SOUTH EAST EUROPE
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SEERISK

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GUIDELINE

ON CLIMATE CHANGE ADAPTATION AND RISK ASSESSMENT IN THE DANUBE MACRO - REGION

The guideline presents a collective effort of SEERISK Project Countries from the Danube macro – region. It was prepared based on data, information, text contribution and guidance on specific issues according to the prerequisites of *„Joint Disaster Management Risk Assessment and Preparedness in the Danube Macro - Region"* SEERISK Project funded by South East Europe Transnational Cooperation Programme.

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- Velingrad Municipality, Velingrad, Bulgaria.
- Koprivničko-križevačka County - **KKZ**, Koprivnica, Croatia.
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- Federal Ministry of the Interior - **BM.I**, Vienna, Austria.
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LIST OF ABBREVATIONS AND ACRONYMS

CC	Climate change
EU	European Union
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
a.s.l.	Above sea level
NCCS	National climate change strategy
NGO	Non-governmental organisation
SPI	Standard Precipitation Index
UHI	Urban Heat Island

FOREWORDS

Lieutenant General
Dr. György Bakondi
Director General of the MoI-National Directorate General for Disaster Management, Hungary

The countries in the Danube region are connected not only by the European Union's largest river and common historical heritage, but they also share the effects of our more extreme climate. The acknowledgment of this phenomenon has led to the launch of the SEERISK project, a cooperation between nine countries. We are proud to be the first in the region to begin joint assessment of the risks associated with climate change from a disaster management point of view.

The frequency of sudden downpours, flash floods, strong winds and snow storms has multiplied in the countries of our region, while prolonged droughts are not uncommon. The year 2005 was made memorable by tornadoes and heavy rainfalls. The water played a major role in next year as well: in 2006 great floods marched down the Danube and Tisza River practically at the same time. In almost all the cases of natural disasters, the authorities in the region have had to take care of vulnerable people left without a roof, of whom the housing had been endangered and settlements out of reach. Additionally during the floods in 2001, 2002, 2010 and 2013 regional authorities had to organise evacuation and reconstruction of entire villages. Last June, we had to protect the population and goods against the greatest floods of all time on the River Danube.

Climate change also affects the quality and length of the seasons. Since 2007, almost every year an unusual heat wave places new demands on the authorities to alert the community. Last winter, heavy snowfall and prolonged frost caused serious problems in Bosnia and Herzegovina and Serbia. Agricultural areas in Croatia were endangered by extreme temperature fluctuations. The sudden snowfall occurring in March 2013 hit thousands of people in Austria, Hungary and Serbia, who were temporarily left without some kind of primary infrastructure. Beyond all these problems our Slovak, Romanian and Bulgarian partners experience similar events and suffer permanently from sudden thunderstorms.

Recognising that storm clouds and floods do not stop at borders, stricken neighbouring countries have been supporting one another in recent disaster incidents. This mutual support is vital but it must be kept in mind that further collaboration will be beneficial. Significant time and money can be spared by jointly assessing the risks endangering our countries, cities and villages. The project presented in this Guideline has developed a practical Risk Assessment Methodology based on the results of the latest climate research and on detailed meteorological and geographic information system data. This methodology has been adapted to our region, and with its unified principles, it will assist professionals in making risk assessment task simpler.

Modern societies are making huge efforts to gain control over the natural and man-made risks, but this effort is not always crowned with success. For that reason it is vital that the disaster management professionals and municipalities take into account climatic variables, instead of exclusively relying on facts that are already known.

Prof. David Alexander
Institute for Risk and Disaster Reduction
University College London, United Kingdom

Europe is a continent of ten million square kilometers in which 740 million people live in 50 countries, six enclaves and seven dependencies. In this crowded geographical space, natural hazards frequently cause damage and casualties, and there are signs that climate change has begun to intensify this problem. The combination of hazardous natural phenomena and high vulnerability leads to complex and cascading effects. Critical infrastructure is seriously at risk in Europe, and transboundary impacts are increasingly common. It is therefore vitally important that European countries redouble their efforts to estimate and assess the risks posed by natural hazards. Only by gaining a detailed understanding of how the risks operate, and in particular how hazards act upon the many sources of vulnerability, will it be possible to design remedial measures. Warning, evacuation, preparedness, response and recovery all depend on having a solid understanding of the risks.

One of the problems of risk assessment is that many different methodologies are available to accomplish it. Moreover, social measures tend to differ from the more empirical methodologies used by engineers and physical sciences. No matter how many facets it has, risk is a holistic phenomenon that needs to be understood in its entirety. This is difficult to achieve when the norms, laws and regulations governing risk mitigation and management are different from one country to another, or, indeed, from one region to another. Hence, the European Union has issued guidelines on how to assess risk in order to reduce and respond to disaster impacts. Many of the worst risks of disaster occur in the south and east of Europe, where the Alpine mountain chain and the Mediterranean basin harbour geophysical and meteorological hazards that are often more intense than they are elsewhere in the continent. This part of the continent is therefore a vital laboratory for testing the methodologies proposed by the EU and adapting them to local circumstances.

SEERISK is a collaborative project that has conducted research into the application of risk assessment methodologies in the Danube basin and other areas of southeast Europe that are seriously threatened by meteorological and hydrological hazards. It represents the best of European co-operation in applied science and is a model of how collaboration between institutions and countries can reduce a seemingly intractable problem to something that offers solutions and methodologies for making Europe safer. SEER!SK has produced practical guidelines for managing risks and responding to floods, droughts, heat waves, ice storms, cold snaps and other hazards that are common. Readers who are involved in managing the response to such events are urged to consult these guidelines and make use of them so that the citizens of Europe can be better protected in the future.

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EXECUTIVE SUMMARY

Relative to the past century societies and the environment around the globe often suffer the consequences of natural hazards that lead to loss of life and property, environmental degradation, destruction of infrastructure and business disruption. The costs of natural disasters are rising, while the consequences are becoming more and more serious. Therefore, it is essential to better understand these natural processes, to find appropriate risk management options and to address the potential changes resulting from socio-economic and environmental development. Many research groups and institutions in several countries are working on improving risk management concepts and strategies.

In South-East Europe, extreme disaster events are also a major concern; for this reason, the SEERISK project has been launched to investigate the specific conditions in detail. Guidelines aimed at providing assistance to disaster risk management professionals.

This Guideline summarizes the results of the first part of the SEERISK project and reveals policy recommendations aiming to improve local adaptation to climate change-related natural hazards. One of the main aims of SEERISK is to develop a common, generic and adaptable risk assessment methodology. Risk assessment is a systematic, science-based decision making process, which provides a comprehensive profile of the risks, their causes, probabilities and consequences. It comprises the overall process of risk identification, risk analysis and risk evaluation. The common risk assessment methodology integrates the European Commission's *Risk Assessment and Mapping Guidelines for Disaster Management*, considers individual challenges of the end users and offers practical solutions. The methodology took into account a variety of natural hazards and elements at risk, and resulted in a harmonized risk assessment process in the partner countries. Risk matrices, risk scenarios and risk maps have been used in the mapping process and have been based on past recorded events in six pilot areas.

This methodology has been tested in practice in the different countries participating in the project, by taking into account local deficiencies, such as the lack of records of local historic disaster events, spatial data and other relevant data. Therefore, the methodology offers various alternative solutions for implementing the risk assessment process and specifically for developing risk maps..

As widely discussed, climate change is expected to influence the frequency and magnitude of natural hazards such as floods, extreme temperatures, storms, droughts and wildfires. Thus, health, material, economic and environmental consequences of related disasters are also becoming more serious.

The social aspect of the climate change in the Guideline involves an assessment of the awareness and preparedness of individuals and stakeholders in the pilot communities. Social awareness questionnaire surveys for the pilot communities as well as semi-structured interviews and analysis of the local planning documents have been carried out. As a combination of risk assessment and social surveys, gaps have been identified between the actual exposure to hazards and the degree of preparedness of the communities.

Subsequently the SEERISK consortium formulated applicable recommendations for both local and national levels. These policy recommendations designed for participating countries can be also applied elsewhere, with minor modifications. Although policy recommendations are the main product of the Climate Change Adaptation and Risk Assessment Guideline, SEERISK also deals with the practical aspect of preparedness at a later stage. This includes, for example, disaster simulation field exercises in the pilot areas, a GIS best practice compilation and an emergency communication strategy. All the practical products, guidelines and methodologies will be available in electronic form as *Disaster Risk Assessment and Climate Change Adaptation Toolkit.*[1]

[1] Please visit the SEERISK Project web site www.seeriskproject.eu

1. INTRODUCTION

SEERISK project countries from the Danube macro – region have been often affected by a range of natural hazards that have caused a significant number of negative effects manifested in human casualties, infrastructure damage and environmental impacts as presented in Figure1.1. Many hydro-meteorological hazard events, such as storms or flash floods are direct consequences of climate extremes (extreme weather events), while others like floods or wildfires are becoming even more frequent or extreme due to climate change.

According to the most recent IPCC report (2012), climate change is "*an alteration in the state of climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer*".

However, although changes in climate are expected to influence the frequency and intensity, spatial extent, duration and timing of hazardous phenomena, extreme weather and climate events may lead to disaster only if: 1) communities are exposed to those events, 2) the vulnerability of these communities is high, and 3) their adaptation potential is low. In Europe, for example, despite the fact that hazard exposure has increased, vulnerability has significantly decreased, due to improved adaptation policy, regulations and risk prevention and management strategies (IPCC 2012, EEY 2008, UNISDR 2009).

As far as changes in climate are concerned, it is accepted that the Earth's surface has experienced extraordinary and rapid warming since the late 1800's. At the global,

Figure 1 *SEERISK project pilot areas hazard events (Sources: SEERISK pilot areas - Arad, Senica, Siófok)*

continental and regional levels, numerous long-term changes in climate have been observed. Observations of increases in the global average air and ocean temperatures, widespread melting of snow and ice, global rising of the sea level, and warming of the climate system in recent decades have confirmed that global climate change is occurring (NOAA, 2013). Despite some controversy in the past, it is now recognized that human activities are the main contributing factor to global warming that has been observed in the last 50 years (IPCC, 2007).

In more detail, IPCC estimated that by 2100, global temperature is expected to increase between by 1.1 to 6.4°C, while, sea level is forecasted to rise between 18 – 59cm. It is further approximated that acidity of the oceans might increase, hot extremes might become more frequent, tropical cyclones more intense and precipitation might increase in higher latitudes, whereas in subtropical areas it is expected to decrease (UNISDR, 2008). Due to the observed changes of mean annual temperature, precipitation and the decrease of snow precipitation and duration of snow cover, a decrease in mean annual water discharge and an increase of runoff during the winter period is most likely to be expected. Additionally, low water availability during the summer period as a consequence of low summer precipitation and high evapotranspiration might be particularly strong. This summer, water scarcity might particularly increase the frequency of moderate and severe drought events.

In Europe generally, higher temperatures are causing retreating glaciers and are increasing the frequency and severity of wildfires (UNISDR 2008). The observed and projected changes in Europe related to climate change are demonstrated in Figure 2.

In South-East Europe and especially in the Carpathian Area, particularly the southern parts of Hungary and Romania, as well as the Republic of Serbia, Bulgaria and the region of the Danube Delta are likely to face severe drought and water stress, resulting in water shortages (ICPDR, 2012).

On the other hand, future projections of flood events are characterized with high uncertainty. However, an increase of flood hazard probability and magnitude is likely to occur in the Danube basin, especially in small water catchments. A pronounced increase in flash floods is to be expected. as well (ICPDR, 2012)

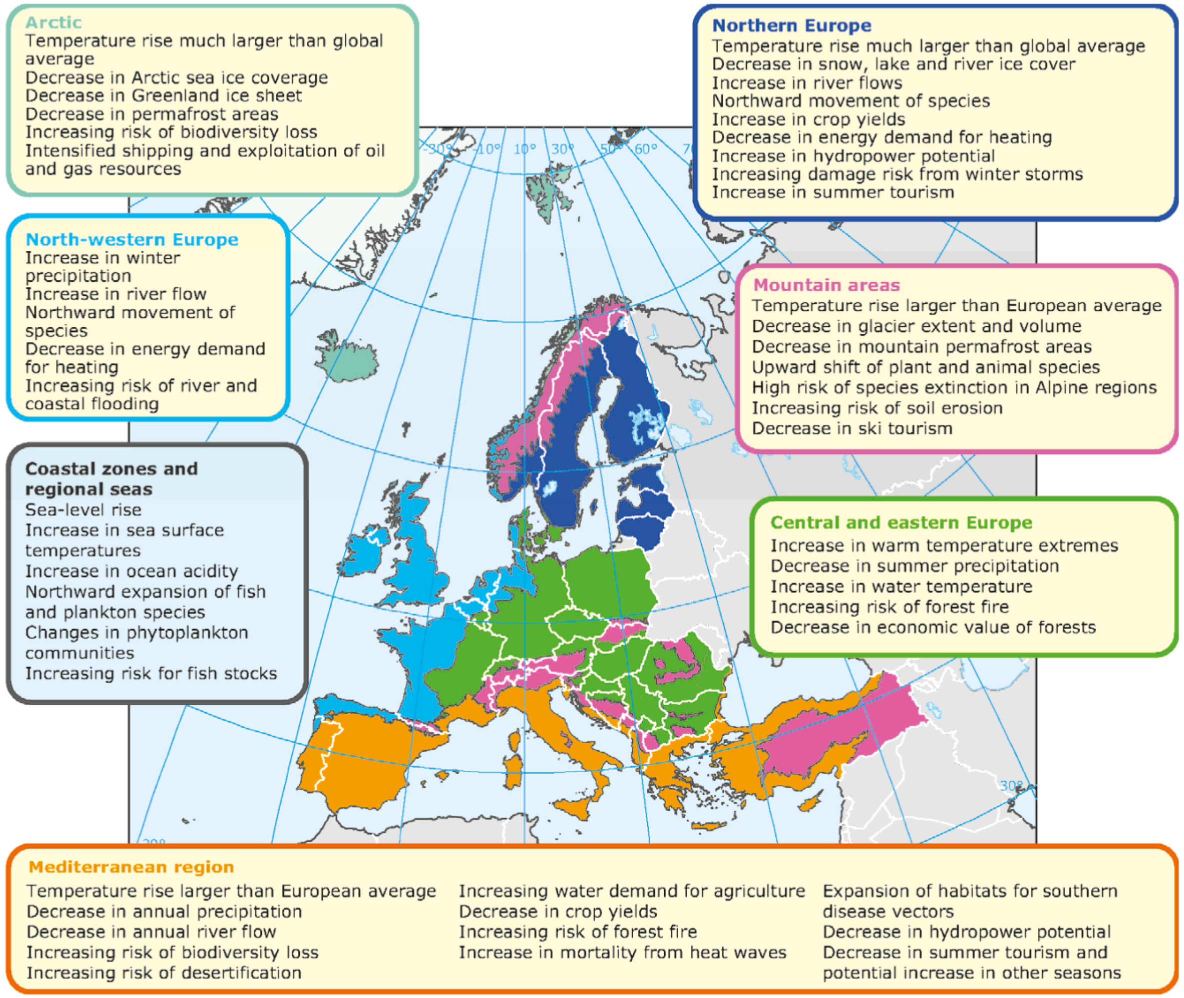

Figure 2 *Observed and projected changes in the different European regions (EEA, 2012).*

More particularly, as far as SEERISK project partner countries in the Danube macro – region are concerned, climate change poses a real and growing problem (refer to Fig. 3). By combining the IPCC emission scenario (A1B, A2, B1 and B2) and Global and/or Regional Circulation Models it was possible to spot future trends of climate parameters such as air temperature and precipitation. Various simulations show a decrease in summer precipitation of about -20% to-35% for SEERISK project countries in the Danube macro – region. While winter variability increases significantly, there are no clear trends for spring and autumn.

Due to the expected changes in climate, natural hazards spatial pattern, frequency and magnitude are modified as well and as a result, the associated consequences are also significantly altered. The schematic relationship between disaster risk and climate and socio-economic change is clearly shown in Figure 3.

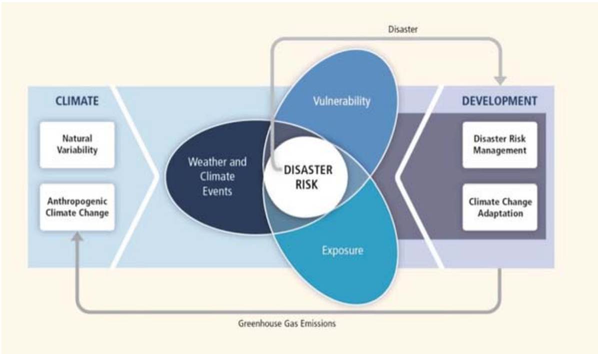

Figure 3 *The relationship between disaster risk and global environmental change (IPCC, 2012)*

Climate change, in combination with socio-economic changes is expected to modify the spatial pattern of risk too in SEERISK countries. Furthermore, climate-related extremes and hazards are not restricted within national borders. For this reason, collaboration between neighbouring countries and harmonization of the existing practices and methods are essential. Furthermore, detailed investigations and high regionalized predictions are critically important for drafting preparedness and adaptation policies. The existing risks should be reduced by implementing specific regional adaptation policies and measures. As far as the SEERISK project partner countries are concerned, coherent and comprehensive transnational action plans and programs should be elaborated for the whole area, defining the necessary instruments and costs of implementing the proposed measures.

