the EU flood Directive, this process has been guided by the principles of the EU flood Directive 2007/60/EC. The plan was focused on the complete cycle of FRM (prevention, preparedness and recover) and has involved a regional working group with all the interested stakeholders (regional, national, local and other involved stakeholders) in a participatory and learning process. The methodology for creation of the FRM plan comprised the following steps following the EU flood Directive:

- Setting up a regional working group on FRM including all relevant local, regional and national actors. At least 8 working group meetings associated with trainings related to the methodology, EU Flood directive, and stakeholder's engagement were done in a time span of 18 months.
- Identification of the most affected Local Government Units (LGU) based on the existing facts, assessment and analysis conducted by Albanian authorities and

international consultants. By the time the project was running, PFRA was not done since former events and significant flood damages has clearly demonstrated which were the areas with significant flood risk.

- Development of Hazard maps, using a simplified methodology due to the lack of a comprehensive forecasting model (hydrological and hydrodynamic one) and due to limited accuracy of the data availability (such as low-resolution DEM etc.) All the mapping activities are done based on existing flood hazard and risk information generated from satellite images and aerial photos of former events. The first version of the maps consisted of a GIS database (orthophotos, power distribution, water supply, communication, hospital, schools, kindergarten, churches, mosques etc.) provided by IncREO (Increasing Resilience through Earth Observation) and satellite images of the flood extent during specific flood events which were integrated to this GIS database (January 2010 and December 2010). The flood extent of December 2010 has been estimated as an extreme flood event and the one of January 2010 as a medium flood event.
- Flood risk maps were prepared based on the available information on the exposure and vulnerability of the society/area multiplied by hazard, with a focus on risk areas and risk objects relevant for human health, environment, cultural heritage and economic activities (Figure 5). Regarding the exposure the maps contain information of the assets at risks and information on dikes, embankments, drainage channels and affected house areas. All this information has served as basis for flood risk assessment which was compiled into two steps (flood hazard and risk maps and fact sheets). The maps and the factsheets were improved together with the expertise of the stakeholders (communes and regional actors) as part of the Working group, more than three times to make sure that risk assessment is done completely. In the end of the process the flood risk maps for each area were displayed in public places.
- Development and agreement on the regional and local FRM plans [18], including a common picture of the flood risk management measures and further activities for the region and the communes.
- Following the objective of FRM according to the EU Flood Directive, there is a need to establish a framework for the assessment and management of flood risks aiming at reduction of the adverse consequences on human health, environment, cultural heritage and economic activity. From the flood's directive, more detailed objectives and measures (such as: prevention of new risks in the flood risk areas, reduction of existing risks in the flood prone areas, reduction of adverse consequences during and after a flood event) were generated, proposed and discussed among the working group meetings. All the identified measures that would contribute to the reduction of flood risk in the region were divided into two main groups (regional - to be realized by regional or national actors and local - to be taken by the communes/LGU).
- In accordance with step 4 of EUFD a Catalogue of measure and a checklist was used to define measures that cover administrative instruments, protection aspects, technical flood protection aspects and preparedness aspects. The identified measures were prioritized based on a joint indicative assessment and each of them has the description and the respective responsibilities for each of the actors implementing it.
- The last step consisted of preparing the documentation for the final report and supplementary maps/ FRM plans are the summary of the risk assessment and the

action plans. They include the Regional FRM plan (regional strategy, framework, regional measures) as well as the 8 Local FRM plans and focus on prevention, protection and preparedness.

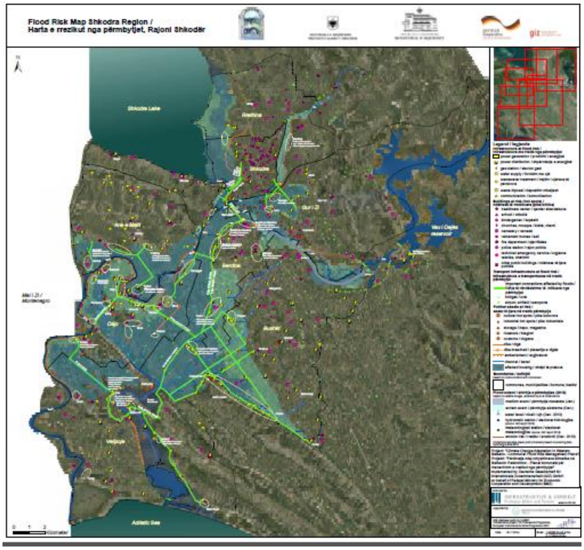

Figure 5. Flood Risk Map of the study area.

SUMMARY

This chapter presented an analysis of Flooding Risk Assessment. Models for determination of flood hazard and vulnerability of the built environment were introduced and supported by a case study. The case study presented generated several conclusions and recommendations:

- Western Balkans are more and more exposed to the impact of climate change, and Albania is not being left aside, so there is a clear need for action in terms of preparedness, response and recovery to successfully face its consequences;
- FRM is a continues process characterized by repeated activities such as flood risk analysis, considerations and evaluations of measures and instruments, policy making etc.;
- For better results on flood risk management a participatory approach is needed among all the institutions at all the levels;
- Monitoring and reviewing the FRM plans and list of measures is very important to assure that flood risk reduction is successfully achieved;
- Cooperation and information exchange on a transboundary level plays a crucial role;
- The Steps of the FRM such as data collection, data mining, evaluation of hazard and risk play a crucial role on it;

For a better and successful implementation of the EUFD, on the Drin River Basin here are listed some recommendations:

- The FRMP should have a dedicated budget for the implementation of joint measures;
- The mainstreaming Flood Risk Management into relevant sectors should be considered in both local and national level;
- Cooperation and information exchange should be further fostered not only within the country but also at a transboundary level;

Public information and awareness should be considered a key milestone in the process:

- Regular working group meetings on the national level but also local working groups with LGU on flood risk management and on emergency response should be organized;
- Further improvement/update on the risk assessment and mapping including here creation of joint risk assessment and maps for the complete basin;
- Capacities on joint forecasting/ modelling within the responsible institutions in the countries starting from universities should be strengthened;
- The emergency response in small scale on case to case basis, but also joint emergency response plans and regular table top exercises should be strengthened;
- Investment on adequate human and financial resources for updating reviewing and monitoring of the plans should happen;

The full FRM Plan for Shkodra region along with its risk maps can be downloaded at Shkodra Qark web page [18].

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EARTHQUAKE RISK ASSESSMENT

Igor Džolev

1. INTRODUCTION TO EARTHQUAKE RISK ASSESSMENT

Seismic risk has been defined, for most management purposes, as the potential economic, social and environmental consequences of hazardous events that may occur in a specified period of time, thus, referring to the risk of damage from earthquake to a building, system, or other entity.

Seismic risk is often determined using a seismic modelling computer program which uses the seismic hazard inputs and combines them with the known susceptibilities of structures and facilities, such as buildings, bridges, electrical power switching stations, etc. The risk may be measured in terms of expected economic loss, in terms of human lives lost, or in terms of physical damage to property, where appropriate measures of damage are available. Risk may be expressed as average expected losses or in terms of probabilistic manner and should include proper consideration of vulnerability and exposed values. For the specific case of earthquake risk assessments, this process can be described by the flowchart presented in Figure 1.

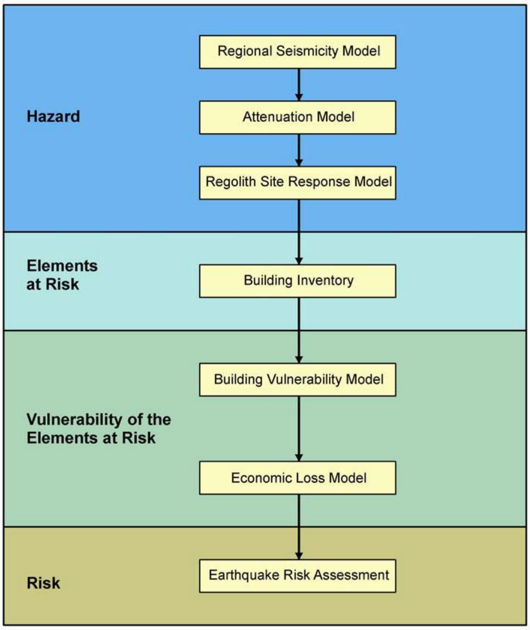


Figure 1. Earthquake risk assessment process [1]

While the results can be used as a general measure of seismic risk for types of buildings, the actual seismic risk for any individual building may vary considerably and will depend upon its exact configuration and condition. Acquiring and analyzing the specific data for an individual building or facility is one of the most expensive aspects of seismic risk estimation. Progress is made if the "fragility" or seismic capacity of the components within a structure can be calculated.

The approach to the problem of risk analysis depends on the scale. For individual existing buildings or construction sites, the analysis can be conducted in detailed manner, taking into account geotechnical information about the site, location of probable hazard sources and estimated seismic influence, using advanced numerical or simplified methods of structural analysis and considering all relevant elements at risk. Obviously, this is a finance and time-consuming procedure and it is applicable only for individual sites, in particular for critical buildings and facilities. The next level (microzonation) is applicable for urban areas on the basis of available hazard microzonation maps and building stock inventory. Depending on the problem under consideration the inventory of the building stock is implemented building by building as a rule using visual screening procedures and representative buildings for simplification. In the same manner distribution of the exposure at risk can be estimated. For the next level corresponding to regional or national scale, another set of input data and more generalized methods of analysis are used [2].

Earthquake risk assessment methodologies consider and combine three main factors:

- earthquake hazard,
- fragility/vulnerability, and
- inventory of assets exposed to hazard.

2. EARTHQUAKE HAZARD

A hazard is defined as a condition, event or circumstance that could lead to or contribute to an unplanned or undesirable event. While in some cases, safety or reliability risk can be eliminated, in most cases a certain degree of risk must be accepted, as in the case with seismic risk assessment. Since earthquakes are relatively rare events which may or may not occur during service life of a building, but could potentially have devastating consequences (Figure 2), structural design level that could assure the response of buildings in the linear-elastic region, eliminating the potential damage, would not be economically feasible. A certain level of damage due to earthquake is thus allowed, under the conditions that human lives are protected, the damage is limited and the structures important for civil protection are to remain operational [3]. In order to quantify the expected costs, the potential consequences and the probability of occurrence need to be considered. Assessment of risk is made by combining the severity of consequence with the likelihood of occurrence in a matrix. Risks that fall into the "unacceptable" category (e.g. high severity and high probability) must be mitigated by some means to reduce the level of safety risk.

A hazard analysis is used as the first step in a process used to assess risk. A hazard is a potential condition that either exists or not (probability is 1 or 0). It may in single existence or in combination with other hazards (sometimes called events) and conditions become an actual Functional Failure or Accident. The way this exactly happens in one particular sequence is called a scenario. This scenario has a probability (between 1 and 0) of occurrence. It also is assigned a classification, based on the worst case severity of the end condition. Risk is the combination of probability and severity. Preliminary risk levels can be provided in the hazard analysis. The validation, more precise prediction (verification) and acceptance of risk is determined in the Risk assessment analysis. The main goal of both is to provide the best selection of means of controlling or eliminating the risk.

Figure 2. Soft-story collapse, followed by the collapse of the whole structure of Hotel “Slavija” in Budva after the Montenegro earthquake in 1979 (R. McGuire, U.S. Geological Survey, 1979)

Engineers who construct buildings need to know how strongly a particular site might be shaken by earthquakes. This is achieved by compiling all known earthquake sources, their distance from the site in question, and other seismological and geological information to project potential maximum expected ground motions at a site over a particular period of time. These estimates are computed for hundreds of thousands of evenly distributed sites, and the information is then summarized into a series of maps.

Different maps portray different types of ground shaking information; some maps are designed to inform engineers on the design of small residential structures affected by high frequency ground motion, others are useful for designing tall buildings and long bridges that are more susceptible to longer wavelength ground shaking.

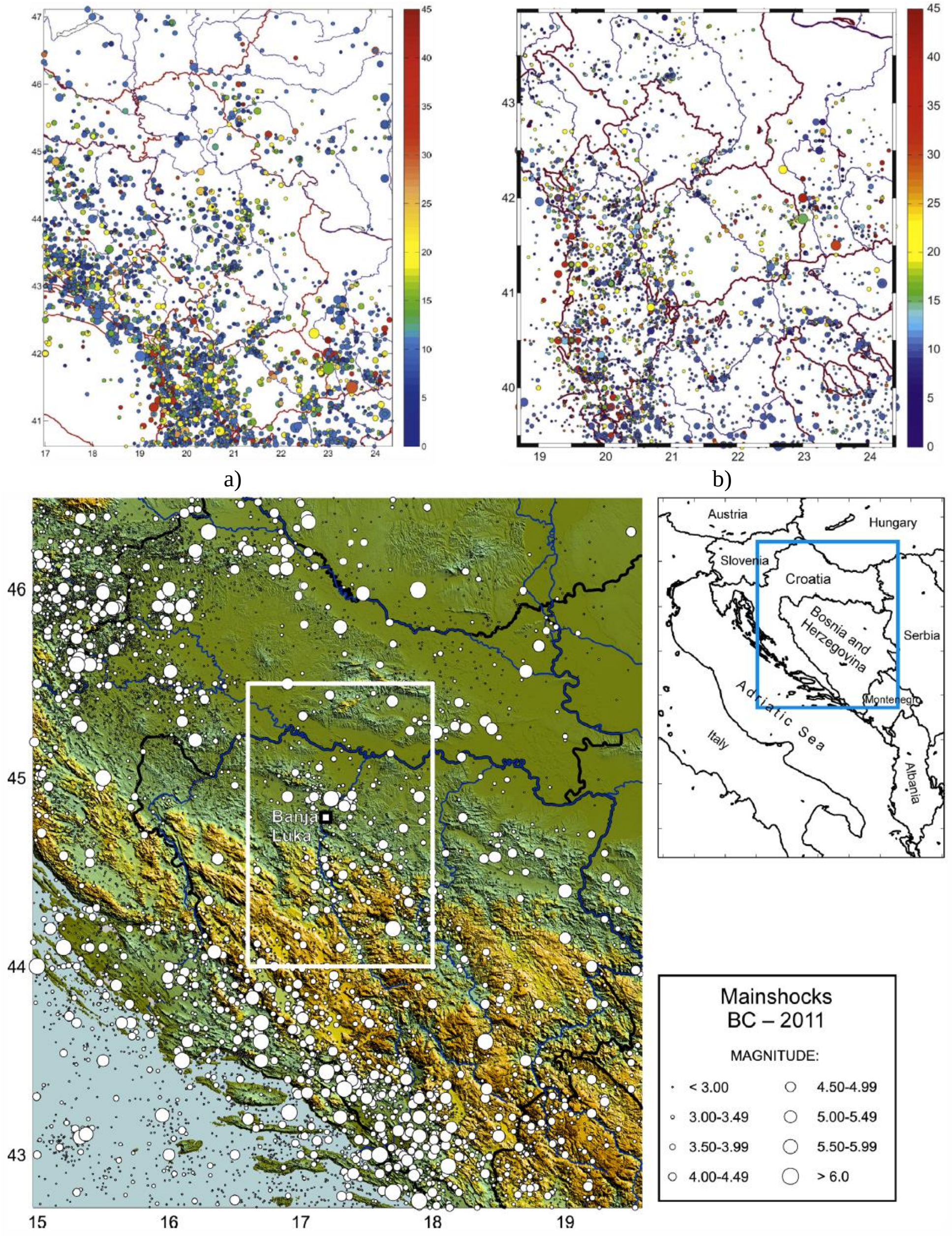
A seismic hazard is the probability that an earthquake will occur in a given geographic area, within a given window of time, and with ground motion intensity exceeding a given threshold. High intensity earthquakes may result in partial or complete damage of buildings, dams, roads, bridges, etc. which concludes into loss of life and property. Effect of earthquake also depends on various factor like topography, epicenter, magnitude and location of fault rupture.

The Balkan Peninsula is a hazard prone area regarding these phenomena. Some margins of large lithospheric plates as Eurasia and Africa and smaller units as Arabian plate, Adria microplate, as well as numerous active tectonic faults inland are responsible for stress accumulation producing a seismic activity in the form of devastating earthquakes. The first historically documented information on Balkan’s earthquakes dates back to 6^{th} century, BC. Many historical earthquakes destroyed different Balkan’s cities and towns. It is well-known today that the Balkan Peninsula exhibits the highest seismic activity in the whole western

Eurasia. On the average, M = 6.3 earthquake occurs every year in this area. Only during last century, there were more than 80 disastrous earthquakes in Balkan territory, marking seismic hazard as the highest and most dangerous of the geohazards [4].
Balkan Peninsula belongs to Alpine–Mediterranean seismic belt. The energy released in earthquakes from this belt is about 15% of the world total. The seismicity of the Balkans is the highest in Europe and is caused from multiple plate interactions in the Aegean Sea and Adriatic Sea and complicated deep tectonics in the Carpathians. In this zone, the concept of plate tectonics is especially complicated from the presence of numerous blocks and the release of stress through plastic deformation on a large part of the zone. The region is comprised of relatively rigid blocks as Adriatic, some sectors of Alpine belt, Alps, Carpathians, Balkan Mountains, Dinarides, Hellenides, the Hellenic Arc, and Anatolian belt as well as internal basins as Tyrrhenian, Aegean, Pannonia and Black Sea [4].
Geographical distribution of earthquake epicenters in the Balkan region, showing seismic activity mainshocks with magnitude exceeding M = 3.4, are presented in Figure 3.
With an estimated hazard, risk can be assessed and included in such areas as building codes for standard buildings, designing larger buildings and infrastructure projects, land use planning and determining insurance rates. The seismic hazard studies also may generate two standard measures of anticipated ground motion:

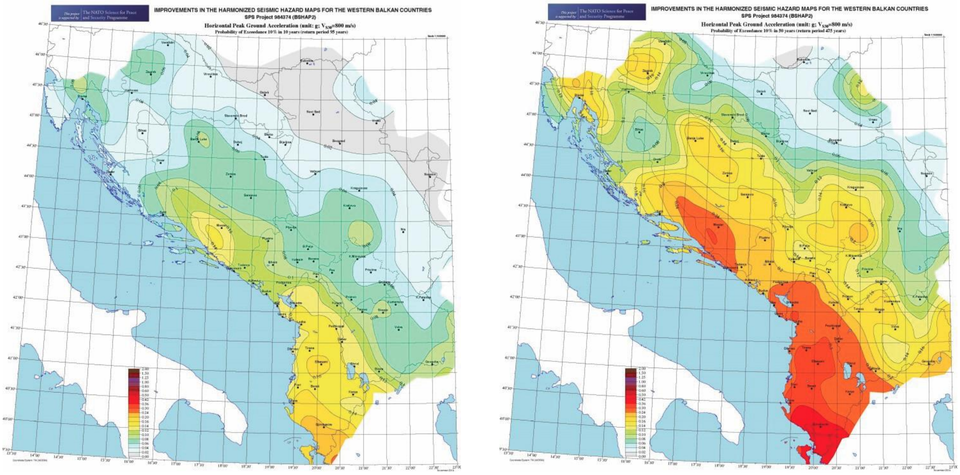
- simpler probabilistic maximum considered earthquake, used in standard building codes, and
- more detailed and deterministic maximum credible earthquake incorporated in the design of larger buildings and civil infrastructure like dams or bridges.

The probabilistic seismic hazard analysis approach (PSHA) estimates the probability that a particular level of strong earthquake ground motion amplitude, calculated for the whole ensemble of different earthquakes that are expected to occur in the selected region, will be exceeded during the life period of a structure [11]. The result of a PSHA is a seismic hazard curve (annual frequency of exceedance vs ground motion amplitude) or a uniform hazard spectrum (spectral amplitude vs structural period, for a fixed annual frequency of exceedance) [12]. To estimate seismic hazard, the theorem of total probability is applied, to combine the uncertain shaking at the site caused by a particular fault rupture and the occurrence frequency or probability of that rupture. Earth scientists create models, such as earthquake rupture forecasts, that specify the locations and rates at which various fault produce earthquakes of various sizes. The uncertain shaking given a fault rupture is quantified using a relationship variously called an attenuation relationship or a ground-motion prediction equation. Seismic hazard maps for the Western Balkan counties, obtained using PSHA approach, are presented in Figure 4. The results are expressed in terms of peak horizontal acceleration (PGA) for 95 and 475 years return periods, which is aligned with Eurocode 8 requirements.
The deterministic seismic hazard analysis (DSHA) approach, on the other hand, proposes design for only several earthquakes that are estimated to produce the most severe ground motion at a site. Regardless of the selected approach, the basic input data on past earthquakes at a specific region of interest, resulting in the definition of the seismic source zones and their properties, is practically the same. The DSHA can further be aimed either at finding the maximum possible strong earthquake ground motion at a site of interest, or at finding the values of the selected ground motion parameter that are compatible with the results of the corresponding probabilistic seismic hazard analysis [11].



c)

Figure 3. Earthquake epicenters (main shocks only, M ≥ 3.4), indicating focal depths and magnitude: a) Serbia and Montenegro, b) Albania and Northern Macedonia, c) Croatia and Bosnia and Herzegovina [5] - [10].



a) b)

Figure 4. Seismic hazard map of Western Balkans showing peak ground acceleration for: 10% probability of exceedance in 10 years (RP 95 years) (left) and 10% probability of exceedance in 50 years (RP 475 years) (right) [13].

A "maximum considered earthquake", or "maximum considered event" for a specific area, is an earthquake that is expected to occur once in approximately 2,500 years (2-percent probability of being exceeded in 50 years). It has been used specifically for general building codes, which people commonly occupy. A "maximum credible earthquake", which is used in designing for skyscrapers and larger civil infrastructure, like dams, where structural failure could lead to other catastrophic consequences, require determining more than one specific earthquake event, depending on the variety of structures included.

Investigations of earthquake damage and its irregular distribution in space, showed that for comparable epicentral distances, the variations were related to the geologic and soil site conditions. To account for these variations, it was proposed that city planners and earthquake engineers should be provided with microzoning maps with coefficients that characterize expected spatial variations in the amplitudes of shaking. The equivalent horizontal earthquake force, and later, the response spectrum amplitudes, which were used in the seismic design of structures, were then increased or decreased according to the values of the amplification coefficients defined in the microzoning maps.

Preparation of seismic microzonation maps involves many intermediate steps including description of seismic activity surrounding the site, attenuation (from source to the site) of the quantity (peak acceleration or velocity, site intensity, spectral amplitudes, duration of strong shaking, power of strong shaking, energy required to initiate liquefaction, peak strains for design of underground structures and pipes, simultaneous action of surface faulting with strong shaking), and ultimately their probabilistic combination to determine the balanced outcomes.

Mapping seismic hazard parameters for use in earthquake-resistant design must satisfy the guidelines for performance-based design (PBD). At present, PBD requires specification of two spectral amplitudes, one in which the structure will remain essentially linear, and the other in which it may undergo a nonlinear response and will vibrate with longer-system period. These requirements cannot be satisfied via one (same) fixed spectral shape, and such spectra cannot be scaled by peak ground acceleration. Another source of difficulty in the selection of the PBD-design amplitudes occurs when the standard spectrum shape is not capable of describing excitation from large distant earthquakes.

After the first direct empirical scaling equations of spectral amplitudes started to appear, it become possible to formulate seismic zoning and microzoning in terms of more comprehensive approaches. Such approaches could include the probabilities of earthquake occurrence, the spatial distributions of earthquake sources, the frequency-dependent attenuation of strong-motion amplitudes, and the site geologic and soil conditions [5]. The advantage of this new approach was that it considered simultaneously, and in a balanced way, all factors that contributed to the end result. Methodologies have been developed that allow the direct determination of maximum spectral accelerations for specified values of the period of a single-degree-of-freedom system and for a given probability of exceedance. A plot of such spectral acceleration values is referred to as a uniform hazard spectrum (UHS) and is presented in Figure 5 for the territory of Serbia.

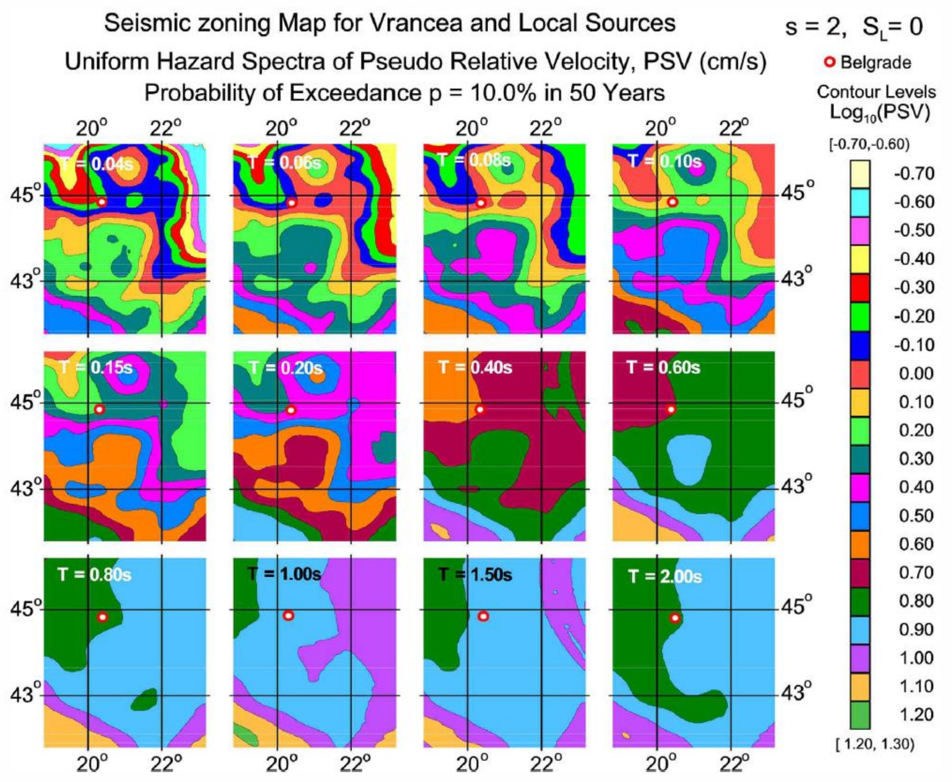


Figure 5. An example of a seismic zoning map for Serbia, for pseudo spectral velocity (PSV), for a 5% fraction of critical damping, computed with the UHS method, for local seismicity and contribution from Vrancea earthquakes combined, at the basement rock sites (s = 2), rock soil sites (S_L = 0), at 12 periods ranging from 0.04 to 2.00 s, for probability of exceedance p = 0.10, and for an exposure time of Y = 50 years. The circle shows location of the city of Belgrade. [6]

3. FRAGILITY AND VULNERABILITY

The earthquake risk value depends not only on the hazard level, but also on the aggregate elements at risk (both in human and economic terms) and their vulnerability to probable seismic influence. The quantitative approach to the problem of risk analysis correspondingly implies the proper hazard, vulnerability and exposure evaluation.

A particular building's capacity to resist collapse in an earthquake may not vary much over time, but that capacity is unknown before the building collapses, so it is uncertain. It is common in earthquake engineering to try to distinguish between two categories of uncertainty: aleatory (having to do with inherent randomness) and epistemic (having to do with one's model of nature). An example of a possibly aleatory uncertainty from earthquake engineering is the uncertainty in structural response resulting from randomness in the ground motion, sometimes called the record-to-record variability. Epistemic uncertainties are supposedly reducible with better knowledge, such as with a better structural model or after more experimental testing of a component.

The concept of a fragility function in earthquake engineering first appeared in the 1980s, with a definition of a fragility function as a probabilistic relationship between frequency of failure of a component and peak ground acceleration in an earthquake. More broadly, a fragility function can be defined as a mathematical function that expresses the probability that some undesirable event occurs (typically that an asset or a component reaches or exceeds some clearly defined limit state) as a function of some measure of environmental excitation (typically a measure of acceleration, deformation, or force in an earthquake, hurricane, or other extreme loading condition). Also, a fragility function represents the cumulative distribution function of the capacity of an asset to resist an undesirable limit state. Capacity is measured in terms of the degree of environment excitation at which the asset exceeds the undesirable limit state. For example, a fragility function could express the uncertain level of shaking that a building can tolerate before it collapses. The chance that it collapses at a given level of shaking is the same as the probability that its strength is less than that required to resist that level of shaking. The most common form of a seismic fragility function is the lognormal cumulative distribution function (CDF), Figure 6.

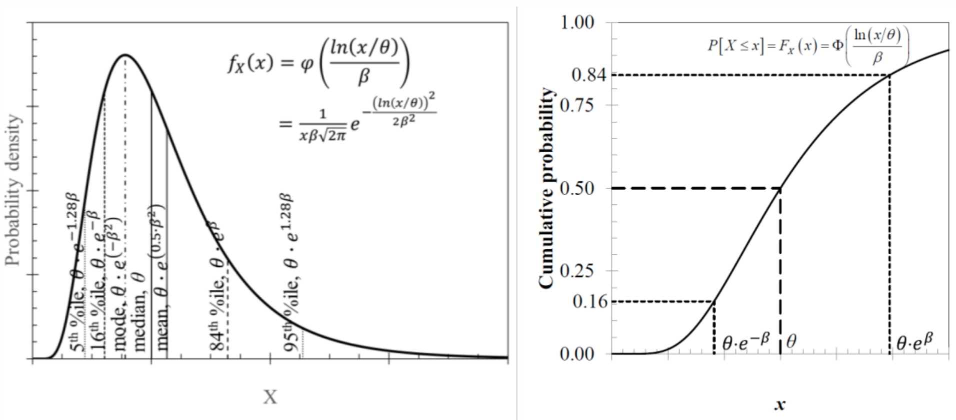


Figure 6. Lognormal: probability density function (left) and cumulative distribution function (right) [14].

Three general classes of fragility functions can be distinguished by the method used to create them:

- Empirical. An empirical fragility function is one that is created by fitting a function to approximate observational data from the laboratory or the real world. The observational data are one of: (1) ordered pairs of environmental excitation and a binary indicator of failure (i.e. reaching or exceeding the specified limit state), for each of a set of individual assets; or (2) ordered sets of environmental excitation, number of assets exposed to that level of excitation, and the number of those that failed when subjected to the environmental excitation.
- Analytical. An analytical fragility function is one derived for an asset of class of assets by creating and analyzing a structural model of the asset class.
- Expert opinion or judgment-based. An expert opinion fragility function is one created by polling one or more people who have experience with the asset class in question, where the experts guess or judge failure probability as a function of environmental excitation.

Fragility functions can be defined by a combination of these methods, for example by using judgment to create a fragility function for one limit state based on empirical data or an analytical model of another.

The HAZUS-MH technical manual [15] offers a number of whole-building fragility functions, defining for instance probabilistic damage to all the drift-sensitive nonstructural components in the building in 4 qualitative damage states (slight, moderate, extensive, complete) as a function of a whole-building measure of structural response (spectral acceleration response or spectral displacement response of the equivalent nonlinear SDOF oscillator that represents the whole building), as illustrated in Figure 7.

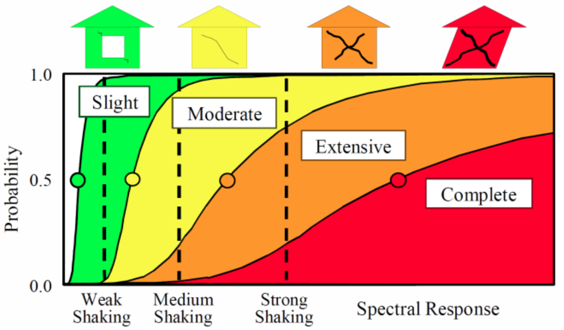


Figure 7. Example fragility curves for slight, moderate, extensive and complete damage [15].

As an example, fragility curves were derived for twelve industrial precast building classes [16]. A nonlinear dynamic analyses on sample buildings from these classes were conducted, taking into account selected seismic events. Damage states were defined on the basis of the physical damage occurring to the vertical panels, horizontal panels, or masonry infills. The curves are presented in the form of spectral acceleration corresponding to the optimal period of the building class (Figure 8), as well as for the peak ground acceleration, which is an intensity measure, independent of the building class (Figure 9). This means that all these fragility functions can be used to discuss how the variation of structural configurations, code levels, and the type of non-structural components and their fastenings affect the overall seismic response of industrial precast building classes, at a given level of the seismic intensity measure.

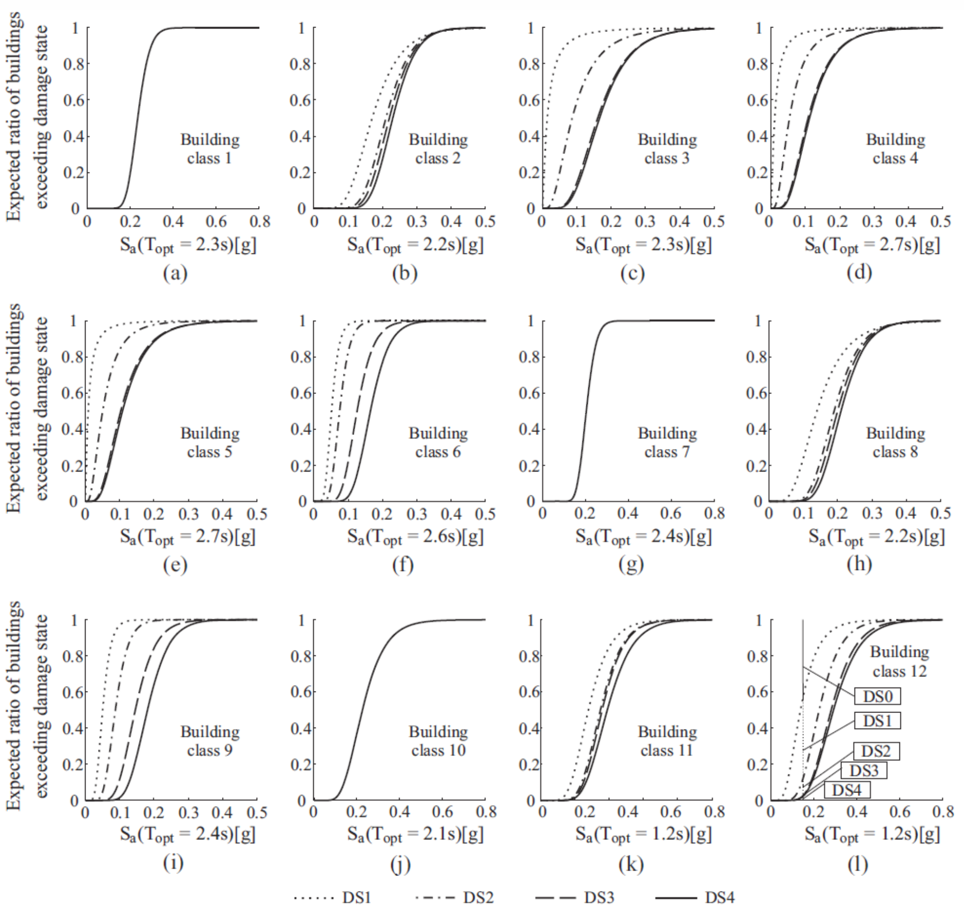


Figure 8. Fragility functions for the twelve investigated building classes and the geometric mean of the spectral accelerations in both horizontal components at the optimal period [16].

Damageability is also measured in terms of the degree of the undesirable outcome, called loss, in terms of repair costs, life-safety impacts, and loss of functionality (dollars, deaths, and downtime), or in terms of environmental degradation, quality of life, historical value, and other measures. When loss is depicted as a function of environmental excitation, the function can be called a vulnerability function. A seismic vulnerability function relates uncertain loss to a measure of seismic excitation, such as spectral acceleration response at some damping ratio and period. A seismic vulnerability function usually applies to a particular asset class.