The vulnerability and adaptation potential of societies will also change the spatial pattern of the associated risks, as well as direct and indirect consequences of hazards. The development of appropriate climate change adaptation strategies, based on comprehensive risk assessment is essential and could significantly reduce risks (Fig. 1.4). The need for an improved and harmonized methodology for risk assessment and mapping is clear and for this reason, a major part of the SEERISK project is dedicated to elaboration of such methodology. An adequate assessment of risks for different types of climate change-related hazards and a variety of elements at risks (e.g. buildings, people, industrial or agricultural areas), as well as their mapping is an essential basis for risk reduction strategies and decision making. Effective disaster management, emergency and evacuation plans, preparedness and efficient warning systems are based on reliable risk information. In the SEERISK guidelines such a methodology is not only developed, presented and tested but the relationship between risk assessment and climate adaptation is also highlighted.

In fact, a major overlap and complementarity can be observed between the policy fields of disaster risk reduction and climate change adaptation. Disaster risk reduction may contribute to climate change adaptation, with relevant legislation development, multi stakeholder platforms, technical networks and approaches to community, whereas climate change adaptation approaches, such as vulnerability assessments, capacity building and response strategies will directly support disaster risk reduction (UNISDR, 2009).

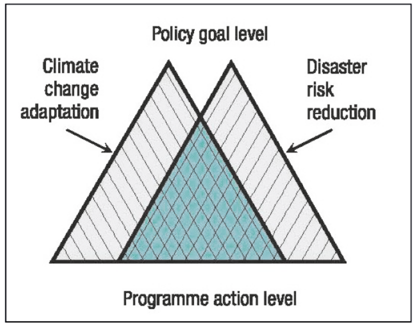

Figure 4 *The relation between climate change adaptation and disaster risk reduction policies (UNISDR, 2009).*

Moreover, The Hyogo Framework for Action 2005-2015, adopted in Kobe (Japan) in 2005, expressed the need to address climate change as part of disaster risk reduction strategies (UNISDR, 2009).

National climate change strategies focus on the assessment of the present situation and conditions as well as the requirements for adaptation to climate change. In Hungary, the National Climate Change Strategy (NCCS) for the Period 2008-2025. was adopted in 2008. Consultations about the revised version (NCCS. 2) is underway. It is planned to be adopted in 2014. As part of the NCCS, the Hungarian National Adaptation Strategy defines adaptation objectives and tasks for the period 2014-2025 with an outlook until 2050. In Romania, an approved NCCS for 2013-2020 is in use, which also comprises recommendations for local authorities. In Slovakia, preparation of the NCCS has begun and the first draft of the National Adaptation Strategy was published in 2013. In Bulgaria, an interministerial working group was established to promote and coordinate the development of a NCCS aiming at CC adaptation. In Bosnia and Herzegovina and Serbia the a NCCS and National Adaptation Strategy are being prepared.

The Guidelines on Climate Change Adaptation and Risk Assessment presented here set the focus on climate change adaptation, using a risk assessment methodology. This methodology considers the specific characteristics of the SEERISK partner countries, their legal and administrative framework, their requirements, the needs and challenges that they have to face (e.g. lack of data, difficulties in communication between agencies, transborder collaboration). It also attempts to provide a harmonized solution for the partner countries, which will enable them to assess and map risks. SEERISK partner countries will be able to use the methodology in order to assess and visualize risks and consequently make informed decisions regarding disaster management measures and plans. The SEERISK partner countries will be able to use this risk assessment methodology as a basis for climate change adaptation and disaster risk reduction policies.

2.OBJECTIVES OF THE GUIDELINE

The Guideline on Climate Change Adaptation and Risk Assessment are designed to assist disaster risk management practitioners and decision makers in taking appropriate risk assessment and climate change adaptation measures and actions.

The **overall objective** of Guideline is to assess and reduce risks from climate change related natural hazards to human life, welfare and environment in the Danube macro – region. The document aims to enhance preparedness and disaster management response capability, as well as provide applicable mitigation and climate change adaptation actions.

The **specific objective** is to develop and propose a unified approach to risk assessment, shared principles and strategies on climate change adaptation. This includes:

1. Carrying out the process of risk assessment by developing a common risk assessment methodology;

2. Explaining how the common risk assessment methodology can be put into practice via the results in six case study areas;

3. Revealing gaps between the challenges imposed by the natural hazards related to climate change and the level of overall preparedness of the society;

4. Suggesting possible adaptation solutions to the challenges imposed by the changing climatic conditions;

5. Raising people's awareness of climate change and enhancing overall local-level disaster management preparedness.

2.1. THE CONCEPT OF LOCAL RISK ASSESSMENT

The rationale behind the SEERISK project and the novelty it brings is that it combines *identification and analysis of risks posed by climate change related hazards* with *analysis of the perception the society and institutions have of these risks and their preparedness* for them.. In this way the natural/climatic and social aspects of disaster risk assessment became part of the same platform.

The proposed framework of a comprehensive local disaster risk assessment process follows logical order of essential outputs and steps. This general workflow has been designed for SEERISK in such way that it can be ideally applied to any local circumstances in different environmental and social and political settings (Figure 5).

In the initial stage, the natural hazard that needs to be assessed and managed throughout the process is to be properly identify. This can be done by using a custom-designed risk assessment questionnaire which reveals and ranks the relevant hazard. The second stage of the identification process involves adoption or development of risk assessment methodology which allows risk assessment to be performed locally.

The analysis of the risks can be made possible by developing three useful risk-related products: risk matrices for classifying risks levels, risk scenarios for credibly describing a disaster and risk maps for demonstrating risks geographically.

To thoroughly analyze the perception the society' and public institutions have of the risks and their preparedness for these risks, a survey on social risk awareness and an analysis of the local planning document shall be conducted.

The risk evaluation stage, where all the previously developed results have been processed, ends with formulation of policy recommendations for decision makers aiming to rectify current weaknesses and take advantage of climate adaptation opportunities.

The findings and the recommendations in the climate change adaptation and risk assessment guideline can be best shared via climate change adaptation platforms, which can be maintained as a permanent forum for the interested stakeholders.

In order to enhance and reinforce the preparedness of disaster management to deal with the identified natural hazards, disaster simulation field exercises could be organized. Moreover, an efficient emergency communication strategy shall be in place.

The following chart shows the main stages of the SEERISK project which is drawn up broad enough so as to provide as practical guidelines for any local-level risk assessment exercise, as well.

In the following chapters, the different stages of the project will be explained in more detail.

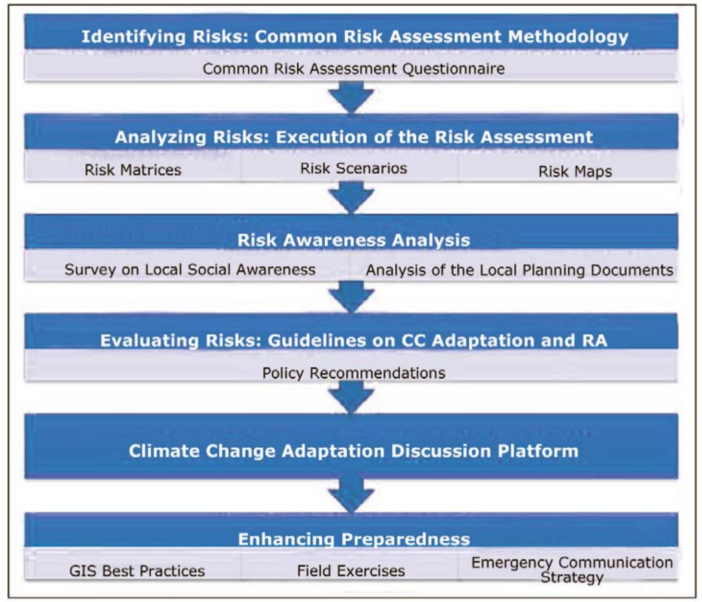

Figure 5. *The concept of the SEERISK Project*

3. GENERAL DESCRIPTION OF THE COMMON RISK ASSESSMENT METHODOLOGY

The common risk assessment methodology has been developed in order to improve the consistency in risk assessment among Southeast European countries and provide the local authorities and other end-users with a tool that will enable them to conduct risk assessment and mapping for a range of hazard types, hazards of different scale and elements at risk. A questionnaire about common practices in risk assessment and mapping, damage assessment, data availability and institutional background was completed by each partner. The results of this questionnaire were analysed and were very much taken into consideration during the development of the common methodology. The methodology was developed by the University of Vienna and it received strong support by NDGDM (Hungary) and the entire SEERISK consortium.

The principal aim of the methodology is to provide a tool for local authorities that can assist them in the implementation of risk assessment and in the estimation of potential changes of risks associated with specific scenarios, including climate change related scenarios. In more detail, the risk assessment methodology aims at:

a) Integration of the EC guideline in risk assessment and mapping;

b) Taking into consideration individual challenges of end users, such as data scarcity;

c) Being solution oriented: the methodological framework incorporates practical solutions in order to face the challenges and deliver the final products (risk matrices, risk maps and risk scenarios);

d) Production of risk matrices by the users, based on past recorded events;

e) Production of risk scenarios;

f) The framework for mapping risk of different types of hazards and elements at risk;

g) Harmonisation of the risk assessment process in the partner countries that leads to comparable outputs

3.1. SEERISK PROJECT METHODOLOGY

The common methodology considers drawbacks, such as lack of significant data sets and it offers alternative steps, in order to provide a methodology that is feasible and usable even with limited data availability. Therefore, the methodology is solution-oriented. Moreover, the methodology has been designed in accordance with the EC Guidelines for Risk Assessment and Mapping (EC, 2010). It provides a step-wise approach, regarding the risk assessment procedure, a methodology on the development of risk matrices and scenarios and finally a theoretical approach to risk mapping. The theoretical framework of risk mapping presented here is applicable to all hazard types which have been in the focus of SEERISK.

3.2. STEPS OF RISK ASSESSMENT

The risk assessment process is part of a greater risk management process as demonstrated in Figure 6. Risk assessment incorporates three steps: risk identification, risk analysis and risk evaluation. These three steps often overlap and one does not necessarily have to be completed for the next one to begin. The actions that are involved in each step are thoroughly described in the EC guidelines (EC, 2010).

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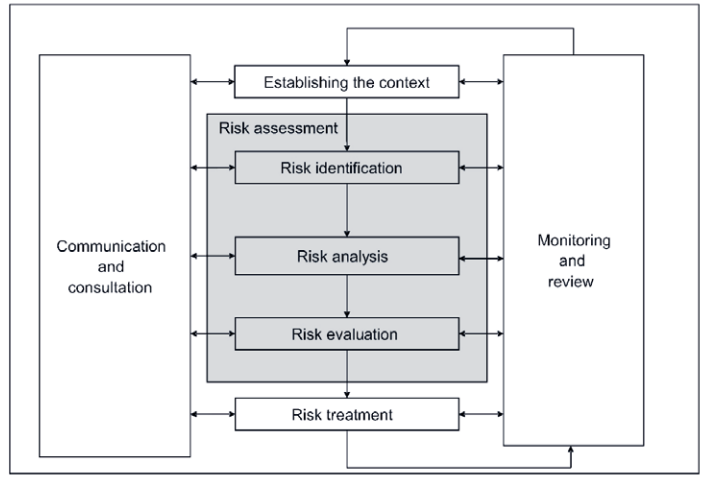

Figure 6. *The process of risk assessment as part of risk management (IEC/FDIS31010, 2009*)

The SEERISK common risk assessment methodology is shown in Figure 7. The risk assessment process incorporates three steps: 1. establishing the context and risk identification, 2. risk analysis and finally 3. risk evaluation. However, the three steps are interconnected and often overlap (e.g. establishment of risk criteria in step 1. and the levels of risk matrix in step 2. are used during risk evaluation, step 3.). In the following paragraphs the steps of the risk assessment procedure are briefly reviewed and explained.

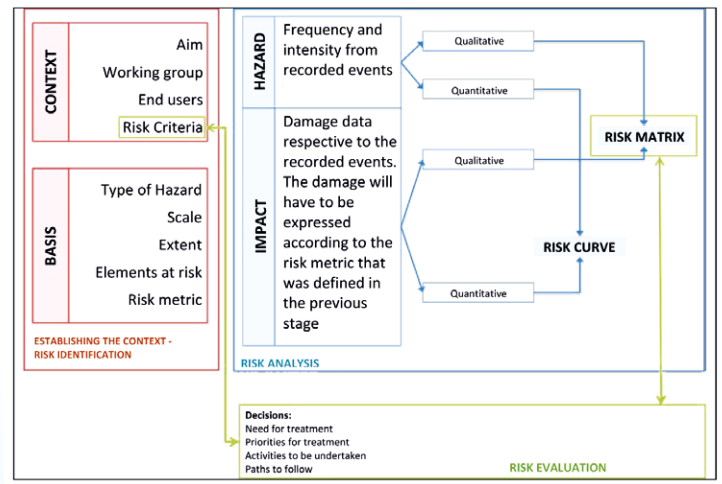

Figure 7. *Risk Assessment Procedure (modified from AEMC (2010)*

3.2.1. CONTEXT AND RISK IDENTIFICATION

The context of the risk assessment has to be determined from the beginning of the risk assessment procedure. The context includes the aim of risk assessment, in other words, the reason for conducting risk assessment has to be made clear (e.g. emergency planning, prioritization of funding allocation, a basis for decision making, etc.). Moreover, the working group that will conduct risk assessment has to be identified together with the end users of the final product. The end-users will define the focus of the risk assessment, as well as the form of presentation of the results. Finally, the risk criteria i.e. the terms of reference against the significance of a risk, should be evaluated by the working group (IEC/FDIS31010, 2009). These criteria are unique for each area and hazard type. On the other hand, the basis of risk assessment indicates the details of the procedure such as the type of hazard or hazards, the scale of risk assessment and the extent of the study area. The scale may range from local to national, but it may also be site- or catchment-specific. The limitation of the study area may be imposed by administrative borders or limits that will be set by the working group. Finally, the elements at risk (buildings, people, etc.) and the risk metric (the way risk is going to be measured, e.g. number of people, damage in euros) have to be defined. One way of obtaining basic hazard and risk data, i.e. in the identification phase, is to use a risk assessment questionnaire (see Disaster Risk Assessment and Climate Change Adaptation Toolkit for template).

3.2.2. RISK ANALYSIS

Risk analysis is a process that involves understanding of the risk and determination of its level (EC 2010). Generally, risk analysis involves an assessment of the probability of occurrence of an event (or hazard) and an assessment of its impact on the elements at risk. In other words, risk analysis has to address: Hazard Analysis and Vulnerability Analysis (Table 1).

Table 1. *The actions included in hazard and vulnerability analysis (EC, 2010)*

Hazard Analysis	Vulnerability analysis
(a) Geographical analysis (location, extent)	(a) Identification of elements at risk (exposure)
(b) Temporal analysis (frequency, duration, etc.)	(b) Identification of vulnerability factors/ impacts
(c) Dimensional analysis (scale, intensity)	(c) Assessment of likely impacts
(d) Probability of occurrence	(d) Analysis of self-protection capabilities reducing exposure or vulnerability

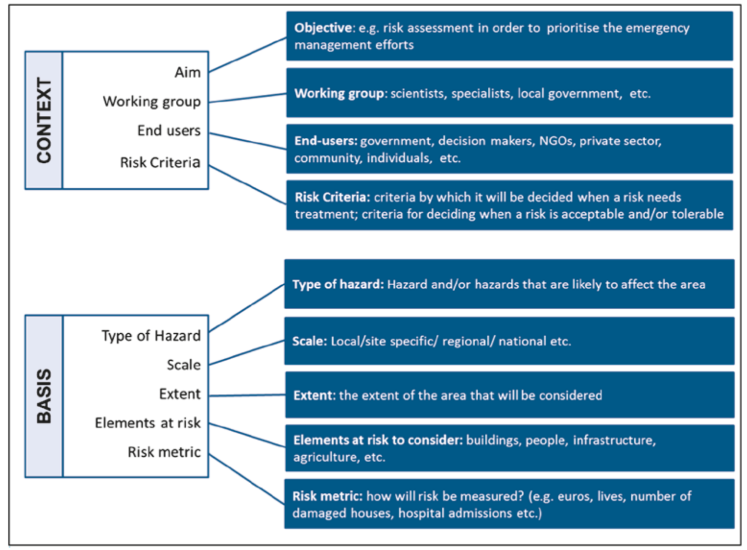

Figure 8. *Establishing the Context and the Basis for the Risk Assessment Procedure*

3.2.2.1. HAZARD ANALYSIS

At this stage, records of past events have to be investigated first, in order to obtain information on the probability of occurrence and the intensity (and extent) of each event. The type of information available may be either qualitative (high/medium/low probability) or quantitative (return period of e.g. 100, 30, 10 year flood).

3.2.2.2. IMPACT ANALYSIS

Information regarding the impact of specific events has to be collected and analysed. Impact analysis involves collection of information regarding a specific element at risk and the risk metric (e.g. number of deaths, damage in euros). The identification of the elements at risk (exposure) in the study area and their characteristics that affect their vulnerability (vulnerability factors and indicators) have to be included. Preparedness and coping capacities should also be considered in the impact analysis.

3.2.2.3. QUALITATIVE, QUANTITATIVE AND SEMI-QUANTITATIVE RISK ANALYSIS

Risk assessment may be qualitative, quantitative or semi quantitative. Qualitative risk assessment methods classify risk as high, medium and low, based on expert classification schemes, whereas quantitative risk assessment methods express risk in quantitative terms, such as number of lives lost or damage in Euros (€). (Note: Semi-quantitative methods which use indices to express the respective risk are not covered by this methodology).

3.2.2.4. RISK MATRIX

After performing hazard and impact analysis in the qualitative form in steps 1 and 2, the risk matrix can be developed (step 3). The risk matrix is based on historical data and for this reason has to be unique for the specific pilot area, such as for the element at risk and the type of hazard considered. In order to develop a risk matrix, like the one shown in Figure 12, the following sub-steps have to be taken:

a. The likelihood or probability of occurrence of a specific hazard
b. The impact of this specific hazard on the selected element at risk
c. The risk levels or risk rating (e.g. low, medium, high) and a description of each category.

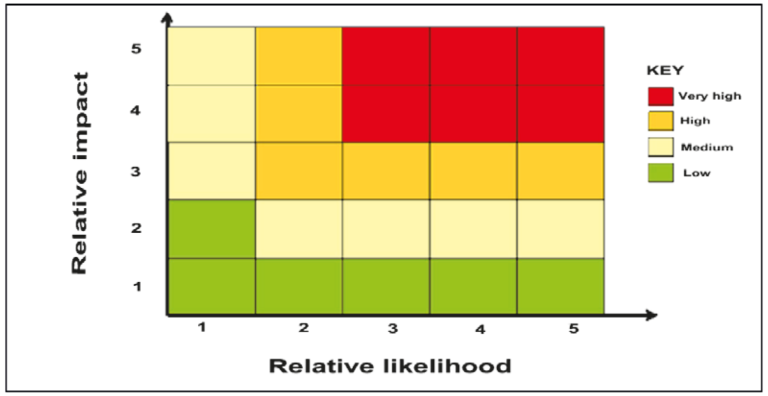

Figure 9. *The risk matrix based on EC (2010) (Note: (1), (2), (3) etc. refer to the different ratings of impact and likelihood)*

The risk matrix shown as an example in Figure 9 is only a suggestion, developed based on the EC Guidelines. A risk matrix may have as many impact and likelihood categories as necessary, depending on the type and quality of data used.

LIKELIHOOD RATING

Likelihood rating is the first essential step in the development of a risk matrix. According to IEC/FDIS31010 (2009), there are three different approaches to estimating the likelihood of an event: a) Use of historic data, b) Probability forecasts, c) Expert opinion. The choice of one of the above approaches depends on the availability of past records, data, resources, and experts for the specific process in the study area. According to IEC/FDIS31010 (2009) the probability scale may have any number of points. The probability range has to be relevant to the case study area and the chosen hazard type. The probability scale may span the range relevant to the study area, considering that the lowest probability must be acceptable for the highest defined consequence (IEC/FDIS31010, 2009).

IMPACT RATING

Impact rating is the next major step in developing the risk matrix. First, experts have to decide on the element at risk (e.g. human lives, material damage) and the risk metric (e.g. number of fatalities or injured inhabitants, monetary damage in euros). Impact rating can be determined according to these two pieces of information. For example:

- Catastrophic: more than 1 death per 10.000 inhabitants
- Major: more than 1 death per 100.000 inhabitants
- Moderate: more than 1 death per 1.000.000 inhabitants
- Minor: Isolated cases of serious injuries
- Insignificant: minor injuries.

The intervals can be absolute numbers or descriptions (thoroughly explained). The impact rating has to be based on real past events and their consequences or expert judgment. The range of impacts should extend form the highest credible impact to the lowest impact of concern (IEC/FDIS, 2009).

RISK LEVELS RATING

At this stage, end users have to decide what high, medium and low risk applies to them. This decision might also be connected to specific actions. For example, low risk (green) might mean no action, medium risk (yellow/orange) might mean alert and high risk (red) might mean evacuation. This step is also connected to the third step of risk assessment, namely, risk evaluation. At this stage, decision makers have to identify which risks they are going to accept and which ones they are going to treat.

3.2.2.5. RISK CURVE

In case information regarding the probability of occurrence and the impact is available in quantitative form, a risk curve can be developed. The risk curve shows the relationship between the probability of occurrence and the respective loss (Figure 10).

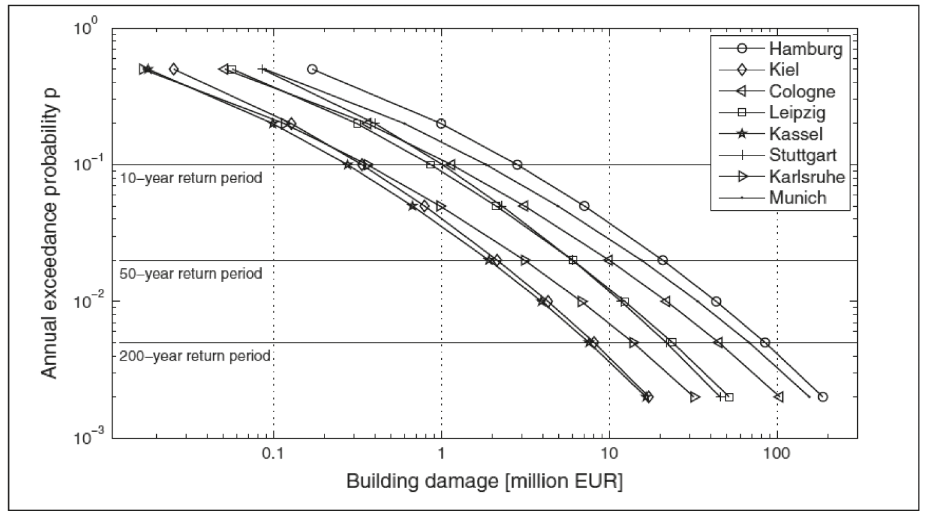

Figure 10. *An example of a risk curve for storm risk assessment for different German cities (Heneka and Ruck, 2008)*

3.2.3. RISK EVALUATION

Risk Evaluation is the procedure of deciding which risk is acceptable or tolerable and has to be treated. Decisions related to risk evaluation (e.g. acceptable risk criteria) have to be made right at the beginning of the procedure. At this stage, the results of risk analysis and risk criteria have to be compared.

3.2.4. RISK MAPPING

Risk mapping is an essential tool for local authorities and decision-makers and it should accompany risk assessment. The methodology of risk assessment and mapping considers the shortcomings of potential users, such as limited data availability. Three alternatives are given, followed by an EXIT option. The EXIT option is to be chosen only in case other options are not available, due to lack of adequate data. The EXIT option does not lead to a risk map, but to an impact or exposure map instead that may also be used by the authorities and the decision-makers.

The step-by-step tutorial on risk mapping techniques (GIS Best Practices) is part of the DRACCAT package and will be available at a later stage of the SEERISK project.

3.2.4.1. TYPES OF RISK ASSESSMENT AND MAPPING

Theoretically, risk mapping is the overlay (combination and analysis) of hazard mapping and impact mapping. Risk assessment can be qualitative (it can be expressed as high, medium or low) or quantitative (it can be expressed as possible damage (in euros) lives lost in absolute numbers). In qualitative mapping, hazard and impact are also expressed in qualitative terms (e.g. high, medium, low).

QUALITATIVE ASSESSMENTS

QUALITATIVE HAZARD ASSESSMENT AND MAPPING

Figure 11 illustrates the general workflow for qualitative hazard assessment and mapping. If a hazard map for the specific hazard type and required scale already exists, it can be used right away for risk mapping. If such a map is not available, the probability of intensity of a hazard can be described in qualitative terms by using information based on historic data to define the probability of occurrence (high, medium, low) for different parts of the study area (alternative 1). The result can be mapped and the map can then be used for risk mapping. If incomplete or no data on previous events are available, then expert judgment can be used to identify low, medium and high hazard zones (alternative 2). A raster map of the area can be adequately attributed according to the hazard level. In case this is also not possible then an exit strategy may be used. However, the exit strategy does not lead to the development of a risk map. By using the exit strategy the expert will use the whole administrative unit or area of interest to conduct impact consequence mapping only. An impact map offers still some valuable spatial information that can be of interest to the decision makers. In case the production of a hazard map is possible, the expert can move to the next step of the risk assessment and mapping and continue with the impact analysis. However, the hazard map and the reliability of the information it provides should be validated and improved by taking into consideration future events. Nevertheless, the experts shall make sure that hazards are thoroughly recorded in the future. In this way, the information necessary for the development of a detailed hazard map will be available in the future.

QUALITATIVE IMPACT ASSESSMENT AND MAPPING

Impacts can be assessed and mapped by using different alternatives, depending on data availability, in the same way hazard assessment is conducted. In case an impact or vulnerability map is already available, it can be overlaid with the hazard map for risk mapping. If such a map is not available, then an impact map has to be made (alternative 1) by using information regarding the damage caused by past events or information on the vulnerability of the elements at risk. The element at risk under investigation (e.g. people) and the risk metric (e.g. lives lost) were identified in the previous stages of the risk assessment. In this way, a map of potential losses can be developed and the raster map of the study area can be attributed accordingly (high, medium, low). If historical data is not available, then a similar map can be developed by suing expert judgment (alternative 2) and information on land use. The exit strategy proposes consulting a land use map (e.g. in case of human casualties: residential areas-high, commercial areas-medium, industrial areas-low) that will lead to exposure mapping. The resulting maps of the first three alternatives have to be validated in the future and the exit strategy has to include a step for improving data collection techniques regarding damage caused by hazards (Figure 12).

QUALITATIVE RISK ASSESSMENT AND MAPPING

The two qualitative maps (hazard and impact) can be overlaid in GIS. Each pixel will be given a colour which will indicate a risk level according to the matrix and according to its level of hazard and impact. In this way, the whole map can be attributed, indicating areas of high, medium, low risk (please note: risk categories can be more than three). In Figure 13 the process of combining hazard and impact maps and the development of a risk map is described.

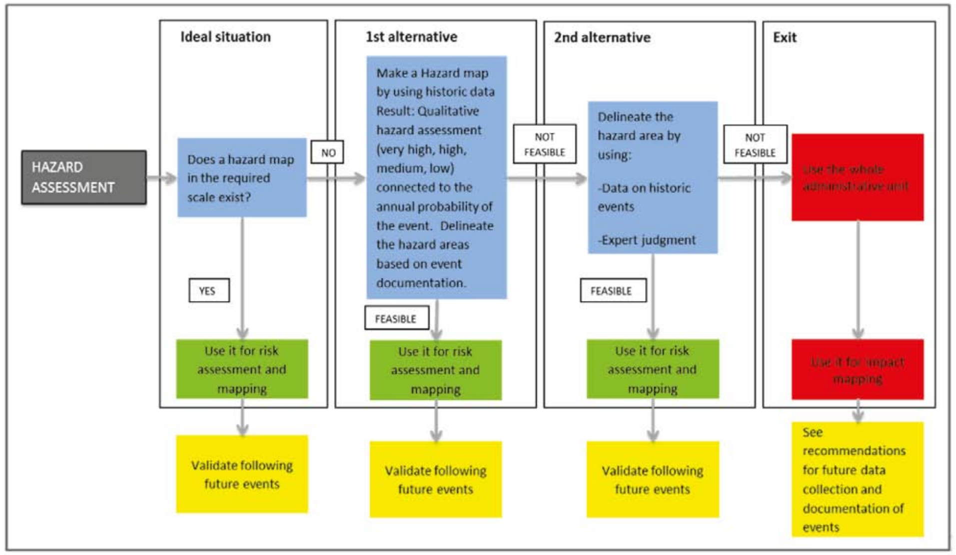

Figure 11. *General workflow for qualitative hazard assessment*

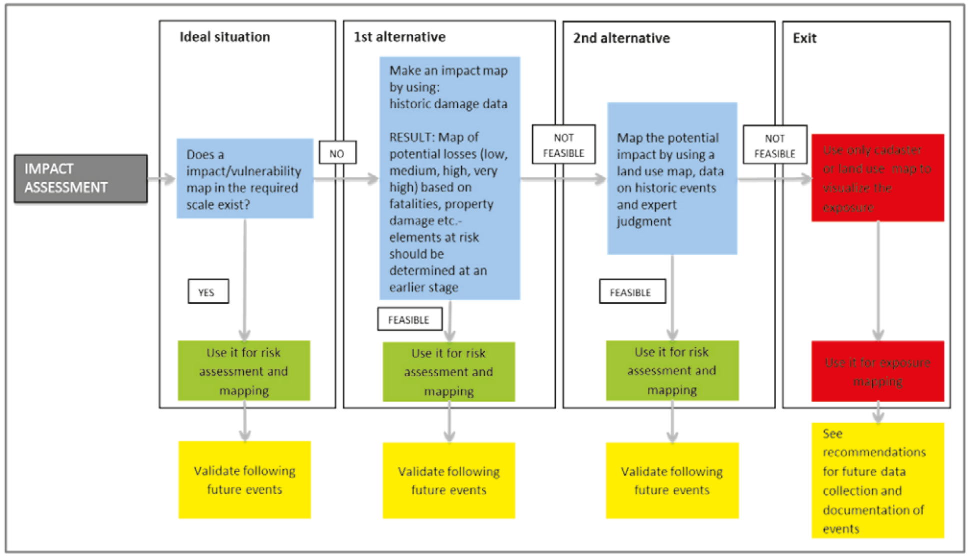

Figure 12. *General workflow for qualitative impact assessment*

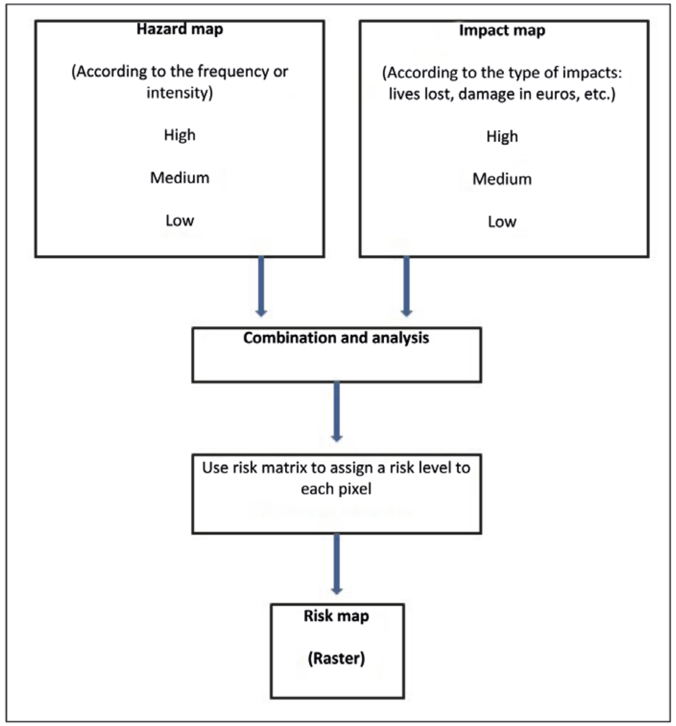

Figure 13. *Qualitative risk assessment and mapping*

QUANTITATIVE ASSESSMENTS

When data regarding past events are available in quantitative form, the development of a quantitative risk map is possible. The process is similar to the one described for qualitative risk assessment and mapping offering alternatives in case of lack of data. Similar to the qualitative risk assessment and mapping, a map indicating spatial distribution of probability and intensity levels has to be developed, followed by a map showing the potential impacts in the study area.