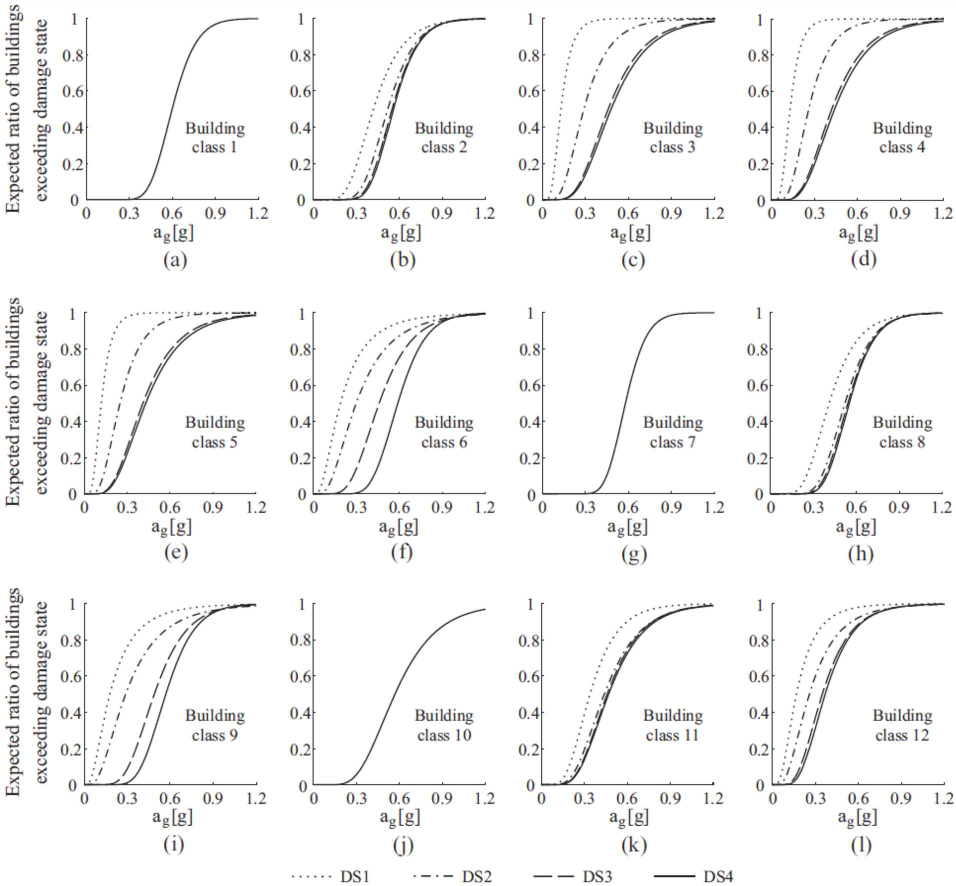


Figure 9. Fragility functions for all the twelve investigated building classes and the geometric mean of the peak ground accelerations in both horizontal components. [16]

Apart from simple correlations with intensity or magnitude and population density, the casualty numbers are generally estimated via a correlation with the damage state experienced by a structure, the time of day, the structural use, and other factors. Casualty estimations encompass significant uncertainties since the casualty numbers vary greatly from one earthquake to another. HAZUS-MH model estimates casualties directly caused by structural or nonstructural damage under four severity levels to categorize injuries, ranging from light injuries (Severity Level 1) to death (Severity Level 4) [15].

Vulnerability functions relate a given risk figure, as for example the expected economic loss or the mean damage ratio and their corresponding variances, to the hazard intensity parameter. The formulation of vulnerability functions requires the definition of the loss L as a random variable, providing all the necessary information to calculate the probability of reaching or exceeding a loss value, given the hazard intensity [17].

As for the fragility functions, methods to derive vulnerability functions can be classified into three general approaches: empirical, analytical, and expert opinion.

Empirically derived vulnerability functions are generally the most desirable from a risk management viewpoint because they are derived wholly from observations of the actual performance of assets in real earthquakes. For that reason they are highly credible. One collects observations of many facilities without preference to degree of damage (i.e. without selecting samples because they are damaged), recording:

- x_i = environmental excitation (ground motion, wind speed, etc.) at each property i
- y_i = loss (repair costs, fatality rate, duration of loss of function, etc.) at property i
- c_i = attributes of property i (structural material, lateral force resisting system, height, age, etc.)

The samples are then grouped by one or more attributes (e.g., by model building type) and for each group a regression analysis is performed to fit a vulnerability function, usually to the mean and to the standard deviation as functions of environmental excitation. The vulnerability function can be expressed in a table of mean and standard deviation of loss at each of many levels of excitation for the given class of facility. Empirical wind and flood vulnerability functions date at least to the 1960s, and empirical earthquake vulnerability functions at least to the 1970s.

Empirical method, however, has drawbacks:

- Many building types have not yet experienced strong motion, such as the combined shearwall and frame high-rise systems built in the Western United States after the 1994 Northridge earthquake.
- Observations tend to be few or missing at high levels of excitation, where high losses are most likely.
- Estimations of repair costs need to be based on a detailed visual examination of the buildings. Professional construction cost estimators would never estimate costs without visually examining all the damage. Too much loss can be hidden from a superficial view of the front of a building.
- It can be challenging to acquire loss data either from construction permits or insurers. The cost of a construction permit is generally proportional to the size of the construction contract, so permits tend to reflect an underestimate of repair cost. Despite the hopes and expectations, insurers almost never part with or share their loss data with researchers. Losses are sensitive business data for insurers, valuable intellectual property, and they can be costly to extract in a form useful to researchers.
- It can be difficult to estimate shaking at the observations. Accelerometers are commonly spaced many miles or even tens of miles apart even in densely population areas, and ground motion can vary greatly between them.
- Empirical observations tend to shed light neither on the causes of damage, nor on the effects of building details such as soft-story conditions, because researchers tend not to record these details, or record too few observations to distinguish the effects.

Analytical methods use engineering first principles to estimate the vulnerability function. Almost all analytical methods employ the same four analytical stages, illustrated in Figure 10 [14]. In the method, the asset at risk is first defined in detail: its location, site conditions, structural design, architectural design, and even inventories the damageable mechanical, electrical, and plumbing elements, as well the furnishings, fixtures, equipment, and people in the facility. Next, a hazard analysis is performed, estimating the probability or frequency with which various levels of environmental excitation occur. The next stage is structural analysis, in which the member forces and deformations, story drifts and accelerations are estimated, throughout the facility at each level of excitation. The structural responses are then input to component fragility functions to estimate probabilistic damage to each damageable component at each level of excitation. Probabilistic damage is then input to a loss analysis, in which the uncertain cost to repair damage, life-safety impacts, and time to repair damage (the dollars, deaths, and downtime), is estimated. The process is repeated to propagate uncertainties and to relate environmental excitation, such as ground motion to loss.

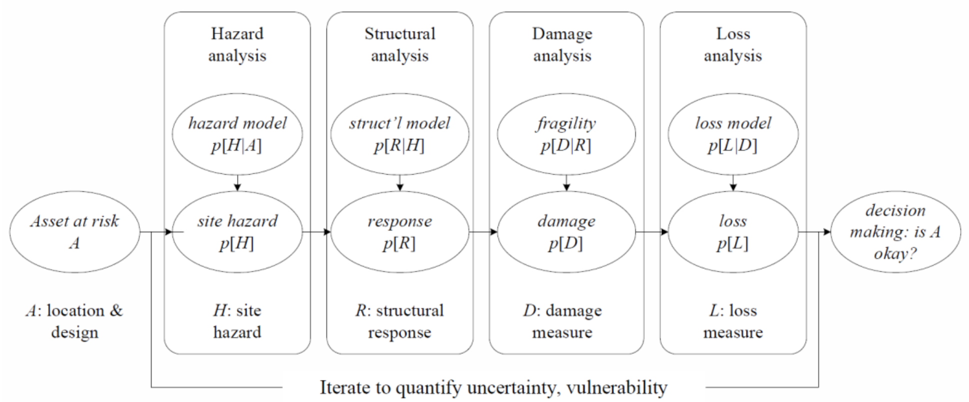


Figure 10. Analytical methods for estimating seismic vulnerability of a single asset [14].

The analytical method provides insight where the empirical method does not. It can be used to estimate the vulnerability of building types which have not yet experienced strong motion. It also includes the behavior of buildings at higher levels of excitation than have shaken the building type of interest in actual earthquakes. It provides a method to estimate repair costs, life-safety impacts, without relying on proprietary insurance data or questionable construction permits. It avoids problems associated with sparse accelerometers, and it can also refer to the causes of damage and the effects of building details such as soft-story conditions.

All these strengths come with two important costs: first, the method is time-consuming, taking days or weeks to estimate the behavior of a single building or class of buildings. Second, it lacks built-in validation. While all the elements of the analysis may be validated by earthquake experience, tests, and construction experience, the overall vulnerability function lacks the credibility of an empirical vulnerability function. One can perform a cross-validation of a new vulnerability function against existing, related ones, but validation against other models is not as compelling as derivation from actual whole-building disaster data.

An analytical vulnerability procedure is developed for the risk-management software HAZUS-MH. The building is idealized as a single-degree-of-freedom nonlinear oscillator. The method employs nonlinear pseudostatic structural analysis to estimate the acceleration and displacement of the oscillator, which is then translated to acceleration and drift imposed on three aggregate building components: structural, nonstructural drift-sensitive, and nonstructural accelerations-sensitive components. Four damage states are defined for each along with repair costs and other consequences. The great value of the methodology is that

all the parameters required to estimate repair costs and other consequences for virtually every building type in the United States are estimated.
Where empirical data are insufficient and analytical methods are too costly, an expert opinion can be employed. Expert opinion is very efficient, capable to produce a new vulnerability function at the cost of a few person-hours each, of estimating the performance of buildings that have not yet experienced strong motion, and of estimating the effects of building features such as soft-story conditions. Its great disadvantages are: (1) lack of credibility because it cannot be objectively tested other than through cross-validation; and (2) underestimation of uncertainty. Experts often have an exaggerated idea of their own sagacity, but it can be controlled with careful conditioning of the experts.
Many vulnerability functions are expressed with conditional probability distributions that give a probability that loss will not exceed some specified value given the excitation, for a particular asset class. The distribution is often assigned a parametric form such as lognormal or beta, in which case the parameters of the distribution are all required, some or all of them conditioned on excitation.

4. INVENTORY OF ASSETS EXPOSED TO HAZARD

The asset definition includes locations, values exposed to loss, and the characteristics necessary to estimate vulnerability.
To estimate catastrophe risk to many assets, a portfolio catastrophe risk analysis is performed, referring to a group of many assets. Portfolio catastrophe risk models generally characterize portfolio assets as samples of one or more classes, each sample having engineering attributes taken as independent and identically distributed. Portfolio models limit the need to gather information about the geometry and engineering characteristics of each asset or to perform geotechnical or structural analysis of each asset. A portfolio approach takes advantage of the law of large numbers to make reasonable estimates of aggregate losses to the portfolio, at the cost of greater uncertainty in the estimated losses to individual assets. The alternative to a portfolio catastrophe risk modeler is sometimes referred to as a site-specific analysis, in which much more information about each asset is gathered and a geotechnical, structural, or other performance-based earthquake engineering analysis is performed of each asset.
Catastrophe risk models generally start with a collection of available data about the assets at risk: their geographic locations, quantities exposed to loss and attributes (for example, the number of stories). Available data often appears in a format different from the parameters required by the model that will be employed, using different terminology or missing attributes that the model requires, so the modeler must estimate the model parameters from the available data, through an asset analysis. When the available data contain less information than the model requires, the modeler can perform a probabilistic asset analysis, estimating the probability distribution of model parameters conditioned on the input data.
Financial loss is, essentially, the translation of physical damage into total monetary loss using local estimates of repair and reconstruction costs. Studies on economic impacts of earthquakes have been usually examined in two categories: (1) loss caused by damage to built environment (direct loss), and (2) loss caused by interruption of economic activities (indirect loss). HAZUS-MH estimates losses at three levels of accuracy: Level 1 - a rough estimate based solely on data from national databases (demographic data, building stock estimates, national transportation and infrastructure data) included in the HAZUS-MH software distribution; Level 2 - a more accurate estimate based on professional judgment and detailed information on demographic data, buildings and other infrastructure at the local

level and; Level 3 - the most accurate estimate based on detailed engineering input that develops into a customized methodology designed to the specific conditions of a community [18].

Portfolio risk analyses usually start by compiling the following attributes of each asset in the portfolio [14]:

- A unique identifier *i*. It sometimes appears below as a subscript on the other attributes to indicate, for example, location of asset *i*.
- Location *o* in terms of latitude and longitude, and occasionally elevation, based on the vector location (φ, λ), where φ denotes longitude in decimal degrees east of Greenwich, and λ denotes latitude in decimal degrees north of the equator.
- Site conditions *s*, including the average shearwave velocity in the upper 30 meters of soil and depth to bedrock. The site's proximity to a known active fault, landslide susceptibility, and liquefaction susceptibility are also relevant site conditions for earthquake risk. Site soil conditions are usually uncertain, with the rare exception of sites for which the analyst has soil boring logs. Even in such cases, depth to ground water can fluctuate seasonally, which affects liquefaction susceptibility.
- Values exposed to loss *V*. If the loss measure of interest is repair cost, the replacement cost of the building and its contents need to be known. If the aim is to determine the risk in terms of casualties, number of occupants by time of day and day of week is the important value measure. If business interruption loss or additional living expenses are the important loss measure (usually referred to as time-element loss), the economic loss associated with various durations of loss of function need to be known. The values exposed to loss are usually uncertain, even though many catastrophe risk models ignore that uncertainty.
- Asset category *a*. There are many classification systems. The HAZUS-MH taxonomy is commonly used. Buildings are identified by structural material, lateral force resisting system, height category, code era, and occupancy classification. Some models refer to some attributes as modifiers that are used to adjust losses calculated for a broad category to account for the effect of the attribute, such as soft story conditions in an earthquake risk analysis. The modifiers are treated here as merely a further subdivision of the category system. Asset category is usually uncertain, with the rare exception of a portfolio whose asset categories have been established by a structural engineer examining structural drawings.
- Contract details *c* for contracts that transfer risk from the property owner, tenant, or other entity experiencing damage to a second party such as an insurer or the seller of a bond that acts like insurance. These risk-transfer contracts relate property repair costs, duration of loss of function, and casualties to the economic liability of the second party. The mathematical function *c* usually has additional parameters, especially the deductible *d* (the repair cost that the insured must pay before the insurer's liability begins), limit of liability *l* (the maximum amount that the insurer must pay), and pro rata share *p* (the fraction of loss in excess of the deductible that the insurer must pay).

A portfolio risk analysis can be characterized as comprising the portfolio definition followed by three analytical stages: hazard analysis, engineering loss analysis, and financial loss analysis. The last stage only applies in the case of a contract that transfers risk.

The commonly used risk metrics in earthquake insurance are [18]:

- Average Annual Loss, and

- Loss Exceedance Probability curves.

The probability distribution function for the loss to a portfolio depends on the spatial correlation of the ground motion and the vulnerability of the buildings. When spatial correlation is considered, the losses at longer return periods increase. On the opposite side, the losses at shorter return periods may be overestimated if spatial correlation is not included in the analysis.

Earthquake risk/loss assessment models should explicitly account for the epistemic uncertainties in the components of analysis, especially in the inventory of assets and vulnerability relationships.

In Probabilistic Seismic Risk Analysis (PSRA) the annual frequency of exceedance (or the return period) of different levels of risk (i.e. loss ratio or monetary loss) due to earthquakes are assessed. The annual probability of exceedance of such losses can be obtained from the annual frequency of exceedances using appropriate probability models. Similar to PSHA, the results of a PSRA can also be disaggregated to identify the components of the overall system (i.e. earthquake scenarios) that are contributing significantly to the seismic risk.

The Loss Exceedance Curves and the Average Annual Loss constitute the two important metrics of PSRA. Loss Exceedance Curves describe losses versus probability of exceedance in a given time span (generally, annual). The Average Annual Loss (AAL) is the expected value of a loss exceedance distribution and can be computed as the product of the loss for a given event with the probability of at least one occurrence of event, summed over all events. For earthquake insurance purposes, the AAL is of particular importance in determining the annual premiums.

Earthquake losses in HAZUS-MH are expressed in building-damage, economic, and social terms. Direct losses are estimated based on physical damage to structures, contents, inventory, and building interiors. Economic losses include repair and reconstruction costs, as well as lost jobs and business interruptions. The loss assessment methodology that HAZUS-MH uses consists of the main components of: Potential Earth Science Hazard, Direct Physical Damage, Induced Physical Damage and Direct Economic/Social Loss. The general finding of the studies on the uncertainties in earthquake loss estimation is that the uncertainties are large and at least as equal to uncertainties in hazard analyses.

Through use of statistical regression techniques, a compilation of cumulative economic losses for each country can be developed as a proportion of Purchasing Power Parity (PPP) at the time of disaster. Such data from past earthquakes can be used to develop Loss Functions for predicting economic losses, which can also be estimated by using analytical procedures in connection with a Monte Carlo simulation techniques. A quick and approximate estimation of earthquake loss using detailed local *GDP* and population data combines seismic hazard, *GDP*, population data, published earthquake loss data, and the relationship between *GDP* and known seismic loss, to estimate earthquake loss using the following relationship:

$$L = \Sigma\, P(\mathrm{I}) \times F(\mathrm{I,GDP}) \times GDP \qquad (1)$$

where L is the economic loss, $P(\mathrm{I})$ is the probability of an earthquake of intensity I, and $F(\mathrm{I,GDP})$ is a measure of the area's vulnerability to earthquake damage for the given *GDP* value and the earthquake of intensity I [18].

An approach to calculate vulnerability functions using Monte Carlo simulations considers following parameters in the vulnerability and loss assessment procedure [17]:

- Residual drift limit: if the residual drift exceeds a specified limiting value, the building would be considered irreparable and would be demolished and replaced.

- Excessive repair costs: if the repair costs exceed certain limit, the best decision would be to replace the building with a new one.
- Minimum seismic intensity level for damages: low level of damages are not considered formally for seismic intensities lower than a specified limiting value.
- Specific considerations for estimation of indirect costs such as: (1) business interruption cost per unit of time as a percentage of the building replacement cost; (2) level of seismic intensity below which no business interruption costs are generated; (3) consideration or not of efficiency and scaled economy to estimate repair costs and times depending on the number of simultaneous interventions; (4) maximum time frame for repairs; (5) time lapse required to initiate the repair works and to re-occupy the building once the repair works are finished; (6) number of simultaneous construction workers teams for structural and non-structural repair works.

As a result of such methodology implemented on a study of six prototype buildings, vulnerability functions are presented in Figure 11. All buildings are reinforced concrete moment resisting frames (MRF). Two (P2), five (P5) and ten (P10) stories models are considered. Building models referred as DMI are ordinary MRF buildings designed for a typical low hazard zone design spectrum (PGA = 0.1 g) with minimum code requirements (no seismic considerations). Building models referred as DES correspond to special MRF buildings designed for a typical high seismic hazard zone design spectrum (PGA = 0.25 g) with full consideration of special seismic design requirements.

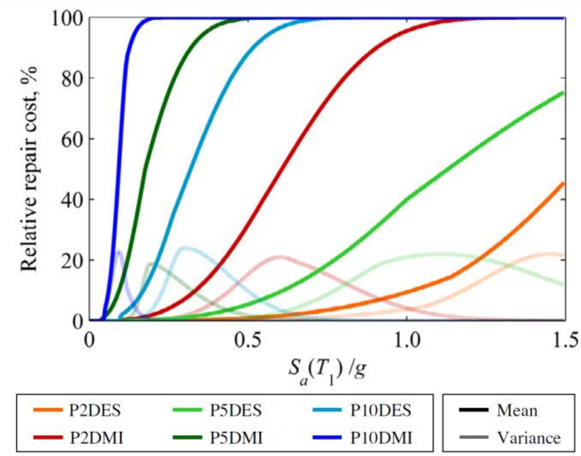


Figure 11. Vulnerability functions referring to relative repair cost based on spectral acceleration for the fundamental structural period for six prototype building models. [17]

SUMMARY

This chapter discussed the topic of earthquake risk assessment. Seismic risk has been defined, for most management purposes, as the potential economic, social and environmental consequences of hazardous events that may occur in a specified period of time. It causes damages to a building, system, or other entity. Seismic risk is often determined using a seismic modelling computer program which uses the seismic hazard inputs and combines them with the known susceptibilities of structures and facilities, such as buildings, bridges, electrical power switching stations, etc. The risk may be measured in terms of expected economic loss, in terms of human lives lost, or in terms of physical damage to property, where appropriate measures of damage are available. Risk may be expressed as average expected losses or in terms of probabilistic manner and should include proper consideration of vulnerability and exposed values. The factors considered and combined during an earthquake risk assessment methodologies include earthquake hazard, fragility/vulnerability, and inventory of assets exposed to hazard. They were thoroughly discussed in this chapter.

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FIRE RISK ASSESSMENT AND FIRE SAFETY IN BUILDINGS

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1. INTRODUCTION TO FIRE SAFETY IN BUILDINGS

The practice of fire safety designs is changing in many countries. The change is from traditional practice that simply follows the prescriptive code requirements to those that are based on fire safety analysis to obtain the required level of fire safety for the occupants. The change is a result of many countries moving towards the more flexible performance-based codes, which allow flexibility in fire safety designs as long as the designs can provide the required level of fire safety to the occupants.

Fire risk assessment is an assessment of the fire risks, or the levels of fire safety, that are provided to the occupants and property in a performance-based fire safety design. Fire safety designs involve the use of fire protection measures to control fire growth and smoke spread and to expedite occupant evacuation and fire department response. None of these fire protection measures, however, is 100% effective. For example, sprinklers do not have a 100% reliability in controlling fires, nor do fire alarms have 100% reliability in getting occupants to leave immediately. As a result, certain levels of fire risks to the occupants and property are implied in each fire safety design. The assessment of these levels of fire risks is the subject of fire risk assessment.

If designers are to explicitly consider the levels of fire safety and protection in buildings designs, then there must be a fundamental change in the methods that are used to design buildings for fire safety and protection [1], [2]. In addition, there must be recognition that societal levels of fire safety and protection in buildings are the result of a large number of fire scenarios, multiple responses of building fire safety and protection subsystems to these fire scenarios and a multitudinous number of human behavior responses to these scenarios. A rigorous and systematic approach to the assessment of explicit levels of fire safety and protection requires a comprehensive risk analysis to be undertaken of building fire safety and protection systems [3]. Fundamentally, this requires explicit consideration of multiple fire scenarios, response of building fire safety systems and human behavioral responses [4].

Risk assessment models are needed to identify those combinations of building subsystems which provide the requisite level of safety in a cost-effective manner. Deterministic fire-engineering design methods cannot be used for that purpose because it is necessary to estimate both the likelihood of the possible fire scenarios and their consequences, and then combine the results in order to evaluate the likely cost and safety level. Risk analysis is defined as the process of estimating magnitudes of consequences and probabilities of the adverse effects resulting from fire in a building. It provides rational criteria for the choice of remedial actions, including explicit considerations of uncertainty. It is obviously the preferred base for decision making.

Fire safety objectives and basic characteristics of traditional fire risk assessment methods (including case study) and fire risk assessment methods based on a fundamental approach are discussed in these paper.

2. FIRE SAFETY OBJECTIVES

The primary goal of fire protection is to limit, to acceptable levels, the probability of death, injury, and property loss in an unwanted fire.

The life safety has been given more emphasis by recent national codes than property protection [5]. Many codes consider that fire damage to a building is the problem of the building owner or insurer, with the code provisions only intended to provide life safety and protection to the property of other people. Automatic sprinkler systems, as many other measures, provide both life safety and property protection. It is important for the owner of the building to understand the distinction between life safety and property safety, because there is a possibility for fire damage extension to the building and contents, even if the building complies with minimum code requirements.

Ensuring the safe escape is the most important goal in providing life safety. First of all, it is necessary to alert people to the fire, provide suitable escape paths, and make them safe of fire and smoke, so people cannot be injured while escaping through those paths to a safe place. It is also necessary to provide safety for people unable to escape, as well as people in adjacent buildings. There are also provisions to be made for fire-fighters who enter the building for rescue or fire control purposes.

Property protection includes protecting the structure and fabric of building, and the moveable contents. Protection also must apply to neighboring buildings. If there is a possibility of irreplaceable loss of heritage values or major damage to main infrastructures, it is necessary to apply an extra level of fire protection.

Environmental protection is an additional objective, formulated in a way to limit environmental damage in the event of major fire. Emissions of gaseous pollutants in smoke and liquid pollution in fire-fighting run-off water can both have major environmental impacts.

All of above listed objectives can be met if any fire is extinguished before growing large, which depends on the reliability of predicted fire protection measures.

3. TRADITIONAL FIRE RISK ASSESSMENT METHODS

Fire risk assessment is the assessment of the risks to the people and property as a result of unwanted fires. A simple risk assessment considers the probability of the occurrence of a certain unwanted fire scenario and the consequence of that scenario. A comprehensive risk assessment considers all probable unwanted fire scenarios and their consequences.

If the assessment of the expected risk to life to the occupants in a building is considered as a result of one single fire scenario, the expected risk to life can be expressed by the following equation:

$$\textit{Expected risk to life} = P \times C \qquad (1)$$

where P is the probability of a certain fire scenario and C is the expected number of deaths as a consequence of that fire scenario. If the probability of a certain fire scenario occurring in a building is once every five years, then P = 0.2 fires per year. If the consequence of that fire scenario is two deaths, then C = 2 deaths per fire. From Equation (1), the expected risk to life as a result of that fire scenario is equal to 0.4 deaths per year, or 2 deaths every 5 years.

Because fires can occur in a building in more ways than one, the risk to the occupants is usually assessed based on all probable fire scenarios. A comprehensive fire risk assessment can be expressed by the following equation:

$$Expected\ risk\ to\ life = \Sigma i\ (Pi \times Ci) \qquad (2)$$

where Σi represents the summation of all probable fire scenarios, *Pi* is the probability of one fire scenario (i), and *Ci* is the expected number of deaths as a consequence of that fire scenario (i).

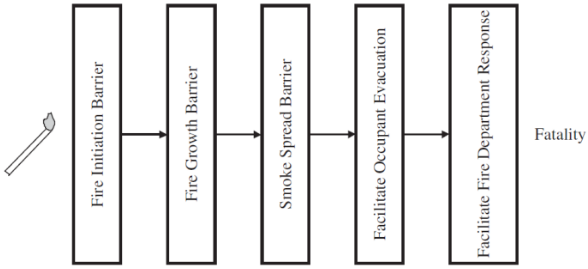

Figure 1. Five major fire barriers between fire source and fatality [6]

A fire scenario is a set of fire events that are linked together by the success or failure of fire protection measures. There are basically five major hazardous events that must occur before a fire can cause harm to the occupants (Fig. 1). They are: (1) fire ignition, (2) fire growth, (3) smoke spread, (4) failure of occupants to evacuate and (5) failure of fire department to respond. Each of these five hazardous events can be prevented by fire protection measures, or barriers.

The probability of a fire scenario that can lead to harm to the occupants depends on the combined probability of failure of all fire protection measures, or barriers. The lower the individual probabilities of failure of fire protection measures are, the lower is the probability of the fire scenario that can lead to harm to the occupants. Fire risk assessment concerns not only the number of fire protection measures that are put in place, but also how reliable and effective these fire protection measures are.

The risk to the occupants depends not only on the probability of the fire scenario that can lead to harm to the occupants, but also the level of harm to the occupants as a result of the consequence of that scenario. The consequence of a fire scenario can be assessed by using time-dependent modeling of fire and smoke spread, occupant evacuation and fire department response.

3.1. Fire risk assessment based on past fire experience

Fire risk assessments can be performed based on past fire experiences. Such fire risk assessments, however, are valid only if the situation in the past and that to be assessed at the present are the same. This requires that the controlling parameters that govern the fire scenarios in both situations are the same. Often, they are not the same because of changes over time such as the introduction of new furnishing materials or new fire protection systems. Controlling parameters include fire protection systems, such as sprinklers that control the development of a fire or alarm systems that expedite the evacuation of the occupants. Controlling parameters also include physical parameters, such as the type and amount of combustibles that govern the development of a fire or the number and length of the egress routes that govern the required evacuation time. If these controlling parameters are not the same, then a fire risk assessment based on the past experience can be quite wrong.

Fire statistics e.g. fire loss information from fire incident reports, stored in databases that can be extracted for various statistical analyses (access to databases in our country requires special permission from Ministry of Interior), could provide valuable information for risk assessment. For example, data can be extracted for certain type of occupancy, such as residential buildings. Within that occupancy type, further breakdown of the information can be obtained. For example, fire loss information can be obtained based on the area of fire origin, or source of ignition, or object first ignited and so on. Fire loss information can also be obtained based on the presence or absence of fire protection systems, such as smoke alarms or sprinklers. Following this approach, one can extract statistical information for a specific set of controlling parameters. For example, one can extract statistical information on fires originating in the kitchen in apartment building, with or without alarms or any other preventive measure. This allows the results to be applicable to situations with similar controlling parameters.

3.2. Qualitative fire risk assessment

Qualitative fire risk assessment is based on subjective judgment of not only the probability of a fire hazard or fire scenario occurring, but also the consequence of such a fire hazard or fire scenario. The term fire hazard generally describes any fire situation which is dangerous and which may have potentially serious consequences; whereas the term fire scenario was defined previously as a sequence of fire events that are linked together by whether the fire protection measures succeeded or failed. Qualitative fire risk assessment is usually employed in order to obtain a quick assessment of the potential fire risks in a building and to consider various fire protection measures to minimize these risks.

In qualitative fire risk assessments, there are no numerical values for the probability or consequence that can be used to obtain the product. Instead, the product is assessed using a simple two-dimensional risk matrix (Tab. 1), with one axis representing the level of the probability of occurrence and the other representing the severity of the consequence.

Table 1

Risk matrix diagram, after [7]

PROBABILITY	Anticipated	Negligible Risk	Moderate Risk	High Risk	High Risk
	Unlikely	Negligible Risk	Low Risk	Moderate Risk	High Risk
	Extremely unlikely	Negligible Risk	Low Risk	Low Risk	Moderate Risk
	Beyond extremely unlikely	Negligible Risk	Negligible Risk	Negligible Risk	Negligible Risk
		Negligible	Low	Moderate	High
	CONSEQUENCE				

In general qualitative fire risk assessments may be performed in two ways: (1) a checklist is used to go through the potential fire hazards, the fire protection measures to be considered and the subjective assessment of their fire risks; (2) an event tree is used to go through the potential fire scenarios and the fire protection measures to be considered and the subjective assessment of their fire risks. The outcome in both cases, is a list of potential fire hazards or fire scenarios, the fire protection measures to be considered and their assessed fire risks. In this context, assessed risks are described in qualitative rather than quantitative terms.

The checklist method employs the creation of a checklist of potential fire hazards and the consideration of fire protection measures, either in place or to be added, to arrive at a subjective judgment of the fire risks. The creation of a checklist of potential fire hazards allows a systematic check of potential fire hazards that are in place. The listing of fire protection measures alongside with the potential fire hazards allows a quick check of any safety deficiencies and any need to provide additional fire protection measures to minimize the risk. The checklist method, therefore, is an enumeration of potential fire hazards, fire protection measures, either in place or to be added, and the subjective judgment of the residual fire risks. It is used to identify any deficiencies and any corrective measures needed to minimize the fire risks. It does not include, however, the consideration of the logical development of fire events, which can be discussed using an event tree.

An event tree is another way to identify potential fire hazards, judge their probabilities and consequences and arrive at risk ratings. Different from the checklist method, an event tree shows more than a list of potential fire hazards and fire protection measures for the judgment of the probabilities, consequences and eventually the risk ratings. The event-tree method constructs an event-tree subsequent to the initiation of a fire hazard, which provides more information for the judgment of probability, consequence and risk rating.

3.3. Quantitative fire risk assessment

Quantitative fire risk assessment is an assessment involving numerical quantifications of both the probability of occurrence of a fire hazard or fire scenario, and the consequence of that fire hazard or scenario. The multiplication of the numerical values of probability and consequence gives each fire scenario a numerical fire risk value. The cumulative sum of the risk values from all probable fire scenarios gives an overall fire risk value. The assessed risk can be risk to life, loss of property and so on. Quantitative fire risk assessment allows a numerical comparison of the overall fire risk values of different fire safety designs in a building. It also allows the assessment of equivalency by comparing the fire risk of an alternative fire safety design with that of a code-compliant design.

There are two ways in general of conducting systematic quantitative fire risk assessments: (1) using a checklist to go through a list of potential fire hazards and the quantitative assessment of their fire risks; (2) using an event tree to go through a set of the potential fire scenarios and the quantitative assessment of their fire risks. Within the checklist method, there are specific methods that have been developed by various organizations for their own use. The risk indexing method uses well-defined schedules or tables to rate the risks.

In both the checklist and event-tree methods, the outcome is a list of potential fire hazards or fire scenarios, and their assessed fire risk values. Summation of all these individual risk values gives an overall fire risk value in a building that can be used for comparisons with those of alternative fire safety designs. The quantification of both the parameters was based on statistical data, if they are available, or subjective judgment, if such data are not available. More fundamental and rational approaches to quantification, includes the use of mathematical modeling.

4. HIGH RISE RESIDENTIAL BUILDING FIRE SCENARIO

The group of residential high rise buildings, observed in the case-study, includes three buildings with cellar, ground floor and 14 stories (Fig 2, Fig. 3). Similar groups of two or three buildings with 9 to 14 floors are built at four other locations in Novi Sad city area. These buildings were built in the period from 1968 to 1976, applying “IMS” prefabricated building technology – prestressed reinforced concrete elements, skeleton system. The load bearing construction is designed to be stable in case of fire for at least 2 hours [8].

Possible Fire scenario event tree (Fig. 4) was formulated based on available statistics, building performance, field investigation, survey and findings completed during fire drills, using event-tree method.
According to the available statistics data from 2009 of Fire Brigade Novi Sad (Republic of Serbia, Ministry of Interior, Sector for Emergency Management), 881 fire events, 215 in buildings, were recorded in Novi Sad: 67% residential, 22% offices and 11% others. In residential buildings, 37% fires started in kitchens (forgotten meal on stove or malfunction of kitchen apparatus), and 23% fires started on electrical installations in apartments. In the period 2000-2004 in Novi Sad, the year average number of fires was 750 and 19 deaths in fire. According to that data, the inherent rate of risk for human life in a fire is 0.02533.
Based on statistics of fire events in Serbia in the period 2001 – 2009 (Republic of Serbia Ministry of Interior, Sector for Emergency Management), two main fire hazards in apartment buildings are human negligence and inaccurate or untested electrical installations. Consequently, the inherent rates of fire occurrence for those hazards are 37% and 23% respectively. In both cases, fire initiation barrier can be formulated as fire prevention education for residents in order to raise awareness about fire events and to apply prevention measures: (1) to examine the apartment before leaving it and (2) to test electrical installations regularly, especially when the building is over 40 years old and there are no records of regular maintaining activities or testing.

Figure 2. High-rise residential building with no fire stairs

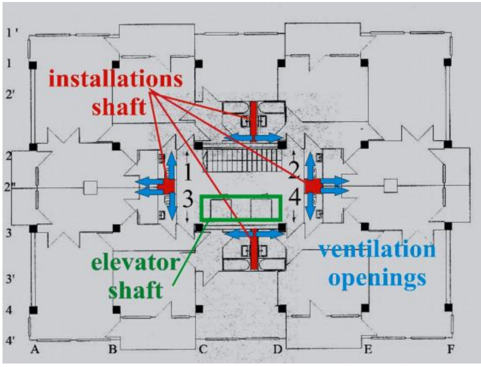

Figure 3. Typical floor layout – 4 apartments

Assumed fire ignition source in fire event scenario is forgotten meal on stove or malfunction of kitchen apparatus when no one is at home.
During the research work on fire safety of residential towers, many contacts with residents, including interviews and polls were included. Only 10% are of opinion that residents are well informed about fire prevention and evacuation, but 5% thinks that residents are trained well about actions in the case of fire and 80% are aware that they are neither prepared nor trained for fire event. So far, fire drills were performed every month in residential towers in Novi Sad city area, but residents lacked attention, although they were notified in advance

and supplied by information leaflets about fire preventive measures. In one specific building, only 10% of residents responded to an appeal to take part in the drill and education process. It is assumed that all of them would apply recommended measures and the probability of successful implementation of measures is 10% while the residual probability multiplier for low fire occurrence is 0.9.