QUANTITATIVE HAZARD ASSESSMENT AND MAPPING

In Figure 14 the process of development of a hazard map using quantitative data is shown. A hazard map may be deterministic (showing the distribution of the intensity of a specific hazard scenario) or probabilistic (showing the distribution of the probability of occurrence in the study area). Ideally, such a hazard map exists, but if not, the first alternative suggests that a quantitative hazard map should be to be developed. This kind of map can be made using detailed historical data in order to map the probability or spatial distribution of intensity classes. Methods and techniques of developing a hazard map vary significantly and they depend on the type of hazard and the available data. Often, hazards can be modeled or in other cases point data can be interpolated. However, in order to model a hazard or to map spatial distribution of its intensity, a very large amount of detailed data is required and that is often not available. Therefore, if the development of such a map is not possible, the second alternative should be used. According to this, expert

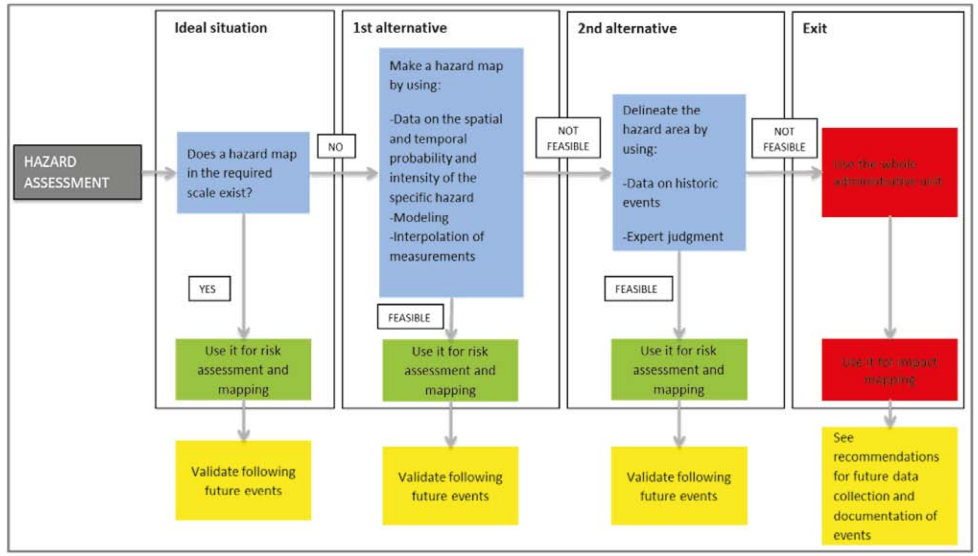

Figure 14. *General workflow for quantitative hazard assessment and mapping*

judgment should be used to indicate the areas where the probability of occurrence is higher than elsewhere in quantitative terms. The exit strategy is similar to the one described in the qualitative risk mapping procedure and future steps (marked yellow) are also similar.

QUANTITATIVE IMPACT ASSESSMENT AND MAPPING

In Figure 15 the steps for developing a quantitative impact map are demonstrated. If such a map is not available then the possible impact can be mapped by using the existing vulnerability curves. On the other hand, such a map can be also developed by mapping exact damage data of previous events, when available. The second alternative proposes the use of expert judgment, combined with land use information and historic data. The exit strategy is similar to the one described in the qualitative risk mapping procedure and future steps marked yellow are also similar.

QUANTITATIVE RISK ASSESSMENT AND MAPPING

The procedure for using the information provided by the above maps, developed for risk assessment and mapping is described in Figure 16. The equivalent of a risk matrix for quantitative data is a risk curve. The risk curve shows the relationship between the probability of occurrence and the impact of an event. Risk curves can be used to assess the risk in the areas where the probability is known but the damage is not. F-N curves are similar to risk curves, only they refer to human lives rather than material loss. More information on F-N curves and risk curves is given elsewhere in this document. By using risk curves or F-N curves, the risk in different areas or pixels on the map can be assessed and visualised. The resulting risk map may be raster or vector depending on to the original data used for the development of the hazard and impact map.

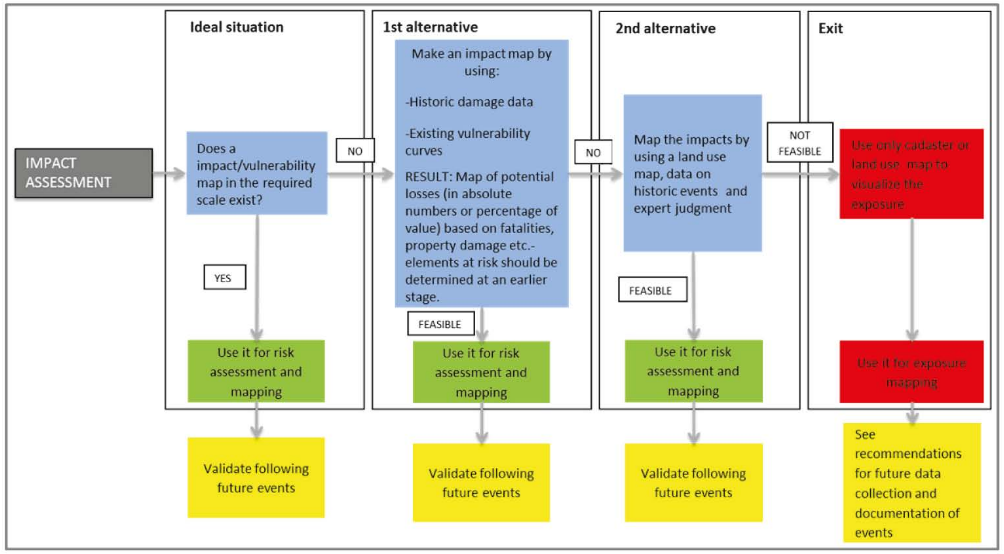

Figure 15. *General workflow for quantitative impact assessment and mapping*

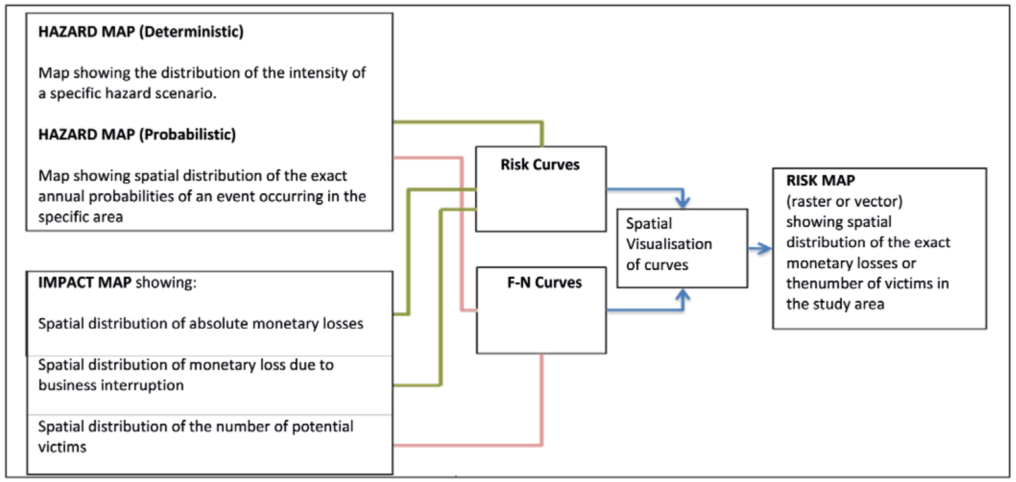

Figure 16. *Quantitative risk assessment and mapping*

3.2.5. CONSIDERATION OF CLIMATE CHANGE AND FUTURE SCENARIOS

The severity of the impacts of climate change does not depend only on the process itself but also on the level and spatial distribution of vulnerability and exposure.

As risk is a combination of hazard and vulnerability, changes in the latter will lead to changes in risk. Global change (meaning environmental and climate, as well as socio-economic change) should be considered as part of risk assessment and management.

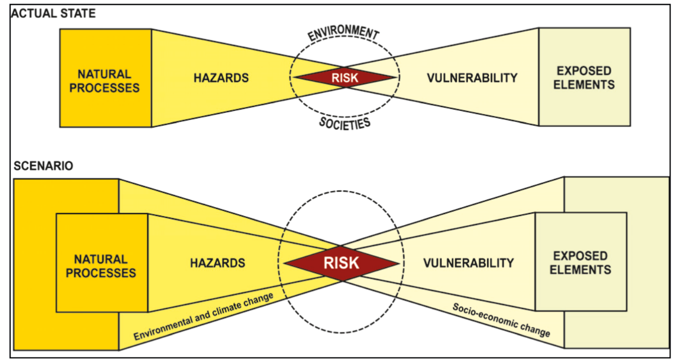

Figure 17. *Consideration of changes in climate and in the society and the economy is essential in risk assessment (Malet et al., 2012)*

Figure 17 demonstrates the consideration of global change in the common risk assessment methodology. The inner frame describes the current situation, whereas the outer frames describe the situation for future scenarios (e.g. 2050 or 2100). In order to assess the change in hazard based on, for example, climatic change models that can model the weather variable (e.g. precipitation, temperature etc.) or the hazard itself may be used. On the other hand, the changes in vulnerability will depend on socio-economic factors, mostly land use changes in the study area. These changes can also be modelled or they can be assessed by using spatial development plans from municipalities, regional governments or national governments. In case models, data or information required for assessing the change in hazard and vulnerability are not available, the exit strategy has to be used, which is based on expert judgment (Figure 18).

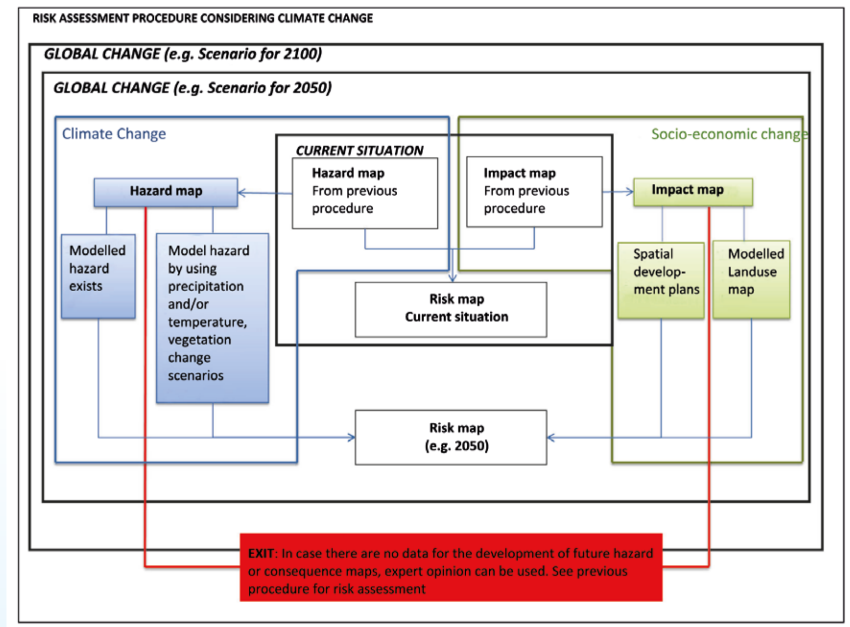

Figure 18. *Consideration of Global change for future risk assessment*

For a more detailed description of the methodology, as well as for the modification of the methodology for different hazard types (floods, heat waves, drought, extreme wind and wildfire) please consult the full version of the methodology that can be found in the Methodology document.[2]

2 Please use the link *www.seeriskproject.eu* to obtain full documentation on the Jointly Developed Common Risk Methodology.

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4. EXECUTION OF RISK ASSESSMENT AT PILOT AREA LEVEL

The Common Risk Assessment methodology described in the previous chapter was applied in six case study areas (Figure 19). Each case study area prepared a risk matrix focusing on the hazard that they chose as the most relevant for their area and developed a risk scenario describing the hazard and its consequences. In a parallel process, NDGDM produced a series of maps including hazard, impact and risk maps for the specific scenario for each case study area. Finally, all risk products have been harmonized.

Figure 19. *The SEERISK pilot case study areas*

4.1 ASSESSING AND MAPPING HEAT WAVE RISK IN ARAD, ROMANIA

Arad is the capital of Arad County in Western Romania, close to the Hungarian border. The city that covers a 47 km^2 area has a population of 147,922 people. It lies on the High Plain of Arad at 110 m above sea level and it is crossed by the river Mureş/Maros. The city's climate is continental with a Mediterranean influence. The Lunca Mureşului (Mureş Floodplain) Natural Park, situated between Arad and the Hungarian border, is on the Ramsar List of Wetlands of International Importance. Arad is a university centre and an industrial city with important automotive, furniture and textile industries. An important power station connects the Romanian and Hungarian power supply systems. The city is surrounded by large agricultural areas.

Hazard type: The identified hazard type for this case study is heat wave, since the frequency and intensity of this climate phenomenon has significantly increased in the last three decades (Busuioc et al. 2010) and its consequences on the population, economy and environment are often significant. Between 1992 and 2012 seven heat wave have been recorded there. During these events, the maximum temperature reached or exceeded 37 C° for at least 2 days. Heat waves have a negative impact on people with cardiovascular and respiratory diseases and might cause health problems to the elderly and children over a short period of time.

Risk matrix: The element at risk considered during risk mapping was the local population of the city of Arad. The risk metric used was the number of medical interventions per 150,000 inhabitants necessary to eliminate the consequences of heat, as explained below. As for the hazard, the so called Urban Heat Island (UHI) index was applied to qualitatively estimate spatial distribution of likelihoods of extreme temperature both during daytime and at night.

The interpretation and the use of the risk data is explained in details in GIS Best Practices (for further details please use the following link *www.seeriskproject.eu).*

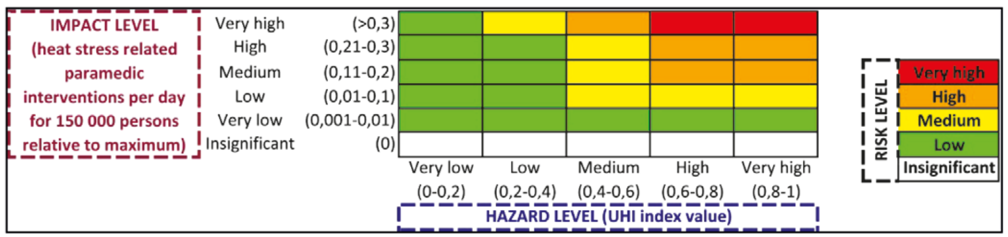

Figure 20. *The risk matrix applied to Arad*

Description of Hazard Levels: (5) Almost certain: UHI>0.8, (4) Very likely: UHI 0.6 - 0.8, (3) Likely: UHI 0.4 - 0.6 , (2) Unlikely: UHI 0.2 - 0.4, (1) Rare: UHI 0.0 - 0.2. Hazard levels have been defined by standardized Urban Heat Index. Standardization is made by dividing each value by the maximum one in order to make a comparable the daytime and night time classification of likelihood.

Description of Impact Levels: (5) Very high: more than 0.3, (4) High: 0.21 - 0.3, (3) Medium: 0.11 - 0.2, (2) Low: 0.01 - 0.1, (1) Very low 0.0 - 0.01. Relative impact is a standardized variable. The numbers of paramedic interventions related to heat stress per 150 000 inhabitants in each district were standardized by dividing each of them by the maximum value in order to make a comparable the daytime and night time classification of relative impact for risk maps.

Description of Risk Level Rating: **Very high:** Measures are taken (at the workplace, as defined by law) or by the municipality (health aid in public spaces); High: Measures are taken (at the workplace, as defined by law); Medium: No measures (Information transmitted via mass media) and Low and Insignificant: No measures.

Risk scenario: The risk scenario for Arad is based on a heat wave event (max temperature during the day above 37° Celsius for two consecutive days at a least) which according to the risk matrix is almost certain. The UHI index can express the intensity of the urban heat island phenomenon and it is qualitatively equivalent to the likelihood of the event. In other words, according to the risk matrix an event that will be associated with a UHI Index above 0.8 it has a very high likelihood (almost certain). Heat waves in urban areas are reflected in the urban heat island, as higher temperatures occurring inside the town, where the intensity of urban heat island is stronger. In this case, the entire Arad city administrative unit would be exposed to heat waves, but intervention will be focused on the zones where the UHI index (and associated likelihood level) is above 0.8. Based on past heat wave events in affected area more than 15 people can be the affected by high temperatures, the heat wave would lead to deterioration of asphalt in the streets due to heavy traffic in daytime. The number of medical emergencies/incidents among elderly people and people with chronic diseases (heart and lung conditions, etc.) would be influenced by high temperatures. Life of people with chronic diseases could be disrupted because of thermal stress which intensifies health issues.

Every year, the Inspectorate for Emergency Situations Arad updates the "Risk Assessment and Intervention Plan" for Arad county which includes measures for situations with prolonged period of high temperatures. In case of multiple medical interventions or severe medical situations in the territory of Arad county the "Red Plan" should be used in which efficient response of all medical mobile units (public and private ambulances, medical emergency teams) and public hospitals coordinated. Also Public Health Directorate in Arad has its own regulations and procedures for dealing with heat waves effects (setting up tents for sheltering people walking in the streets during high temperatures periods, providing cold water, etc.) with the support of NGO's (Red Cross, etc.).

Risk mapping: In the first step, two hazard maps have been prepared for Arad, which show the distribution of the UHI (Urban heat island index) value in the municipality during daytime and at night (Figure 21). It is obvious that the hazard level is higher in the city centre where surface temperature is increased by the heat trapping effect of high buildings, as well as by the fact that the ground is covered with materials characterized by high heat capacities, the associated decrease in vegetation cover, and vehicle emission and air quality. The second step consisted of making two impact maps (daytime and night time that show the level of impact expressed as a standardized index based on the number of interventions of the emergency services per 150,000 inhabitants (Figure 22). The number of interventions per 150,000 inhabitants in each district of Arad is divided by the maximum value. High impact areas do not always coincide with the high hazard areas of the maps shown in Figure 21 as higher number of interventions is probably associated with the characteristic of the people living there (e.g. health condition, age etc.).Finally, two risk maps have been prepared for the municipality of Arad (daytime and night time) as it is shown in Figure 23.

The area with the highest risk levels is geographically coherent and is comprised of housing areas (old buildings, block of flats, detached houses), gardens, small industrial areas and, the city's main railway station. There are three districts in Arad with a very high risk level (marked red). Moreover, there are three with high risk (marked orange) in daytime. As for the nighttime, there is one district red-coded for very high risk level and four orange-coded for high risk level. These districts compose the core of the city with an estimated population of 60 000 inhabitants (40% of the population) and covering the area of approximately 28 km2 (61 % of the territory). The spatial pattern of the impact during the day and night is very similar (Impact maps), however, the spatial pattern of the risk in day time and night time is slightly different. In more detail, risk in the Sega district is the highest during day and the high risk covers a larger area during the day. This can be explained by the fact that Gradiste district, which makes the main difference between day and night risk maps, has very particular social features leading to less interventions during nighttime when the effects of urban heat island are very significant there, too.

The risk maps will be used by the local authorities in order to develop shelters with air conditioning for local people in the areas where the risk is high. Moreover, rescue teams may use the maps to identify locations with an increased need for intervention during the days when the heat wave strike and plan their actions more effectively.

Hazard and risk maps will be further improved by using newly acquired satellite data.

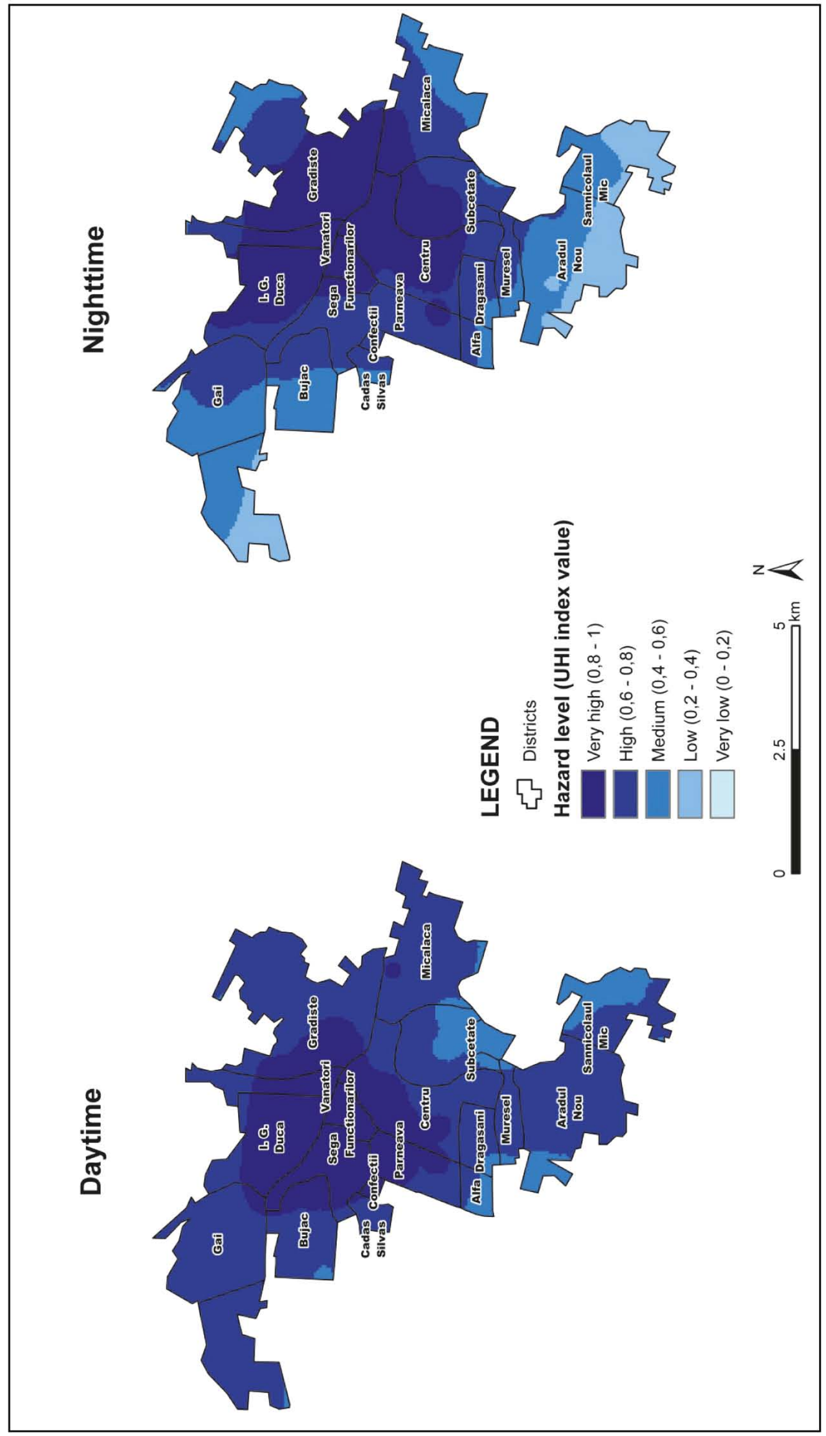

Figure 21. *Day and night time heat wave hazard map of Arad, Romania*

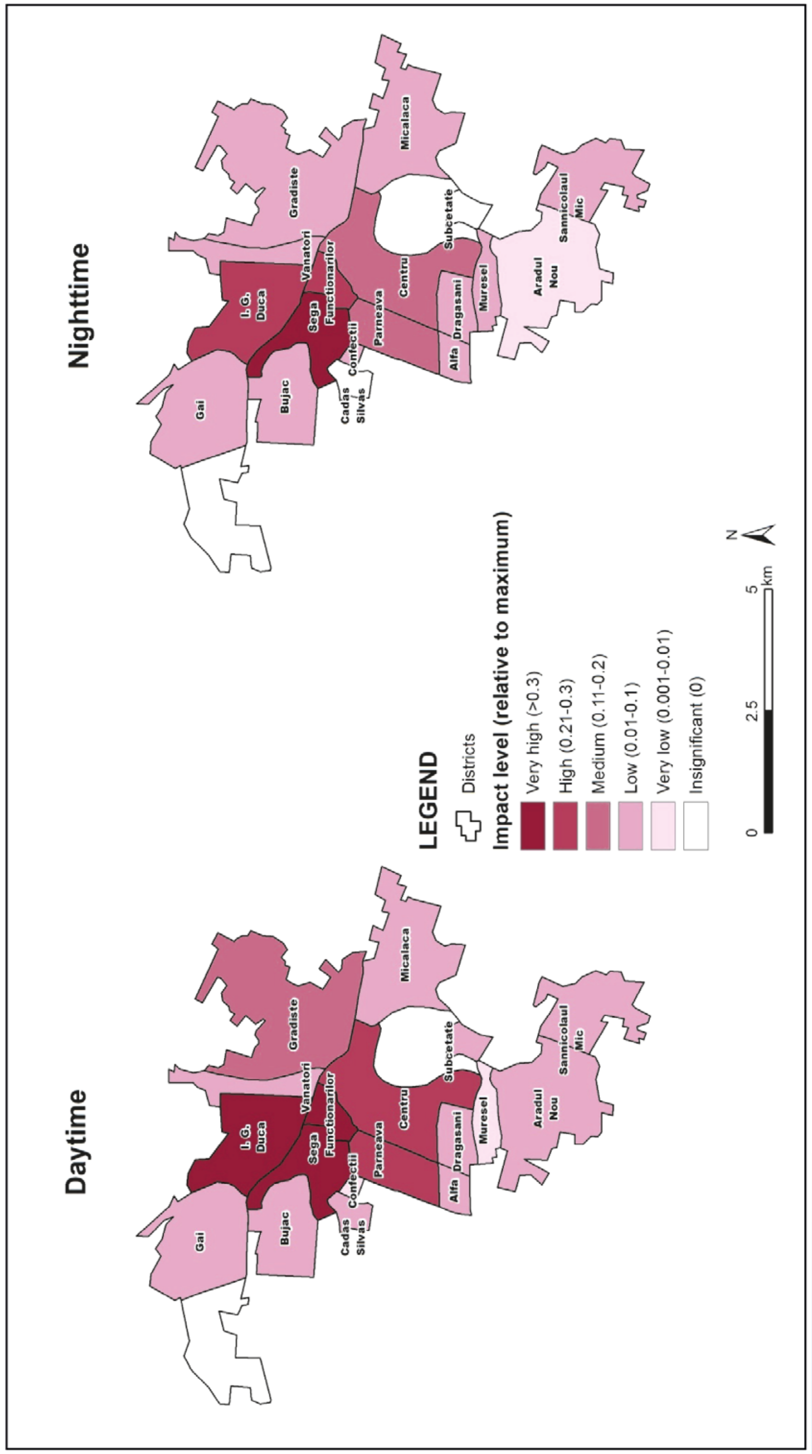

Figure 22. *Day and night time heat wave impact map of Arad, Romania*

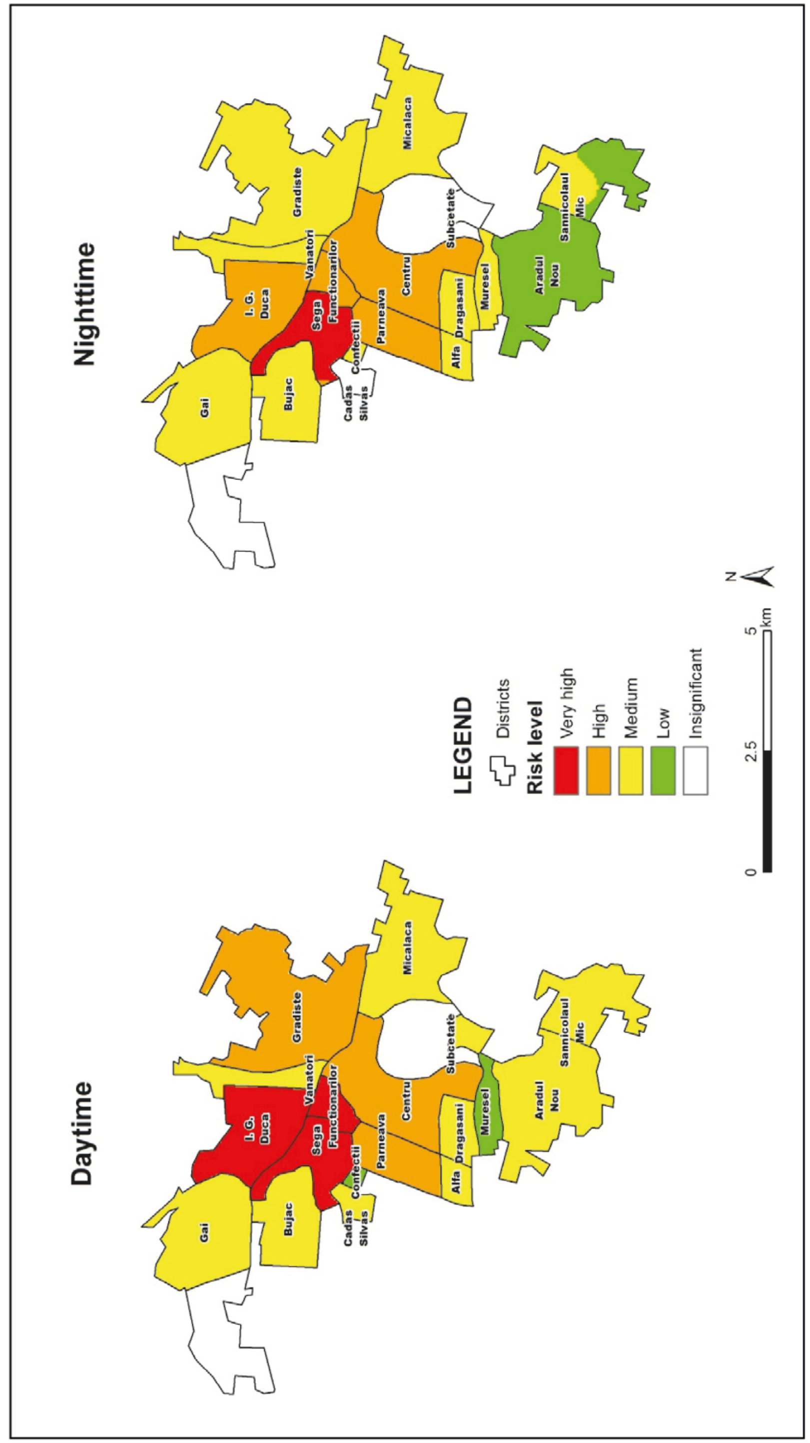

Figure 23. *Day and night time heat wave risk map of Arad, Romania*

4.2 ASSESSING AND MAPPING DROUGHT AND WILDFIRE RISK IN KANJIŽA, SERBIA

The municipality of Kanjiža consists of 13 settlements and is located in the North Banat district in Vojvodina by the Hungarian border at 78 - 108 m a.s.l.. It has a population of 25,950 people, where the Hungarian minority makes up 85% of the population. Its administrative territory covers a 399 km^2 area. Tisa River flows east of Kanjiža and around 200 km long network of channels criss-crosses the municipality. The climate is moderate continental, with an average precipitation of 550 mm per year and high percentage of sunny days. There are two protected areas in the municipality. Agricultural land covers 75% of the territory, and large areas are covered by pastures, meadows and wetlands, while forests cover only around 2% of the area. Agriculture is the main branch of the economy, followed by industry (production of construction material and food) and tourism, as well as oil and natural gas extraction.

Hazard types: There were two hazard types selected for Kanjiža: Drought and wildfire. Drought may have significant adverse impact on agriculture and the related activities, which are the basic source of economic activity in the municipality. Apart from economic losses droughts also have negative physical and environmental impacts. Between 2001 and 2012, 12 drought periods were registered, with an average duration of 30 days. The latest drought in 2012 was the most severe of all, lasting for more than 90 days. It caused direct and indirect damage, estimated to have exceeded 200 million euro.

Rising spring and summer temperatures and low precipitation, coupled with low ground water levels, increase wildfire risk. Wildfires mostly occur on pastures, meadows and natural grasslands, frequently along the highway, regional and local roads and near settlements. Between 2007 and 2012, 210 wildfires happened, causing damage of about 65,000 euro.

Risk matrix: In both cases (drought and wildfire) the element at risk considered was the type of agricultural crops (and other land cover types). In the case of drought, the risk metric was their yield value in euro per hectare while in the case of wildfires, the risk levels were formulated from a civil protection point of view (protection of people and inhabited areas against fires).

Two risk and one hazard matrices were developed. The first risk matrix describes drought risk levels based on the SPI (Standard Precipitation Index) classification and the associated impacts. SPI was analysed for the time period 2000-2012.

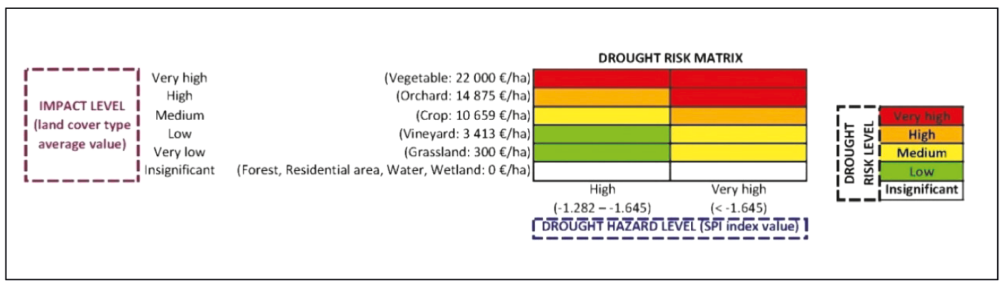

Figure 24. *The drought hazard matrix for Kanjiža, Serbia*

Description of Hazard Levels:
High: -1.645<SPI≤-1.282
Very high: SPI ≤ -1.645
Description of Impact Levels:
Insignificant: Forest, Residential area, Water, Wetland (not relevant from the viewpoint of drought)
Very low: Grassland – average yield value: 300 euro/ha
Low: Vineyard – average yield value: 3413 euro/ha
Medium: Crop – average yield value: 10659 euro/ha
High: Orchard – average yield value: 14875 euro/ha
Very high: Vegetable – average yield value: 22000 euro/ha
Description of Risk Level Rating:
The drought risk level rating uses a two category hazard classification, where SPI score between -1.282 and -1.645 means high hazard, while bellow -1.645 score represents very high hazard. The impact level is basically determined by the value of the affected crop type during a drought period. Very low SPI score associated with high value crop type represents the highest drought risk level (dark grey) in the matrix. The risk levels change depending on crop value types and SPI scores. The blank areas are geographical locations where drought has no relevance.