The apartment door is locked. No one is at home to extinguish the initial fire. There are no sprinklers to prevent fire growth to flashover in the apartment.

The whole building is one fire sector: there are no fire or smoke compartments separated or any additional fire barriers. In the case of fire, in every apartment, fire and smoke are easy to spread around and get into the neighbor's apartment and the whole staircase in at least three ways:

- through four vertical installation shafts, each linking half of building's apartments through ventilation openings in bathrooms and commons, and are separated from staircase with a wooden plate;
- through apartment doors made of a wooden plate, into staircase;
- through elevator shaft which is separated from staircase with a 4mm glass wall.

Fire spreading is also possible through apartment walls and façade, but it would take more time then former listed ways. The floor layout design includes no fire stairs, so the only evacuation route is down the main staircase, or they can be trapped in apartments, until the fire brigade comes and rescues them.

Smoke is spreading through ventilation and installation shafts into other apartments in the building.

In time, someone would notice the smoke or fire and try to alarm the residents in other apartments and the Fire brigade. The fire alarm system - manual pull stations were installed once, but some of them disappeared and the rest of them were never checked, so it is incomplete and unreliable. A manual fire alarm system depends on a human factor, which is in most cases unpredictable, but in these circumstances there are no other options to include fire alarms in event scenario. Based on investigation, it can be assumed that the reliability of the fire alarm is 35%.

The most of house fire hydrants (80%) are also damaged and incomplete, so their reliability is questionable, too. Fire brigade, during previous drill, excluded them as a fire protection supply.

Smoke evacuation from staircase is possible only through a one-square-meter large exit opening on the flat roof. Smoke spreading after flashover develops fast into main staircase through apartment door. Single smoke vent on the roof is usually locked, so it cannot be taken into account in event scenario. Staircase becomes a deadly trap, soon after flashover [4]. Emergency light and signalization is badly damaged and incomplete, so it can slow down people movement during evacuation and increase disorientation. Elevators are as old as the buildings, so they are still in function in the case of fire (without an automatic shutdown system), and there is a possibility that someone could try to go down with the elevator. Its shaft would be soon filled up with smoke, and even if the fire does not damage it, it is another trap to residents. It is positive that poll results showed that no one would take a lift in the case of fire.

Residents who took part in the drill and education process knew about it, but the others did not know that it was recommended to evacuate immediately when they spot first signs of smoke and fire, or to block the apartment door and the ventilation openings with wet blankets and stay in their apartments until fire brigade arrives [9]. For that reason, it is assumed that there is only a 10% possibility for fast/safe evacuation.

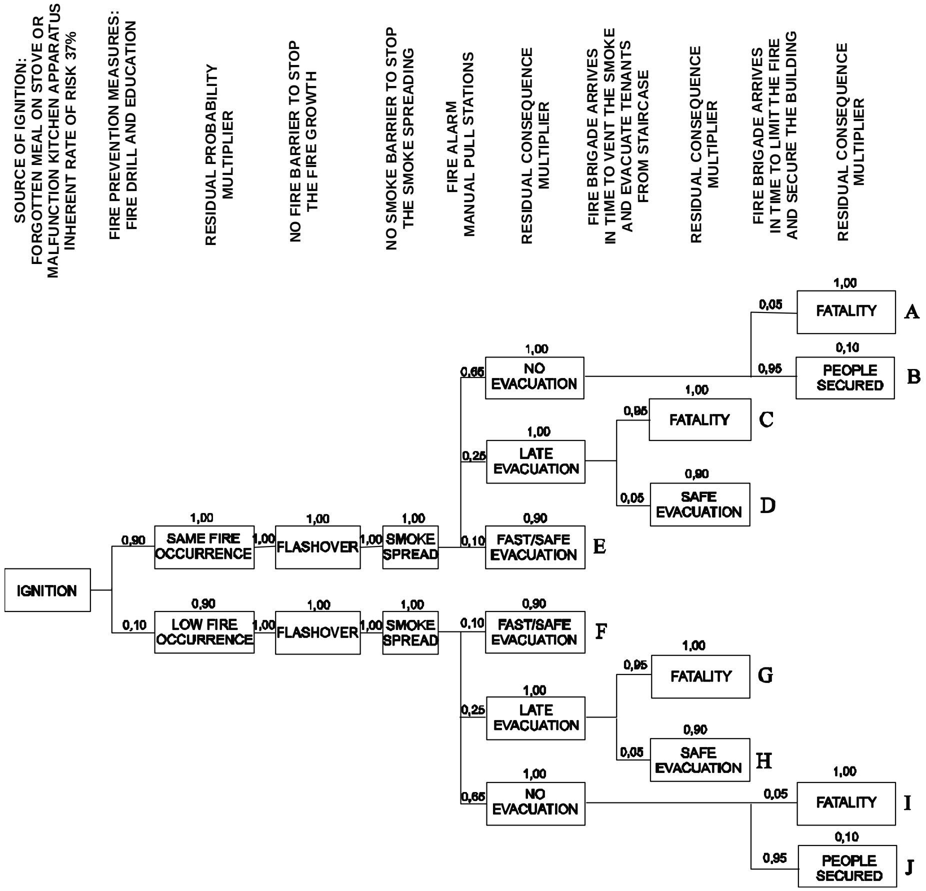

Figure 4. Fire Scenario Event Tree - High-rise residential building with no fire stairs

The results of the poll conducted among residents of high-rise residential building showed that only 25% paid attention on evacuation routes and the sign in their buildings, therefore it is assumed that they will try to take the main staircase. Poll results also showed that 90% of residents will use fire stairs for evacuation - if there is one, and 65% thinks that the fire brigade will come in time to rescue them and they will be waiting in their apartments in the case of fire.
According to the fire department dates and time measuring during the drill, it takes 8 to 10 minutes for the Fire brigade to arrive. Additionally, difficult circumstances are included in arrival time: inappropriate building position regarding approach possibility for fire squad interventions - parked cars or other barriers at access routes, or impossibility to approach some sides of buildings. Their activities are focused on saving lives and limiting fire on actual stage and extinguishing it. Smoke can also slow down fire-fighter teams' intervention and make life-saving operations more difficult. For that reason, first activity the fire brigade

takes is to open the roof door and engage mobile smoke ventilation and suppression facilities.
Fire scenario development after fire brigade arrived is possible in two deferent ways – depending on protection measures: (1) fire brigade came in time to limit and extinguish the fire, but too late to save residents who started late evacuation and (2) Fire brigade came in time to save the residents who started late evacuation through staircase filled with smoke.
The most probable scenario is Scenario B: the best chances to save their lives have the residents who stay in their apartments and wait for fire brigade to come to rescue them.
The most probable fatal consequence scenario is in the case the residents try to evacuate with delay – late evacuation, when the stairway is filled with smoke (Scenario C).
The results of quantitative fire risk assessment for the various fire scenarios in high rise building with no fire stairs, based on event-tree method are presented in Table 2.

Table 2
Assessment of probability, consequence and residual risk values for the various fire scenarios in high rise building with no fire stairs based on event-tree method

Fire Scenario	Scenario Probability	Residual Probability Multiplier	Residual Risk Multiplier	High Risk
A	0.02925	1.00	1.00	0.02925
B	0.55575	1.00	0.90	0.50018
C	0.21375	1.00	1.00	0.21375
D	0.01125	1.00	0.10	0.00112
E	0.09000	1.00	0.90	0.08100
F	0.01000	0.90	0.81	0.00729
G	0.02375	0.90	0.90	0.01924
H	0.00125	0.90	0.09	0.00010
I	0.00325	0.90	0.90	0.00263
J	0.06475	0.90	0.81	0.04502
	1.00			**0.89958**

The fire scenario was formulated according to the present state of building and its fire safety performance (structure, materialization, floor layout, existing route of escape, fume ventilation, etc.) and recorded fire protection measures applied: (1) fire drill and education, (2) manual fire alarm, (3) fire brigade intervention. Combined residual risk multiplier of implementing these three fire protection measures is 0.89958; which means that the residual risk to human lives is reduced to 89.96% of its inherent value. That is, in the case of a fire, protection measures applied so far are insufficient to reduce the risk to an acceptable level.

SUMMARY

Every building is unique for its location, structure, building material and floor layouts, so the fire risk assessment based on fire scenario event tree method assesses different combinations and provides detailed information about success or failure of proposed protection measures, as well as comparison of different combinations.
The assessment of expected occupant fatalities and property loss in a building for a particular fire scenario is achieved by modeling fire growth, smoke spread, fire spread, occupant evacuation and fire department response. Expected risk to life for the occupants is the sum of all expected occupant fatalities from all probable fire scenarios that may occur in a building during the building designed lifetime.

Regular inspection and maintenance of fire protection systems is required in risk-based, or performance-based, fire safety designs. Without such regular maintenance and evacuation drills, the consequence is that the expected risk to life to the occupants is higher than that assumed by the fire safety design. The reliability of fire protection systems can be modeled based on failure rate and service time interval.
The various fire scenarios that a fire initiation can develop into are governed by the success and failure of fire protection measures. The sequence of fire events that follows the course of an actual fire development includes fire growth, smoke spread, occupant evacuation and fire department response. The performance based approach is to follow the logical development of these fire events in specific building.

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APPLICATION OF SERVICE ORIENTED GEOGRAPHIC INFORMATION SYSTEM IN RISK ANALYSIS

Gordana Jakovljević

1. BASIC CONCEPTS

Hazard is a potentially damaging physical event, phenomena and/or human activity, which may cause loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hazards can have different origins: natural (geological, hydrometeorological and biological) and/or inducted by human processes (environmental degradation and technological hazards).

Vulnerability is susceptibility to suffer loss or a set of conditions and processes resulting from physical, social, economic and environmental factors, which increase the susceptibility of a community, an individual, an economy or a structure to the imapct of hazards.

Reference [1] define disaster as "A serious disruption of the functioning of a community or a society involving widespread human, material, or environmental losses and impacts which exceeds the ability of the affected community to cope using only its own resources." Disaster is function of the risk. It results from the combination of hazards, conditions of vulnerability, and insufficient capacity or measures to reduce the potential negative consequences of risk.

Risk is defined as „the combination of the probability of an event and its negative consequences" [1]. The term disaster risk therefore refers to the potential (not actual and realised) disaster losses, in lives, health status, livelihoods, assets and services, which could occur in a particular community or society over some specified future time period resulting from interactions between natural- or human-induced hazards and vulnerable conditions. Disaster risk is the product of the possible damage caused by a hazard due to the vulnerability within a community and is expressed by the notation:

$$\text{Risk} = \text{Hazards} \times \text{Vulnerability} \tag{1}$$

One important consequence of the definition (1) is that a high probability hazard with small consequences has the same risk as a low probability hazard with large consequences.

2. DISASTER RISK MANAGEMENT

Integrated disaster management is an iterative process of decision making regarding prevention of, response to, and recovery from, a disaster. It involvs complex intersections within and between the natural environment, represented by natural system, human populationa, human activity systems that frame actions, reactions and perceptions, and built environment (human made system). Integrated disaster management includes measures for before (prevention, preparedness, risk transfer), during (humanitarian aid, rehabilitation of basic infrastructure, damage assessment) and after disasters (disaster response and reconection) Figure 1.

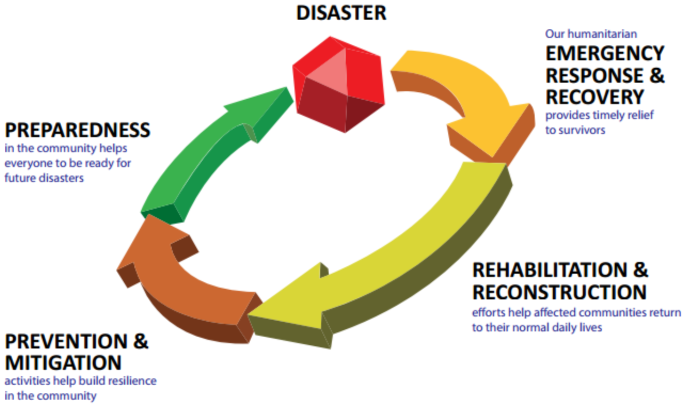

Figure 1. Integrate disaster risk management cycle [2]

Disaster risk reduction (DRR) is development and application of policies, strategies and practices to reduce vulnerabilities and disaster risks throughout systematic efforts to analyse and manage the causal factors of disasters. DRR strategies include, primarily, vulnerability and risk assessment, as well as a number of institutional capacities and operational abilities. Disaster risk management (DRM) is the systematic process of using administrative directives, organisations, and operational skills and capacities to implement strategies, polices and improved coping capacities in order to lessen the adverse impacts of hazards and their possibility of disaster. DRM is more focused on the practical implementation of initiatives to achieve DRR goles [3] i.e. disaster risk reduction concerns activities more focused on a strategic level of management, whereas disaster risk management is the tactical and operational implementation of disaster risk reduction.

Mitigation is long-term planning and it involves identifying the vulnerability of every part of the territory to particular types of hazards, and identificatio of steps that should be taken to minimize the risks. Disaster mitigation measures are those that eliminate or reduce the impacts and risks of hazards through proactive measures taken before an emergency or disaster occurs (hazard mapping, implementing and enforcing building codes, floodplan mapping).

Preparedness for disasters is intended to avoid or reduce loss of life and damage to property if an extreme natural event occurs. Preparedness includes such activities as formulating, testing, and exercising disaster plans; providing training for disaster responders and the general public.

Disaster response activities include emergency sheltering, search and rescue, care of injured, for fighting damage assessment, and other emergency measures. The response phase of the integrated disaster management involves the implementation of the measures developed during the mitigation and preparedness phases.

Disaster recovery (DR) involves a set of policies, tools and procedures to enable the recovery or continuation of vital technology infrastructure and systems following a natural or human-induced disaster.

3. DECISION MAKING PROCESS

In disaster situations, ineffective decisions can lead to great losses (infrastructure destruction, human losses, etc.). Decision analysis is a formal method of identifying, representing and assessing various alternatives to determine the best cours of action. The main protagonists in the decision analysis process are: a decision-maker (person charged with finding solution for decision-making problem), a decision analyst (gives advices and clarification to the decision maker in order to aid the in finding the best decision alternatives) and a stakeholder. Decision-making is an important task in disaster management because it appears in all management activities before, during and after a catastrophic event. Therefore, decision-making represents an activity that aims to reduce the aftermath of a disaster. Decision-making process presents a big challenge for disaster stakeholders and can be devided into following steps: Define the problem, determine requirements, establish objectives, identify alternatives, define criteria (that should be: able to discriminate among the alternatives and support the comparasion of the performance of the alternatives, include all important aspects of the objectives, operational and concise, non-redudant with each criteria its own sifle concept, few in number, measurable, so that the alternatives can be expressed on either a quantitative or qualitative measurement scale), select a decision making tool, evaluate alternatives against criteria and validate solutions against the problem statement.

4. DECISION SUPPORT SYSTEM

Decision Support Systems (DSS) are computer-based tools designed to support management decisions. DSS incorporate modeling or analysis tools along with database managemet systems and user interface which provide access and allows decision makers to combine personal judgment with computer output, in a user-machine interface, to produce meaningful information for support in a decision-making process. Such systems are capable of assisting in solution of all problems (structured, semistructured, and unstructured) using all information available on request [4]. A DSS can be designed as: very specific to a particular decision or component of particular decision (e.g., a watershed nutrient loading model built for a specific watershed), a framework that allowa a particular type of application to be modeled (e.g. watershed management) and generic framework for modeling any type of decision [5]. According to the way in which decision-making is supported there are two types of DSS: Information-Based DSS and Model-Based DSS. For information-based DSSs, decision-making is supported indirectly by providing access to information that is relevant to the decision at hand. Although numerical analysis tools might be involved, the decision component is qualitative. For model-based DSSs, a further step is taken in order to quantitatively support decision making. Basic construction includes building a model structure, specifying the model, and processing the model.

4.1. General structure of DSS

The general components of DSS system are: data component (Data Warehouse, Tools for extracting and filtrating data, query tools), model component (model base for analysis and decision making, tools for analysis and decision-making model building and toold for executing analysing and decision making models) and component for data presentation (Charts, GIS, Virtuar reality). The data component facilitates the merger of data from different sources without explicit instructions from the user how to accomplish this task. Model component of DSS keeps track of all of the possible models (statistical models, sensitiv analysisi models, optimization analysis models,) that might be run during the analysis as well as controls for running the models.

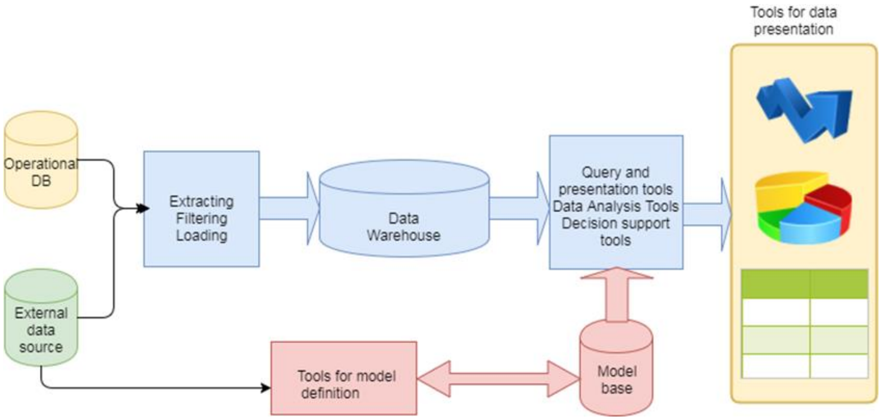

Figure 2. Basic structure of DSS

An operational database contains data about the state of organisation or enterprise in specific time. External database contain data outside the organisation operating system. From external database only data which are significant for decision making are collected. Data generated by algorithms (mean, linear programming) are stored in Model database.
The goal of the DSS is to bring together appropriate business intelligence and models to help that individual to consider a problem or opportunity from more perspectives with better information [7].
Business is collection of activities carried out for whatever purpose while intelligence is defined as "the ability to apprehend the interrelationships of presented facts in such a way as to guide action towards a desired goal." [8] The goal of business intelligence (BI) is to provide managers with information about the business in time to allow them to make decisions that can solve problems or take advantage of opportunities. The BI is the proccess and the systems that create those process is called DSS. In term of DSS, BI describe the emerging practice of transforming raw data from an organization's disparate operational data into a common data warehouse that could be used for discovering and reporting information.
Data Warehouse (DW) is the foundation of all DSS processing. DW doesn't represent the copy of operational database but it contain aggregated and restructure data in such way to support effective query execution. The job of the DSS analyst in the DW environment is immeasurable easier because there is a single integrated source of data to drow from, the granular data in the DW is easily accessible and DW forms a foundation for reusability and reconciliation of data. A data warehouse is a subject-oriented, integrated, nonvolatile, and time-variant collection of data in support of management's decisions [7]. The integration is the most important caracteristics of data warehouse. DW represents a centralized database which contains information about all organizational parts of the company in a standardized format. All data about one entity are stored at one place. Data is fed from multiple, disparate sources into the data warehouse. The data integration is always a complex and tedious task which can be automaticly done by ETL software. Extract, Transform, and Load (ETL) is a process in data warehousing that involves extracting data from outside sources, transforming it to fit business needs, and ultimately loading it into the data warehouse. The application data is integrated as it passes into DW.

The data warehouse is oriented to the major subject areas of the corporation that have been defined in the high-level corporate data model. Each major subject area is physically implemented as a series of related tables in the data warehouse.

Time variancy implies that every unit of data in the data warehouse is accurate as of some moment in time. Time variance implies that every unit of data in the data warehouse is accurate as of some moment in time. Non Volatile means that, once entered into the warehouse, data should not change or delete. More often data are just added to DW.

The data mart is a subset of the data warehouse and is shaped by end-user requirements into a form specifically suited to the needs of the department. Data mart can be defined as Data Warehouse with only one topic.

Data mining is the analysis of (often large) observational data sets to find unsuspected relationships and caracteristics, dependencies, tendencies and summarize the data in novel ways that are both understandable and useful to the data owner [9]. Data mining: analysis operational data, reveals problems or opportunities, hidden in data relations, forming computer models based on these discoveries, and use those models for prediction. Data mining algorithms are based on: statistical methodes (factor, cluster, taxonomy and component analysis), artificial intelligence and neural networks (ANN, CNN, SVM, decision tree), inductive reasoning and prediction logics [9].

Important characteristics of DSS for integrated disaster management include accessibility, flexibility, facilitation, learning, interaction, and ease of use. Decision support systems often do not account for or handle spatial aspects of decision making, and thus extension of the concept of DSS to SDSS has been necessary.

5. SPATIAL DECISION SUPPORT SYSTEM

It is estimated that 80% of data used by managers and decision makers is related geographically [10]. In order to handle different temporal and spatial scales, the majority of DSSs include GIS (Geographic Information System) tools. These specific DSSs are often referred to as Spatial Decision Support Systems (SDSSs) [11]. Spatial data referred to a location on the Earth's and include facts, results of observation, original remote-sensing images all of which are gathered and communicated to the decision maker. At subsequent stage of the decision –making process the original data are interpreted and analyzed to produce information useful to decision makers. The decision situation determines the need and the nature of the information required. Spatial Decision Support System is an interactive computer based system designed to support a user or group of users in achieving a higher effectiveness of decision making [10]. SDSS are explicitly designed to provide the user with a decision-making environment that enables the analysis of geographical and non spatial information to be carried out in the flexible manner. Therefore, SDSS are an extension of DSS concept, with spatial data used for the analysis of decision. Along with generic caracteristics of DSS have four distinguishing capabilities and functions of an SDSS: (1) provide mechanisms for the input of spatial data, (2) allow representation of the spatial relations and structures, (3) include the analytical techniques of spatial analysis, and (4) provide output in a variety of spatial forms, including maps [11]. SDSS aims to improve the effectiveness of decision making by incorporating decision-maker judgments and computer-based programs within the decisionmaking process. The development of SDSS has entailed integrating analytical/decision model with GIS to produce system capable to solving spatial problem.

5.1. SDSS components

SDSS have evolved from DSS and GIS. The database component of DSS deals with nonspatial data collection, management and analysis while GIS porvides spatial and non spatial data collection, storage, management and cartographic display functionalities. The basic structure shown on Figure 2. is in line with SDSS. Spatial data (including geometry, attribute and topology) are stored in operational and external database (which can be accessed trought WMS, WFS and WCS) and DW. GIS tools for the manipulation, storage, management, analysis and visualization of geospatial data are incorporated in such system.

6. GEOGRAPHIC INFORMATION SYSTEM

The GIS subsystem is on of key components of SDSS. A geographic information system (GIS) is a computer system for capturing, storing, querying, analyzing, and displaying geospatial data [12]. Geographical objects are described by two types of data: locational data, which relate the objects to their location in geographical space, and attribute data, which describe other properties of the objects apart from their locations. The world consist of sets of discreate objects, their associated attributes and relationship between objects, if entites are fully definable (e.g. parceles, roads, objects) vector data model was used. For entities that are incompleat, inexact and incompleatly definable (e.g. soil types, vegetation types, elevation) the data model of the world should represent the world as being made up of raster model [12]. GIS database use data model so that geographical data can be stored, manipulated and analyzed. For exact data models, the database contains a set of objects, attributes, relationship between objects and set of rules dafining how they behave (topological realtionship). Both the discrete object and the field models can be implemented by means of the raster and vector data structure.

Data in raster format are stored in a twodimensional matrix of uniform grid cells (pixels). Each cell is supposedly homogeneous, in that the map is incapable of providing information at any resolution finer than the individual cell. Data in vector format are entities represented by strings of coordinates. A point is one coordinate; that is, points on a map are stored in the computer with their “exact” (to the precision of the original map and the storage capacity of the computer) coordinates. Points can be connected to form lines (straight or described by some other parametric function) or chains. A polygon is represented as a set of coordinates at its corners. For example, a point that represents a village or town may have a database entry for its name, size, services, and so on. A line that represents a road may have a database entry for its route number, traffic capacity, emergency route, and so on. A polygon that represents an administrative unit may have a database entry for the various socio economic, environmental, and population characteristics. In the vector representation, the various geographical objects have a definite spatial relation called topology. The topology defines spatial relationships between objects (points, lines, and polygons). It allows a GIS to perform spatial analysis functions on geographical data.

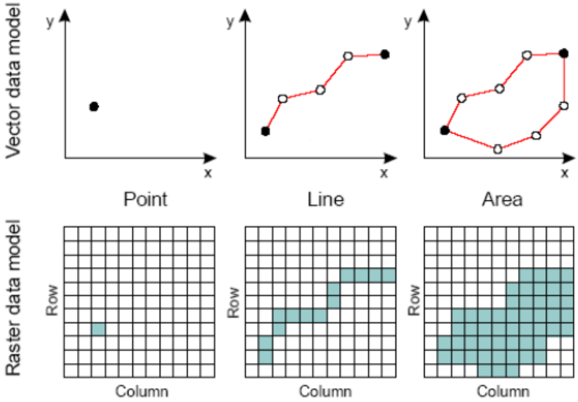

Figure 3. Raster and Vector data model

One of the main strengths of GIS is the ability to store large amounts of non spatial information that are either directly or indirectly related to spatial features. Pieces of information directly related to spatial features are called attributes. A wide variety of characteristics of any vector feature can be recorded in the attribute table of the vector feature class. The ESRI shapefile format (which is made up of anywhere from three to seven files) is an example, with the attribute data being stored in a .dbf (dBase format) and the primitive geometry data stored in the .shp file.
Object-relational databases technology, such as ESRI's Geodatabase, provides an evolutionary approach to the use of objects in databases by building on established relational database research results. The relational database method stores data in a tabla. An advantage is that these methods are based on standard technologies, allowing easy transfer and ease in using technologies such as the Structured Query Language (SQL). Object-oriented data model allows complex data type. Both object-oriented databases and object-relational databases, collectively known as object databases, provide inherent support for object features, such as object identity, classes, inheritance hierarchies, and associations between classes using object references. An object is an abstract concept, generally representing an entity of interest in the enterprise to be modeled by a database application. An object has state and behavior. The state of an object describes the descriptive properties of the object (such as an identifier, a name, and an address). The behavior of an object is the set of methods that are used to create, access, and manipulate the object. Objects having the same state and behavior are described by a class. A class essentially defines the type of the object where each object is viewed as an instance of the class.

7. GEOGRAPHIC INFORMATION SYSTEM

The traditional GIS applications conventionally used to access and analyze local data do not have the ability to interact with online data sources and with other spatial analysis applications [13]. The nature of the geographical applications, especially in the case of disasters management, requires seamless integration and sharing of spatial data from a variety of providers. Interoperability of services across organizations and providers is a main goal for GIS. According to OGC interoperability is defined as capability to communicate, execute programs, or transfer data among various functional units in the manner that requires the user to have little or no knowledge of the unique caracteristics of

those units i.e. interoperability enables the integration of data between organizations resulting in generation and sharing of information and reduce redundancy [14].
Distributed GIS builted around the principles of Service Oriented Architecture is being used to share crucial informations across organizational boundaries via the Internet and emergence of Web services. SOA is an architectural style for building software applications that use services available in a networke such as Web. SOA concept has three components: service provider, service registry and service requester and three operations: publish, find and bind. A SOA relates the roles of three components with three operations to maintain automated discovery and use o services. In contrast of standard GIS applications where normally only a small percentage of the functions in the software are used, application based on SOA provide with just the functionality they needed. Another prominent intention of the design of a SOA is data used for given processing activity are not stored locally, but rather decentralized close to the source of production. The key component in the SOA is services. A service is well defined set of actions. It is a self contained, stateless and does not depend on the state of other services. The implementation of SOA in the web enviroment is called web services. The concept of Web services is based on SOA paradigme where a complete application can be constructed from various services which provide different functionality. In order to create SOA architecture for the GIS services it is necessary to create web services correspondences of each GIS services. GIS services can be grouped into three categories [15]: GIS data services are tightly coupled with specific data sets and offer access to customized portions of that data. Web Feature Service (WFS), Web Feature Service-Transactional (WFS-T), Web Mapping Service (WMS) and Web Coverage Service (WCS) can be considered in this group. WMS produces maps as two-dimensional visual portrayals of geospatial data. WCS provides access to un-rendered geospatial information (raster data). WFS provides geospatial feature data (vector data) encoded in Geography Markup Language (GML) whereas WFS-T enables editing feature coordinate geometry (i.e position and shape) and related descriptive information (i.e. attribute values), as well. Processing Services provide operations for processing or transforming data in a manner determined by user-specific parameters. They provide generic processing functions such as projection and coordinate conversion, rasterization and vectorization. Coverage Portrayal Service (CPS), Coordinate Transformation Service (CTS), and even WMS can be considered in this group.
Registry or Catalog Service allows users and applications to classify, register, describe, search, maintain, and access information about Web Services. Web Registry Service (WRS) and Catalog Service for the Web (CS-W) are considered in this group [16].

8. APPLICATION OF GIS AND GEOSPATIAL DATA IN DISASTER RISK MANAGEMENT

GIS services and tools are used in all phases of disaster risk management. Figure 4 specify application of spatial data and GIS in different phases of disaster risk management.

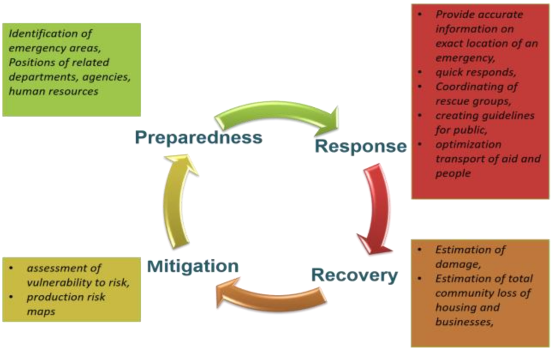

Figure 4. Application of GIS in disaster risk management

Featuremore, develepment of IT technology and launching of Earth Observation satallites, which provide data with different spatial, spectral and temporal resolution over large geographic areas, made disaster risk management unimaginable without integration of satellite images and GIS technology represent nowadays. Remote sensing data has been widly used for detection of burned area, monitoring of floods, landslids, volcaninc eruption ect. The usability of multispectral satalite in disaster risk management is limited by spatia and temporal resolution, spectral characteristics of sensor and presence of haze and clouds. The type and resolution of needed date is determined by characteristics of disaster type. Table 1. lists the necessary data, required accuracy and sensor characteristics for different types of natural disasters.

Table 1
Necessary information for natural disaster management

Occurrence / Need	Earthquake	Volcanic eruptions	Landslide	Tsunami	Flood	Hurricane
Necessary information	Geological and land use maps	Maps of areas endangered by lava, ash and fire	Tilt maps, terrain stability, digital height model, geological and land use maps, standing water areas	Bathymetric/ topographic maps	Maps of flooded areas, land use, land cover, and land humidity	Maps of land use
Spectral channels	Visible and NIR	Visible, close infrared and thermal IR	Visible	Visible including blue and close infrared spectrum	Thermal and close infrared and microwaves	Visible and closely infrared
Spatial resolution	20-80 m	30-80 m	10-30 m	30m	20 m for urban area, 30-80 m for agricultural area	20 m for urban, 30-80 m for agricultural area
Area size	Large areas	Large areas	Large areas	Large areas	Large areas	Large areas
Frequency of observation for planning	1 to 5 years	1 to 5 years	1 to 5 years	1 to 5 years	Per season	Per year

9. SOURCE OF SPATIAL DATA

Major source of spatial data are: remote sensing, aerial photographs, GNNS measurement, other point measurement, digitizing and scanning paper maps. Those data source can be categorized as: official government data (land parcels, objects, ownerships, pipelines, roads), commertial (areal images, DEM, satellite images (WorldView, Quicbird, Rapideye...)) and open data. The provision of data in freely available and reusable formats and under the provision of open licenses (without any restriction both in terms of access and fee) is called open data. The free, full and open data policy adopted for Copernicus, Landsat and Terra programs has granted access to the Sentinel 1-2, Landsat 4-8, MODIS, MERSI, ASTER data products providing global coverage of high, medium and low spatial resolution, optical and radar, images and digital elevation model. Volunteered geographic information (VGI) is the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals. Some examples of this phenomenon are WikiMapia, OpenStreerMap (OSM) and Yandex. The aim of OSM is to create and provide free geographic data in vector format [17]. In addition, the Humanitarian OpenStreetMap Team (HOT) applies the principles of open source and open data sharing for humanitarian response and economic development by providing free, up-to-date maps that are a critical resource when relief organizations are responding to disasters or political crises [17]. Over the years, OSM, Sentinel 1-2, and Landsat image have turned out to be a serious geodata alternative for different applications and was used in a wide range of geographic information systems (GIS) and applications especially in disaster management.

10. MULTI-CRITERIA DECISION ANALYSIS (MCDA)

One instrument that permits the development of a DSS is MCDA [5]. It is capable of taking into consideration all of the variables present in the decision process. Multi-criteria decision analysis (MCDA) is discipline that encompasses mathematics, management, informatics, psychology, social science, economics and it includes a large class of methods for the evaluation and ranking or selection of different alternatives that considers all the aspects of a decision problem involving many actors [18]. MCDA permits the combination of quantitative and qualitative inputs like risks, costs, benefits, and stakeholder views while MCDA algorithms are designed to synthesize a wide variety of information and raise awareness of the tradeoffs that must be made between competing projects objectives. MCDA techinques can be categorised as: Multi-objectiv Decision Analysis (MODA) and Multi-Attribute Decision Analysis (MADA) [5] (Figure 3). Main difference between MADA and MODA are presented in Table 2.

Table 2
Difference between MADA [5]

MADA	MODA
„discrete environment“in which the decisions are selected from a finite number of possible alternatives	„continuous environment“ in which a linear function is created and optimized for reaching the proposed objectives
considers the ‘‘attributes’’ that are measurable values, expressed as a nominal scale, ordinal scale, or comparison scale	considers ‘‘objectives’’ that represent the improving level of the attributes, in this case maximizing or minimizing the functions that are concerned with the attributes (minimizing costs or maximizing earnings)

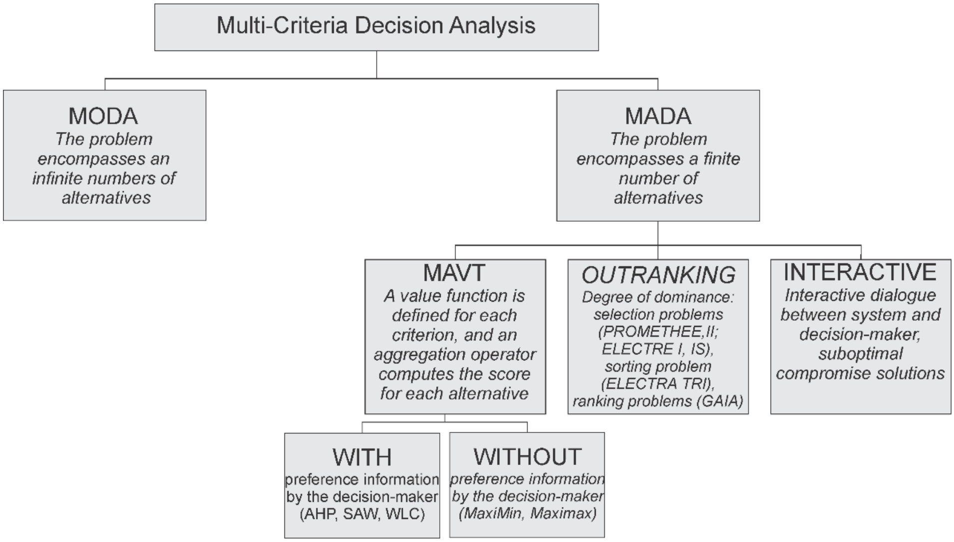

Figure 5. A classification of MCDA problems and methods

10.1. Multiple attribute utility/value theory (MAVT)

Multiple attribute utility/value theory (MAVT) constructs a utility/value function for each criterion. The value functions (sometimes also called ''utility'' functions) convert the attribute values into a common scale, and then these numerical values are aggregated into the final score [5]. Many methods exist to define the value function. The next step consists of the aggregation of this normalized data into a single numerical output, the score of the alternative, or of an intermediate level node of the decision tree, if a hierarchical structure is defined. To this purpose, an Aggregation Operator needs to be defined, that is a multi-dimensional function that satisfies a set of rationality axioms.

11. APPLICATION OF SERVICE ORIENTED GIS IN FOREST FIRE RISK ASSESSMENT

Forest fires are considered to be natural disasters. The causes of fire are most often directly related to human activities, such as negligence, carelessness, accident or arson on the forest areas. Recent research of JRC Technical Reports shows that, due to climate change increasing air temperature and decreasing of humidity, could double the area affected by forest fires in Europe [19]. This fact rises concern and initiates serious analysis of this fenomen and preventive modeling of forest fire risk. The production of forest fire risk map was divided into following steps:

Definition of the problem: Bosnia and Herzegovina is a country with a high risk of forest fires. Acording to European Forest Fire Information System's report, Bosnia and Herzegovina is on high four places, right behind Algeria, Spain and Portugal according to areas which were burned by fire [19]. The aim is production of forest fire risk map. Forest fire risk zones are locations where a fire is highly likely to start, and from where it can easily spread to neighborhood area. Identification of those zones helps us to discover areas with increased risk of forest fire occurrence and its development, which is the base for emergency intervention planning. This creates favorable conditions for minimizing the number of fires and to remove conditions for their formation. Modern tools and technologies in combination with traditional knowledge could have great importance in prevention and forest fire control.

Identification of alternatives: According to suitability for forest fire the five alternatives are defined: very low, low, moderate, high and very high suitability for forest fire ignition.

Identification of criteria: Therefore, in order to reach the right conclusions, causative factors for spreading of fire and the possibility of their extinguishing, was defined based on knowladge database, expert opinion and data mining. The 8 criteria grouped in 4 clusters which are vital for starting of fire and forest fire risk assessment in Municipality of Trebinje are shown in Table 3.

Table 3
Criteria description

Cluster	Criteria	Description criteria
K1 Land use	C1	*Vegetation*. The Vegetation is crucial for the fire spreading because it represents the total fuel available for the fire [20].
K2 Topography	C2	*Aspect.* Generally, in the north hemisphere, south and southeast aspects are the most suitable for both, ignition and spreading of fire [21], they receive more direct sunlight and because of that they have a higher temperature and a minor humidity.
	C3	*Slope.* Slope affects speed and capability of firefighter and equipment movement and there for speed of fire extinguishing. increasing of the slope for 10% can double the rate of the fire spreading.
	C4	*Elevation.* Elevation is associated with wind behavior and fire spreading it's affects a structure of vegetation, total fuel available for fire, air humidity and temperature.
K3 Climate	C5	*Mean annual air temperature.* Air temperature is one of the most important climate factors. Fires can occur at any temperature, but their number depends on increasing of the temperature [22].
	C6	*Mean annual precipitation.* Precipitation is an important factor which influences suitability for ignition and fire spreading.
K4 Socioeconomic	C7	*Distance from roads.* The roads are a significant factor because their presence means human activity, therefore the forest near roads have a higher risk of forest fires.
	C8	*Distance from settlements*. It was found that the man is the main cause of the fire, so it was logical that with increasing of distance from human's residence the number of fires would decrease.

Define decision making tool: Weighted Linear Combination is one of widely used Multi Criteria Decision Analysis method for analysing land suitability. One of the weaknesses of WLC is in establishing the weights effectively and in realistic fashion without user bias. To address this shortcoming, another multiattribute technique that has often been used in spatial

decision- making processes and SDSS applications is the Analytical Hierarchy Process (AHP).
AHP is a very popular method, originally developed by Saaty [23]. It is flexible because it provide that for complex problems with large number of criteria and alternatives it is relativy easy to finde relation between factors, recognizes their explicit or relative influence and importance in real terms and determines the dominance of one factor relative to the other. Methodologically speaking, the AHP is a multi criteria technique based on the interpretation of a complex problem in the hierarchy structure. The decision hierarchy is structured from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).

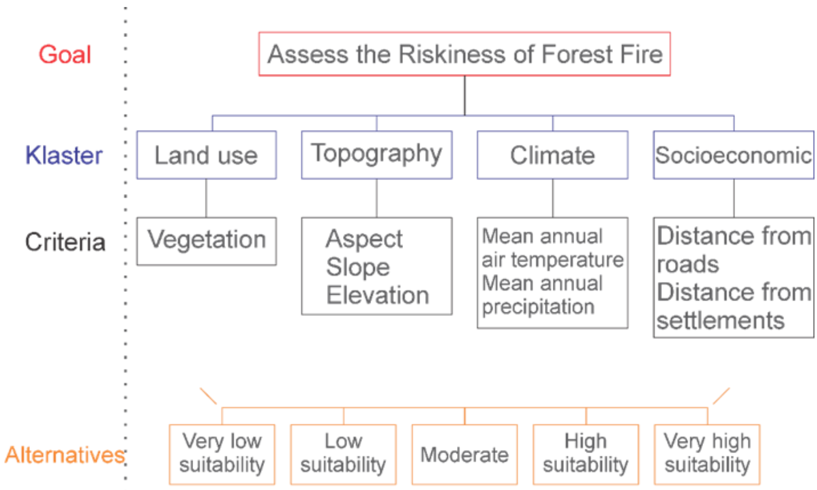

Figure 6. Hierarchy structure of the forest fire risk prediction

AHP first requires construction of pairwise comparison matrices and calculation of their weight with regard to goal. The goal is at the top of the hierarchy and it is not comparable. At the first level, n criteria were compared in pairs and with respect to a pattern element at a higher level. If an element A is n times preferred over B, then B is preferred 1/n over A [23]. The comparison of two elements of the hierarchy, at the same level, is performed using Saaty's fundamental scale with 9 levels of relative importance [23].
Observing the defined goal, for each pair of the criteria, the importance of one over the other are entered in the matrix of comparison. In this way, the amounts of cells along the matrix diagonal is 1. Based on comparison matrix the weight of the weigh priorities in the level immediately below was calculated. Then for each element in the level below weighed values are added in order to obtain its overall or global priority. In a completely consistent evaluation, the pairwise comparison matrix A, containing the comparison results, would be identical to the matrix X:

$$X = \begin{bmatrix} \frac{w_1}{w_1} & \cdots & \frac{w_1}{w_n} \\ \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \cdots & \frac{w_n}{w_1} \end{bmatrix} \quad (2)$$

where wi denotes the relative weighted coefficient of the element i. The weight vector wi can be calculated by solving the following system of homogeneous linear equations:

$$A \cdot w = n \cdot w \text{ or} \quad (3)$$

$$(A - n \cdot I) \cdot w = 0 \quad (4)$$

where n is the eigenvalue of the comparison matrix A. Comparison matrix at the cluster and criteria levels are shown in Table 4. and Table 5.

Table 4
Comparison matrix and weights to clusters

Cluster	K1	K2	K3	K4	w_i
Land use (K1)	1	3	4	2	0,450
Topography (K2)	1/3	1	2	1/3	0,142
Climate (K3)	1/4	1/2	1	1/4	0,087
Socioeconomic (K4)	1/2	3	4	1	0,321
λ_{max}=4,108 CI= 0,036 CR= 0,040					

Table 5
Comparison matrix and weights to criteria

Criteria		C2	C3	C4	w_i
Aspect (C2)		1	3	4	0,623
Slope (C3)		1/3	1	2	0,239
Elevation (C4)		1/4	1/2	1	0,138
λ_{max}=3,026 CI= 0,013 CR= 0,022					

Criteria	C5	C6	w_i
Mean annual air temperature (1981-2010) (C5)	1	3	0,750
Mean annual precipitation (1981-2010) (C6)	1/3	1	0,250

Criteria	C7	C8	w_i
Distance from roads (C7)	1	3	0,750
Distance of settlements (C8)	1/3	1	0,250

The final Forest fire risk map was calculated by the Weighted Linaear Combination. Application of weighted linear combination (WLC) requires that all data sets are standardized (reclassified) [24] in units that are comparable (same numerical scale). There are a large number of approaches that can be used in order to make map attribute layers comparable, and some of them are described in Malczewski [10]. In accordance with the practice, the experts' experience and literature, the suitability of criteria, in this study, was performed using linear standardization on a score from 1 to 5, where 5 is the highest risk and 1 is lowest risk value of alternatives (a cell) for the ignition of the fire. Standardized criteria, with a defined class values are shown in Table 6.

Table 6
Standardization criteria

Criteria	Intensity of importance				
	1	2	3	4	5
	very low	low	moderate	high	very high
C1*	(512)	(112,332,333)	(211,242,243)	(222,231,321,324)	(311,312,313)
C2	N	NE, NW	E, W	Flat, SE	S, SW
C3	0-5º	5-15º	15-25º	25-35º	>35º
C4	0-200 m	200-400 m	400-600 m	600-800 m	>800 m
C5	< 10 Cº	10-15 Cº	15-20 Cº	20-25 Cº	>25 Cº
C6	>1750 mm	1500-1750 mm	1250-1500 mm	1000-1250 mm	< 1000 mm
C7	>1200 m	900-1200 m	600-900 m	300-600 m	0-300 m
C8	>2000 m	1500-2000 m	1000-1500 m	500-1000 m	0-500 m

The preparation of criteria layers and final forest fire risk map generation was preformed in open source software QGIS. The information of defined criteria are obtained from different sources. Corine Land Cover map was used as source of vegetation layer. Digital elevation model, obtained from USGS, was used as a source for topography cluster. Based on the DEM and Terrain analysis tool in the QGIS slop (Slop function) and aspect layer (Aspect function) was created. OpenStreetMap database is used for obtaining information about settlements and roads. The zones defined in Table 5. are created by using Buffer tool. After that vector layers are rasterized and reclassify in the scale from 1 to 5.

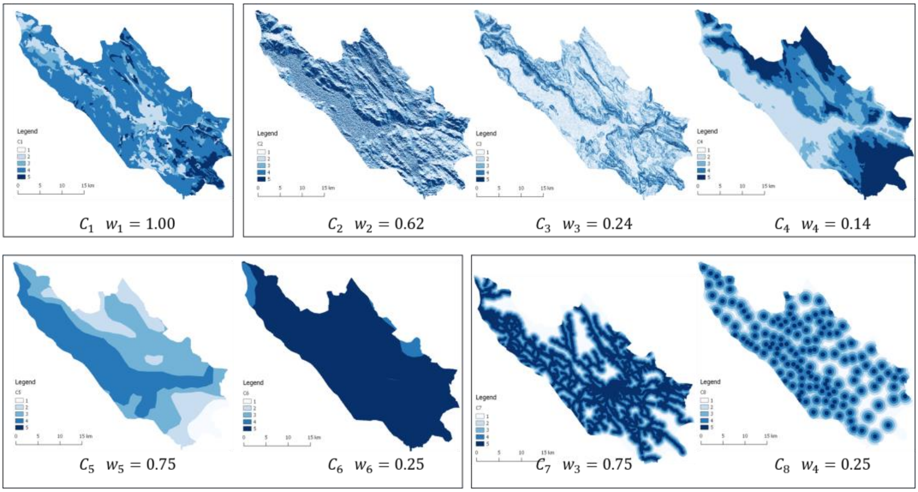

Figure 7. Standardized criteria

As a result of multiplying weight criteria obtained as a result of AHP, with a cell's score of each criterion by appling Weighted Linear Combination (WLC), that is integrated into Easy AHP tool, according to the formula (5) the final forest fire risk map is generated.

$$S = \Sigma\, w_i \cdot x_i \quad (5)$$

where S is the fire hazard rating, wi is normalized weight of factor i, and xi is the criterion score of factor i.

Based on defined criterias and clusters, final map is represented in the same score as criteria from 1 to 5 (Figure 8). Larger values of cells score are characterized for location with high risk of fire ignition. On Figure 7 areas that are the most critical when it comes to the spread of fire are represented with dark colors.
Analyzing the results, the total area of the most endangered area (value of cell 5) of forest fire in Municipality of Trebinje is 163.08 km^2, which is about 19.17% of its territory. Mainly, those areas are the parts of the municipality which are located near settlements on steep slopes and that are mostly covered by pastures and conifer forests.

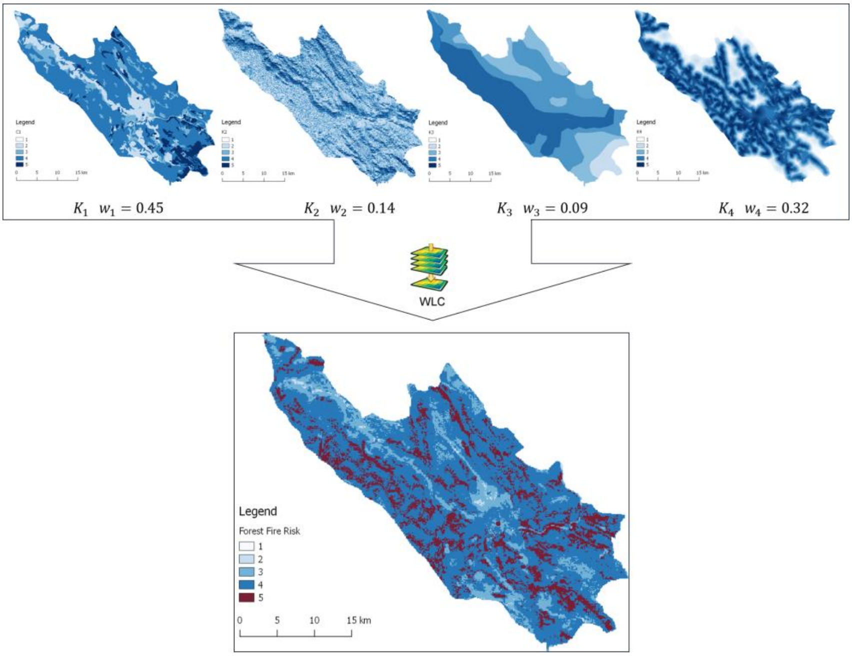

Figure 8. Aggregation of forest fire risk map, municipality of Trebinje

Validation of proposed method was performed by using forest fire map created based on Sentinel 2 satallite images. The object based image analysis and Neural Networks was used for extraction of burned area from Sentinel 2 images obtained in 24.06.2017. The coparasion of predicted forest fire risk zones and extracted burned areas is shown at figure 9.

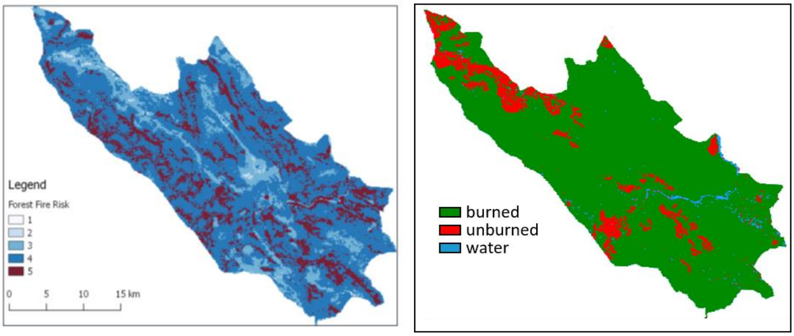

Figure 9. Predicted vs. Burned area

SUMMARY

The measurement and assessment of the evolving risk environment is the base for the creation of comprehensive, proactive instriments that enable the prioritization of risk reduction investments. Hazard mapps is one of most used measure that provide information needed for respons and recovery from disasters. Disaster managemet and hazard mapping requires seamless integration and sharing of spatial data from a variety of providers. Therefor, Spatial Decission Support System which integrates Service Orientrd GIS and decision analysis tools (several MCDA methods) is needed to support decision maker. In this case, combination of SO GIS and AHP MCDA method is used to determine forest fire risk zone in the municipality of Trebinje.

Prediction of forest fires was carried out on 8 criteria grouped in four clusters (land use, topography, climate and socio-economic). The AHP multicriteria method is used to calculate a correspondent weight of criteria. Comparisons matrix are based on the experience of experts, literature and current practice. The final risk map is obtained in the WLC methods. Approximately 19.1% of the Municipality of Trebinje area belongs to the zone of very high, 66.5% of the zone of high, 13.8% moderate zone, 0.5 % of the low zone and 0% zone of very low risk of fire. For validation spatial relationship between forest fire risk map and historical data was performed.

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Additional Case Studies and Original Research

FIRE RESISTANCE DESIGN CASE STUDY - INFLUENCE OF DESIGN PARAMETER IN FIRE SAFETY OF STRUCTURAL STEEL BEAMS

Endrit Hoxha

1. INTRODUCTION

A large number of dramatic fires have been the reason of the evolution of structural fire engineering within the construction industry. In 1967 around 300 people died as a result of a fire at the Innovation supermarket in Brussels. In Vienna, Austria in 1979, at the Augarten Hotel, 25 people were killed by the smoke of the fire. In 1980, at the psychiatric hospital in Górna, Poland 55 in-patients died, while one year later, 14 people died at the gastronomic complex in Szczecin. Another dramatic fire occurred in 1994, at the show hall in GdaMsk Shipyard, where seven people lost their lives [1]. In addition to the lives lost, there was also an estimated material damage counting up to millions of euros in losses. These consequences and the high risk of fire accruement have led to the development of regulations and codes.

Historically, the issues of fire have been within the remit of the architects, but nowadays with the development of codes and regulations, structural engineers are responsible for fire safety analysis [2]. In Europe, methods of evaluation of structures for fire are given in Eurocodes. Respectively, methods and rules for fire safety analysis for reinforced concrete structures, steel, composite, timber, masonry and aluminum structures are described in part 1.2 of Eurocode EC-2, EC-3, EC-3, EC-4, EC-5, EC-6 and EC-9 [3-8]. Within building structural typology, that of steel is the weakest to resist in case of fire. For this reason, several researches are published regarding the properties analysis of steel in high temperature [9-11] and proposed active and passive strategies for increasing fire resistance [12-13]. However, based on a literature review and current knowledge, none of the studies have tried to identify and then rank the design parameters influencing these structures' fire resistance. For this reason, the aim of this paper is to analyze the influence of design parameters in fire resistance of steel beams.

2. METHOD

Influences of design parameters in structural fire resistance of steel beams are evaluated with the help of the critical temperature approach [14] and sensitivity analysis [15]. Firstly, the fire resistance of a set of scenarios is evaluated, created by randomly changing the design parameters of the building, one at a time, while keeping all other parameters constant. Then, the relative influences of design parameters (span, combination coefficients, self weight and section factor) are repeatedly calculated until the steel beams' critical temperature is reached.

2.1. Fire resistance assessment of steel beam

Critical temperature methodology is used for the evaluation of the fire resistance of steel beams in terms of resistance capacity, critical temperature and time duration. Inspired mainly from [14, 16], the methodology includes seven steps and follows the equation recommended by Eurocodes [4].

Step 1: Initially, the permanent and imposed loads applied to the structural element of the building are evaluated. Imposed loads for different categories of use and permanent actions which are calculated by nominal values of materials' densities and their dimensions, are taken from EC-1-1-1.

Step 2: Since the loads do not act at the same time on the structural elements, their most probable combination for ultimate limit state and accidental design situations for the fire case are evaluated.

For the ultimate limit state, the combination of the action is calculated by the formula:

$$\sum_{j\geq 1} \gamma_{G,j} \cdot G_{k,j} + \gamma_P \cdot P + \gamma_{Q,1} \cdot Q_{k,1} + \sum_{i\geq 1} \gamma_{Q,i} \cdot \psi_{0,i} \cdot Q_{k,i} \qquad (1)$$

And for the accidental design situation:

$$\sum_{j\geq 1} G_{k,j} + P + \left(\psi_{1,1} \text{ or } \psi_{2,1}\right) \cdot Q_{k,1} + \sum_{i\geq 1} \psi_{2,1} \cdot Q_{k,i} \qquad (2)$$

Where:

- $G_{k,j}$ - present characteristic permanent action,
- $\gamma_{G,j}$ - partial factor for permanent action j,
- P - relevant representative value of a prestressing action,
- γ_P - partial factor for prestressing actions,
- $Q_{k,1}$ - leading variable action,
- $\gamma_{Q,1}$ - partial factor for leading variable action,
- $Q_{k,i}$ - characteristic variable action,
- $\gamma_{Q,i}$ - partial factor for variable action i,
- $\psi_{0,i}$ - factor for combination values of a variable action,
- $\Psi_{1,1}$ or $\Psi_{1,1}$ - combination values should be related to the relevant accidental design situation.

Step 3: A pre-dimensions of the thickness of the composite slab is evaluated based in the internal loads for ultimate limit state design combination. Approximately [17] is calculated with the help of the equation:

$$h \geq \frac{M_{Rd}}{A_{pl} \cdot f_{yP,d}} + e + 0.5 \cdot \frac{A_{pl} \cdot f_{yP,d}}{0.85 \cdot f_{cd} \cdot b} \qquad (3)$$

Where:

- A_{pl} - effective cross-sectional area of the profiled steel sheeting,
- $f_{yP,d}$ - design value of the yield strength of the profiled steel sheeting,
- f_{cd} - design value of the cylinder compressive strength of concrete,
- b - width of the element,
- e - distance of centroidal axis of the profiled steel sheeting from lower sheet,
- M_{Rd} - design value of the resistance moment of a composite section or joint.

In additional, EC-4-1-1recommends that the minimal overall depth of the slab should not be lower than 90mm and the minimal thickness of the concrete 50mm.Thickness of the profiled steel sheeting must also admit fire resistance criterion. A simplified procedure for the evaluation of this thickness is described in [14].
While the dimensions of double-Tee steel beam are approximately evaluated with the following equation:

$$W_{pl} \geq \frac{M_{pl,Rd} \cdot \gamma_{M0}}{f_y} \tag{4}$$

Based in the moment of resistance calculated with equation (4) the properties of the most adequate cross section are found in tables given by ().
Step 4: Critical temperature that the steel beam can reach in order to respect also the resistance criteria is evaluated with the equation:

$$\theta_{cr} = 39.19 \ln\left(\frac{1}{0.9674 \cdot \mu_0^{3.833}} - 1\right) + 48 \tag{5}$$

Where:

- $\mu_{0,M}$ - present the degree of utilization of steel beam and is evaluated:

$$\mu_{0,M} = \frac{M_{fi,d,t}}{M_{Rd}} \cdot \frac{\gamma_{M0}}{\gamma_{M,fi}} \tag{6}$$

Step 5: Finally, the temperature-time curve for the steel beam is found from:

$$\Delta T_s = \frac{0.9 \cdot (F/V)_b}{\rho_s \cdot c_s} \left[h_c \cdot (T_g - T_s) + \sigma \cdot \varepsilon \cdot \left((T_g + 273)^4 - (T_s + 273)^4 \right) \right] \tag{7}$$

Where:

- T_s - temperature of the steel beam (at $t = 0s$ the value of),
- ρ_s - density of the steel (7850 kg/m^3),
- σ - Stefan-Boltzmann constant (56.7x10^{-12}kW/m^{2}K),
- ε - emissivity (0.7 for the steel),
- h_c - convective heat transfer coefficient (25W/m^{2}K of standard fire),
- $(F/V)_b$ - box value of the section factor,
- T_g - temperature of the fire.

According ISO-834 standard (4) the temperature-time fire curve is calculated:

$$T_g = 20 + 345 \cdot \log(8 \cdot t + 1) \tag{8}$$

Where:

- c_s - specific of the steel calculated by the following equation:

$$
\begin{aligned}
c_s &= 425 + 0.773T - 1.69x10^{-3}T^2 + 2.22x10^{-6}T^3 \quad 20^{\circ}C \le T < 600^{\circ}C \\
&= 666 + 13002/(738 - T) \quad 600^{\circ}C \le T < 735^{\circ}C \\
&= 545 + 17820/(T - 731) \quad 735^{\circ}C \le T < 900^{\circ}C \\
&= 650 \quad 900^{\circ}C \le T \le 1200^{\circ}C
\end{aligned}
\tag{9}
$$

At the end, based in temperature-time curve is found the time that the steel beam can last in order to not pass the critical temperature and consequently to respect the resistance capacity.

2.2. Fire resistance assessment of steel beam

Equation used for the assessment of the contribution of design parameters to the fire safety resistance has the form:

$$
R_C = \frac{R_{time\ resistance}}{R_{design\ parameter}} = \frac{\dfrac{T_{\max} - T_{\min}}{T_{\max}}}{\dfrac{D_{\max} - D_{\min}}{D_{\max}}} \tag{10}
$$

Where:

- $D_{\max}$ - maximal value of design parameter,
- $D_{\min}$ - minimal value of design parameter,
- $T_{\max}$ - maximal time resistance corresponding to the maximal value of design parameter,
- $T_{\min}$ - minimal time resistance corresponding to minimal value of design parameter.

3. CASE STUDY

The methodology described in the previous section is applied to a simple support beam of the compartment presented in Figure 1. For this study a double-T cross section with yield strength of 275N/mm^2 is considered. The floor is designed as composite slab of type Cofrastra-70 from Arcelor Mittal producer [19]. Steel sheeting has a height of 7.3mm and yield strength of 350 N/mm², while the concrete poured above the sheet is of the type C25/30. The overall height of the slab and the dimensions of the steel beam are calculated based on the ultimate limit state and accidental load combination (fire safety resistance).

In the following example the dimensions of slab and steel beam for a span of 3 m are calculated by applying the step by step method. First the permanent and variable loads applied on the slab which are summarized in Table 1 are calculated. Overall height of the composite slab is pre-considered to be 13cm with reinforced ϕ8 in the corrugation part and ϕ16 above the support. The steel sheet is chosen with a thickness of 0.75mm. Then, the capacity of the slab is checked, with the help of Bimware MASTER EC-4' software [20] for an ultimate limit state (ULS) load combination.

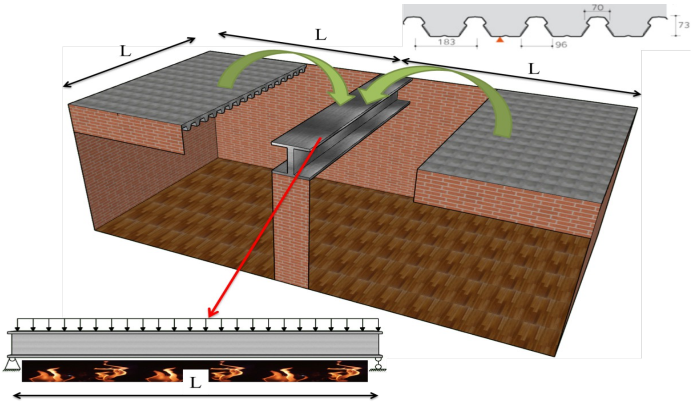

Figure 1. Details of the compartment and its elements

Table 1
Permanent and variable loads of the slab

Typology	Material (layer)	Thickness (m)	Loads (kg/m2)
Permanent	Cement layer	0.03	65
	Vapor layer	0.0002	0.2
	Glass wool	0.02	2
	Polyethylene	0.0002	0.2
	Concrete slab	0.13	250
	Steel sheet	0.00075	10
	Total	327.5	
Variable	Partitions weight	80	
	Permanent load for offices	250	

After the dimension of the slab for ULS combination of load and fire safety, the load applied to the steel beam is estimated. Distribution load for the ultimate limit state combination applied to the beam is valued at:

$$q_{fi,S} = \left(\sum_{j \geq 1} \gamma_{G,j} \cdot G_{k,j} + \sum_{i \geq 1} \gamma_{Q,i} \cdot Q_{k,i} \right) \cdot L = \left(1.35 \cdot 3.3 + 1.5 \cdot (0.8 + 2.5)\right) \cdot 3 \approx 28 kN/ml \quad (11)$$

And distribution load for accidental combination applied to the beam has the value:

$$q_{acc} = \left(\sum_{j \geq 1} G_{k,j} + \sum_{i \geq 1} \psi_{2,1} \cdot Q_{k,i} \right) \cdot L = \left(1 \cdot 3.3 + 0.3 \cdot (0.8 + 2.5)\right) \cdot 3 \approx 12.9 kN/ml \quad (12)$$

For a simple beam the corresponding internal loads for both combinations have the values:

$$\overbrace{\begin{aligned} M_{fi,S} &= \frac{q_{fi,S} \cdot L^2}{8} = \frac{28 \cdot 3^2}{8} = 31.5 kNm \\ V_{fi,S} &= \frac{q_{fi,S} \cdot L}{2} = \frac{28 \cdot 3}{2} = 42 kN \end{aligned}}^{ULS\ combination} \qquad \overbrace{\begin{aligned} M_{acc} &= \frac{q_{acc} \cdot L^2}{8} = \frac{12.9 \cdot 3^2}{8} = 14.5 kNm \\ V_{acc} &= \frac{q_{acc} \cdot L}{2} = \frac{12.9 \cdot 3}{2} = 19.3 kN \end{aligned}}^{Accidental\ combination} \quad (13)$$

Using the value of the bending moment for the ultimate limit state load combination and the yield strength of the steel the minimal plastic moment of resistance that the beam must have is:

$$W_{pl} \geq \frac{M_{pl,Rd} \cdot \gamma_{M0}}{f_y} = \frac{31.5 \cdot 10^3}{275} \approx 115cm^3 \tag{14}$$

Referring to the plastic moment of resistance in the corresponding tables (9) we find the most appropriate cross section. For the actual case the corresponding cross section is IPE-180A.Then the degree of utilization of the elements is found:

$$\mu_0 = \max\begin{cases} \dfrac{M_{fi,d,t}}{M_{Rd}} \cdot \dfrac{\gamma_{M0}}{\gamma_{M,fi}} = \dfrac{14.5}{37.1} = 0.39 \\ \dfrac{V_{fi,d,t}}{V_{Rd}} \cdot \dfrac{\gamma_{V0}}{\gamma_{V,fi}} = \dfrac{19.3}{99.7} = 0.19 \end{cases} = 0.39 \tag{15}$$

With the value of the degree of utilization we are then able to calculate the critical temperature of the steel beam:

$$\theta_{cr} = 39.19 \ln\left(\frac{1}{0.9674 \cdot \mu_0^{3.833}} - 1\right) + 482 = 39.19 \cdot \ln\left(\frac{1}{0.9674 \cdot 0.39^{3.833}} - 1\right) + 482 \approx 624^{\circ}C \tag{16}$$

Then the next step is calculating the time-temperature curve of the fire and the specific heat respectively by referring to equations 8 and 9 (Figure 2).

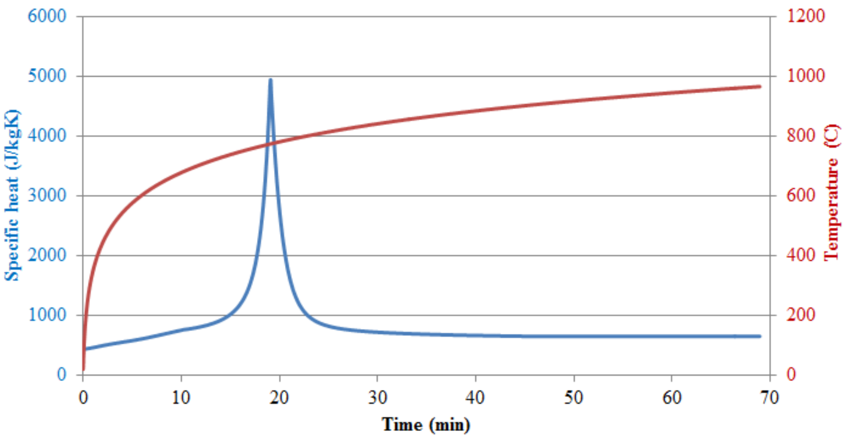

Figure 2. Time-temperature curve according ISO-832 and the specific heat as a function of time

Finally, for an unprotected steel beam, with the help of equation 7 we can calculate the diagram of temperature progression.

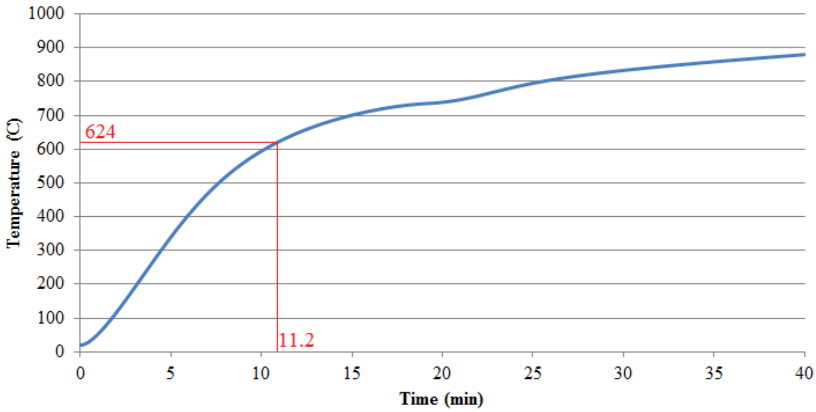

Figure 3. Time-temperature curve of the steel beam

Based on the curve presented in Figure 3 the time required for the beam to reach its critical temperature is obtained.
Through the application of this case it is observed that fire risk analysis of beams presented by time load resistance, critical temperature and time resistance depends mainly on the element's degree of utilization and its cross-sectional properties. Load resistance presented by the degree of utilization influences the critical temperature. Then based on cross sectional properties the beam's heating curve is calculated. In this curve the time resistance for the corresponding critical temperature is found.

4. RESULTS

By repeating the same equations for any span between 3-10m the results presented in Figure 4 are obtained. Results show that with the increment of the span, the critical temperature decreases while the time resistance of the double-T steel beam increases. These results bring in two major observations. First the increment of the span and consequently of the self-weight of the slab increase the beam's degree of utilization. Both of them increase the beam's bending moment and that influences the decrement of the critical temperature that it can resist. In order to resist the increment of bending moment the cross section of steel beam is chosen with adequate properties as shown in the figure. With the variation of the span a reduction of section factor is observed which positively influences the time required by the beam to reach its critical temperature. In conclusion, on the one hand the beam's span and self-weight negatively influence fire risk while one the other hand section factor has a positive influence.

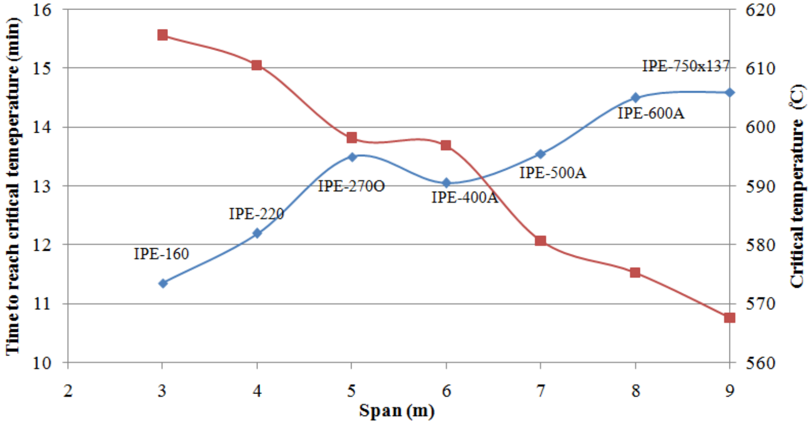

Figure 4. Time to reach critical temperature for different spans of beams

To better understand the observation of the results given in Figure 4, below the variation of these parameters is separately analyzed. Figure 5 shows the influence of the span variation in the degree of utilization of the beam and the time required by the beam to reach its critical temperature. Calculations are made by keeping the self-weight of the composite slab constant at 230daN/m^2, the section factor of the beam at 80m^{-1} (corresponds to IPE-550V) and the combination coefficient at 0.3. Based on these results, we observe a large decrement of the time resistance passing from 3 to 5m of span (about 180minutes). While the degree of utilization of the beam for bending moment increases constantly but is always under the accepted critical value (that is one).