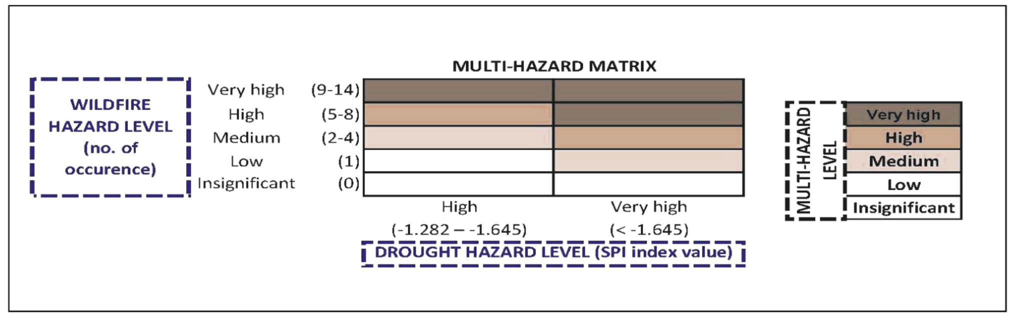

Figure 25. *The multi-hazard matrix for Kanjiža, based on wildfire and drought hazard*

Description of Drought Hazard Levels:
High: -1.645<SPI≤-1.282
Very high: SPI≤-1.645
Description of Wildfire Hazard Levels:
Wildfire hazard level is based on the number of occurrences of wildfires with 200 meter buffer zones in Kanjiža, ranging from 9 - 14 events with a very high hazard level to 0 events with insignificant hazard level.
Description of Multi-Hazard Level Rating:
The multi-hazard level rating is based on a combination of the two-class drought (SPI score) category and the five-class wildfire occurrence hazard scale. The cases with the highest number of annual wildfires during severe (SPI less or equal -1.645) droughts are ranked highest in the multi-hazard matrix.

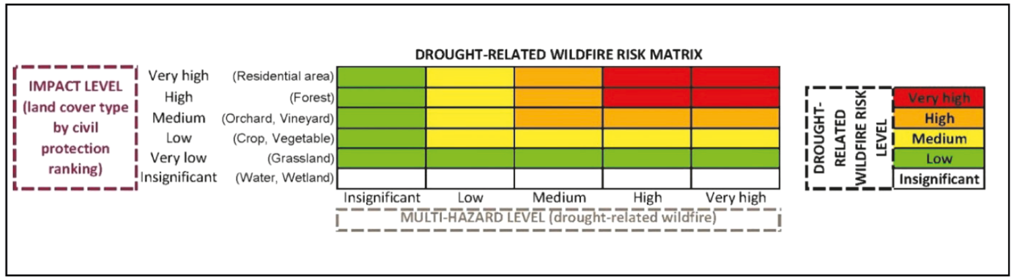

Figure 26. *Drought-related wildfire risk matrix for Kanjiža based on wildfire and drought hazard*

Description of Hazard Levels:
The multi-hazard levels have been determined in the multi-hazard matrix. These hazard levels are combinations of drought index and the wildfire hazard. They range from insignificant to a very high hazard.
Description of Impact levels:
The impact rating has been based on the magnitude of impacts on different land cover types from a civil and fire protection point of view. The impact on the land cover type ranges from very high impact (impacts on residential areas) to insignificant (impacts on water bodies and wetlands).
Description of Risk Level Rating:
Very high risk levels represent situations with the highest frequency of wildfire occurrences in residential areas or forests. These cases need the most urgent emergency actions. The risk levels are ranging from orange, yellow to green accordingly. Green colour code means a risk level with the least frequent wildfire occurrence i.e. the lowest significance for civil and fire protection.

Risk scenario: The worst case scenario describes a drought related event with a return period of 100 years in the area and it is associated with the SPI less or equal to -2.326. The drought will affect the entire municipality of Kanjiža that occupies an area of 399 km^2.

Wildfires in the area may be the result of high air temperature combined with low precipitation and wind. The largest area that may be affected is not larger than 50 ha (as the channel network prevents the spread of wildfires) and the greatest amount of damage expected is less than 10,000 euro. The greatest loss may take place in less than 5 hours. The peak of the wildfire will be reached within one hour and the duration of the event will be maximum 4 hours. The risk scenario considers an event that takes place in the spring or summer during the day. Although any place of the municipality may be affected, the most affected areas are in the vicinity of settlements and infrastructure (e.g. roads).

In case of drought, the following consequences are expected:

- Health problems of highly vulnerable groups of people (e.g. the elderly, people with health problems, low-income people) due to heat wave-drought combination.
- High livestock mortality due to the lack of water.
- Crop yield reduction, in monetary terms, a loss greater than 30 million euro.
- Natural habitats can be narrowed and affected, leading to the migration and lower breading among wildlife species (roe, deer, hare, fox, pheasant and partridge) and degradation of forests, lake and river eco-systems.

In case of wildfire, the following consequences are expected:

- People: loss of life, injury and health problems.
- Man-made environment: losses of property, infrastructure, cultural heritage.
- Economy: disruption of economic activity.

In more detail, the following are expected in case of wildfire:

- Physical impacts: Less than 5 persons and less than 5 objects (houses in the suburban area, barns, stables, etc) will be affected.
- Economic impacts: less than 10,000 euros.
- Ecological impacts: Wildlife habitat is affected by wildfire in such a way that its area can be reduced, wild animals (roe, deer, hare, pheasant and partridge) are forced to migrate, which leads to a smaller reproduction rate. In case of flora, besides agricultural crops being affected by wildfires, they affect protected areas and can cause degradation of natural ecosystems.
- Social and psychological impacts: given spatial distribution of the inhabitants in the Kanjiža administrative unit and the location of the identified wildfire events, it is most likely that approximately 2,000 people could be threatened by the flames.

As far as the preparedness of disaster management and national authorities are concerned in the event of drought and wildfire, the main responsibility lies with the municipal authorities and the Ministry of the Interior, Sector for Emergency Management with their local units (e.g. fire brigade).

Risk mapping: The risk mapping process started with the calculation and interpolation of drought data (SPI) based on provided precipitation data.

Two SPI classes were developed: high and very high drought hazard level. The impact, in the case of drought hazard rating, was the affected crop type and its associated value, expressed in euros. The risk map was made by using the above-mentioned data (Figure 29).

In the second step, drought-related wildfire multi-hazard map was created by using the SPI indices and the number of occurrences of wildfire, placed on the map, with a 200 m buffer zone.

In the last step, a multi-risk map were made by using a combination of drought and wildfire hazard ratings and data on land cover type, based on its value and its importance from a civil protection view point.

Hazard, impact and risk maps were produced via collected available data on the identified hazards for the Kanjiža municipality. The maps clearly show occurrence of the wildfire events along the road network. It is an assumption that this hazard type (wildfire event) is in majority of the cases a consequence of the human activity related to the glass garbage disposal and cigarette stubs. Highest risk levels show places along the highway E-75 near the settlement of Horgoš, in the neighbourhood of Kanjiža city and the dumpsite located on the right side of the road between Mali Pesak and Kanjiža. The risk level is lower near other settlements or roads. The lowest risk levels show places situated far away from settlements. Typical land covers on the sites with the highest risk level are artificial surfaces such as road networks and associated grassland and semi natural areas (scrub and herbaceous vegetation associations).

The presented risk maps for wildfire and drought hazard are a valuable asset for the Municipality. Maps can be used as a quick estimate whether there is a high, medium or low risk on the affected area. Analysis of the presented map results has multiple benefits, such as easier update of local action and development plans and legislation by taking into account the mentioned hazards.

Refinement of the current and achievement of a higher quality of the future maps can be obtained by collecting and providing more frequent and detailed data about the exact time of the hazard occurrence, surface vegetation and/or land cover type at risk, estimated damage and precise pricing for the crop types.

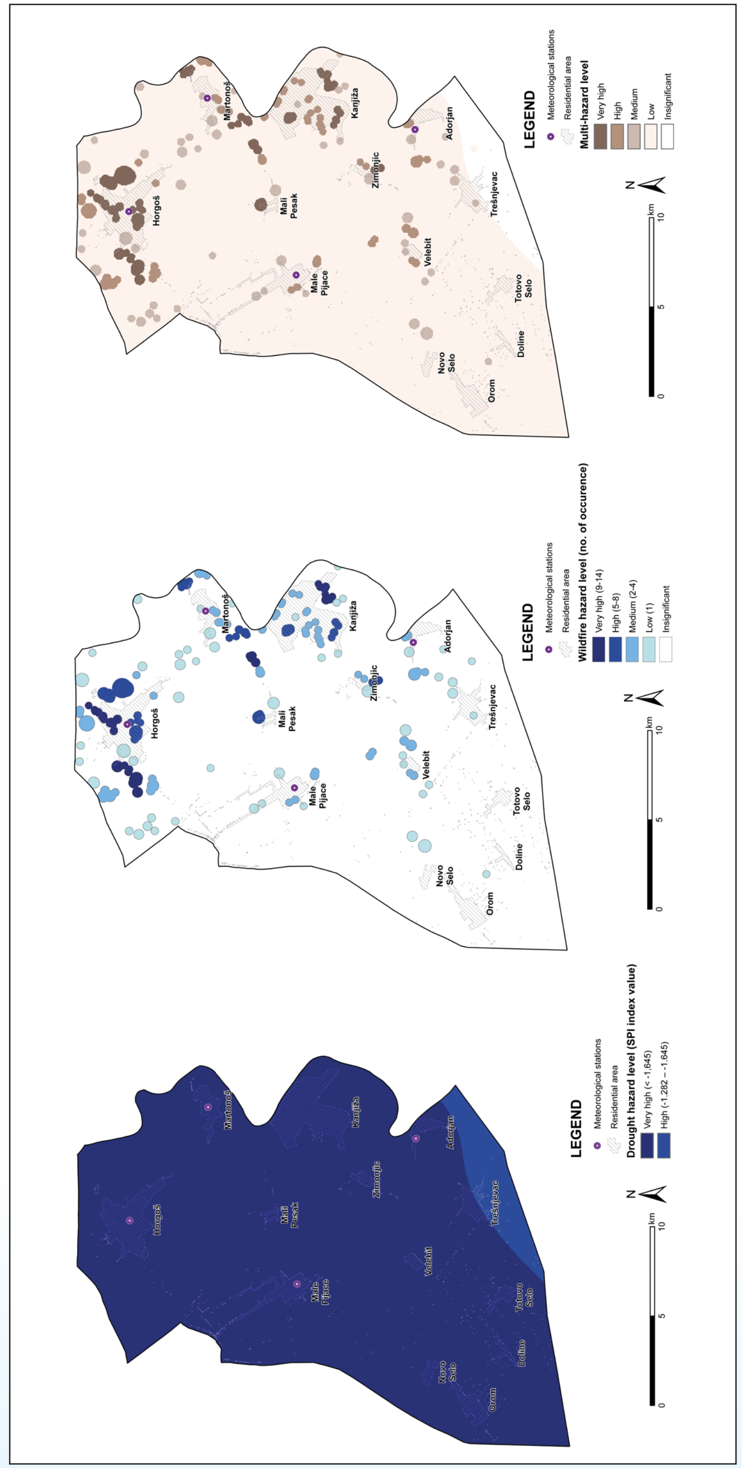

Figure 27. *Drought hazard, wildfire hazard and drought-related wildfire multi-hazard map of Kanjiža, Serbia*

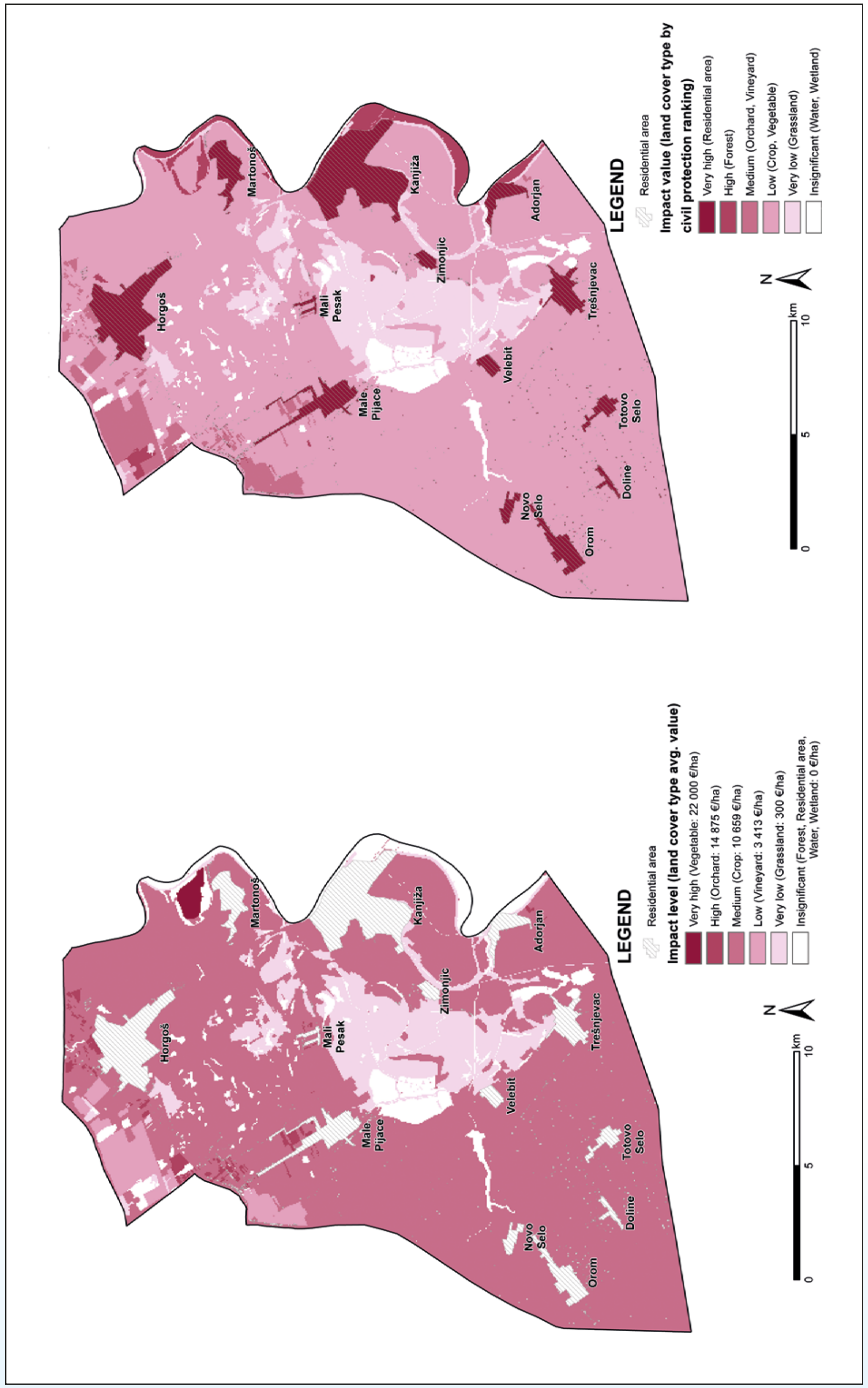

Figure 28. *Drought and drought-related wildfire impact map of Kanjiža, Serbia*

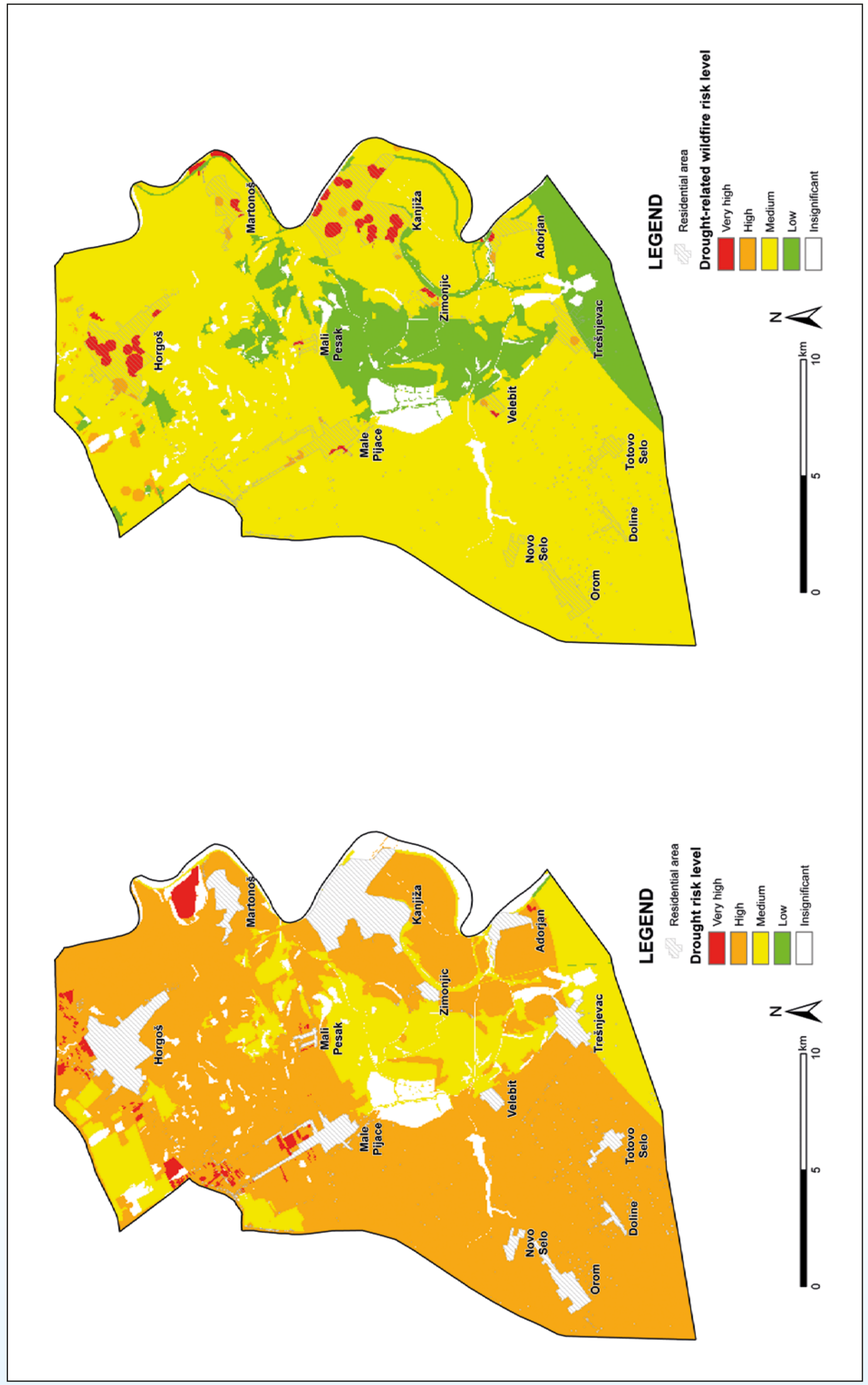

Figure 29. *Drought and drought-related wildfire risk map of Kanjiža, Serbia*

4.3 ASSESSING AND MAPPING FLOOD RISK IN SARAJEVO – ILIDŽA, BOSNIA AND HERZEGOVINA

The municipality of Ilidža is the largest suburb of Sarajevo (the capital of Bosnia and Herzegovina and the centre of Sarajevo Canton). Ilidža has a population of 71,892 people (according to the preliminary data of the 2013 census), its administrative area covers 141 km^2. The average altitude is 503 m asl., but the town is surrounded by mountains, the highest peak rising to 1504 m. The climate in the area is moderate continental and mountainous. River Željeznica, a tributary of River Bosna, passes through the centre of Ilidža, while Bosna itself begins on its outskirts. The protected area around its spring (Vrelo Bosne) is the main source of drinking water for Sarajevo City. The forest cover of Ilidža exceeds 50%, while arable land occupies around 20%. The war had a devastating effect on the town's economy and tourism, but today it is slowly recovering. Sarajevo International Airport is located near Ilidža.