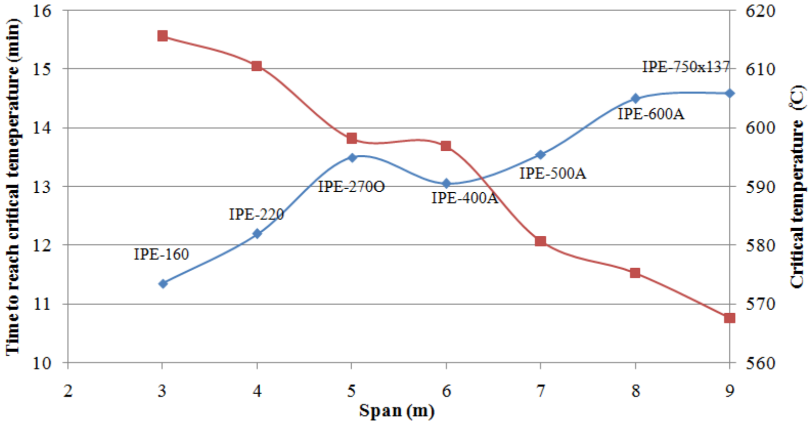

Figure 5. Time to reach critical temperature for different spans of beams

The influence of combination coefficient in the time resistance and the degree of the utilization of the beam are presented in Figure 6. Here the span of beams is considered constant at 5m and the self-weight of the composite slab at 230 daN/m^2 and the section factor of the beam at 80m^{-1} (corresponds to IPE-550V). The combination coefficient has a significant influence when it is varied between 0.3 and 0.35. Within this range the time resistance of the beam decreases with around 50 minutes. Once again, the degree of utilization increases but is always under the critical value.

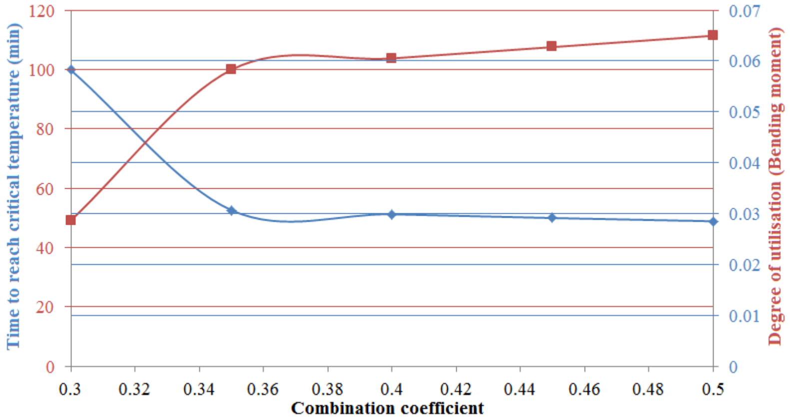

Figure 6. Influence of variation of combination coefficient in time resistance and degree of utilization

Self-weight of composite slab is the next parameter that is varied in order to calculate its influence in the time resistance and the degree of utilization of the steel beam. Here the span of the beam is kept constant at 5m, the combination coefficient at 0.3 and the section factor of the beam at $80m^{-1}$.Soft linear decrement of the time resistance of the beam is observed by the increment of the self-weight of composite slab (Figure 7). The degree of utilization is increased linearly but always remains under the critical value.

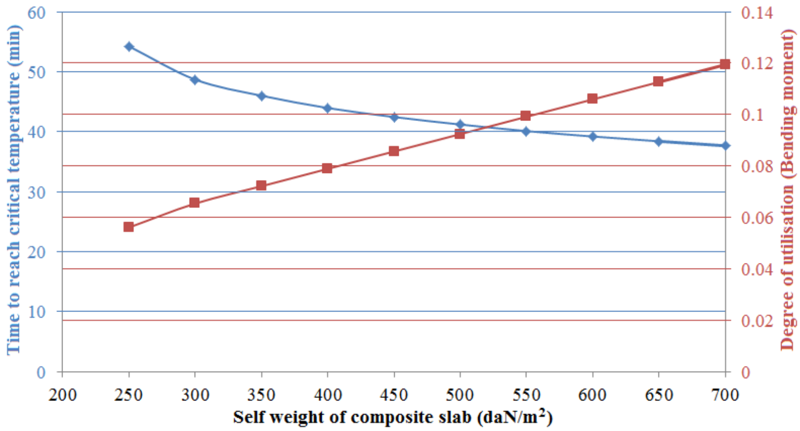

Figure 7. Influence of variation of self-weight of composite slab in time and degree of utilization

For a constant self-weight of composite slab 230 daN/m^2, combination coefficient 0.3 and section factor $80m^{-1}$, Figure 8 shows the results of the influence of section factor on time resistance. While the variation of section factor to the degree of utilization of the steel beam has no influence.

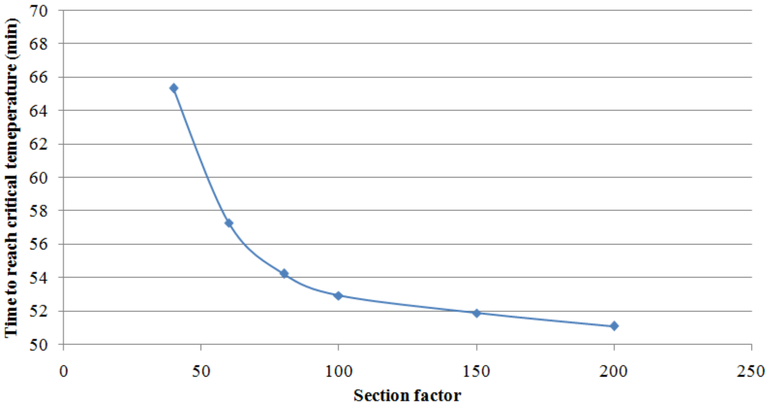

Figure 8. Influence of variation of section factor to time resistance

Finally, the relative influences of four parameters in time resistance of the steel beam are presented in Figure 9. Based on the results obtained we can conclude that the parameter of span has the highest influence followed by the combination coefficient, self-weight of the slab and then the section factor. A relative increment of the span with 100% can decrease the time resistance of the beam by 350%. While the increment of combination coefficient, self-weight and section factor by 100% can decrease the time resistance respectively by 120%, 50% and 25%.

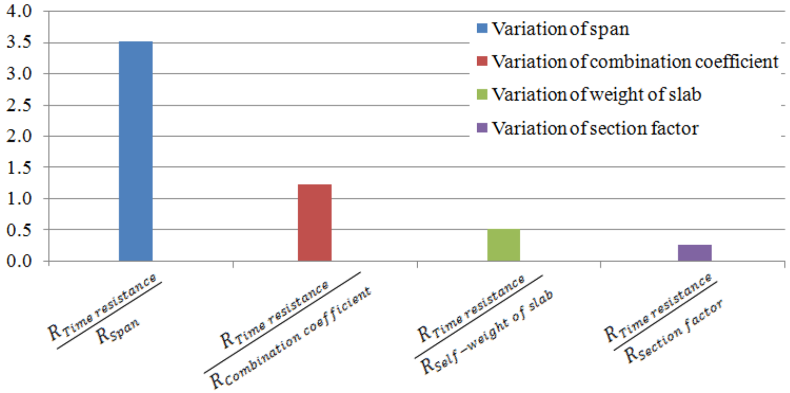

Figure 9. Influence of parameter in time resistance of steel beam

SUMMARY

This study provides an analysis of the parameters influencing the fire resistance of steel beams. Through the evaluation of 35 cases the most important parameters are identified, and they can be classified into two groups. The parameters of span, self-weight of composite slab and combination coefficient are in the first group and the parameter of the section factor in the second one. All of them influence the time resistance of steel beam and increase the risk of fire failure. While the parameter of the second group influences the critical temperature directly those of the first group have transversal influence through the critical temperature. Finally, the parameter of span is identified to have the highest influence on critical temperature followed by that of combination factor, self-weight and section factor. In this study, spans from three to five meters are found as the most adequate. Even though the combination coefficient is a function of the importance of the building, in some cases it should be taken 0.3. Moreover, the structure of slabs should be as light as possible. Section factor has a small influence in the fire resistance of steel beams. However cross sections with a small section factor should be envisaged to be employed in construction. In conclusion, for fire safety, the structural engineers should put their efforts into designing structures with small spans and lighter slab structure. The load resistance condition, represented by the degree of utilization of steel cross section, was always fulfilled. In all cases the degree of utilization was higher with respect to bending moment. These conclusions can be helpful for structural engineers and architects. They give them some recommendations which can be used during the early design stage of building projects. This study is limited to double-T steel beams but in the future we recommend enlarging other structural elements.

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LANDSCAPE PERSPECTIVE ON DISASTER RISK - INDEXING THE VEGETATED NATURAL SURFACES WITHIN THE OHRID-PRESPA TRANSBOUNDARY BIOSPHERE RESERVE BY THEIR WILDFIRE IGNITION PROBABILITY AND SPREADING CAPACITY

Artan Hysa, Egin Zeka

1. INTRODUCTION

Fundamentally, wildfire events are accepted to be crucial phenomena within the ecosystem cycles of a variety of biomes on earth [1]. Naturally, our home planet holds vital burnable conditions based on its characteristics such as: carbon-rich vegetation, dehydrated seasons, oxygen availability, and lightning and volcano eruptions [2], which are among factors promoting originally natural wildfire ignition events. Yet, based on the current literature, a large number of wildfire ignition cases are caused by human factors [3], [4]. Especially in the Mediterranean context, a great majority of wildfire burst events are reported to have been caused by human activities being either intentional or accidental [5], [6].

While, the wildfire ignition occurrences relies majorly on human activities and rarely on catastrophic natural events, the spreading phases of wildfire are mostly dependent on a range of physical and environmental properties of the territory. The factors responsible for fire ignition such as; lightning, uncontrolled burns, arson, negligence, differ from those encouraging fire spread such as; fuel type, meteorological conditions, slope, and capacities for effective fire suppression [7]. Other microclimatic settings such as temperature, precipitation, solar radiation, wind direction and speed, etc., are directly affected by physical properties of the context like altitude, aspect (orientation), latitude, and topographic formation [8].

Even though, wildfires are accepted as crucial part of ecosystem cycles, they result in diverse social, economic and environmental disturbances such as life losses and injuries, property damage, species and habitat harm, and degradation of natural and cultural areas [9][10]. The sensibility about these hazards becomes higher at special areas of the territory such as Wildland-Urban Interface (WUI) or Protected Natural Areas. Referring to the current literature, WUI areas are extensively being studied since they relate mostly with human-life losses and property damage [11]. On the other hand, the protected areas remains relatively at low rates regarding the studies focusing on wildfire risk they are target for. This becomes more critical while recalling the fact that approximately 30% of yearly (2009) European burned areas have occurred within Natura2000 protected sites [12]. The burned surfaces within the protected areas in Europe have been doubled between 2015 and 2016, recording 107906 ha [13].

In this context, this study aims to contribute to the wildfire risk assessment methods that could assist disaster risk management agendas specifically for protected areas. The focal study area will be the transboundary protected core zone within the Ohrid-Prespa Transboundary Biosphere Reserve (OPTBR). It is located in-between Albania and FYROM. OPTBR is accepted to be one of the largest of its sort in Europe, possessing unique geological and ecological values. There exist around 200 endemic species in the area, some of which are homed within the vegetated and forested habitat at OPTBR. More specifically, there exist endemic and irreplaceable forest communities which includes Paeonian grecian juniper, Pinetum peuces, southwestern moesian fir beech, and Helleno-moesian quercus frainetto forests [14].

2. STUDY AREA: Ohrid-Prespa Transboundary Biosphere Reserve (OPTBR)

The Ohrid-Prespa Transboundary Biosphere Reserve (OPTBR), consists of three watersheds; Ohrid, Greater Prespa and Lesser Prespa. Both Prespa sub-watersheds and lakes, covers an area of 1218.1 km^2 [15]. OPTBR includes 9 core zones, 2 buffer zones being enveloped by 1 transitional zone as shown in Fig.1. The focal study area of this study will be only the transboundary core zone being split between Albania and FYROM. Furthermore, the area is located in between Greater Prespa Lake and Ohrid Lake.

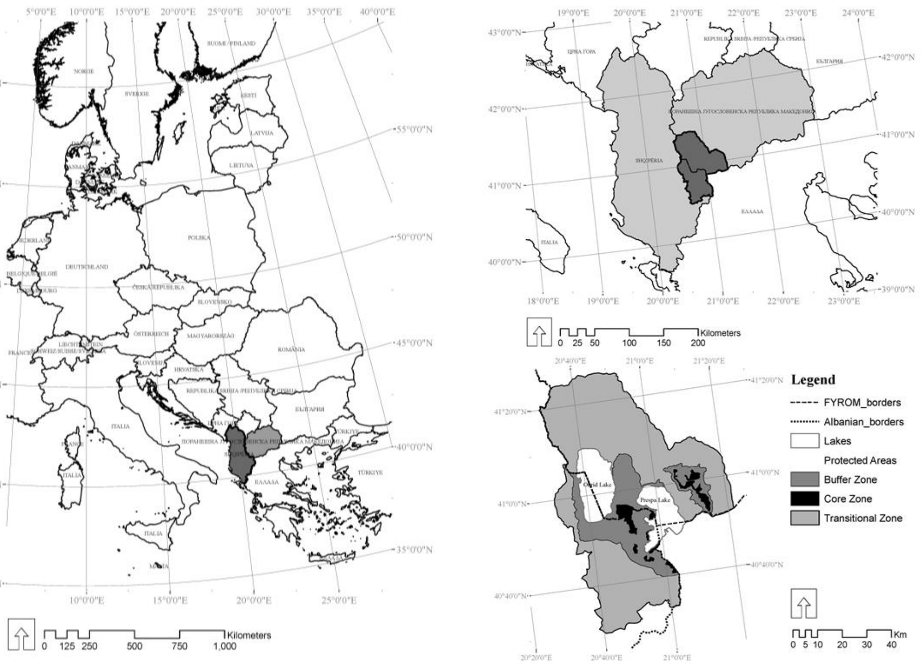


Figure 1. Location of the study area

2.1. Territorial Systems in OPTBR

The study area is located within a rich and diverse region regarding the territorial elements of natural and artificial character. As shown in Figure 2 there are five categories of territorial systems, respectively: *water system, infrastructure, urbanized areas, agricultural lands, and natural zones.* All these elements interlocked with each other create a complex and a cohesive territory distributed in three different countries. To have better understanding of the context it is crucial to analyze the relationship of the study area with these territorial elements. The lake of Ohrid, Greater Prespa and Lesser Prespa are the main water bodies that feed most of the water system in the region. Beside these lakes, there are two important rivers: Devolli river in the southern part and Black Drin river in the north. There are also many surface and underground water streams that penetrate in different directions.

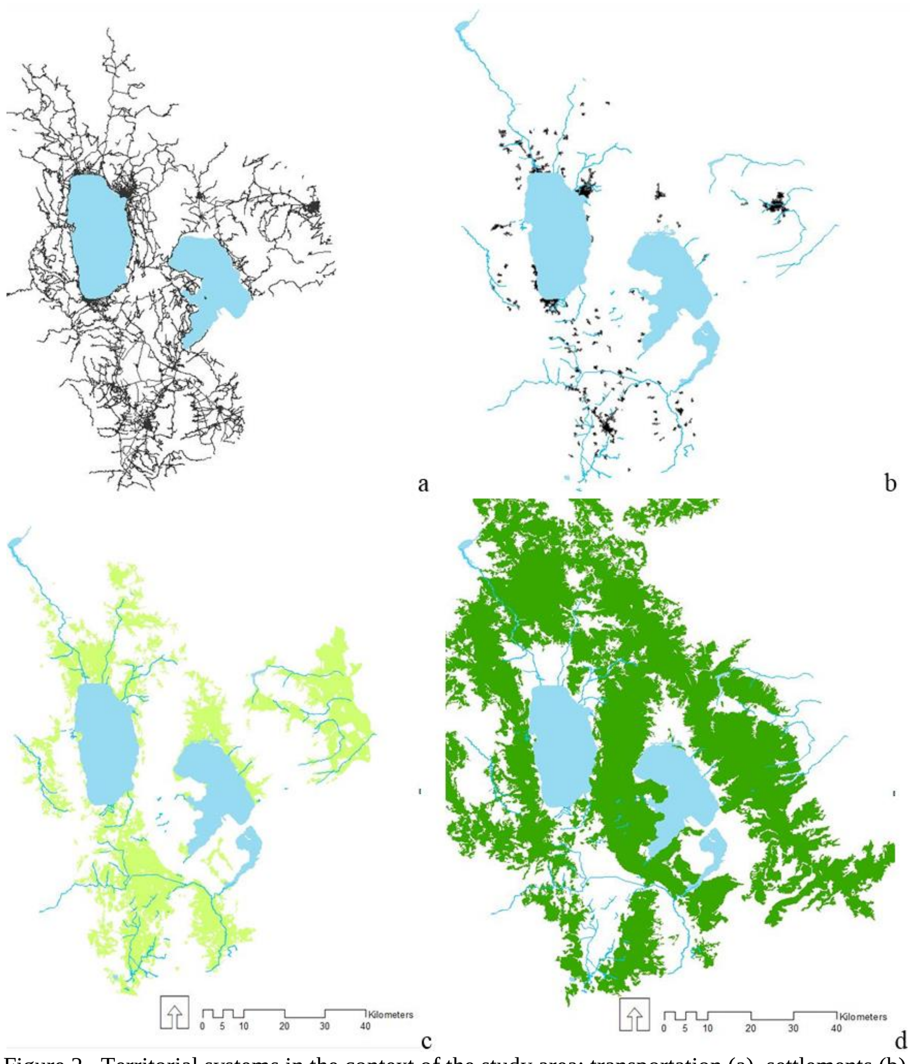


Figure 2. Territorial systems in the context of the study area; transportation (a), settlements (b), agriculture (c), and natural landscapes (d)

The larger part of the territory is covered by natural areas including many forests and National Parks. Among the most important ones: Galichica, Prespa and Shebenik-Jabllanice National Parks can be mentioned. Although it is situated mainly in a mountainous terrain, the region has a considerable agricultural land that is fragmented in four main plains: Korca agricultural plain, in Albanian part; and Struga, Resen and Bitola agricultural zones in FYROM. Regarding the urbanized areas, the Albanian part consist of a more urbanized territory with two main cities- Korca and Pogradec- and a lot of small settlements spread in the area. While, the settlements in FYROM show a more clustered and compact pattern around the main urban zones of Ohrid, Struga, Bitola and Resen.

2.2. Climacteric Properties of the Study Area

The climate in the area is classified as Continental-Central European. Yet the water mass which dominates the area serves as climatic modifier having direct impact on micro-climatic alterations around the lakes. According to measurements performed between 1991 and 1995, the average annual air temperature in the norther part of Prespa watershed (Resen meteorological station) was 9.5°C, while in the eastern region it scored at 10.8°C (Pretor meteorological station)[16]. July is the month with the highest average temperatures of 19.2°C, while January is the coldest one marking an average temperature of 0.2°C [17]. The Mediterranean pluviometric regime characterizes the rainfall regimes in the area. The lowest records of rainfall belongs to July and August, while the majority of precipitation occurs during late autumn and winter [18]. Thus, in this study June, July and August are accepted as the season with the highest probability for wildfire occurrences.

2.3. Forested Surfaces within OPTBR

Among the most crucial forested surfaces within the OPTBR are the *Grecian juniper forests- (Juniperetum excelsae).* It embarks a large variety of vegetation types but among the most significant vegetation species within this habitat are; *Euphorbia characias, Sternbergia colchiciflora, Orchis morio, Ophrys aranifera, Cyclamen hederifolia, Quercus trojana, Erodium guicciardii, Eryngium serbicum, Fritillaria gussichiae, Malus florentina, etc.* Their classification as endangered species under the IUCN Red List and their inclusion in several international conventions and EU Directives (Bern Convention, CITES convention, Habitats Directive) indicate for the special care it should be taken for avoiding threatening conditions they may face. Uncontrolled logging, unsustainable livestock grazing, urbanization, construction activities, archeological excavations, poor communication and forest fires are reported to be among the most risky conditions the *Grecian juniper forests* are under threat [19].

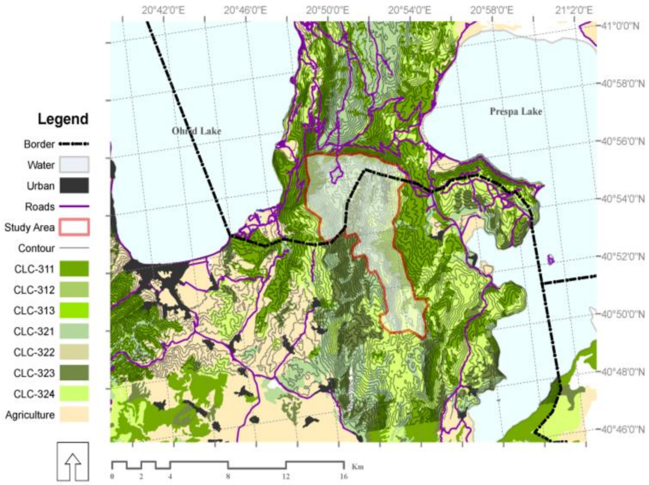


Figure 3. The focal study area and the territorial layers within its hinterland

2.4. Possible risks within OPTBR: Wildfire

More specifically, forest fires are listed among the most severe threats these areas are facing. In the report 'Grecian Juniper forests Conservation Action Plan for the Prespa Lakes' Watershed', forest fires are set as a target to be eliminated by improving the measures of prevention and pre-suppression in order to decrease the number of fires and burned areas. The forest fire events at Grecian juniper forested surfaces especially in the National Park of Galichica[7] is accepted to be at high risk. The area registered the latest severe fire event in 2008 causing wide burned surfaces. Referring to the local inhabitants the largest fire event in Grecian juniper forests occurred about 70 years ago. Yet, certain circumstances (such as: increased tree densities, due to the abandonment of livestock grazing and logging activities, and the invasion of woody species) which rises the wildfire occurrence probability are becoming bolder [19]. The past events of wildfire, the increased risk of wildfire occurrences and the severe consequences it carries due to the value of the area, highlights forest fire risk assessment as an important goal within the management agendas of OPTBR.

3. METHODICAL FRAMEWORK AND RESULTS

The methodical framework of this study is relying on our previous work, proposing an indexing model for the forest surfaces by their wildfire ignition probability (WIPI) and wildfire spreading capacity (WSCI) [20]. The method initially was developed for indexing broad-leaved forested surfaces within a randomly selected area. But, in this work we include all vegetated natural areas within a protected natural reserve. The reason for that relies on the fact that all lands and especially vegetated surfaces within the protected area have indispensable values. Moreover, the natural vegetation surfaces remain potential sites for wildfire occurrences and wildfire spreading events.

The workflow consists of four main stages; *preliminary work* (spatial data collection for each criteria), *Inventory* of absolute values for each criteria, *Analysis* or data clustering for assigning relative values to each criteria, and *Indexing* for assigning a single risk value based on the multi-criteria formula utilizing normalized values for each criteria as generated at the previous stage. Further details about the workflow are represented in Table 1.

Table 1

Steps of generating WIPI and WSCI values via ArcGIS application. (Adapted from [20])

		Goal	**Method**
Preliminary work	**1**	Identification of the Study Area within the protected Area	Identification of the vegetated natural surfaces from CORINE Land Cover data
	2	Data conversion	Shapefile to Raster (pixel size 250 m)
	3	Generate the point cloud of pixel centroids	Raster to Points operation
Inventory	**4**	Multi-criteria inventory	Calculating the values of all criteria for each point
Analyses	**5**	Data clustering	Clustering the values of each criteria into 7 classes according to Jenks natural breaks reclassification method via ArcGIS
Indexing	**6**	Calculating WIPI	Raster calculator (equation 1)
	7	Calculating WSCI	Raster calculator (equation 2)

[7] The NP of Galichica is located in the trans-boundary mountain of Galičica (Albanian: Mali i Thatë) being shared by the FYROM and Albania.

Based on the initial stages as shown in Table 1, we have identified the focus study area being the largest transboundary core protected area within the OPTBR (Fig. 1). The identified feature is converted from a shapefile into a raster data (pixel= 25ha) in ArcGIS software. As shown in Figure 4, the raster is converted into a point cloud of centroid points, which serve as the reference locations within the area of the protected core zone during the further steps of the study. Further on, we have collected either spatial or numerical data for each criterion shortlisted among the most relevant while considering wildfire risk probability. The shortlist have been prepared based on a thorough literature review as reported in our previous study [20].

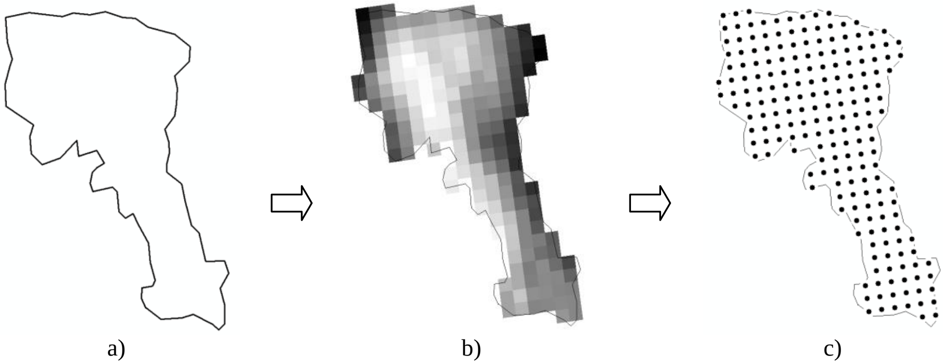


Figure 4. Data conversion steps of the focal study area from shapefile (a), raster DEM (b), and pixel centroid points (c)

In this work we have added an extra criterion based on the land cover or vegetation type being present within the focus study area. This is different from the previous study where the target study area was composed of a monotype land cover (CLC-311). Criteria having a spatial relationship with the focus study area such as; urbanized areas, settlements, main transportation network, water sources, etc., are graphically presented in Figure 4. Other criteria such as; temperature, solar radiation, wind regimes, precipitation, aspect, slope, etc. are introduced as numerical values only.

3.1. Multi-criteria Inventory of Forested Surfaces

The multi-criteria inventory is the initial stage of the operational workflow of this study. It relies on the inventory method we have developed and presented at the 1st symposium within the K-Force project held in Novi Sad [21]. The centroid points spatially representing a specific location within the study area are attributed a specific numerical values for each criteria. Representative inventory is shown in Table 2 for the first, the middle, and last two points. Furthermore, the final column represents the average values of all 198 points being investigated.

According to Table 2, some criteria defines diverse values for specific point locations, while some of them record similar or equal values. For example, the distance of each point to the closest urbanized area (S1) fluctuate from 2385m (pint 151) to 7820m (point 25), marking a standard deviation of 1373m and an average distance of 5068m. Similarly, the distance to buildings (S2), distance to any road (S3), distance to agriculture (S4), distance to watercourse (P3), and distance to water-bodies (S4), record remarkable fluctuation scoring the following respective standard deviation values; 755, 595.2, 1056, 2535, and 1239.

Table 2
Multi-criteria Inventory values for six representative centroids and the total average

centroid		***unit***	***1***	***2***	***100***	***101***	***197***	***198***	***average***
Dist. to Urban areas	S1	m	6577	6573	3897	3509	4857	4574	5068
Dist. to Buildings	S2	m	2258	1759	3280	3053	1712	2166	2329
Dist. to any Road	S3	m	237	449	1412	1413	3	21	730
Dist. to Agriculture	S4	m	661	1155	3530	3079	4715	4563	3464
Solar radiation	E1	w/m^2	221	222	215	214	218	218	218
Precipitation	E2	mm	30	30	30	30	30	30	32
Average Temperature	E3	ºC	18	17	15	16	15	15	15
Max. Temperature	E4	ºC	31	30	26	28	27	27	28
Relative Humidity	E5	%	63	59	65	62	65	65	63
Wind direction	E6	º	1	0	31	0	38	0	21
Wind speed	E7	m/s	2.17	2.17	2.17	2.17	2.17	2.17	2.61
Slope	P1	º	13.82	18.08	11.08	20.22	3.85	1.98	13.66
Orientation	P2	º	302	292	132	108	28	91	132
Dist. to Watercourses	P3	m	4953	5356	1639	1831	1208	1625	2506
Dist. to Water-bodies	P4	m	2055	2480	5264	4884	5047	4552	4623
CORINE Land Cover	P5		311	311	321	321	324	324	

On the other hand, values related with environmental criteria such as; precipitation, relative humidity, solar radiation, wind speed, remain at similar numbers. For example, all six representative points at Table 2, share the same precipitation value as 30mm. Precipitation varies from 27.1mm (point 175) to 41mm (point 71), with an average of 32mm. Similarly, wind speed records equal values of 2.17m/s at selected representative locations presented at Table 2. Yet, it varies from 2.13m/s (point 151) to 3.8m/s (point 39), scoring an average of 2.61m/s.
The values of environmental criteria are derived from Meteonorm software. Meteonorm data are based on the measurements of 8.325 meteorological stations worldwide that provided periodical climatological means for at least eight parameters: global irradiance, ambient air temperature, humidity, precipitation, days with precipitation, wind speed, wind direction, sunshine duration [22]. In this study we have included the average values of three months; June, July, and August. According to fire regimes in Albania, the summer season is reported to have the highest number of wildfire events.

3.2. Data Clustering through Jenks Natural Break Classification Method

The inventory phase results in absolute numerical values for each criterion which are very diverse in character and units. It makes difficult for generating a reliable normalized cumulative calculation for a common indexing method. We have decided to utilize Jenks natural break classification method which aims to define sub-classes within a set of values in order to reach the highest standard deviation among the sub-classes and the lowest among the values within each class [23]. In other words, we have reclassified the range of values of each criterion into 7 most distinguishable sub-classes.
We have utilized the Natural Breaks (Jenks) classification method as applied under the Layer Properties/ Quantities/ Graduated colors in ArcGIS 10.1.1. For example, Figure 5 presents the classification of the contour lines (isohypses) into 7 classes. The software delivers information about the “Break Values” of each class.

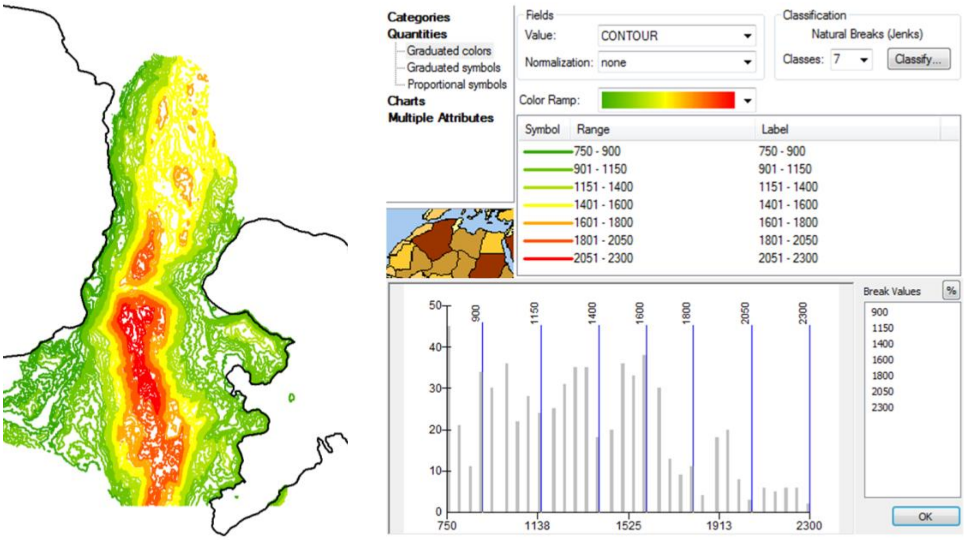


Figure 5. Natural Break (Jenks) classification of contour lines into 7 classes

The break values of each criteria is shown in Table 3. In principle the higher the class the higher the risk of wildfire ignition or spread. For example, the higher the temperature, solar radiation, orientation (aspect), or distance to water sources, the higher the chances to have a wildfire event. Yet, some of the criteria have an inverse relation with the wildfire risk, consequently are inversely classified. For instance, the lower the precipitation or relative humidity the higher the risk of a wildfire event. However, some criteria correlate differently to wildfire ignition and spreading phenomena. For example, the shorter the distance to urban areas and transportation network the higher the probability of a wildfire ignition but the lower the capacities of its spread due to human orchestrated suppression agendas. Figure 6, shows the spatial distribution of 7 classes of each criteria within the study area.

Table 3
The Break Values of each criteria according to Jenks natural break method into 7 classes

Jenks classes		*unit*		*1*	*2*	*3*	*4*	*5*	*6*	*7*	*average*
Dist. to Urban areas	S1	m	>	0	3303	3954	4512	5138	5881	5846	5068
Dist. to Buildings	S2	m	>	0	954	1521	2066	2525	2958	3353	2329
Dist. to any Road	S3	m	>	0	144	337	576	816	1171	1602	730
Dist. to Agriculture	S4	m	>	0	2032	2762	3285	3757	4231	4715	3464
Solar radiation	E1	w/m^2	>	0	15	215	217	219	221	223	218
Precipitation	E2	mm	<	41	39.67	38	35.33	33.67	30.33	29.67	32
Average Temperature	E3	ºC	>	0	9	13	14	15	15	17	15
Max. Temperature	E4	ºC	>	0	21	25	26	27	28	29	28
Relative Humidity	E5	%	<	79	68	66	64	62	60	59	63
Wind direction	E6	º	>	0	13	43	73	103	133	163	21
Wind speed	E7	m/s	>	0	2.17	2.87	3.07	3.3	3.47	3.63	2.61
Slope	P1	º	>	0	4.80	9.10	13.00	16.20	20.80	26.40	13.66
Orientation	P2	º	>	0	13	43	73	103	133	163	132
Dist. to Watercourses	P3	m	>	0	751	1270	1931	2843	2825	4679	2506
Dist. to Water-bodies	P4	m	>	0	2768	3634	4261	4803	5378	6057	4623
CORINE Land Cover	P5		=	322	321	323	324	313	311	312	321

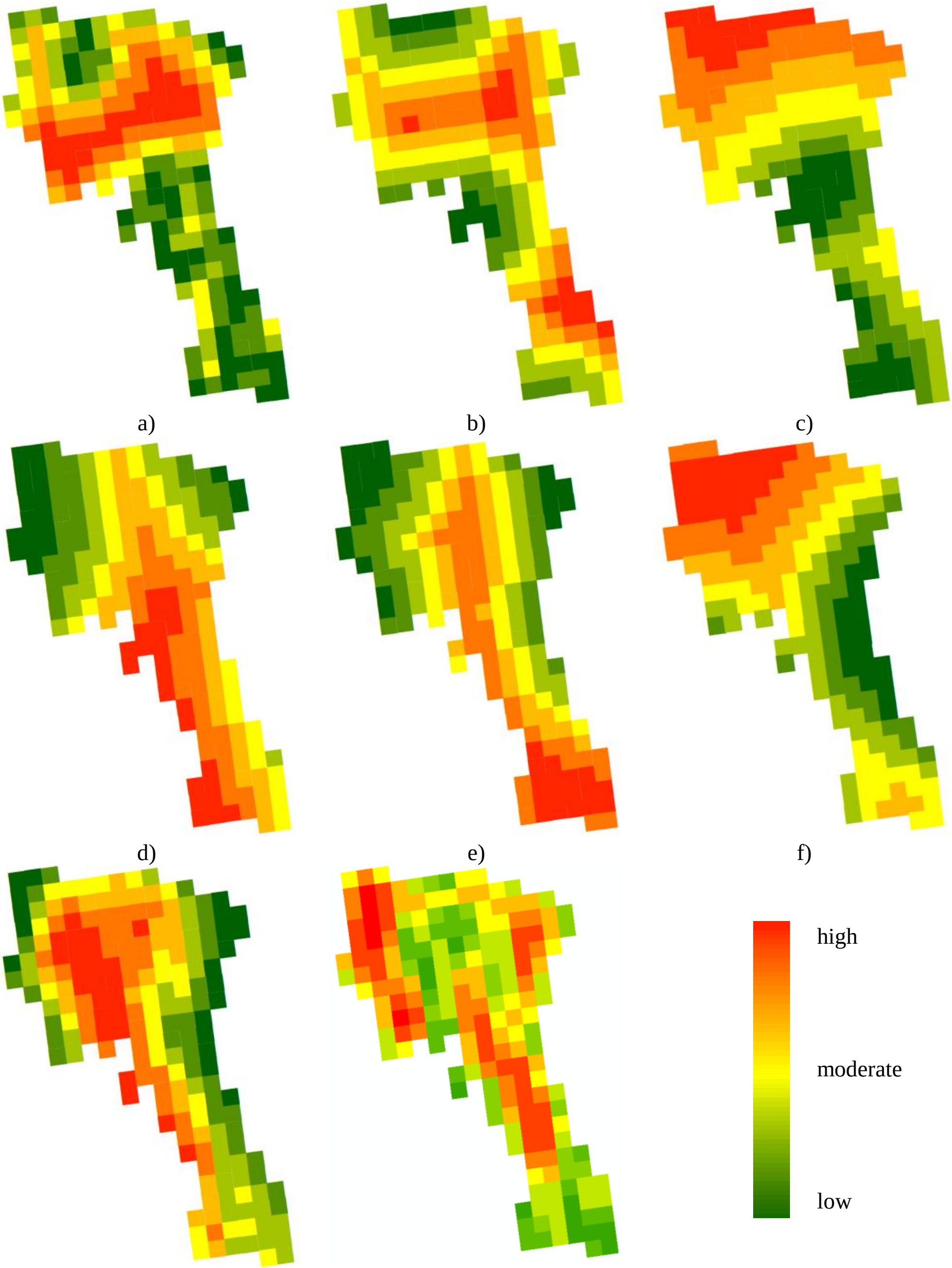


Figure 6. Distance to; roads (a), buildings (b), watercourses (c), water bodies (d), agriculture (e), urban areas (f), altitude (g), slope (h)

3.3. Indexing the Vegetated Surfaces within the Protected Core Zone, by their Wildfire Ignition Probability Index (WIPI) and Wildfire Spread Capacity Index (WSCI)

Referring to Table 1, the final stage of this study consists of the indexing procedure for the vegetated surfaces within the core protected zone by WIPI and WSCI values. As stated before, first, the relative range of values of each criteria is normalized by the Jenks natural break method generating 7 classes for each criteria. Yet, the listed criteria do not have the same impact either on the wildfire ignition probability or wildfire spreading capacity. Through Analytical Hierarchy Processing (AHP) technique they are assigned an impact factor or relative weighted value between 0 and 1. A detailed calculation of each factor via AHP method is published in our previous work [20]. Here we have relatively modified the values due to the presence of an extra criteria (Land Cover).

Table 4
WIPI and WSCI Coefficients of each criterion as calculated via AHP method. (Adapted from [20])

criteria	***Dist. to Urban areas***	***Dist. to Buildings***	***Dist. to any Road***	***Dist. to Agricultural Lands***	***Solar radiation***	***Precipitation***	***Average Temperature***	***Maximum Temperature***	***Relative Humidity***	***Wind direction***	***Wind speed***	***Slope***	***Orientation***	***Dist. to Watercourses***	***Dist. to Water-bodies***	***CORINE Land Cover***
	S1	S2	S3	S4	E1	E2	E3	E4	E5	E6	E7	P1	P2	P3	P4	P5
unit	m	m	m	m	w/m^2	mm	ºC	ºC	%	º	m/s	º	º	m	m	
factor	1	1	1	1	1	-1	0	1	-1	0	0	1	1	0	0	1
WIPI Coeff.(α)	0.076	0.153	0.202	0.292	0.032	0.040	-	0.059	0.059	-	-	0.025	0.012	-	-	0.047
factor	-1	-1	-1	0	1	-1	1	0	-1	1	1	1	1	-1	-1	1
WSCI Coeff. (β)	0.009	0.002	0.040	-	0.037	0.107	0.050	-	0.078	0.043	0.207	0.150	0.049	0.049	0.049	0.130

As a result of the AHP procedure some criteria figure out to be of primary importance in causing wildfire ignition or motivating further spreading. While some other remains at minimum blame. According to the values in Table 4, *distance to agricultural lands (S4)*, *distance to road (S3)*, and *distance to buildings (S2)*, are responsible of the 65% of the wildfire ignition risk. This remains on the same line with the fact- as referred to literature- that the majority of wildfire ignitions are caused by human behavior. On the other hand, the lowest factors affecting WIPI value belong to physical criteria such as *slope* (P1) and *orientation* (P2).

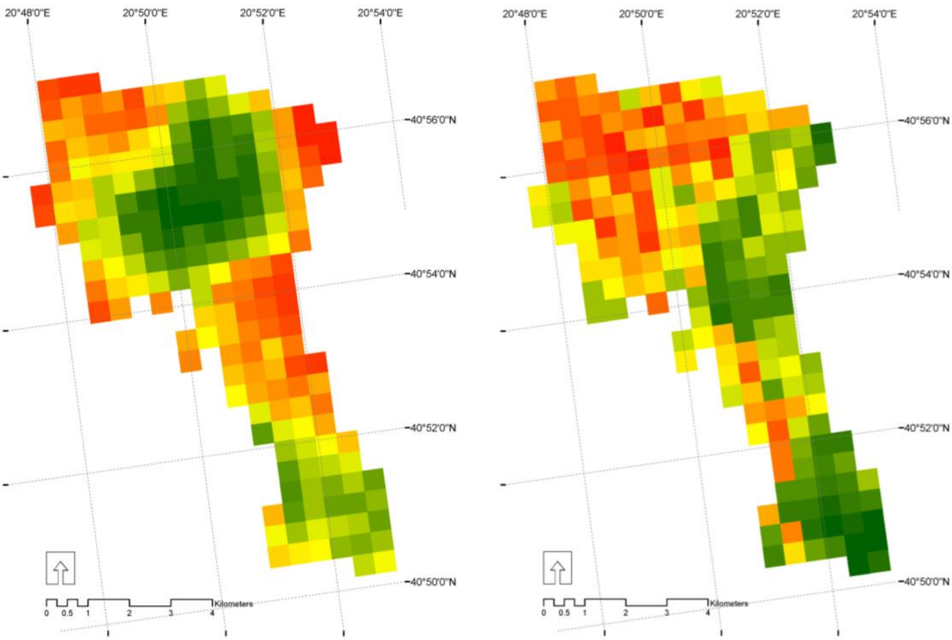
Similarly, certain criteria are relatively more critical considering the wildfire spreading capacities of a natural landscape. For instance, *wind speed* (E7) is reported to have the highest impact in WSCI value considering the boosted propagation rates by strong winds during a wildfire event. The *slope* (P1) is important since a forest fire on a steep slope has more chances to be spread further above. Further on, *land cover* (P5) scores high due to the high risk certain vegetation types have within a threatened area. *Precipitation* (E2) is listed as the fourth most affective criteria for WSCI value since it is related with the drought condition of the fuel. The criterion affecting the less WSCI value is *distance to buildings* (S2) since they are believed to have no remarkable responsibility during a wildfire spreading phases.

The WIPI value is calculated through the Equation 1. Basically, it consists of the sum of the multiplication of each criterion with its unique impact factor (α). Each point within the study area is attributed its specific WIPI value. In this calculation there are excluded the criteria which are accepted to have no effect on wildfire ignition phase or are assigned a null impact factor as shown in Table 4.

$$WIPI = \alpha_{s1}(S1) + \alpha_{s2}(S2) + \alpha_{s3}(S3) + \alpha_{s4}(S4) + \alpha_{e1}(E1) + \alpha_{e2}(E2) + \alpha_{e4}(E4) + \alpha_{e5}(E5) + \alpha_{p1}(P1) + \alpha_{p2}(P2) + \alpha_{p5}(P5) \quad (1)$$

Similarly, each point location is assigned its unique WSCI value (Equation 2), representing the sum of the multiplication of each criterion class with its specific weighted factor (β). Here again there are certain criteria that are not included due to their irrelevancy regarding the wildfire spreading capacities such as *distance to agriculture* (S4). Both equations are utilized via field calculation operation in ArcGIS. The results are shown in two different maps as shown in Figure 7.

$$WSCI = \beta_{s1}(S1) + \beta_{s2}(S2) + \beta_{s4}(S3) + \beta_{e1}(E1) + \beta_{e2}(E2) + \beta_{e3}(E3) + \beta_{e5}(E5) + \beta_{e6}(E6) + \beta_{e7}(E7) + \beta_{p1}(P1) + \beta_{p2}(P2) + \beta_{p3}(P3) + \beta_{p4}(P4) + \beta_{p5}(P5) \quad (2)$$



a) b)

Figure 7. WIPI (a) and WSCI (b) values of the focal study area

SUMMARY

This study presented a rapid method for indexing the natural vegetated landscape surfaces within a protected area by their wildfire ignition probability and wildfire spreading capacity. The core study area was the trans-boundary core protected zone within Ohrid-Prespa Transboundary Biosphere Reserve. The study follows a multi-criteria approach in assessing the wildfire ignition probability or wildfire spreading capacities, considering simultaneously social, environmental, and physical properties of the context where the study area is located. At this stage the procedure is applied to point locations representing 25ha of surface area. But, more frequent representative points or smaller surface areas could deliver much more reliable results especially while considering the WIPI values. This is because the ignition event is dependent to incidents happening at finer spatial scale.

The results imply for a good utility of the method in preparing rapid wildfire risk assessment at landscape scale for similar protected natural reserves. The presented method can be of use during disaster risk management and fire safety (DRMFS) agendas for transboundary protected natural sites.

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Section III

Economic Perspective

ECONOMIC EXPOSURE AND FINANCIAL CAPACITY IN CASE OF DISASTERS

Elona Pojani

1. INTRODUCTION

Disasters have a major impact on the living conditions, economic performance and environmental assets and services of affected countries or regions. These have been principally conditioned by the increases in population and assets exposed to adverse natural events, a trend likely to worsen with growing urbanization, environmental degradation and expected increase in the number and intensity of hydro-meteorological events resulting from climate change [5]. It is recognized that disasters can have widespread impacts, causing not only harm and damage to lives, buildings and infrastructure, but also impairing economic activity, with potential cascading and global effects. Consequences may be long term and may even irreversibly affect economic and social structures and the environment. In Addition, considering the natural disasters as separate events may lead to an underestimation of natural disasters impact on the world economy. This was argued by Sahin (2011), who by using data on 171 major disasters for the period between 1990 and 2007 and the Computable General Equilibrium (CGE) model (GTAP), discussed the global and regional impacts of disasters. They show that the economic losses produced by the Global CGE model exceed the sum of individual country loss reported by Munich Re Statistics for each simulation year The conclusion of this model is that the economic burden of natural disasters is not confined to the region where the disaster physically occurs; in the short to medium term, natural disasters lead to new global balances through trade linkages and price effects [18].
In line with these observations, this chapter will discuss the economic exposure in case of disasters, focusing of models conceived for the assessment of potential damage loss. Further, the chapter will offer an introduction of financial means for disaster risk management. Reference and examples will be focused mainly on flooding events. A section on Climate Finance is also discussed. Finally, the remaining of the paper will discuss the practice of damage assessment in Albania, focusing on a specific case study, and will discuss the lack of ex-ante damage assessment in the case of floods and other disaster events.

2. MODELS FOR DAMAGE ASSESSMENT

Disaster risk management is process composed of many components. The different phases of this process outline the necessity of informed decision making. Essential to achieve this is the assessment of potential damage of disaster events. Over the past decades, a great variety of different methods for the ex-ante estimation of flood damages have been developed [14]. However, different methodologies have been applied in different countries, making it difficult to compare damage assessments with each other [9].
Analysis of flood damages can be made on a macro-, meso- and micro-scale. Macro-scale analyses consider areas of national or international scale and should provide decision support for national flood mitigation policies. Meso-scale analyses deal with research areas

on regional scale, i.e. river basins or coastal areas. Here, the planning level refers to different large-scale flood mitigation strategies. Finally, the aim of micro-scale analyses is the assessment of single flood protection measures on a local level. The main differences between the three approaches relate to the spatial accuracy of damage potential analysis, to the differentiation of land use categories and to the damage functions used [14].

The challenge of flood research is to develop a wider perspective for flood damage evaluation. Usually, flood damage analysis mainly focuses on the economic valuation of tangible flood effects, while neglecting the important economic, social and ecological aspects of flood [14]. In this regard, Giupponi et al (2015) discuss how the estimation of risk should not only be based on direct tangible costs, but it should also go beyond to contain indirect and intangible costs [6]. The later should take into consideration the social indicators and the capacities of local communities to cope with risks and adapt to them. If all of the above factors are considered, a total costs estimation might be produced. Another study on the estimation of damage and recovery costs considering human losses in the Republic of Korea develops a linear regression equation that connects these factors [19]. Its estimation equation considers human losses, damage costs, and recovery costs.

Often the literature makes a distinction between models of loss calculation and risk assessment in urban areas and rural areas. Li (2016) argue that flood risk analysis is more complex in urban areas than that in rural areas because of infrastructural characteristics of urban areas, different kinds of land uses, and large number of flood control works and drainage systems. For the purpose of flood risk analysis and damage assessment, they use a comprehensive analysis based on the concept of disaster risk triangle. Two models were integrated for this purpose: Urban Flood Simulation Model (UFSM) and Urban Flood Damage Assessment Model (UFDAM). They show the relationship between flood control measures and flood risk based on flood return period. By applying scenario modeling in the Pudong area in Shangai (China), they showed that the flood prevention measures may cease to be effective when the flood scale exceeds the flood control standard [11]. Another study which applies damage assessment methodologies in urban areas was conducted by Genovese (2006) using Prague as a case study [4]. Vojinovic et al (2008) attempt to incorporate the GIS technology with computer-based flood modelling results for flood damage assessment and disaster planning in the case of urban floods [20.]. Bouwer et al (2009) discussed a method that is able to simulate inundation in polder areas which can be used for detailed scenario studies of the impact of future socio-economic and climatic developments on flood risks. They noted that the usefulness of the hydrodynamical modelling is limited for high spatial resolution loss estimates for large areas. They use the inundation depth assessment for different scenarios to illustrate the potential range of flood losses and to assess the relative impact of land use and socioeconomic changes. By using loss probability curves they try to calculate maximum losses, as well as the expected annual average losses, also discussing uncertainties of the results of the method [1].

Following the challenges of damage assessment and different methodologies applied for this purpose, Huizinga et al (2017), applied a comprehensive methodology which aimed at developing normalized damage curves for each continent, based on an extensive literature survey. They computed a consistent set of maximum flood damage values for all countries using statistical regressions with socio-economic World Development Indicators. They also give guidance on how the damage curves and maximum damage values can be adjusted for specific local circumstances, such as urban vs. rural locations or use of specific building material. They argue how this dataset can be used for consistent supra-national scale flood damage assessments, and to guide assessment in countries where no damage model is currently available [9].

3. FINANCING APPROACHES AND INSTRUMENTS FOR DISASTER RISK MANAGEMENT

Financial strategies for disaster risk management are intended to ensure that individuals, businesses and governments have the resources necessary to manage the adverse financial and economic consequences of disasters, thereby enabling the critical funding of disaster response, recovery and reconstruction. The analysis of financial exposure of a country to disasters is an important part of disaster risk management strategy. However, it is only one component of a comprehensive disaster risk management strategy. This analysis is a subset of the overall macro-economic analysis [5]. Financial protection will help governments mobilize resources in the immediate aftermath of a disaster, while buffering the long-term fiscal impact of disasters. The comprehensive risk management strategy covers many other dimensions, including programs to better identify risks, reduce the impact of adverse events and strengthen emergency services (Figure 1).

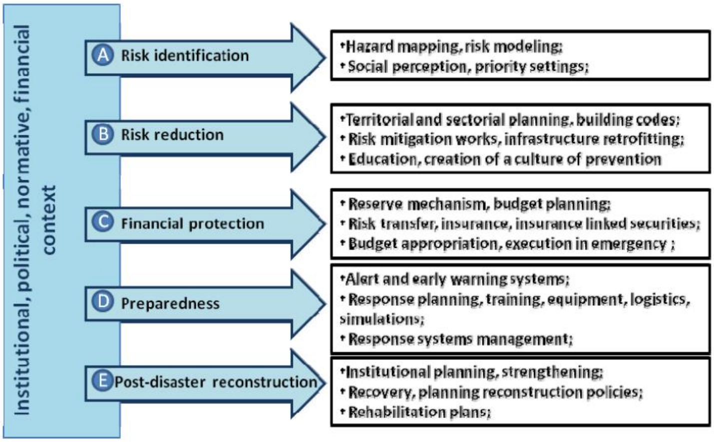

Figure 1. Comprehensive disaster risk management strategy [5]

Risk financing instruments against disaster risks can be categorized into risk transfer and risk spreading instruments [8]. While the dominant risk financing instrument is a risk transfer by insurance and reinsurance, other non-market risk transfer instruments, like collective loss sharing, are also available [13]. Table 1 illustrates the main risk management approaches and instruments. The following chapters of the book, will offer a more in-depth analysis of each of these instruments.

Risk-financing and risk-reduction strategies can be targeted to different layers of risk in terms of their severity (Figure 2). Particularly for structured investments, risk-reduction measures may be largely appropriate for low-loss events that occur frequently (low-layer risk), while risk sharing and transfer addresses risks, often are discussed at higher levels, where risk cannot be cost effectively reduced. In highly vulnerable countries, very low-probability, high consequence (high-level) risks are typically absorbed by governments and donor organizations [12].

Table 1
Risk management approaches and instruments [8]

Approach	Examples of instruments
Non-market risk transfer	Government assistance (taxes) for private and public sector relief and reconstruction funding Kinship agreement Some mutual insurance arrangements Donor Assistance
Market risk transfer	Insurance and reinsurance, Micro insurance, Financial market instruments: Catastrophe bonds, Weather derivatives
Inter-temporal risk spreading	Contingent credit (financial market instrument), Reserve fund, Microcredit and savings

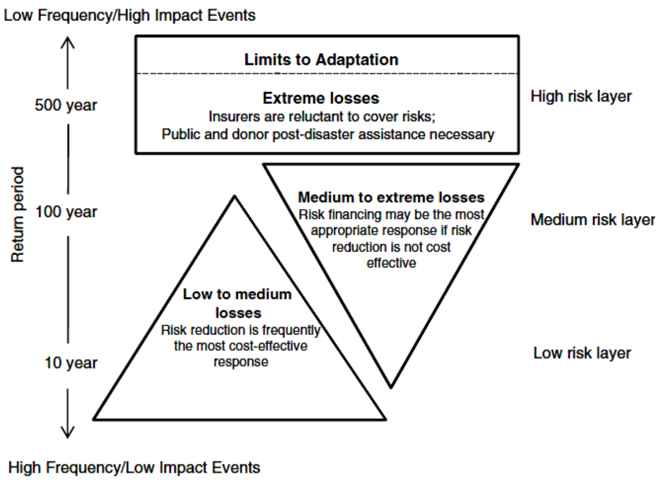

Figure 2. Disaster Risk Layers [12]

Ghesquiere and Mahul (2010) provides an assessment of the time necessary to mobilize funds through these instruments (Figure 3) [5]. In the event of a disaster, immediately available and lowest-cost financing options would typically be used first. For example, financing through an existing calamity fund and/or insurance, reinsurance or catastrophe bonds would have priority. Similarly, part of budgeted resources from existing government programs would be transferred to meet immediate emergency needs. In some cases, development funds (municipal, social, urban, rural) may also be used. At the same time, the government would seek as much international aid and donations as possible and resort to contingency credits. If the government has access to emergency credits such as the IDB's Emergency Reconstruction Mechanism, it would request them and would also begin negotiations to direct resources from existing loans to finance disaster recovery [10].

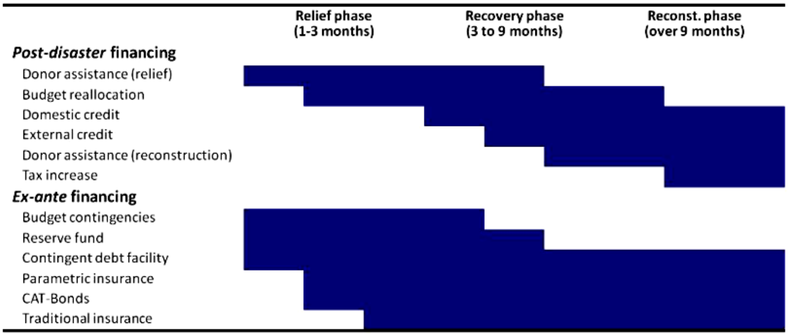

Figure 3. Sources of post-disaster financing [5]

Finally, as the frequency of disaster events is expected to increase with the increasing risk of climate change, exposure of businesses, infrastructure, assets and economies to disaster risk will be even more serious. Under these observation, the following section will discuss the topic of climate finance in relation to the disaster risk management process.

4. CLIMATE FINANCE

Climate change is expected to affect the likelihoods and severness of disaster events all over the world, thus increasing the risks to businesses, infrastructure, assets and economies. Therefore, strategies of disaster risk management should include climate change modeling. Apart from disaster risk financial means, there are further financial strategies targeting directly climate change. Disaster risk reduction and risk financing contribute importantly to climate change adaptation by lessening exposure and vulnerability and enhancing resilience to the potential adverse impacts of climate extremes. Recognizing the complementarities between risk reduction and risk financing as they contribute to disaster events of different severities can improve the contribution of disaster risk management to climate change adaptation. The risk layer approach can be helpful to policy makers and practitioners to this aim. However, still there are concerns about striking the right balance between investments to reduce risk, transfer risk and address damage impacts, and about fully recognizing the link between risk financing, risk reduction and climate change adaptation.

Addressing climate challenges will require the implementation of different projects and programs in the area of climate change mitigation and adaptation. While multinational donors, such as the GEF, have certainly become the mainstay of funding for projects with global environmental objectives, it is also becoming increasingly apparent that funds of this nature alone do not provide the long-term answer to financing global environmental protection measures. Consequently, additional sources of revenue that can provide predictable funding flows are needed, not only to ensure that future projects can be fully financed, but also to ensure that measures instigated by the past and current work of bodies such as the GEF are maintained [15]. A decentralized approach to ‘innovative financing’, focusing on taxation, development-based charges, entry fees, small-scale enterprises and initiatives taken at the local level between the private sector, government authorities and NGOs could fill in the gaps left by large environmental funds and, in this way, ensure sustainable funding for global environmental objectives. International and domestic options are available within these innovative financing sources.

Climate finance is increasingly targeting a portfolio of strategies that include mitigation, adaptation, and technological development to address issues required to diminish the risk associated with climate change. These synergies will also increase the cost effectiveness of actions to tackle the impacts of climate change. Understanding how to involve the private sector in responding to these risks – or encouraging them to take advantage of the new business opportunities that may arise from changing climate conditions – is crucial to catalyze greater investment in activities that increase countries, businesses, and communities' resilience. Development Finance Institutions (DFIs) are a means to drive private sector investment in climate resilience. Studies have found that a combination of policies, regulations, and longer-term debt from DFIs can trigger private investments in climate resilience, especially in the context of compliance with European regulations and pressure to meet changing market demand. Technical assistance measures can help stimulate demand for private investment by addressing knowledge gaps.

There is no single, perfect institutional arrangement to mobilize and deliver climate finance, and efforts to strengthen coordination around climate finance must contend with messy domestic landscapes, with new sets of policies needed for diverse sets of actors. Ministries of environment, finance and non-governmental actors, all have vital roles to play: the key is to create incentives and accountability for these institutions to work together. Institutional arrangements for climate finance lie on a continuum wherein they 'dock' international or external climate finance in the national system, or 'mainstream' climate considerations into core policy and associated investment decisions and financial frameworks. Some financing mechanisms that could be used within adaptation and mitigation policies and programs are summarized in Table 2. They include both international and domestic funds.

Table 2
International and domestic financing mechanisms

Source of funding	**Financing instruments**	**Field of action**	**Examples of adaptive measures**
International funds	Grants and Donations	Biodiversity Forestry Ecosystems And/or any other areas of international importance	- Measures related to the reforestation, forest regeneration, grazing control, fire prevention and introducing agro-forestry practices in Forest Areas - Measures in the protected areas (PAs) including management of coastal PAs, lagoons, biodiversity restoration and monitoring plans - Coastal wetland restoration for increasing ecosystem resilience and adaptation capacity
	Soft credits and loans		
	Swap contracts		
	IPA		
Domestic funds From the private sector	Payment for Environmental Services (PES)	Tourism Agriculture Forestry	- Technological improvements - Provide appropriate tourist Infrastructure in response to the changes of the sea level
	Financial conditions for the approval of private activities located in tourist		

	or protected areas		
	Compulsory insurance of property		
	Licensing fees for touristic operators		
Domestic funds From households	Environmental taxes and charges for municipal services	Population and Settlements	- Increase adaptive capacity and livelihood support to the coastal human communities - Adaptation of buildings, construction techniques and building models in order to minimize the negative effect of high temperatures
	Compulsory insurance of property		
Domestic funds From the state sector	Review of budgetary allocations for infrastructure, forestry, agriculture	Infrastructure Hydrological Regime and Water Resources Forestry Agriculture Biodiversity	- Protection of water resources from coastal erosion - Introduction of agro-forestry practices - Forest fires prevention and warning systems - Introduce monitoring system in protected areas - Improve the lagoon systems
	Reserve and Development Funds		
	Environmental taxes		
	Insurance		
	Entry fees in protected areas and touristic locations		
	Subsidies		

5. CASE STUDY: DAMAGE ASSESSMENT IN CASE OF FLOODS IN ALBANIA

Albania has a high exposure against disasters. The causes of disasters are various, ranging from natural causes, to anthropogenic and ecological causes. The consequences of disasters in different groups of society may reach serious levels. The levels of vulnerability have significantly risen with the increase of the number of population and with massive migration of population especially to coastal areas, which are exposed to higher risk of natural disasters. Among disaster events, flood have the major number of occurrence.

Albania has experienced many flood cases during the last century. Especially, the western lowland seems more affected [2]. The increase of the sea level and weather scenarios are thought to increase floods risks, especially for the inhabitants of the coastal areas. Anyhow, still nowadays there have been no studies and no developed methodology on ex-ante disaster damage evaluation, regardless the fact that the country is constantly affected by these events that cause a serious pressure to its economic development. The evaluation of damages is conducted only after the occurrence of the catastrophical event and not always is made public. Also, data for damages, when made public, have been aggregated to a total value, without differentiating values for different damages categories. Moreover, also because of political factors, damage values are very often underestimated.

Some data on damage assessment have been reviewed from public documents. As stated above, the registered data of flood damages costs seem to be limited. Flooding events of December 2010 in Shkodër region in Albania have the most accurate data on damage compared to all other events affecting Albania. According to the ex-post damage evaluation

in the area, the documented total number of affected evacuated inhabitants was about 12,145 and the number of affected houses was about 7,120 (4,540 flooded houses and 2,580 houses surrounded by water), while the number of assets at risk in this area was more than 400 of different types. According to the evidences of the Directorate of Agriculture in the Region, during the flood events the cultivated land and croplands were highly affected (about 10,280 ha, from which about 4,887 ha of cultivated land) and the economic damage was about 500,350,000 ALL. While for the livestock the situation can be considered more dramatic as some of the animals were surrounded by water and drowned (about 32,634 animals were evacuated) [7].
The lowest part of Kurbin and Lezha have also experienced many flooding events. Some data on damage experienced in the area have been also made public. This area experiences a different kind of flooding, caused by sea level rise. The variations of the non-normal rainfalls and their distribution have resulted in aggravated erosion levels and intensification of floods. In September 2002, a surface from 26.000 ha working land was flooded and the general loss for the affected families and the country infrastructure is evaluated to be approximately 17 million dollars. The floods of 4 December 2004 destroyed in total 1500 ha of the working land. The houses near the river banks of Drini and Buna suffered from aggravated damages. The damages affected bridges, and national and rural roads too. Floods also influenced the biodiversity of the area, as a tendency of natural communities to move inland was observed. Also, specific communities, including the existing coastal dunes, salted marshlands and legatines decreased their surface. The last case of the massive floods in the area has happened during the winter 2009-january 2010. The increase of the sea level, accompanied with the increase of the whirlands and rain, caused aggravated flood in many fields. As a result, more than 600 ha of land were flooded, causing an economical loss estimated for 14 000 000 lek (150 000 USD) after the occurrence [3].
One of the few attempts for conducting an ex-ante damage evaluation was realized in the framework of the project “Identification and Implementation of Adaptation Measures in Drini-Mati River Deltas”, financed by GEF (Global Environmental Faciltity) and implemented by UNDP Climate Change Program. In focused on a study area positioned on the deltas of Mati and Drin rivers, including the counties of Lezha and Kurbin. In the framework of this project, the damages experienced by the local economic units (families) from the floods in the area for a time horizon of 100 years, were evaluated. The experts of the project have developed a prediction of the consequences for the flooded people until the 2100 year (Table 3).

Table 3
Forecasting of flood damages [17]

Parameters	**Entity**	**2030**	**2050**		**2080**	**2100**	
Flooded people	1000/year		0.019	0.040		0.006	0.007

The developed scenario predicts a decrease in the number of the flooded people as a consequence of the reduction of the area population. By using these data and the benefit transfer method, the damage calculation in the 100 years time horizon was made available. The benefit transfer method uses data from international studies for the damage evaluation and applies this data to specific local areas, after making adjustments to the reported values. A study of Meyer and Messner (2005) has estimated the costs of the damage for a flood event in the Netherlands. They calculated the damage value of 172.000 EUR/economic unit during a flooding event. This value was adopted for the case of Albania by adjusting it based on the level of GDP of both states [14]. Through the usage of the GDP ratio of both states on the year when the study was conducted, the transferred value of 308085 EUR/family of floods damages in the study area was obtained. With the help of the regression equation that represents the trend of the flooded families during the time horizon, a value of damages ranging from 1.7 million to 1.9 million EUR for the study area was calculated [16]. This estimation has not taken into consideration the social damages of floods.

The forecasting and the used method summarized above has its own shortcomings, as identified in the project files, but the case under consideration outlines one of the few attempts for the calculation and prediction of the damages from floods in Albania. The use of the benefits transfer method was necessary, as there is no specific data or developed methodology in Albania for the calculation and evaluation ex-ante of damages from the floods that the families experience.

This lack of studies in this field has been especially conditioned by the lack of risk maps for the vulnerable areas, which are essential for applying methodologies of damage evaluation presented in the first part of this chapter. In this framework, an important contribution has been given for the development of the flooding maps for the region of Shkodra through the support of this initiative from international projects. The project "Climate Change Adaptation in Transboundary Flood Risk Management in the Western Balkans", implemented by GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit), aimed to support the systematic identification and mapping of main flood hazard areas in the Drin River Basin in compliance with the EU Flood Directive and to assist the local authorities to implement adaptation measures as part of their flood risks management plan. The flood risk maps serve as an input on the process of flood risk assessment where the current versions of local flood risk maps of the Shkodër region give an overview of affected areas as well as affected infrastructural assets [7]. The products of this project set a cornerstone to the implantation of methodologies for ex-ante disaster risk assessment in Albania in the future.

SUMMARY

This chapter discusses the importance of damage assessment of disaster events in general and flood events in particular, in order to outline the economic exposure of a country to a hazard. The role of the damage assessment process is displayed through different global estimation methods where the forecasting of the damage costs in cases of flood events seems to be necessary. Referring to the worldwide practices and methods, it is proposed that the flood damages costs estimation should include the indirect costs such as the social indicators to reflect the total costs and the impact of the consequences of the flood events. Also, the usage of GIS mapping technique and its incorporation with the numerical model results is essential for the damage calculation caused by flood events. The economic analysis of costs and benefits of flood protection and mitigation measures should be included in the forecasting methods for flood risk management and the economic, social and ecological impact should not be underestimated.

This chapter also offered an overview of financial sources available to use in case of disasters. These sources were classified on the basis of their approach, time frame and nature. Finally, a section on climate finance was included, as an important topic in international public discussions. It is very important for businesses to gain opportunities that may arise from changing climate conditions and to catalyze greater investment in activities that increase countries, businesses, and communities' resilience.

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RISK TRANSFER MECHANISMS – INSURANCE AND REINSURANCE

Gentiana Sharku

1. INTRODUCTION

Managing the losses resulted from disaster events is a challenge for every country. There are several traditional forms of risk management from loss control to loss financing and insurance is one of them. But in case of disasters, insurers often require partnerships between governments, individuals, and international donors. This chapter will briefly review some concepts regarding the risk management; will analyze the kinds of risks transferred through insurance; how the insurance mechanism is dealing with disaster risk; and which are the alternatives available to insurance market to cover catastrophe losses. At the end of the chapter, several case studies demonstrate the way by which insurance market deals with disaster risk.

2. THE RISK MANAGEMENT PROCESS

2.1. Again, on the definition of risk and probability

At a glance, risk seemed to be a very simple notion. When there is a risky situation, one may think that there is the possibility of a loss or an unpleasant outcome. The financial literature provides several definitions of risk. Cambridge Dictionary defines the risk as "the possibility of something bad happening, or something bad that might happen". Oxford Dictionary defines the risk a situation involving exposure to danger. According to "PRINCE" Glossary term, risk is a set of events that, should they occur, will have an effect on achieving the project objectives. Risk is defined in different ways depending on the field or the purpose of use. For example, the Business Dictionary, in general defines the risk as the probability or threat of damages, injury, liability, loss, or any other negative occurrence that is cause by external or internal vulnerabilities, and that may be avoided through preemptive action. But also, it provides several definitions regarding the studying filed, such as finance, insurance, securities trading, food industry, and workplace act. The insurance literature provides different definitions of risk, too. However, in general risk has been defined in terms of two elements: uncertainty and the loss. Therefore, in insurance risk is defined as uncertainty of loss.

The risk can be perceived in two ways: objectively and subjectively. The objective risk is statistically measured. It is defined as the ratio of relative variation of actual loss from excepted loss, to expected loss. For example, suppose an insurance company insures 100.000 house against fire. According to the calculations it expects that about 200 houses will burn on average each year. The word "average" makes the difference. The actual number of burnt houses may be from 190 to 210 houses, or it may be from 170 to 230 houses. In the first case the objective risk is 5%, while in the second case it is 15%. This means that the second case is even more risky situation for the insurance company.

The subjective risk is defined as uncertainty based on a person's mental conditions or state of mind. It cannot be measured statistically and may be perceived in different degree by different individuals. It depends on the personal attitudes of the individuals toward the risk. Different attitudes of people may be as result of age, gender, education, culture, personal experiences, information, etc. High subjective risk produces very conservative conduct and low subjective risk tends to produce less conservative conduct.

It is necessary to distinguish between the risk and probability. In general individuals tend to wrongly use the term of risk and probability instead of each other. As risk, probability may be objective and subjective. Objective probability refers to the long run chance or frequency of a loss. For example, the probability of head in a coin flip is 50%; or the probability of drawing a "Queen" out of 52 playing cards is one-thirteenth. The probability cannot always be measured so easily (a priori or inductive reasoning). The probability that a person will be disabled before the age 60, can be "a priori" measured. Insurers can calculate this probability by using the deductive reasoning based on the past disability experience. Subjective probability is the personal estimation of an individual regarding the chance of a loss. Due to the low level of statistical knowledge or their superstition degree, people may overestimate or underestimate the chance of loss or profit. In the above-mentioned example, the probability of fire was 2%, but the objective risk was 5% in the first case and 15% in the second case.