Hazard type: Flood is the type of natural hazard that has the most significant consequences in the pilot area. In recent years, floods have been triggered by extreme rainfall and in some cases sudden snow melting. The precipitation regime shows an increase in the intensity of rainfall, i.e. more rainfall in shorter time intervals, causing flash floods in higher parts and floods in lower parts of the municipality, where it is also combined with drainage problems and inland excess water. Heavy rainfall is recorded usually between October and April, due to which there is a high groundwater level. There are also frequent episodes of rapid snow melting on the steep slopes of the mountains surrounding the Ilidža municipality.

Between 2009 and 2013, floods occurred almost every year even more than once, affecting almost the entire municipality. In December 2010, rapid snow melting caused large-scale flooding in the lower part of the municipality. Around 200 houses were flooded and traffic was interrupted on several local roads. Due to the efficient reaction of civil protection, there were no casualties, but considerable damage to houses and belongings as well as agricultural produce was recorded.

Risk matrix:

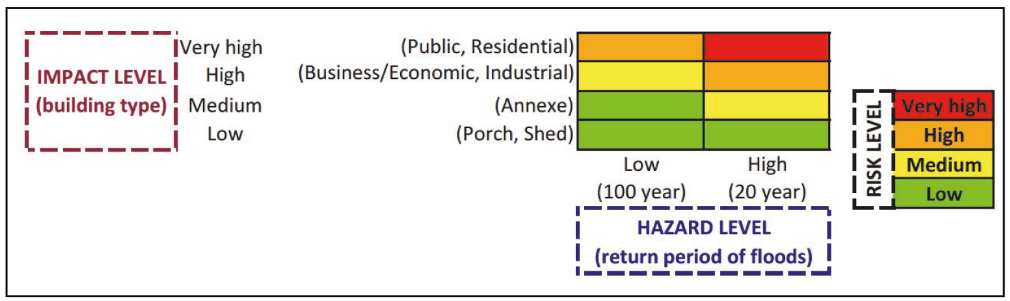

Figure 30. *Hazard and risk matrix for Sarajevo - Ilidža, Bosnia and Herzegovina*

Description of Hazard Levels: The hazard is described by twenty- and hundred- year flood return periods.

Description of Impact Levels: The impact categorization of building types has been made from a civil protection point of view, with a focus on residential population. Building types range from public and residential buildings with a very high impact to deserted areas with low impact.

Description of Risk Level Rating: Risk levels are associated with the following emergency actions: Very high risk (evacuation); High risk (flood protection activities); Medium risk (alert) and low risk (no action).

Risk scenario: The scenario is based on a flood that may be caused by to heavy precipitation or rapid snow melt. A 10.73 km^2 area expected to be affected by flooding. The event will take place between late autumn and the end of winter. The time of onset is 1-2 days and the span of flooding 4 to 8 days. After 8 continuous days of flooding 12,000 people are expected to be affected (2,180 children and 1,800 elderly). Moreover, 2,250 buildings are expected to be flooded, including 4 industrial complexes. Water and electricity supply of the area is also expected to be affected. Landslides and agricultural land degradation is to be expected. Besides, the population in the affected area is poor so the flood will have a significant impact on the social and psychological well-being of the affected community.

The existing preventive measures are managed by 17 members of staff, whereas 68 people are responsible for regular flood protection. Moreover, there are 103 staff members responsible for emergency flood protection.

Risk mapping: Hazard mapping is based on a twenty- and hundred-year flood return period. An inundation map has been produced first, which showed the polygons of the maximum extent of inundation for the two return periods. This map has been made more detailed by using borderlines of building polygons. Each building inside the maximum extent inundation area has been assigned the appropriate level of hazard, which resulted in creation of the final version of the hazard map. The impact map shows the vulnerability of different building types in case of flooding; the impact levels have been formulated by referring to the expert opinion of civil protection units in the pilot area. The risk matrix has been developed and used for the building polygon based analysis. The buildings outside the maximum extent flooding area have been excluded from the analysis and marked as insignificant. The vector-based risk map thus shows risk levels of different types of buildings situated in the inundation areas.

A significant part of the pilot area is located on flat terrain on Sarajevo Plain (Sarajevsko polje). It is where the majority of the population and residential areas, industrial, cultural, sport and agricultural facilities, etc. are concentrated. There is a dense river network, water streams belong to the basin of the river Sava. These are the river Bosna and its tributaries: Željeznica, Miljacka, Dobrinja and Zujevina. Most of these rivers do not have regulated riverbeds, which often leads to flooding of settlements situated along the river banks.

A 10.73 km^2 area with homogenous high risk areas spreading on both sides of the river Bosna is the most affected by flooding. There are mostly family houses, several public buildings, some industrial structures and agriculture areas there. The most vulnerable settlements in the Municipality of Ilidža are Stup and Otes on the right bank of the river Željeznica; and Osjek and

Blažuj on the left bank of the river Bosna. The above-mentioned rivers just flow into the River Bosna in the high risk area.

The impact of floods on agricultural land is the most severe, as they destroy crops and damage farmland. Also, there is evident damage to residential, business and commercial structures, various water supply facilities, waterbeds, embankments along the rivers, roads, communication networks, and other infrastructure. The ultimate consequence of a flood is temporary evacuation of people and property from threatened areas, however in many cases there is simply a so-called "in-house evacuation" to higher floors.

The risk map could be used by local and cantonal civil protection units for identification of locations where the highest priority should be given to protection of the civilian population and their belongings, either through mitigation or emergency actions. These pilot maps may serve as a basis for these agencies as well as other related agencies on a higher level (like water management agencies) to build their own capacity for development of maps for other areas by using the methodology developed as part of this project.

Higher quality of hazard and impact maps could be achieved by applying more flood return periods and geo-coded population numbers. These additional data sources – and eventually the application of hydrologic models – would highly improve the quality of the risk map.

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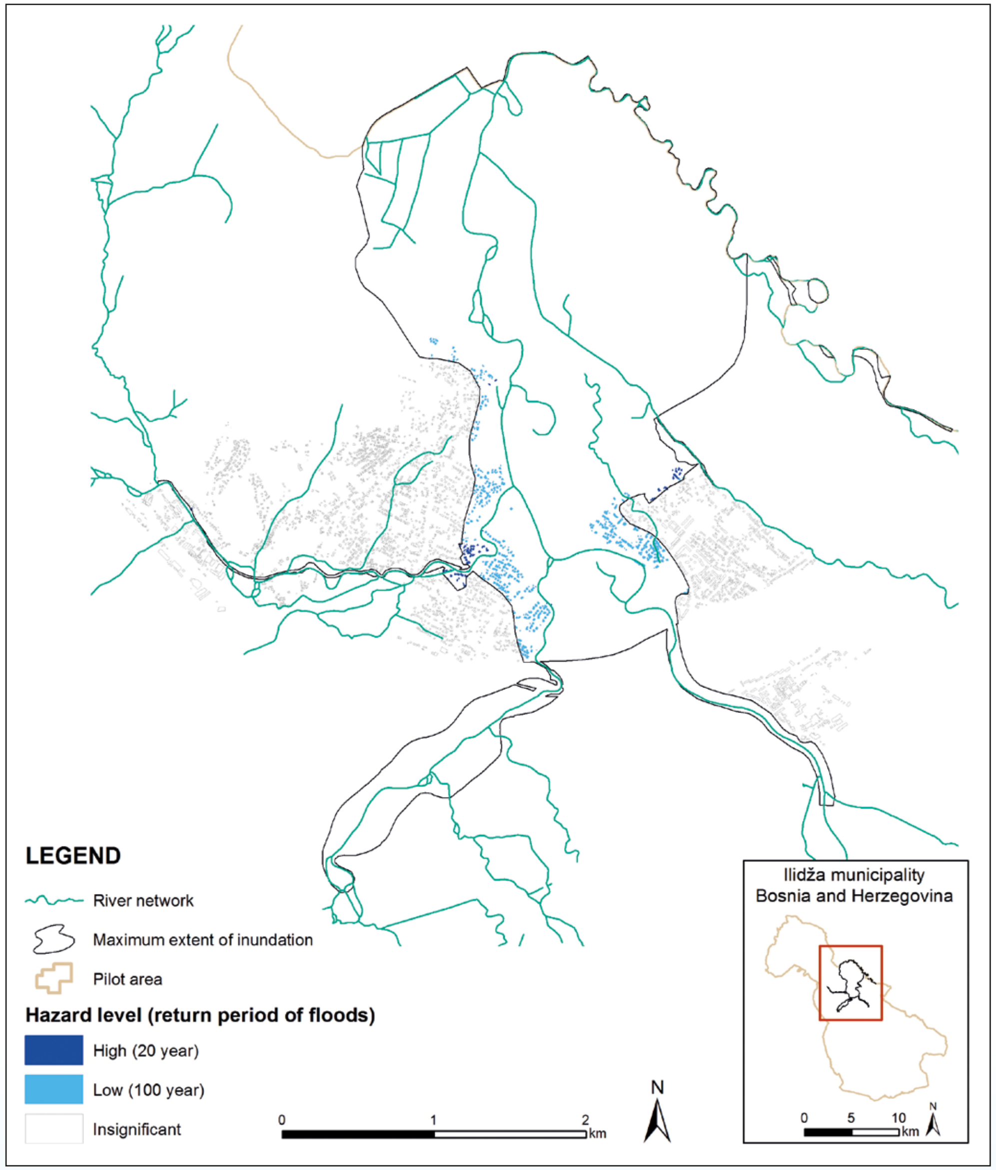

Figure 31. *Flood hazard map of Ilidža, Bosnia and Herzegovina*

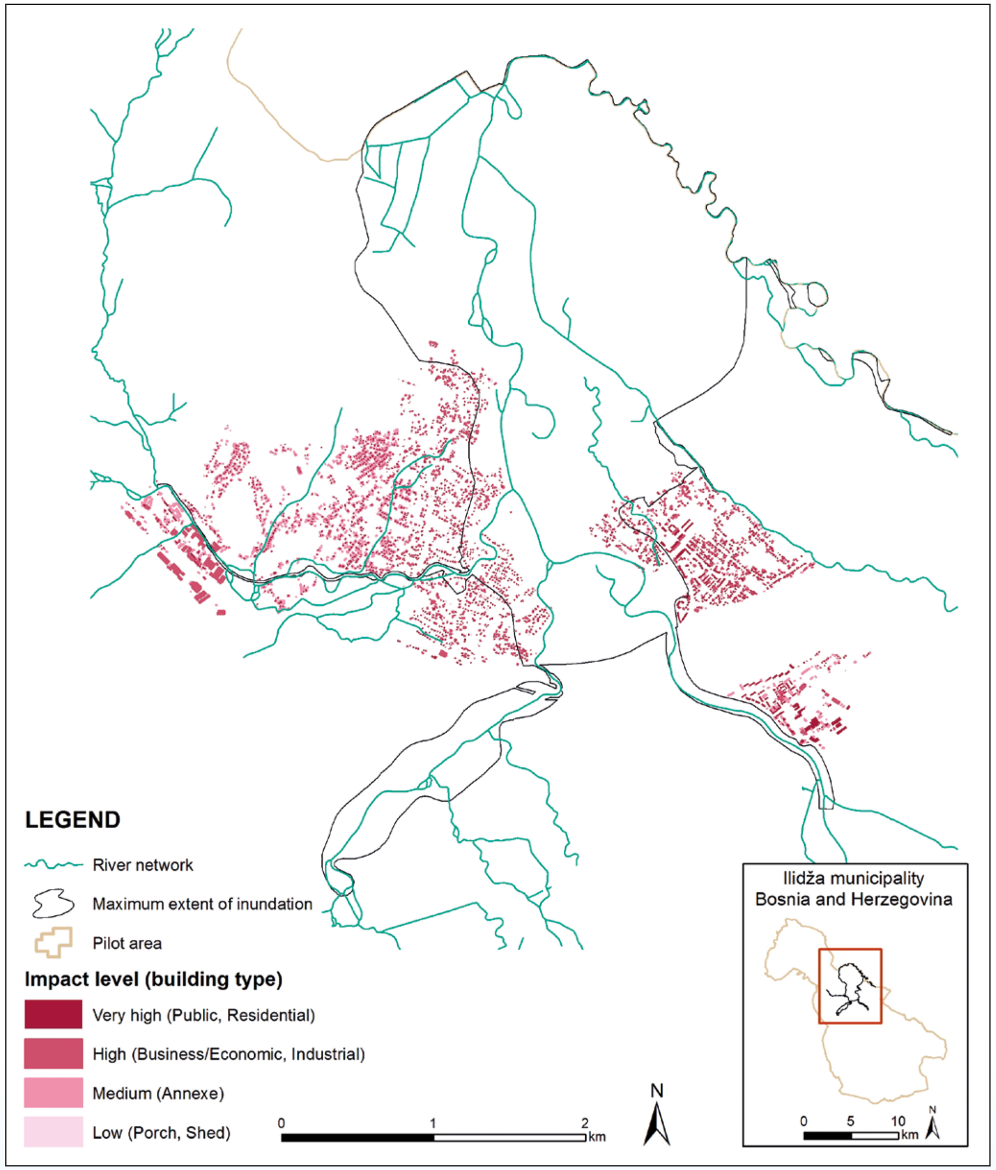

Figure 32. *Flood impact map of Ilidža, Bosnia and Herzegovina*

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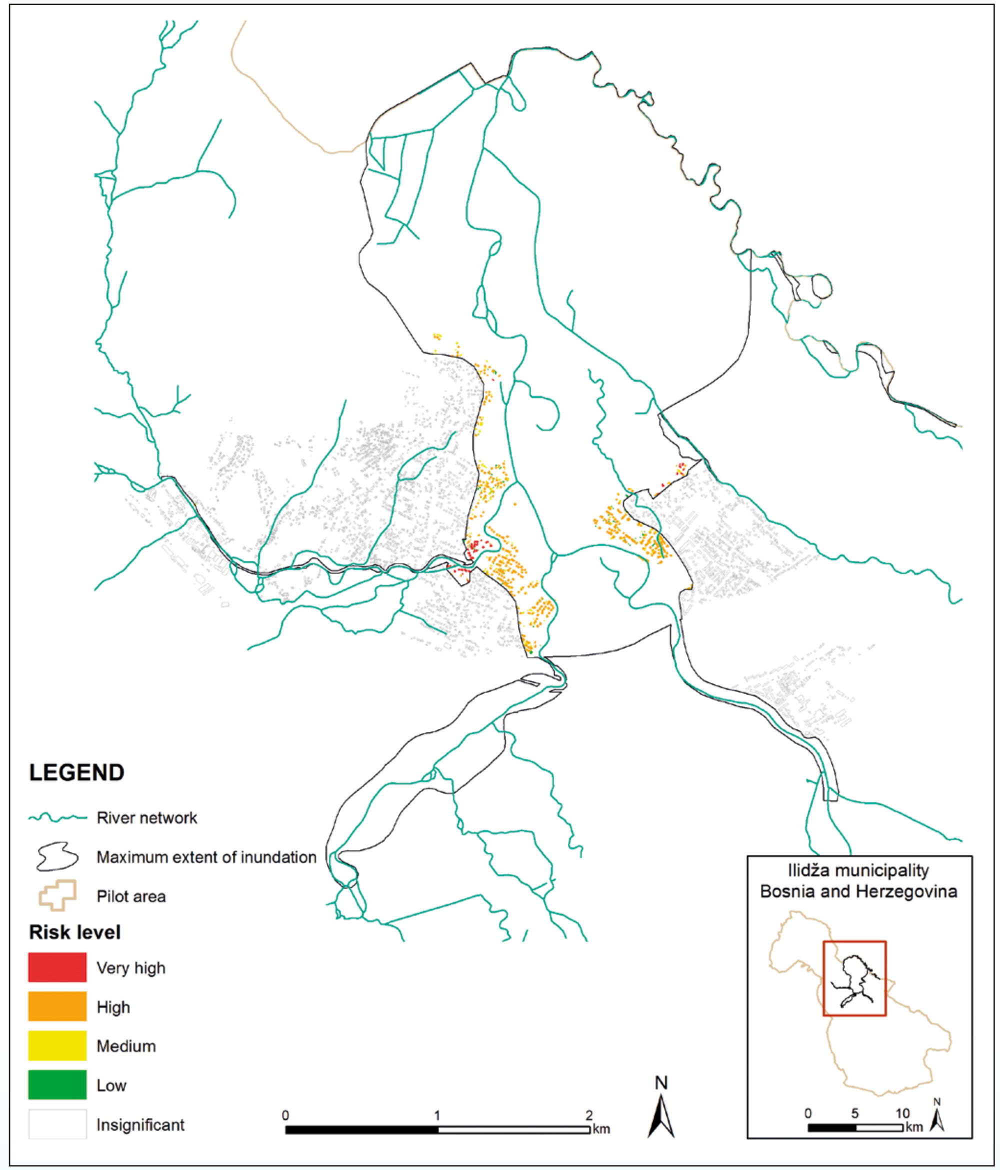