2.2. Some concepts related to risk – peril and hazard

The insurance literature uses some other concepts related to risk, such as peril and hazard. Peril is defined as the cause of loss. Hazard is defined as the condition that creates or increases the frequency or the severity of a loss from a peril. For example, one of the perils that can cause an auto loss is the collision. The collision is the peril – which is the direct cause of loss. Why does collision occur? Through this question we find the hazard: the icy street or the high speed above the allowed limits, or frost. Each of these hazards may increase the probability of a collision. There are three main types of hazards: physical, moral, and morale. The above-mentioned hazards are of physical type. The physical hazard is a physical condition that creates or increase the frequency or the severity of a loss. Such hazard may or may not be within the human control. Moral hazard is defined as the dishonesty of an individual which creates or increases the frequency or the severity of a loss. Examples of moral hazard include faking an accident to collect the insurance money, deliberating starting a fire, submitting a higher amount of claim, etc. Morale hazard is defined as the indifference to a loss because of the existence of insurance. In this case, the loss is not deliberately caused by the insurer. The loss is caused by a careless behavior. Example of morale hazards are leaving the car keys in an unlocked car which increases the chance of loss or theft.

2.3. How is the risk managed?

The risky situations are not pleasant to individuals. The presence of risk results in undesirable social and economic effects. First, due to the risky situations, people set aside a reserve fund in case of emergency. Second, the risky situations increase the fear and worry that the people face. Third, the due to the presence of risk, the society may be deprived of certain goods and services. As result, most people try to avoid risk as much as possible or to reduce its negative consequences. In general, the individuals are risk averse, which mean that if they should decide between two risky alternatives that have the same expected outcome, they will choose the alternative whose outcomes are less variable – less risky. Risk averse individuals generally are willing to pay in order to reduce the risk, or they would like to be compensated if they take more risk.

Risk Management is a process that identifies loss exposures faced by an organization/individual and selects the most appropriate techniques for treating such exposures. Risk management process is useful before and after a loss occurs. It involves four steps, as the Figure 1 shows.

Risk Identification – During the first step, the risk manager defines and identifies all sources of risk: actual, anticipated, and perceived. The identification of all sources of risk may be a very difficult task because practically is almost impossible to identify all the sources of risk.

Risk Quantification – During this step, the risk manager estimates the financial impact on the firm of all pure and speculative risks identified. The financial impact may be estimated by determining the size (severity) and the frequency of the loss. The loss severity is the probable size of the losses that may occur. The loss frequency is the probable number of losses that may occur during at some period of time. Depending on the loss frequency and loss severity, the risk manager can select the appropriate technique for risk management.

Figure 1. The Risk Management Process

Risk Management – during this step the risk manager decides how to handle the risk. There are five basic methods of handling risk, which can be classified in two groups: *risk control techniques*, which aim to reduce the frequency and the severity of losses, and *risk financing techniques*, which aim to finance the losses.

Risk Control techniques include a) avoidance which means that the risk is abandoned; b) prevention which refers to the measures that reduce the loss frequency; c) reduction which refers to the measures that reduce the loss severity; d) diversification which reduce the risk by spreading the loss exposures among different parties.

Risk financing techniques include a) retention by which an organization or individual retains a part or all losses that can result from a given risk; b) transfers through contracts like hedging (using financial derivatives such as forwards, futures, options and swaps) and insurance. In order to determine the appropriate risk management techniques, risk manager may use the classification of the losses according to their frequency and severity shown in Table 1.

Table 1
Classification of the losses according to their frequency and severity

Loss Frequency	**Loss Severity**	**Appropriate RM Technique**
Low	Low	Retention
Low	High	Transfer
High	Low	Loss control
High	High	Avoidance

Risk Monitoring – Tracks and assesses the performance of the risk management strategy in light of actual experience. A risk management program must be periodically reviewed and evaluated to determine whether the objectives have been achieved or not.

3. THE INSURANCE MECHANISM

3.1. The concept of insurance

One of the usual techniques used to transfer the catastrophe risk is insurance. As a technique of risk management program, insurance is appropriate for loss exposure that have a low probability of loss but a high severity of loss. The transfer of risk from the individual to the insurance company is carried through a contractual agreement under which the insurance company, in consideration of the premium paid by the insured and his promise to abide the provisions of the contract, promises to make payment to or on behalf of the insured, for losses caused by the perils covered under the contract. The main purpose of the insurance is to indemnify the insured, to restore his financial position prior to the occurrence of the loss. The indemnification of the injured parties is possible through the process of pooling and sharing of losses. The losses suffered by a small group of insured are spread on the entire group of insureds, and the average loss (included in the premium) substitutes the large actual loss. But insurance companies do not cover all the kinds of risks. According to the insurance literature the risk can be classified in several distinct categories: pure risk and speculative risk; dynamic risk and static risk; fundamental risk and particular risk.

Pure risk is a category of risk in which the sole outcome is either loss or no loss. Examples of pure risk include the uncertainty of loss of one's life or property by fire, flood, windstorms, earthquakes or other perils. The speculative risk is a category of risk in which the outcome will be either a profit or a loss. Examples of speculative risks include a business venture, gambling transactions, investing in real estate or stocks etc. Insurers generally insure only pure risks, while the speculative risk is normally handled by techniques other than insurance, such as diversifications, hedging or assumption of risk etc.

Dynamic risks are risks produced because of changes in economy. Examples of dynamic risks are variations of prices level, consumers' preferences, incomes level, technology and production innovations etc. Such changes may cause losses to some citizens. But on the other hand, the society may benefit in long-run due to the redistribution of resources. Static risks include losses that would occur even there is no change in the economy level. Examples of static risks include uncertainties due to random events such a fire, windstorm or other people's negligence. As result of occurrence of static risks there is no chance of profits for anyone. Therefore, this kind of risk is privately insurable.

A fundamental risk is a risk that affect the whole economy or a large part of population or community. Examples of fundamental risks include the wars, earthquakes, health diseases, economic recessions, inflation etc. Fundamental risks may be static or dynamic. Particular risks affect an individual or a small group of individuals. They affect the individual and not the entire group. Insurance can be easily used for the management of the particular risks, but the government assistance is necessary to insure the fundamental risks, such as social insurance programs or unemployment compensation programs.

3.2. The requirements of an insurable risk

There are some requirements that should be fulfilled before a pure risk can be privately insured. The criteria are as follows:

There must be a sufficiently large number of similar exposure units. Insurers use the law of large number to predict probable losses. Therefore, it is essential that a large number of independent and similar, not necessarily identical, units be exposed at the same peril. To be successful, an insurance plan must reduce the risk by making losses predictable within certain ranges of accuracy. According to the law of large number, as the number of exposure

units increases, the more certain is that actual loss experience with equal probable loss experience. The insurance is the device through which the objective risk is significantly decreased.
The loss must be accidental and unintentional. The loss must be result of a contingency i.e. there must be some uncertainty surrounding the loss. Otherwise there would be no risk. If there is no risk, insurance would be worthless, as its purpose is to reduce the risk. The loss should be beyond the control of the insured. To satisfy this requirement, insures usually exclude in all policies any loss caused intentionally by the insured.
The loss should be definite and measurable. The loss must be definite in time, cause, place and amount. Most losses are easily determined with reasonable accuracy, such as death, property losses etc. However, some losses are difficult to be determined such as disability or sickness, and some others are difficult to be measured such as the loss from "pain and suffering".
The loss should not be catastrophic. A large number of units must be exposed at the same peril, but not all or the most part of the exposed units should suffer from the loss at the same time. Catastrophic loss exposure is defined as a potential loss that is unpredictable and capable of producing an extraordinarily large amount of damage relative to the assets held in the insurance pool [2]. The insurance principle is based on the notion of sharing losses. If all the exposure units in a certain class incur a loss at the same time, the pooling will not work, and the insurance will be no longer an effective technique.
The chance of loss must be calculable. The insurer must be able to calculate the probability of loss. Some probabilities of loss can be determined by logic alone (by deductive reasoning), for example the probability of rolling a six with a single die is 1/6. Other losses must be empirically determined (by indicative reasoning), for example the probability that a person age 30 will die before the age 50. If no statistics on the chance of loss are available, the degree of accuracy of the insurer's calculation would be low, despite the large number of insureds.
The premium must be economically feasible. The insurers collect the premium to pay the losses, the loss-adjustment expenses and to provide a profit for themselves. The rates charged by insurers should be adequate to pay all losses and expenses, and they should be not excessive in order that insured pay no more than their coverage. If the chance of loss is much above 40 percent, the policy will exceed the amount the insurer must pay under the contract [7]. Otherwise, if there is a sufficiently large group of insured, the cost may be spread over the entire group and the premium may be feasible.

3.3. The natural disaster risk and insurance

According to the above classification, the natural disaster risk is:

- a pure risk as the society does not benefit when a natural disaster loss occurs, i.e. insurable risk,
- a static risk as it occurs due to random events and it is not a source of gain for the society, i.e. insurable risk,
- a fundamental risk as it affects a large group of population, i.e. not entirely privately insurable.

The natural disaster risk meets the following requirements:
There is a large number of units exposed to the natural disaster hazards. The losses resulted from the natural disaster risk are out of the individual control. There are accidental and

unintentional. If insurers cover a sufficiently large group of exposures the premium may be feasible.
The natural disaster risk does not fully meet the following requirements:
When a natural disaster takes place, often it is very difficult to measure the amount of loss, or at least the actual loss can be measured only after a certain time period. As the "catastrophe" is the synonym of disaster, the loss resulted from the natural disasters is catastrophic. The natural disasters occur in irregular basis therefore their probability cannot be accurately estimated.
As result the natural disaster risk does not fully satisfy the requirements of an insurable risk. Although these requirements represent the ideal, in practice, insurance is written under less-than-ideal conditions. However private insurance ventures that depart too far from the ideal are likely to fail [2].
The insurance companies would ideally wish to avoid the catastrophic losses because they are unpredictable, the loss distribution is hardly to be evaluated, and the rate making process is very difficult. Actually, insurance companies provide coverage for catastrophic losses, natural catastrophes and man-made disasters. Financiers have developed arrangements that provide protection to insurance companies faced with catastrophic losses. That means that insurance companies have found a way to use the resources of the financial market to meet the problem of catastrophic losses. There are at least three basic methods that allow them to accept exposures that otherwise would have been refused.
First, reinsurance may be used by which insurance companies are indemnified by reinsurers for catastrophic losses. Reinsurance is a method created to divide the risk among several insurance companies. Reinsurance is the shifting of a part or the whole risk written by one insurer, called the ceding insurer, to another insurer, called the reinsurer. The transaction is carried through agreements, called treaties, which specify the ways in which risks will be shared by the participating insurers. The first decision taken by the ceding insurer is to define the retention limit, which is the amount of insurance retained by the ceding company, which varies with the financial position of the insurer and the nature of the exposure.
There are several types of reinsurance treaties. The excess-loss-treaty is designed largely for catastrophic protection (Cat-XL). Losses in the excess of the retention limit are paid by the reinsurer up to some maximum limit. The excess-of-loss treaty can be written to cover: a) a single exposure; b) a single occurrence, such as e natural disaster loss, or c) excess losses when the primary insurer's cumulative loss exceeds a certain amount during a certain period [11]. For example, suppose that Vienna Insurance Group wants protection for all the losses resulted from floods in excess of 2 million Euro. Vienna Insurance group can write an excess-of-loss treaty with Swisse Reinsurance Company, to cover a single occurrence during a year. In this case the reinsurer agrees to be liable for all the loss resulted from flood, exceeding 2 million Euro, but to a maximum of 10 million Euro. If a 6 million flood loss occurs, Vienna Insurance Group would pay the first 2 million Euro (the retention limit), and the Swisse Reinsurance would pay 4 million Euro.
Second, the possibility of a catastrophic loss will be reduced by distributing the insurance coverage over a large geographical area. If a multinational insurance company would cover the fires in Russia, the earthquakes in Italy and the flood in France, then the insurance company would have a more diversified portfolio and will have more stable financial results. Distributing their coverage all over the world will permit the insurance companies to assume different types of risk. Through this geographic diversification they would be able to mitigate the risk they face.

Third, insurance companies use the financial market to transfer a part or all the catastrophic risk to investors, in the form of insurance linked securities (ILS). Examples of ILS are contingent surplus notes, catastrophe bonds and exchange traded options.

Contingent surplus notes allow an insurance company to protect itself from paying a large number of claims resulted from a disaster. The investors put the funds in a trustee that buy treasury securities. The investors receive the interest from the government securities plus an additional interest paid by the insurance company, in order to induce the investors to put the funds in the trustee then to invest the funds directly in government securities. If a catastrophe occurs, the insurer has the legal right to replace the government securities with its own contingent notes, or in some cases with its own preferred stock. The insurance company continues to pay the interest and the principal of its own notes, but there is also more risk of default, because it is now the insurance company and not the government which is paying the interest.

Catastrophe bonds are another financial arrangement that allow insurance companies to transfer the risk of catastrophe. Catastrophe bonds (Cat bonds) are special bonds issued by insurance companies to help them pay for natural catastrophic losses. The investors put the funds in a trustee, called the special Vehicle Purpose (SVP), that buy safe securities (treasury bonds) and other high-quality securities. The Cat-bonds are issued by the SVP. The bonds are usually rated below investment grade (junk bonds) and pay relatively high yields. If a catastrophe event occurs the insurance company can withdraw funds from the SVP to pay claims and no repayment is made to the investors. If the specified catastrophe event does not occur, the investors receive their principal plus interest that is relatively high.

The insurance companies can transferee the catastrophe risk through exchange traded options. These options that are sold by speculators and purchased by insurance companies, are standardized contracts that give the insurance company the right to a cash payment from the seller (the speculator) if a specified index of catastrophic losses reaches a certain level within a specified period of time.

3.4. Micro-insurance

Micro-insurance, as a financial tool that belongs to microfinance, is widely recognized and known as a flexible and essential device in developing countries context. The aim of micro-insurance is to provide insurance against natural disasters to poor individuals. It is a financial device that provide low-income households, farmers, and business with access to post-disaster liquidity, thus securing their livings and providing for their reconstruction. It has some basic features as households or farmer participation, small group involved, and small geographic area. It can be used by low income people, who cannot have access to traditional forms of insurance. This product is characterized by the member’s willing to pay and low-cost transactions. Micro-insurance can be indemnity based, where products are written against actual losses, or index-based, where products are written against physical or economic triggers, that is, against events that cause loss, not against the loss itself. The index-based insurance is effectively used especially in agriculture. Any independent gauge can be used and developed as an index for an insurance contract which is secure and must be highly correlated with agricultural losses [16]. To avoid the high transactions cost of indemnity-based insurance schemes, index-based or parametric schemes create the payouts contingent on a physical trigger, such as rainfall, temperature or wind speed measured in a local weather station. In the case of weather derivatives, farmers collect an insurance payment if the index reaches a certain measure or “trigger” regardless of actual losses.

The World Bank has provided technical assistance for implementation of innovative index-based crop insurance schemes in developing countries. For example, in Malawi, where the economy and livelihoods are severely affected by rainfall risk, groundnut farmers can receive loans that are insured against default with an index-based weather derivative, or in Mongolia_herders can purchase an index-based insurance policy to protect them against livestock losses due to conditions of extreme winter weather. The insured farmers and herders are more credit-worthy, therefore insurance can also promote investments in productive assets and higher-risk/higher-yield crops. Moreover, insurance can encourage investment in disaster prevention if insurers offer lower premiums to reward risk-reducing behavior. Thus, micro-insurance is an effective risk-transfer mechanism and an integral part of an overall disaster risk management strategy.

A report by the International Fund for Agricultural Development and World Food Programme cites 36 weather index insurance programs, including 28 addressing individual farmer/herder, slum dweller, village or cooperative risk [3]. Index insurance reduces moral hazard since claims are independent of losses. As another innovation, albeit with only one pilot application, insurance payouts can be linked with forecasts so that clients have the liquidity to take preventive measures to reduce losses [15]. The private sector is taking an interest in micro-insurance markets. Few insurers, however, are optimistic about the prospects of disaster micro-insurance for the very poor (below USD 1.25/day) unless it is supported by the government, NGOs or international donors.

4. HOW THE DISASTER RISK IS ACTUALLY INSURED ALL OVER THE WORLD?

According to the Swiss Re Sigma publication, economic losses from natural catastrophes and man-made disasters across the world were estimated USD 175 billion in 2016. Natural catastrophe-related economic losses were estimated USD 166 billion in 2016, coming mostly from earthquakes, tropical cyclones, other severe storms and droughts in Asia, North America and Europe. Insurance coverage is not universal. There was an all-peril catastrophic protection gap of USD 121 billion in 2016. Therefore, the insurance industry covered about USD 54 billion - less than one third - of the economic losses in 2016. Figure 2 shows the difference between insured and economic losses over time, termed the insurance protection gap. The rate of growth of economic losses has outpaced the rate of growth of insuring losses over the 25 past years. In terms of 10 rolling averages, insured losses grew by 4.6% between 1991 and 2016, and economic losses by 5.6% [13].

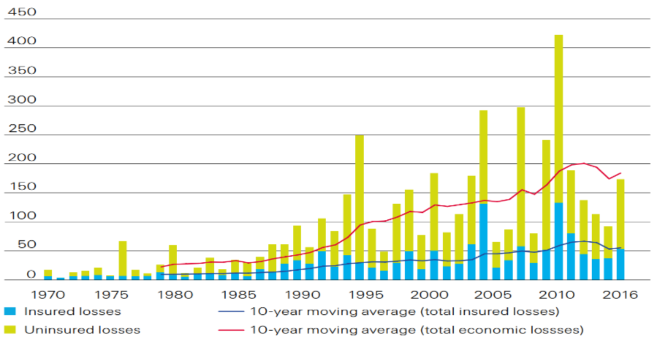

Figure 2. Insured losses versus uninsured losses, "Sigma"

Although the difficulties to cover the losses resulted from natural disaster risk, many insurance companies all over the worlds have found the mechanism to insure these losses. Disaster risk insurance schemes often require partnerships between governments, international organizations and the insurance industry. Several countries have used different schemes for transferring the natural disaster risk faced by individuals, businesses firms, insurance companies and governments. As the governments are the ultimate responsible for the financial loss resulted from natural disasters, especially in developing countries, where the financial system is not developed, they are very interested in developing innovative financial solutions to mitigate the financial impacts of natural disasters. Some examples of public-private insurance programs implemented in several countries are as follows:

In *Mongolia* herders can purchase an index-based insurance policy to protect them against livestock losses due to conditions of extreme winter weather. The insurance program is a combination of self-insurance, market-based insurance and social safety net. Small losses which do not affect their viability are retained by the herders, while larger losses are transferred to the private insurance industry. Only the final layer of catastrophic losses is borne by the government.

According to the *Turkish Catastrophe Insurance Pool* launched in 2000, earthquake insurance policies are obligatory for all property owners in Istanbul and other high-risk urban centers. Apartment owners pay a premium based partly on their risk to a privately administered public fund. If the fund cannot meet claims after a major earthquake, the World Bank provides a contingent loan .to the pool.

In 2005 nearly 1000 smallholder farmers in *Malawi* participated in a pilot weather insurance project that allowed them to access an input loan package for better groundnut seed. According to the project, the farmer enters into a loan agreement with a higher interest rate that includes the weather insurance premium, which the bank pays to the insurer. The insurance payments are index-based depending on precipitation measured at one of three weather stations within the region of the pilot program. In case of a severe drought, the borrower pays a part of the loan, and the rest is paid by the insurer directly to the bank.

The *Mexican* government has chosen to insure its catastrophe reserve fund, FONDEN, against earthquakes with a mix of reinsurance and a catastrophe bond. In 2006, FONDEN issued a USD 160 million catastrophe bond (CATMEX) to transfer Mexico’s earthquake risk to the international capital markets. It was the first country that issue a multi-peril multi-region cat bond using the World Bank’s Multicat Program.

In *France*, private insurers are required to offer catastrophe insurance in all-hazards property policy. Policies are not risk based and the program is reinsured through a public administered fund. If the fund does not satisfy the claims, taxpayers will be called to pay.

The *Caribbean Catastrophe Risk Insurance Facility* (CCRIF) went into operation in June 2007 with the participation of 16 Caribbean countries. The Caribbean Island States have formed the world’s first multi-country catastrophe insurance pool, reinsured in capital markets, to provide governments with immediate liquidity in case of large losses due to hurricanes and earthquakes.

In *Romania*, in 2008, the Pool Against Natural Catastrophes (PAID) was set up as an insurance reinsurance company, formed by the association of 12 insurance companies. The insurers which are members of Catastrophe Insurance Pool, sell mandatory indemnity-based insurance against earthquakes, floods and landslides.

5. CASE STUDY– ALBANIAN INSURANCE MARKET CAPACITY FOR MANAGING DISASTER RISK

At the present the insurance market is not actively involved in the process of disaster management. Up to now, the management of disasters, especially natural ones, has been considered as a government responsibility. In Albania, people always have relied on government to provide protection and financial relief from natural disasters and they have historically been indemnified from the state budget. But when the government offers protection against the risk of natural disasters, it is not free. In other words, all the citizens have to contribute in indemnifying the damages through paying higher taxes. The funds that the government use to indemnify the disaster damages have been removed from other sectors of the economy. The experience of all developed countries over the world, provide several methods of relieving the state burden, by involving the insurance market in the disaster management process.

According to the World Bank, in Romania, where the insurance against seismic risk is obligatory, about 60 percent of the homeowners has purchased insurance policies. Following the successful experience of Romania, this option is suggested in 2014 by the World Bank to be followed in Albania. The World Bank has given some suggestions regarding the coverage range and the premium rates. The draft-law has been discussed by the interested parties and the people have been very sensitive especially in the insurance price. First of all, they consider the premium very high in respect to their revenues. In Albania, the citizens spend on average Euro 35 (in 2016) for insurance products (with the exception of social insurance). The imposition by law of a new extra premium is considered as a large burden to them. Perhaps this is one of the reasons of dragging the approval of the law. Another problem related to the premium, is that not all the citizens should pay the same premium. There are many buildings, constructed after 1990, without any legal permission, in very risky areas. But actually, almost all the buildings have been provided or are going to be provided with the legal documents, and it is not fair that all homeowners pay the same premium. The bonus-malus system should be applied. The premium amount should depend on the riskiness of the area and the value of the building. But the insurance market in Albania does not implement the bonus-malus system, even for the motor third party liability which shares the largest part of the insurance market. Free of bonus-malus system, the insurance market in Albania will not provide the insured with fair premium rates and it is going to keep far away the potential customers, even in the compulsory insurance schemes.

SUMMARY

The risk is present in the whole life of everyone. The academics and practitioners have developed mechanism to manage the risk faced by individuals and organisations. Insurance is one of the oldest devices used to deal with risk. Disaster risk insurance plans cover, against a premium, the costs incurred by the insured subject from catastrophic losses. If the event occurs, the insurance company refunds a part of the costs incurred. The risk must meet some requirements in order to be taken into consideration by insurance companies. Disaster risk does not fully satisfy these requirements. In spite of that, insurance companies have designed solutions that provide protection to insurance companies faced with catastrophic losses, such as reinsurance, distributing the coverage over a large geographical area, financial market instruments and collaboration with government programs. Especially in Western Balkan countries, the losses resulted from disaster risk constitute a large burden to the state budget. This burden should be shared with other operators in the market, such as

insurance companies. Disaster risk needs to be considered as a political priority to ensure the required cooperation across all the interested parties and to increases the resilience of individuals, companies and public entities to disaster losses.

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CONTRIBUTION OF INSURANCE AND CAT BONDS TO DISASTER RISK MANAGEMENT

Perseta Grabova

1. INTRODUCTION

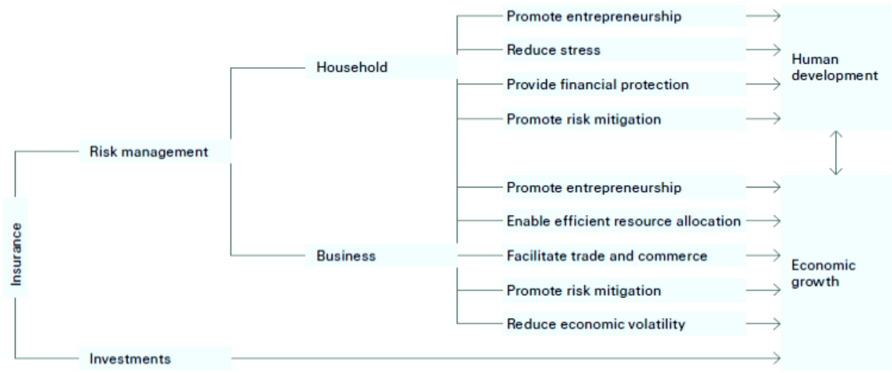
There is almost no part of the world which has not experienced natural disaster of any kind [2]. In the past decade the Western Balkans has seen a significant growth in the number of natural disasters:

- In the third week of May 2014, a massive low-pressure cyclone swept through South-Eastern Europe resulting in extensive flood damage in Croatia, Bosnia and Herzegovina, and Serbia. Within these three countries, the storm resulted in the loss of 79 lives, the evacuation/displacement of over 990,000 people and the loss of tens of thousands of homes, livestock, agricultural land, schools, hospitals and businesses.
- In Bosnia and Herzegovina, the estimated total economic impact of the disaster reached 2.04 billion Euros or fifteen per cent of the country's gross domestic product (GDP) for 2013.
- Similar flood disasters have occurred in Albania. In 2015, over a three-day period from 31 January to 2 February, around 350 mm of rain fell in south-eastern Albania, affecting 42,000 people and flooding 12,225 hectares of arable land. The economic cost of damage to the agricultural sector alone was 31.5 million Euros.
- In the Former Yugoslav Republic of Macedonia during this same three-day period 0.75 meters of recorded rainfall affected 965,569 people in 43 municipalities and resulted in the death of one child. On 3 August 2015, a severe storm and intense rainfall in the Polog region affected more than 85,000 people causing 6 casualties and inflicting € 30 million in damages.

Statistics not only reflect the changes in their magnitude but also tell us that this trend is likely to become more pronounced in years to come. More people are suffering the direct and indirect adverse consequences of these events and it will continue to be the most vulnerable who bear a disproportionate share of the impact [36]. There is evidence related to the increase of the cost of natural disasters as often more and more valuable properties are being built in risky locations [33]. This chapter will give a comprehensive overview of contribution of insurance and cat bonds to Disaster Risk Management.

2. THE CONTRIBUTIONS OF INSURANCE INDUSTRY

The insurance industry is one of the oldest in the financial sector, with over 400 years of experience. The contribution of insurance to lessen financial instability for consumer and business has been widely recognized. Apart from that the emerging market benefits from insurance as it also contributes to alleviating poverty and to enabling inclusive increase [33]. No matter how challenging is to estimate its values, the findings confirm that through its ex-ante risk management, insurance contributes to a better distribution of resources, to the improvement of trade and to promoting risk management. On the other hand, insurance enables the whole societies to get over serious shocks faster through the ex-post protection. The above-mentioned benefits from insurance pertain in both advanced and emerging markets.



Source: Swiss Re Institute.

Figure 1. The contributions of insurance industry

3. PRODUCTS OFFERED FOR DISASTER RISK MANAGEMENT IN THE INSURANCE MARKET

Disasters were not included in the insurance scheme for years, because of their characteristics. Meanwhile, today in developed economies the majority of natural catastrophes or human disasters have been included in the insurance market functioning as shock absorber for various risks. Considering the indispensability of cost-effective loss reduction measures to rebuild and recover damages from disasters, insurance should be prioritized as an essential component of household and community resilience against disasters [35]. Furthermore, in some developed countries some elements of catastrophic events are mandatory as stated by law. For instance, commercial banks request this mandatory insurance from those who apply for a loan in order to cover the risk. Brown and Churchill (2000) explained that there is a difference between disaster insurance and other products of insurance. Due to the fact that disasters are events experienced by a large number of populations at the same time, the existence of informal safety nets (family and friends) which suffer simultaneous consequences related to their life, health and property, it is difficult to estimate them. A question raised in literature is whether all types of catastrophic risk are insurable. Nowadays many insurance companies offer policies that cover a considerable part of the catastrophic risk. However, there are cases excluded from the insurance industry.

In the case of catastrophe insurance products there are no separate policies. They are included in the insurance policies against natural events or fire. In general, the term of the insurance policy is annual. The products through which catastrophic risk can be transferred also differ according to what they cover and who the insured are [8]:

Home Insurance: In many countries, home insurance is not a mandatory insurance. Home coverage is provided in case of catastrophic events such as earthquakes, hurricanes, floods, cyclones, etc. The method of replacement costs is usually used to recover a loss. In the cases where the property is completely destroyed and not rebuilt or replaced, the actual cash value is used (value of replacement minus depreciation). The home insurance is partial and is considered a coinsurance which implies that a part of the loss is covered by the insurance company and the rest by the owner.

Automobile Insurance: Typically, the all-risk type car insurance contract includes partial coverage for a catastrophic event such as floods, hurricanes, etc. In this case it is typical to apply deductible discount which is the amount the insured agrees to pay before insurance coverage kicks in, and it can be thought of as a coinsurance.

Life Insurance: Typically, life insurance policies also provide coverage for cases of loss of life and as a result of catastrophic events. The application of catastrophic coverage in the case of group life insurance may pose additional cost to the insurer if the insured are all located in the same area of the disaster.

Health Insurance and Employee's Insurance: This type of insurance covers the risks of health damage from disasters and it provides coverage for medical expenses, diagnosis, hospital service, medication, etc. It also covers the payments to the insured in the event that income is interrupted by his/her disability.

Liability Insurance: Liability insurance can also include coverage of elements from catastrophic events. It is mainly applied for building liability and rented buildings as well as other elements. Some of the cases covered by the policies of liability insurance are damages caused by lack of protective measures or negligence related to technical regulations.

Business Interruption Insurance: Business interruption insurance (also known as business income insurance) is a type of insurance that covers the loss of income that a business suffers after a disaster. The income loss covered may be due to disaster-related closing of the business facility or due to the rebuilding process after a disaster. It differs from property insurance in that a property insurance policy only covers the physical damage to the business, while the additional coverage allotted by the business interruption policy covers the profits that would have been earned. This extra policy provision is applicable to all types of businesses, as it is designed to put a business in the same financial position it would have been in if no loss had occurred.

Commercial and Industrial Property Insurance: Commercial property insurance is used to cover any commercial property. Commercial property insurance protects commercial property from perils such as fire, theft and natural disaster. A variety of businesses, including manufacturers, retailers, service-oriented businesses and not-for-profit organizations carry commercial property insurance. Commercial property insurance can be a major expense for businesses that use equipment worth millions or billions of dollars, such as railroads and manufacturers. This insurance essentially provides the same kind of protection as property insurance for consumers. However, businesses can usually deduct the cost of commercial property insurance premiums as expenses. When determining how much a company should pay for commercial property insurance, the value of a business' assets, including the building, is the primary factor. Before meeting with an agent to discuss coverage, a company should take an inventory of their physical assets located at their property. This information will help determine what exactly would be the replacement value and the level of coverage the business should get.

Agricultural Insurance: Agricultural insurance protects against loss of or damage to crops or livestock. Agriculture is one of the sectors experiencing numerous natural catastrophic disasters. Agricultural insurance has great potential to provide value to low-income farmers and their communities, both by protecting farmers when shocks occur and by encouraging greater investment in crops. However, in practice its effectiveness has often been constrained by the difficulty of designing good products and by demand constraints. Example: The Indian government adopted risk financing and insurance principles to transition its National Crop Insurance Program from a social crop insurance scheme to a market-based crop insurance program. As a result, farmers receive the claims payments much faster and have improved coverage of their assets.

4. VARIOUS BARRIERS CAUSED BY DEMAND AND SUPPLY CONCERNING INSURANCE

The various barriers caused by demand and supply have caused less efficiency in the emerging markets than in the advanced ones. The benefit of insurance and the cost of providing insurance are related to that extent that when the former gets higher so does the latter. In the emerging market framework eight relevant barriers, summarized by Swiss Re Institute (2017), have been identified. Also, Savitt (2017) evaluates the literature about hazard insurance availability and purchase and the challenges of insurability in case of disasters [31]. A total of 70 articles were included in his study, elaborating more on the demand and supply side barriers that the insurance market face when dealing with disaster events.

4.1. Demand-side barriers

Affordability: There is a negative correlation between the price of goods and demand for them. Demands fall as prices rise. Yet in emerging markets demand for insurance remains very low even when subsidies are provided [28].

Liquidity constraints: Liquidity constrains remain a concern which refrain consumers from purchasing insurance. Lack of finance is one of the most serious barriers for consumers as individuals (ex. farmers), for small and even medium enterprises in emerging markets [11].

Trust: Another serious barrier to insurance demand is the lack of trust in insurance providers. This is even more evident in emerging markets where payment of valid claims can hardly be enforced because the legal system does not function properly. Contract non-performance is significantly resulting in lack of trust which then affects demand negatively [13].

Awareness: Insurance demand is also influenced by lack of awareness. There are findings which show that consumers with high financial literacy are likely to have higher demand for insurance. Still when programs to increase consumers' financial literacy have been conducted, the outcomes have been mixed with some increase in insurance demand on the one hand [11] and on the other no impact at all on the some consumers [13].

Insuring SMEs in emerging markets: Even though small businesses owners are crucial to economic development, there are findings related to insurance of SMEs in emerging markets which is much lower than health and agricultural insurance [17].

Informal risk sharing: Development of formal insurance market is hindered by informal risk sharing networks. There are findings which prove that strong informal networks have been a barrier to the health insurance schemes of the government [20]. On the other hand there are also cases when risk-sharing networks compliment formal insurance [28]. Still recently there is evidence that the formal insurance mechanisms can be a barrier to informal risk-sharing mechanisms. To get a better understanding of the formal insurance it needs to observe the awareness of how beneficial is informal sharing to the participants [25].

Quality of service: The consumers also take into consideration the quality of service when they decide to buy insurance. This factor is decisive especially in the case of health insurance where the consumers observe the quality of health case, the distance to and quality of hospitals [12].

Behavioural biases: Individuals demonstrate behavioral biases when they have to make decisions concerning insurance. The main biases are as follows: 1. Loss aversion is the case when they disapprove to having to experience losses related to gains they are expected to get. (e.g. when individuals have purchased insurance but do not experience a loss and as a consequence, they consider insurance policy they have bought as a loss.) 2. Self-control is another bias according to which individuals are inclined to put more value to the present consumptions and as a result they do not purchase insurance in advance for a benefit which they will get in the future. Some of the different ways to address behavioral biases is by promoting saving aspects of whole life insurance instead of term life products with no saving aspects.

Cultural factors: Cultural factors sometimes demonstrated in very specific contexts may be a barrier to insurance demand. In the case of natural disasters, the lack of risk-preparedness culture associated with the dependence of the government or non-government funding relief is a serious barrier.

Economic considerations: Some of the conclusions related to economic considerations are: The demand for disaster insurance increases as income increases which is related to the fact that disaster insurance is a normal good; demand increases as price increases; when price for insurance or income change this does not result in considerable change of demand for insurance [1].

Psychological characteristic: The costs and benefits of the insurance urge the consumers to decide whether to purchase insurance or not. If the cost of insurance goes beyond the expected value the consumers may not want to purchase insurance. However, another concern is that the cost of discovering one's disaster risk may be very high and the information on insurance may be missing or difficult to find.

As mentioned above there is evidence on the rationality of the customers. However, they have proven also to be irrational as they do not understand considerably what the appropriate amount of insurance they should purchase is. It is not that they are unaware about the risk but they do not know how to react when they get the appropriate assessment of the risk and how probable it is. It is stated in the literature by most of the authors that no matter how rational or irrational the consumers are to make decisions on purchasing insurance, the number of those who buy disaster insurance is very limited from a societal perspective [23].

Apart from the issue of how rational or irrational the consumers are when making their decision on insurance, what affects their decision is also the issue of major differences among consumers on how they assess the value of gains and damages [6].

The decision to purchase disaster insurance is so complex because of so many psychological reasons and as a result the study of disaster risk management becomes more difficult [31].

Risk preferences and perceptions: The issue of to what extent people are able to estimate their disaster risks is questionable. However, there is evidence that while the perceived risk increases the insurance purchase and the price people are willing to pay increase. A consumer's interest to purchase insurance increases due to his/her belief that a disaster is expected to affect him/her as an individual [1].

It has been argued about the extent of accuracy that the disaster risk is evaluated by people. There are findings that people are willing to pay more for houses in safer locations, which reveal that they are aware to some extent of the disaster risk, related with the place they decide to live [9]. Apart from that insurance purchase increases in relation to geographical proximity to disasters.

The rates of insurance purchase are also affected by the consumers'' perception on disaster risk. Flood insurance is more purchases than other types of insurance when consumers perceive that they will experience flooding in the future [5]. Risk reduction including insurance purchase is more requested when people expect that the consequences of disaster will be more significant than in the case when they believe that it will be less severe. Even though the correlation between the estimation of risk and consumer's perception of risk has not been specified it is probable that it is positive but still weak [31].
Demographic characteristics: The effect of demographic factors on consumer's insurance has also been addressed in the researches but still not so conclusively and consistently [31]. There are findings that the insurance purchase increases just as the value of homes increases [23]. Still the amount of insurance purchases is questionable as some findings show that the home value does not affect how much insurance is purchased and others show that homes with very high or very low value are more likely to have insurance than the homes of medium value. The disaster insurance purchase is likely to increase in the case of higher social classes [9] and also in the case of having children [30]. Despite the disagreements as in some cases of being females or older ages the level of insurance purchase is lower [7] still it is concluded by the researches that consumers who have experienced disasters and have insurance are more likely to purchase disaster insurance.
It is difficult to understand and predict who will purchase insurance and who will not because of the theoretical and empirical diversity. The numerous variables that affect the consumers' decision to buy or not to buy the disaster insurance contribute in understanding this attitude of the customers' to insurance purchase. On the one hand the huge number of variables and on the other the uncertainty of the customers to decide whether to purchase or not the disaster insurance makes the value of insurance for managing disaster risks for society highly questionable [31].

1.1. Supply-side barriers

There are four supply-side barriers faced by emerging markets related to insurance [33].
Transaction costs: Premium collections and distribution costs, underwriting costs and the costs to very insurance claims comprise the administrative costs for the insurers. All these costs result in the increase of the insurance price, and as a consequent the market size is reduced. Another barrier which insurers have to face is the dispersion of risk pool together with the small sums insured. They hinder the benefits of the insurers from economies of scale.
Adverse selection and moral hazard: The insured may become less careful after buying insurance which may result in either less preventive efforts (ex-ante moral hazards or increase loss amount in case of a shock (ex-post moral hazard). Sometimes insurers are not effective in making the distinction between good and bad risks and good risks are priced out of the market.
Institutional setting: The basis for an insurance market is the insurance law which states the definition of the insurance as well as a supervisory authority, licensing criteria and prohibited practices. If the legal system and regulatory environment are weak and ineffective they have a negative effect on the insurance market. Without a regulatory framework to ensure an effective supervision, an insurance industry can decrease because of ineffective and costly regulatory interventions and as a result the consumers' trust can be diminished.
Regulation: There is evidence that some markets are retracting to nationalistic, re/insurance regulations while others are liberalizing. The increased concern about capital outflow in the

form of profit repatriation and the deteriorating balance of profit repatriation and overseas reinsurance have resulted in the rise of nationalistic re/insurance regulations. On the other hand, a liberal insurance market can improve the professionalism of industry to the benefit of consumers and businesses. A liberal insurance market needs detailed and effective regulations on market conduct, competition laws so as to enable the balance between market stability and value of consumers.

2. APPROACHES OF CATASTROPHE BONDS

Nowadays the institutional investor market covering the issue and trade of catastrophe bonds (CAT Bonds), operates like hedge funds. A reinsurer, an insurer, a government entity, a corporation, a pension fund, or a non-profit organization can issue bonds. After buying the bond with a principal payment nearly equal to the face worth of the bond, he/she gets paid usually quarterly. Pension funds, endowment funds and hedge funds comprise the institutional investor in CAT bonds. Institutional investors and accredited individual investors can invest in dedicated ILS funds which are organized like hedge funds. The bond maturity extends from one to five years; however, its span is usually three years. During the period before the bond maturity, in case a covered disaster goes beyond the "trigger point" specified in the bond's contract then a part of the principal paid by the investor covers the indemnities of the issue and the bond defaults [15]. As the issuers need to define the trigger type and the level of protection that is the attachment and exhaustion points, it is the structuring agents who assist them in this process. The attachment and exhaustion points are defined by the structural agents on the basis of their belief in what is beneficial to be sold to the investors. The assistance of the structuring agents also consists in placing the bond with the investors. Investment banks or the capital markets sections of a major broker or insurer play the role of structuring agents. In order to guarantee the claim coverage in case of a disaster the bond is kept in reserve by the Treasury money market fund in safe security.

One of the reasons why the investors are interested in CAT bonds is that the CAT bonds are almost not correlated with the credit risk, interest rate risk and equity market fluctuations [15]. Generally, there is no correlation between the happenings of natural disasters and stock market and interest rate movement. The second reason why the investors are interested in CAT bonds is that the interest rate offered is much higher than the default risk. The interest rate includes the low base interest offered by the Treasury money market funds where the bonds are deposited and also the premium paid by the issuer to cover the insurance aspect. As the reserve requirements for the issuer are reduced and the insurance protection is increased, the CAT bonds appear to be really attractive to the issuers.

The structure of a CAT bond transaction is displayed in Figure 2. The investors need a special purpose vehicle (SPV) or else they have to receive a license (to take on a contract of insurance) in order to provide insurance to the issuer directly. Sometimes SPV is labeled as "transformer", as it transforms the investment of the fund by the investors in a sale of insurance because of its being licensed itself [32].

The types of trigger loss of principal are very difficult to be defined when a CAT bond is created. There are four main triggers [15].

- Indemnity trigger: coverage of actual excess claims paid by issuer
- Industry loss trigger: coverage based on whole-industry losses on the extreme event
- Parametric trigger: coverage based on exceedance of specified natural parameters
- Modelled trigger: coverage based on claims estimated by a computer model

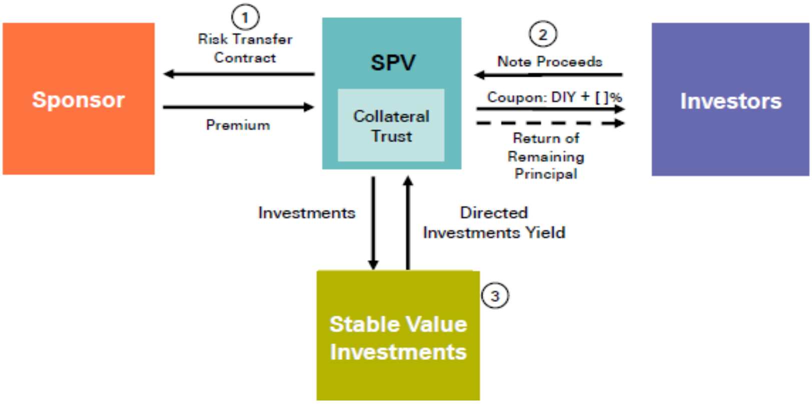


Figure 2. The structure of a CAT bond transaction

3. WHY TO INVEST IN CATASTROPHE BONDS?

A unique characteristic of catastrophe bonds is that the return from them is not correlated with macroeconomic factors and in this way, it enables profitable diversification qualities to portfolios of more traditional asset classes. Apart from it is of interest to the investors to protect themselves from market forces in uncertain financial climates. Furthermore, another beneficial characteristic of catastrophe bond is that the poor performance is likely to be self-correcting. The investors are enabled to recover from some of their losses after a natural disaster as the insurance premium increases (and thus the potential returns to catastrophe risk securities) in a relatively short period. Therefore, the increased request for insurance, a decreased ability of insurance and reinsurance companies to take risk and the growing evaluation of probability modes used to evaluate the cost of security risk of catastrophes and insurance are some of the advantageous factors [10].

Even though the investors may lose a part or all of their principal investment in case of a disaster, it is because of the low option of numerous large-scale natural disasters to occur within the same period of time, that their risk exposure is reduced by diversifying across different catastrophe bonds.

A final benefit of investing in catastrophe bonds is that the likelihood of incurring extreme losses is far lower than the chance of benefitting from extreme returns [10].

4. ARGUMENTS AGAINST CATASTROPHE BONDS

A number of advantages of CAT bonds and ILS market have been mentioned earlier. Referring to CAT bonds as a source of systemic risk in the financial system is the fact that this kind of business operates in offshore areas where there are less strict regulations on capital requirements and discloser of financial information. As a result, the investors find it difficult to monitor their risk exposure and they are concerned about lack of transparency. Investors in CAT bonds often do not consider the risk before investing as they do not have enough knowledge on climate change risk and are tempted by high returns. Another disadvantage for the investors in CAT bonds is that large sums of investments in these products may be lost unexpectedly since by underpricing the risks of climate disasters, the investors expect that they are getting high returns constantly. As a result of this loss, the market will experience a crisis or even collapse [29].

Another concern is related to the catastrophe modeling and the pricing of cat bonds. The complexity of catastrophe models needs the contribution of meteorologists, geologists, structural engineers, and actuaries to create them and as a result the final outcome may be unreliable and ineffective [21]. Insufficient data also may cause uncertainty of models. It is indispensable to improve the data quality and model techniques before using them for calculating their pricing accurately.

There are critics who do not agree on their ability to contribute in addressing climate change risk or increased systemic risk. It is argued that the least likely to be insured through this system are the most vulnerable. The poorest regions are the most exposed to the risk of climate disasters and they have to pay the most for financial protection because of the climate insurance tools. Therefore, it is the innocent parties who co-finance the expenses of environmental risks, imposed on them by the rich countries [14].

Some critics address the argument that the insured agents may be exposed to moral hazard because of catastrophe bonds. As there is a possibility of insurance, the insurer may undertake construction in vulnerable regions or use dangerous techniques, reflecting increased risky behavior. Another argument is that while the traditional insurance is characterized by a beneficial business relationship between the insurer and the reinsurer, cat bonds are more exposed to moral hazard as the investors of CAT bond do not have any relationship with the insured.

SUMMARY

This chapter offered a comprehensive overview of the contribution of insurance and cat bonds to Disaster Risk Management. It presented the main products offered for disaster risk management in the insurance market. The natural catastrophes are the source of highly complex risks and that is the reason why the concept of insuring the risks is very challenging. Based on the evaluation of the literature, a short overview on the barriers of insurability in cases of disasters was presented. In our century the losses caused by the natural disasters have been so high that it has become urgent to address the insurability of the risks. Nevertheless, it has been made possible for the investors to bear these risks and divide them at a proper cost for the involved risk by transferring CAT bonds to the capital market. Several sections dealt in detail with capital markets instruments such as Cat Bonds.

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EX-ANTE VERSUS EX-POST MEANS FOR DISASTER RISK MANAGEMENT

Gentiana Sharku, Perseta Grabova, Dorina Koçi, Mariola Kapidani

1. INTRODUCTION

Disaster Risk Management is a process that can be conducted by following two major strategies: Ex-ante and Ex-post strategies. Ex-ante strategy for crisis management refers to an active strategy that assess and manage the risk before a disaster happens. The literature review emphasizes that the public intervention in disaster risk management should be oriented toward an ex-ante strategy. Disaster risk management through ex-ante strategy aims to minimize as much as possible the economic and social consequences of a probable disaster. Some studies present different instruments that are available to finance disaster risk through ex-ante strategy [2]. Such instruments include: risk transfer through insurance and reinsurance, reserve funds, contingent credit arrangements. Despite their benefits in case of a disaster occurrence, these instruments have also their costs and that's why there are pros and cons for their use. The benefits from ex-ante strategy instruments are linked with the occurrence of the disaster event, so they arise when the disaster occurs. The costs of ex-ante strategy instruments arise each year and create other opportunity costs. The opportunity costs are forgone in case the disaster doesn't occur. For example, the interest foregone on the resources invested in the fund is the opportunity cost of reserve funds. In case of insurance, the opportunity cost refers to the full premium. Moreover, in case of the reserve funds, there is an additional risk compared to other instruments of the ex-ante strategy. The reserve funds are depleted if the disaster has not occurred until there is a need to use the fund to finance other things that seems important. Also, in case of the disaster occurrence, the reserve fund is depleted eventually and it needs a long time to accumulate it again. Ex-post strategy is more reactive and is based especially on different actions taken by the government in order to mitigate the disaster consequences and to finance loss after the disaster has occurred. Different countries have different levels of exposure, vulnerability and risk and also have different financial and technical capacity to sustain post-disaster losses.

When the governments perceive low levels of vulnerability and due to the fact that high-risk disaster rarely occur, an ex-post strategy is followed [8]. This strategy is more effective in those countries where the budget capacity is big enough to afford the disaster consequences or countries that have a well developed insurance market.

Both strategies rely on different means and financial instruments, that are subject of this chapter and will be explained in the following paragraphs.

2. EX-ANTE MEANS FOR CRISIS MANAGEMENT

2.1. Risk Control Techniques

Risk control refers to the measures taken by an organization/individual that avoid a risk or reduce the severity or the frequency of losses. For example, maintaining plant safety-inspection programs, building with fire-resistant materials or installation of an automatic sprinkler system that extinguishes a fire will reduce the excepted loss; or safety features on products will not permit the consumers to use hazardous products; or putting the snow tires by the vehicle drivers in ice streets will avoid or prevent the accidents occurring, etc. The selection of best methods to handle the risk takes place after the exposure to risk have been recognized and the size of loss has been estimated. Risk management literature suggests that risk control techniques should be used especially when the loss frequency is high and loss severity is either low or high, in order to reduce the undesirable effects of the loss. More formally, risk control includes techniques, tools, strategies, and processes that seek to avoid, prevent, reduce, or otherwise control the frequency and/or magnitude of loss and other undesirable effects of risk; risk control also includes methods that seek to improve understanding or awareness within an organization of activities affecting exposure to risk [11].

The risk control techniques include a) avoidance, which means that the risk is abandoned; b) prevention, which refers to the measures that reduce the loss frequency; c) reduction, which refers to the measures that reduce the loss severity; d) diversification which reduce the risk by spreading the loss exposures among different parties.

Large business organizations often employ loss control engineers and experts to identify sources of loss or injury and to plan and implement corrective measures. For example, injuries during work can derive from the poor conditions of workplace, lack of safety measures or improper training of the workforce. Good loss control programs can be designed and implemented by the risk manager to obtain the required objectives.

2.1.1. **Avoidance**

Avoidance refers to the decision of a firm not to expose to a particular risk of loss. For example, product liability suits can be avoided when a pharmaceutical company decides to interrupt the production of certain drugs with dangerous side effects; or the flood losses can be avoided by building a new plant on a well above a flood plain. Through avoidance, the chance of loss is reduced to zero or eliminated as the activity or the property, giving rise to the possible loss is abandoned. Some authors distinguish between proactive avoidance (when the risk is immediately abandoned or refused) and abandonment (when the risk assumed earlier is later abandoned).

Generally, avoidance is recommended to be employed when the loss exposure to the risk is both severe and frequent, i.e. a loss is expected to occur often and when it occurs it causes large damages. But avoidance can be impractical to be used often. By avoiding a risk, the organization will be sure of not experiencing the potential losses, but it will lose the potential profit that may be derived from the risk undertaking. The businesses know that if there is no risk, there is no profit. In order to gain, they must undertake some risks. The cost of loss avoidance is the sacrifice of the benefits from the activity that gave rise to the potential loss [5].

On the other hand, sometimes avoidance is impossible to be used. Some losses cannot be avoided. For example, a business organization cannot be able to avoid the premature death of a key executive. Avoidance is also called as an extreme example of loss prevention technique.

2.1.2.Prevention

The risk manager is highly involved in loss prevention activities. Ideally, risk manager would like to eliminate the risk. But as above mentioned, it is not always practical and possible. *Loss prevention refers to the measures taken to reduce the frequency of a loss*. Numerous activities reduce expected losses by reducing the frequency of losses. For example, measures that reduce the number of auto accidents include zero tolerance for alcohol and drug abuse, enforcement of safety rules, construction of appropriate barriers, lighting and road signs in highways, etc.; measures that reduce the probability of being suit under product liability law, include careful product design, quality-control tests, placement by using instructions and proper maintenance conditions etc.

2.1.3. Loss reduction

Loss reduction refers to the measures that reduce the potential severity of a loss. Despite the loss prevention measures, some losses occur. Loss reduction technique aims to minimize the magnitude of loss. For example, installation of an automatic fire-sprinkler system would not reduce the probability of loss (it does not prevent a fire from occurring), but it reduces the amount of damage if a fire occurs (reduce loss severity).
Loss reduction activities may occur before and after a loss. Pre-loss activities refer to measures taken before a loss occurs, for example installation of first aid-boxes or air bag systems in the cars. Post-loss reduction activities refer to the measures taken immediately after the loss occurs, in order to reduce the amount of loss, for example rehabilitation of workers with job-related injuries. Disaster planning constitutes a pre-loss reduction activity. The plan for evacuation, medical treatment, power restoration and clean up aim to reduce the severity of the losses from catastrophes.

2.1.4. Diversification

Diversification refers to the measures taken to reduce the chance of loss by spreading the loss exposure across different parties (e.g., customers and suppliers), securities (e.g., stock and bonds), or transactions [10]. Therefore, diversification is used to minimize several types of risk, such as financial risk, production risk, liability risk, etc. For example, an investor may reduce the investment risk by investing in several securities of several businesses; a production company may reduce the output risk and input risk by contracting different customers and suppliers; or a business instead of selling in one limited market, may reduce the risk by entering in different geographic markets.

2.1.5. Duplication

Duplication refers to the measures taken to keep backups or copies of an existing asset in reserve, to be used in case that the original asset is managed or destroyed. Duplication often is employed in cases in which the loss of use arises from the direct damage to the asset. In such cases, the duplication reduces the amount of damage if a loss occurs by reducing or eliminating the indirect loss. Duplication often serves in the dual roles of loss prevention and loss reduction. Duplication reduces the probability of an indirect loss because the duplicate may be available for use if the original asset cannot be used [11]. Examples include storing information and business records (employee records, accounts receivable, sales transactions and other financial information) on a backup server to use in case the original server fails.

2.1.6. Separation

Separation refers to the measures taken to isolate the loss exposures from each other or to divide the assets exposed to loss in order to minimize the damaged caused from the loss. For example, a company may divide the storing inventory in two separate warehouses in order to minimize the losses if one of the building is destroyed; or dividing the interior production area into several compartments separated by fire-resistant materials will prevent the fire

from spreading. This type of loss control method is called separation or segregation of exposure units.
Some authors consider separation as a form of diversification. Indeed, there is a difference between diversification and separation as methods of risk control. Diversification limits the exposure to the risk of a single asset. It reduces the probability of suffering very high losses. According to the diversification principle, by diversifying across several risky assets or markets, the probability of very high losses is reduced, but the expected loss is not changed. As the expected loss, remains unchanged, some authors do not consider diversification as an example of direct loss control. But, as separation increases the frequency of losses and reduces the expected severity of losses, it may be considered as a loss reduction activity. The separation is also called segregation.
The following example explains how the separation reduces the severity of losses. Suppose an agricultural firm that cultivates strawberries would like to expand its activity. The risk manager has two alternatives: (i) to double the size of the existing greenhouse, which value amount to 100.000€; and (ii) to build a new greenhouse in another location, which has the same value as the first one. By building another greenhouse in another location, the risk manager tends to control the losses from the floods. Assume that the floods in each location are independent events and the probability of flood in each location is 1%.
If the firm doubles the existing greenhouse, it has a 1% chance of suffering a loss of 200.000€ and 99% chance of suffering no loss. Therefore, the loss frequency is 1%, the loss severity is 200.000€ and the expected loss will be 2.000€ (200.000€ x 0,01).
If the firm build a new strawberry greenhouse in another location, it has 0,0001 (0,01 x 0,01) chance of suffering a loss of 200.000€, it has a chance of 0,0198 (0,01 x 0,99 x 2) chance of suffering a loss of 100.000€, and it has a chance of 0,9801 (0,99 x 0,99) chance of suffering no loss. Therefore, the expected loss frequency is 0,0199 (0,0001 + 0,0198), the expected loss severity is 100.502,5€ (200.000 x 0,0001/0,0199 + 100.000€ x 0,0198/0,0199), and the expected direct loss will be 2.000€ (100.502,5€ x 0,0199).
Hence, through the separation, the risk manager may reduce the loss severity, increasing the loss frequency, but the expected loss does not change.

2.2. Risk control investment decision

Business organizations reduce the probability of being suit under product liability law by designing, manufacturing and marketing safe products. Selling safe products means that the business should spend money and time to test the products for a longer time period, to place the warning labels on the dangerous products, and to use the quality-control check. On the other hand, reducing the number of lawsuits, the businesses will experience a cut in the legal fees and in the compensation paid to the injured parties, as well as the company's reputation will be less affected. Therefore, the risk control activities are not costless. In deciding upon the proper loss control activities, the risk manager must compare the costs of loss control measures and the benefits expected to be derived. Only when the benefits exceed the costs, the activity must be undertaken. Financial analysis can be employed to assist in the risk control decision making. There are several tools at the disposal of the risk manager, but this section illustrates two of them: Cost-benefit analysis and Capital budgeting.

2.2.1. Application of Cost-benefit Analysis

Loss control measures are effective only if the benefits realized from fewer occurrences of loss are greater than the cost of the loss control measures. Suppose that one company must decide how much to spend on the safety equipment for its plant. Risk management has evaluated that if the company spends nothing on safety equipment, the expected number of the injured workers will be 20; if it spends 25.000 € the number of the injuries will be decreased to 16; if the firm spends 25.000 € more, the number will decrease to 13, and so on as the columns 1 and 2 of the Table 1 shows. The expected average loss to the injured workers is calculated to be 10.000 €. If the firm spends nothing on safety equipment, it will have to pay 200.000€ as compensation to the injured workers (the expected accident cost). But if the firm spends 25.000€, the indemnification amount would be 160.000€, i.e. it will be reduced by 40.000 €. *As long as the benefits exceed the cost (investment), the firm is willing to undertake the investment*. If the firm spends an additional amount of 25.000€, the indemnification amount will be reduced by 30.000€. Again, the benefits are greater than the cost and the firm will make the investment of 150.000€. The Table 1 shows the additional benefits (marginal benefits) and additional cost (marginal cost) for each level of investment.

Table 1
Additional benefits (marginal benefits) and additional cost (marginal cost) for each level of investment

Investment Cost (1)	No. of injured workers (2)	Indemnification payment (3)	Marginal Cost (4)	Marginal Benefit (5)
25.000€	20	200.000€	-	-
50.000€	16	160.000€	25.000€	40.000€
75.000€	13	130.000€	25.000€	30.000€
100.000€	11	110.000€	25.000€	20.000€
125.000€	10	100.000€	25.000€	10.000€

The company will stop investing when the marginal cost exceeds the marginal benefit. As the table shows, the firm will invest only 75.000€, because if the firm invest more than 75.000€, the marginal cost of 25.000€ exceeds the marginal benefit of 20.000€. Hence, the optimal investment level is 75.000€.

2.2.2.Application of Capital budgeting

Risk control investments can be analyzed through the capital budgeting method, by employing time value of money technique. This technique is useful when the cash inflows and/or outflows have been distributed over a period of time. *Capital budgeting is the process that analyze the investment alternatives and select the most appropriate investment(s) that should be undertaken*.

There are several methods employed in capital budgeting, but for risk control decisions, this section considers two of them: the net present value (NPV) and the internal rate of return (IRR). Both methods (i) consider the time value of money technique; (ii) recognize that investment decisions are made in the present and the cash inflows are generated in the future; (iii) compare the investment cash outflows with future cash inflows, bringing them in present values. In the context of loss-control activities, the investment cost constitutes the cash outflow, while the reduction of future payments (damage compensations or indemnifications) constitutes the cash inflows.

The net present value is the sum of the present values of future cash inflows minus the present value of the investment's cost (cash outflows). The present value of the cash flows is calculated by discounting them at the firm's cost of capital. If the NPV is positive or zero, the investment is accepted. If the NPV is negative, the investment is rejected.

The internal rate of return method determines the rate of return which equates the present value of the cash inflows and the present value of the cash outflows of the investment. This rate of return is called the internal rate of return because it is a rate that is unique (internal) to that investment. In effect, the internal rate of return method satisfies the following equation:

Present Investment Cost = Present value of the Cash Inflows

The investment is accepted if the internal rate of return exceeds or is equal to the firm's cost of capital. If the internal rate of return is smaller than the capital cost, the investment is rejected.

Suppose that the risk manager of a pharmaceutical company would like to reduce the number of liability lawsuits from the clients. He discovered that one of the reasons is the untrained workforce. In collaboration with the human resources office, they developed a training program with a training agency. Training program costs 20.000€, and the risk manager has calculated that the expected indemnification for the next five years would be reduced by 5.000€. If the firm's capital cost is 6%, should the risk manager accept the investment proposal?

The present value of the cash inflows (reduced indemnification) for the next five years discounting at 6% is 21.062,82€. Thus, investment NPV is 1.062,82€. As the NPV is positive, the risk manager will accept the proposal.

Regarding the IRR method, risk manager finds the rate of return which equals the present value of 5.000€ per year for five years to 20.000€ (cost of the investment). For this investment the internal rate of return is 7.3%, i.e. greater than the cost of capital (6%). Hence, the investment proposal is acceptable considering both the methods.

3. EX-POST LOSS CONTROL MEASURES

There are measures which may be taken by a government to support relief and reconstruction after serious disasters. Literature elaborates on these ex post measures [9]. Relief and reconstruction after a disaster can be financially supported through different sources such as budgetary resources, taxation, credits from the central bank or private sector, international borrowing, remittances. In the following section we will describe each of the above mentioned resources and present cases where each of these resources were used in the past.

3.1. Using budgetary resources to finance lost

In order to cover the damages and needs in developing countries after a disaster, funds from the state budget can be reallocated. This financial mechanism is considered a usual one especially in developing countries. One of the main disadvantages of diverting resources from the budget to finance the losses following a disaster is the high cost that can occur. By interrupting investments, projects already undertaken by the government, the costs are not considered only financial costs but also political ones. In addition, some disasters might cause financial damages that can exceed the budget resources [6].

Budget reallocations are one of the most frequent measures of disaster recovery from the experience of the Balkan countries. Such measures are undertaken to respond to catastrophes and other disastrous events that can not be overcome without the government assistance. However, to have a fast response in terms of budget reallocation, the legal framework for the Balkan countries must include predictive measures for such events and a certain budgetary flexibility. Serbia provides transfers up to 10% of the budget appropriation to a certain budgeting program [13]. Until 2015 this constrain was at 5% of

the budget. This measure only required the approval from the Ministry of Finances, to create feasible conditions for immediate disaster response.
Meanwhile, reallocation of funds in terms of large scale disasters requires approval at higher levels of government decision-taking. During such events, higher efforts are necessary from different financial sources to cover the recovery and reconstruction resource needs. In the case of Albania, disaster response operations are funded either through the reallocation of line Ministries budgets or through allocations from the Reserve Fund controlled by the Council of Ministers. This Fund is typically financed by a 1.5% set-aside of the annual budget [3].

3.2. The application of a catastrophe tax

In a situation when the economic development is usually very slow after a disaster, it is really an extra burden to face additional taxes. The administrative costs get increased after the application of the disaster tax and in addition the consumption will be decreased and result in the increase of recessionary tendencies. Due to the tax reforms recently undertaken in many developing countries have resulted in reducing many types of tax rated and simultaneously improving the methods of collecting the taxes [6].
In the Balkan countries additional tax instruments in the case of natural disasters are not considered efficient, as they increase the implications for the proper tax administration system as well as taxpayers 'unwillingness to accept such tax. Even though this form of taxation is often referred to as solidarity tax, it is practiced only in those cases when it is highly necessary to generate disaster recovery funds. From the experience of the Balkan countries, evidences of the use of catastrophe tax are present in the case of Republic of Srpska within Bosnia and Hercegovina in the 2014 floods. Other countries of the Balkan region such as Albania, Serbia, Kosovo and Macedonia do not have practices of catastrophe taxation for the ex-post disaster response.

3.3. Credits from the central bank or private sector

Some options to cover the losses after disasters by the government may be credits from the central bank or private sector including commercial banks and private households. Other options may be selling bonds either in the international market or the domestic one, using the foreign reserves or getting loans from IMF or World Bank. Nonetheless, from the viewpoint of macroeconomic policy, it is necessary to consider the issue of how promptly the government manages to borrow sufficient funds for the reconstruction while preserving the sustainability of the fiscal policy. The domestic debt will affect the consumption by reducing it, interest rate will be increased and domestic investments will be reduced. The problem for developing countries is that the future debt will be increased and a fiscal and debt crisis might be experienced [7].
In the case of the Balkans, emergency loaning is provided in Serbia in October of 2014 by the World Bank. The loan agreement was signed for an amount of $300 million for the project of Flood recovery [13]. This emergency response is considered an important measure to prevent further damages caused by natural disasters and respond to the financial needs while adapting other supportive measures such as budget reallocation from the state. In 2017, a 66 million EUR loan was issued by World Bank to ensure immediate access to recover funds for Serbia. This instrument of loan is known as Catastrophe Deferred Drawdown Option (Cat DDO), being the first of its kind in the Europe and Central Asia region. It is designed to fund recovery programs in public health, education, agriculture, and beyond. Considering the limitations in the domestic credit market, international loans are

used to finance the high scale natural disasters such as the 2014 flood emergency in Bosnia and Herzegovina. Council of Europe Development Bank approved 7.67 million EUR in loans to finance housing and crediting for private small and medium enterprises. Other instructions offering crediting in the Balkan region during the response phase of disaster risk include: European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB) the EU, Kreditanstalt für Wiederaufbau (KfW), Norwegian Cooperation, Swiss Cooperation and the United Nations Development Programme [1].

3.4. Private and public donations

After a disaster the private and public donations from private institutions, government agencies and inter- governmental agencies comprise assistance from abroad. Commodities, grants, relief, technical assistance and money are some of the forms of aid. The levels of damage as well as the donors' willingness to provide aid define how much the assistance is expected to be [6]. The uncertainty of how much assistance will be received is one of the main problems of this financial mechanism.

Donor assistance is present in the Balkan region, including domestic donations from different humanitarian organizations, as well as international donations such as EU solidarity programs. However, financial recovery from natural disasters in the form of donations is less predictable and it does not support effective planning of disaster response. In the case of 2014 floods in Bosnia and Hercegovina the World Bank provided $100 million of financing available under the Crisis Response Window [1]. In the case of Serbia, €234.6 million was raised from donations for disaster relief and reconstruction in the 2014 floods [1]. International donor organizations and programs that are present in the Balkan region to facilitate disaster risk management and response include: European Commission, World Bank, GFDRR (The Global Facility for Disaster Reduction and Recovery), United Nations International Strategy for Disaster Reduction (UNISDR), United Nations Development Programme (UNDP), International Red Cross and other institutions. However, the donor assistance from international organizations is relevant to large scale catastrophes, and less consistent in the cases of less harsh occurrences that might be managed by domestic funding.

3.5. Remittances

It has been evidenced in the literature that after any natural catastrophe as well as microeconomic and financial crisis, the households that have migrants abroad receive more remittances which serve as a safety net [12]. There is also evidence provided by referring to cross-country experience about reaction of international flow in case of hurricanes. Yang, 2007 [14] draws the conclusion that the remittance flow for poorer countries increases if there is an increased exposure to hurricanes.

The remittance can be considered an ex-post disaster relief financial mechanism and ex-ante preparedness against future natural disasters source. Some conclusions have been drawn from the analyses of the macroeconomic data and micro-data included in the household surveys. In the countries with a high number of emigrants, it has been observed that the remittances grow in the case of natural catastrophes. In order to increase the ex-ante preparation and reduce the consequences of catastrophes in disaster prone areas the role of migrant remittances is really significant. By financing, house, investment building of concrete houses which are usually more disaster resilient and into communication equipment can reduce vulnerability to natural disasters [12].

SUMMARY

Disaster Risk Management is a process that can be conducted by following two major strategies: Ex-ante and Ex-post strategies. This chapter will give a comprehensive overview of ex-ante strategies that aims at minimizing the economic and social consequences of probable disasters as much as possible. Different countries experience different levels of exposure, vulnerability and risk and have different financial and technical capacity to sustain post-disaster losses. A short overview of the main ex-post strategies will be presented based on the evaluation of the literature. Different means and financial instruments are described and cases where each of these resources were used in the past are presented.

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CONCLUDING REMARKS

Since the beginning of 90s, the European countries have been continuously encouraging efforts to change the perception on disaster, promoting the inclusion of disaster risk management efforts, to reduce the effects of natural and man-made hazards on vulnerable community. Nowadays, despite the quick advancement in science and technology, the only effective way for a resilient society is through education. The individual can play a key role in disaster reduction, recovery capacity and society resilience.

Education system is much affected by the challenges arising from the increase of intensity and frequency of disasters and consequences of climate change. Disasters and climate change affect both demand and supply side of education. The less developed communities are the ones who bear the costs of a damaged environment, and this affects also the quality of education and jeopardies the security of students and teachers involved in the process of teaching and learning. Disasters induced by climate change can damage or destroy school facilities and educational systems, threatening the physical safety and psychological well-being of communities. Migration of population due to climate threats, also causes the interruption of education supply. Furthermore, the economic impacts of disasters reduce school enrolment, as children are kept out of school to help their families cope with disaster consequences.

Despite being threatened by disaster risk, the education sector involves many adaptive capacities. Higher Education Institutions are the place where tomorrow's leaders are trained. Therefore, they have the chance to guide the action toward sustainability and climate change adaptation. Education has already been proven to have an impact on key issues of global importance; therefore it is important that its role is not overlooked.

There are many ways how disaster risk management issues can be mainstreamed into education system. Education for Sustainable Development is a comprehensive and multidisciplinary tool that includes not only relevant content knowledge on disasters, climate change and other sustainability topics, but also focuses on the capacity of schools and education systems to become climate-proofed and resilient as well as sustainable and green. Sustainability education offers many opportunities, but in the same time poses many challenges.

Education is a critical component of adaptive capacity. The way that people are educated and the content of education can provide the knowledge and skills needed for making informed decisions about how to adapt our lifestyle and choices to a changing environment. Education system can affect disaster risk management action by improving literacy in the field, addressing teaching and learning methodologies that foster a problem solving and critical thinking approach, and by making university services more sustainable and greener.

The Western Balkan Countries are working to enhance the disaster resilience in the education sector aiming to address both Disaster Risk Reduction and Emergency Preparedness as an integral part of the education. The aim of this book is to contribute to the provision of knowledge, education and innovation, and to the creation of a culture of safety at all levels.

The editors

Review Excerpt

This publication presents research findings on disaster management referring to Western Balkan countries. The publication and investigation results add greatly to the body of knowledge regarding the safety in disaster management.

The book offers a practical approach to disaster risk management, focusing on one hotspot area of Europe in relation to disaster risk – the Balkans. Both technical and economic perspectives of the issue are addressed. The team of authors has included experts working in the field of disaster risk management in Albania, Serbia and Bosnia-Herzegovina.

A comprehensive overview of different aspects of disaster risk management, enriched with specific case studies from the Balkans are offered. Concepts of risk and vulnerability, existing systems used to manage hazards in risk, stakeholder involvement, specific risk assessments for different kinds of disasters, and finally description and implementation of financial strategies for disaster risk management, are some of the key topics covered by the book.

Co-founded by the
Erasmus+ Programme
of the European Union

The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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