Figure 33. *Flood risk map of Ilidža, Bosnia and Herzegovina*

4.4 ASSESSING AND MAPPING FLOOD RISK IN SENICA, SLOVAKIA

Senica municipality is the administrative, cultural and economic centre of Senica District in Trnava Region, in Western Slovakia. Besides the town of Senica, three villages also belong to the municipality, which has a population of 20,063 people. The total area of the municipality is 50 km^2. Senica is situated at an altitude of 190–325 m above sea level on the Záhorie lowland, close to the Little Carpathians. The area has a warm, slightly humid continental climate with an average yearly precipitation of 600–700 mm. River Teplica and its small tributaries flow through the centre of the town.

Industry is the main economic activity: production of car components, metal, textile and food prevailis. Crop production is dominant on the surrounding large agricultural fields. The proportion of natural vegetation (broad-leaved forests) is fairly low on the area. A recreation area at the Kunov dam lies 5 km away from the town.

Hazard type: Due to long and intense rainfall periods, the municipality suffers from more frequent floods and flash floods than before. Three floods with an estimated probability of a twenty-year return period occurred during the last twenty years (in 1997, 1999, 2006). The town centre including public buildings, family houses, sport facilities and an industrial park were flooded. In case of extreme flooding, the town sewage plant could be also damaged, which would even endanger drinking water supply.

Risk matrix: The risk matrix of Senica was made by using a hazard matrix (Figure 34) which takes into account the return period of floods and average water depth (multifactoral approach) to assess and map flood hazard in the area. Using the multifactor hazard level coming from the hazard matrix and the impact levels, based on the number of residents in the buildings, a risk matrix for floods in Senica was developed (Figure 34)

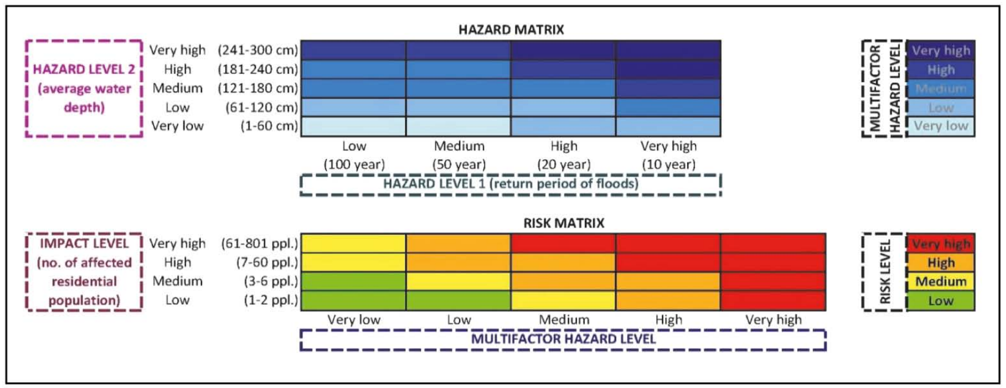

Figure 34. *Flood hazard and risk matrix for Senica, Slovakia*

Description of Hazard Levels: The hazard is described by using two different factors: the water depth and the return period.

Description of Impact Levels: The impact is described as number of people per building. Single-family houses belong to the medium and low impact class whereas buildings housing more families or buildings with uses that require the accommodation of large numbers of people belong to the high and very high impact class respectively.

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Description of risk levels rating: The risk levels are associated with the following emergency actions: Very high risk (evacuation); High risk (flood protection activities); Medium risk (alert); Low risk (no action).

Risk scenario: The scenario is based on a hundred-year flood that in Senica may be triggered by heavy rain and snow melt. The Teplica river will overflow its channel for about 30 hours (between the 15th and 45th hour of the flood). The flood wave will reach its peak in 30 hours. The area that will be inundated occupies 3,353 km^2. Approximately 9,000 people will be affected. Vulnerable groups in the population in the area include the elderly, children and hospital patients . Family houses, blocks of flats, commercial and industrial buildings (factories) and many public buildings (schools, kindergarten, health centre, retirement home, local government office) will be flooded. Additionally, railway, roads, gas, water and telecommunications networks located within the flood extent area can also be affected. There will be an immediate need for evacuation (especially of vulnerable groups of people) and drinking water supply (and maybe also food). Flooding of cellars and buildings, Damage to buildings, factory equipment and products is also expected. Agricultural produce may be destroyed and drinking water contaminated due to the flooding of the sewage plant. Water should be pumped out of buildings and cellars. Roads will be flooded and transport will be interrupted. Control of water, gas and electricity network is necessary. A disruption of the operation of industrial plants is expected and dangerous ammonia leaks are also possible. Finally, people will need psychological support and advice following the event.

Flood protection is organized and carried out – in line with the national legislation – by the local and national government authorities, flood commissions, municipalities and Slovak Water Management Enterprise.

Based on flood plans, flood control activities are performed by an administrator of the watercourse (the branch of Slovak Water Management Authority in the town of Malacky), fire brigades and rescue service, owners of buildings and others. Flood rescue effort includes removal of hazardous substances, protection of water resources, population evacuation, disinfection of wells and water sources, debris removal and maintaining order. According to the flood plans in Senica, public warning is issued immediately after the announcement of the third degree of flood activity by a network of sirens sending the water danger to be broadcast on local radio and television.

The Evacuation Commission will decide about the method of evacuation. The evacuation procedure is based on the principle of the greatest danger and the need to provide support to different groups of people in the following order: school, children mothers in households with preschool children, the disabled, sick people and others. Inhabitants will leave the danger zone go to places of accommodation by designated routes. Emergency accommodation will be provided in the local cultural centre and in primary and secondary schools. Meals will be provided in schools and two restaurants, as well.

Sufficient manpower and resources are dedicated to performing flood - related works. A list of vehicles, machinery, material, technical equipment and members of the fire brigade and other people involved in control and rescue work with phone contacts is available.

Risk mapping: Two hazard maps have been produced based on datasets related to different (100, 50, 20 and ten-year) flood return periods. The first hazard map shows the maximum extent of inundation for each return period, while the second shows the average height of water coverage, for each return period. On the basis of the hazard matrix, a raster-based multifactor hazard map has been made. The final multifactor hazard map has been drawn by adding raster values to polygon layers of residential and public buildings. The impact map shows the distribution of residential population, based on the residential and public building inventory. Finally, based on the risk matrix, the hazard and impact values could be assigned to every building polygon. Thus, a vector-based risk map has been prepared.

The affected area covers 3,353 km^2. The areas exposed to a high risk of flooding are homogenous, mostly on the right, but also on the left bank of the Teplica River. The areas include mostly blocks of flats, partially family houses, schools and retirement homes. In more detail, the hazard map indicates that there are three areas where the hazard will be very high. The west one coincides with the industrial area and although water depth will be high it will not affect any residents . In this case and as it is obvious also from the risk map, the risk in this area will be low. The same situation can be seen for the Eastern high hazard area. However, the middle high hazard area coincides with buildings where population density is high and for this reason high risk areas are located there (buildings represented in red colour). The authorities and the emergency services may use this map to focus their actions on specific buildings where the majority of the people will be located and save precious time. Moreover, a shelter for this people has to be organised in the area and food and water supplies for the inhabitants will have to be provided.

Higher quality of hazard and risk maps should be achieved by using a more sophisticated flood modelling tool – a hydraulic model as a tool for potential improvement of the current outcome.

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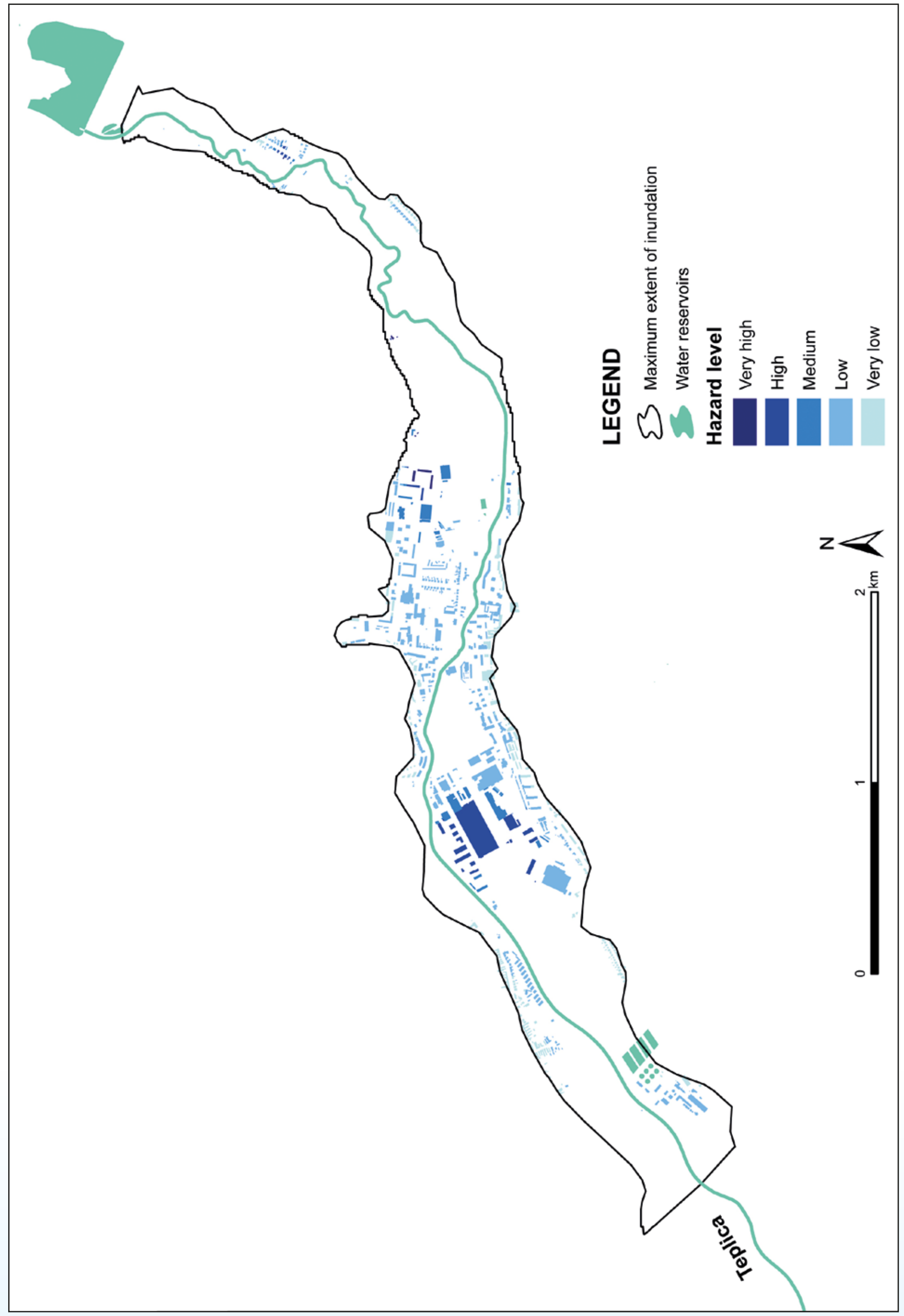

Figure 35. *Flood hazard map of Senica, Slovakia*

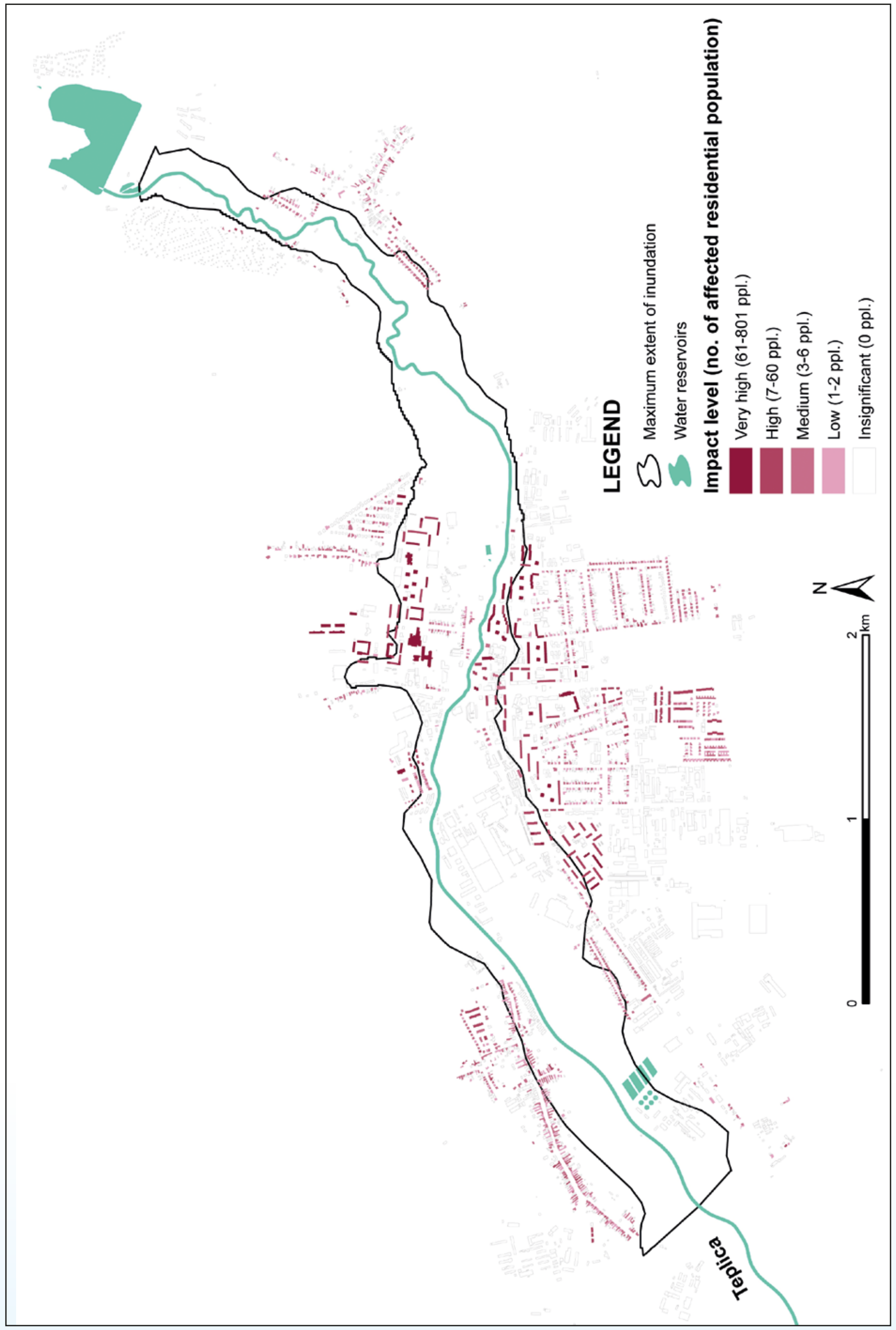

Figure 36. *Flood impact map of Senica, Slovakia*

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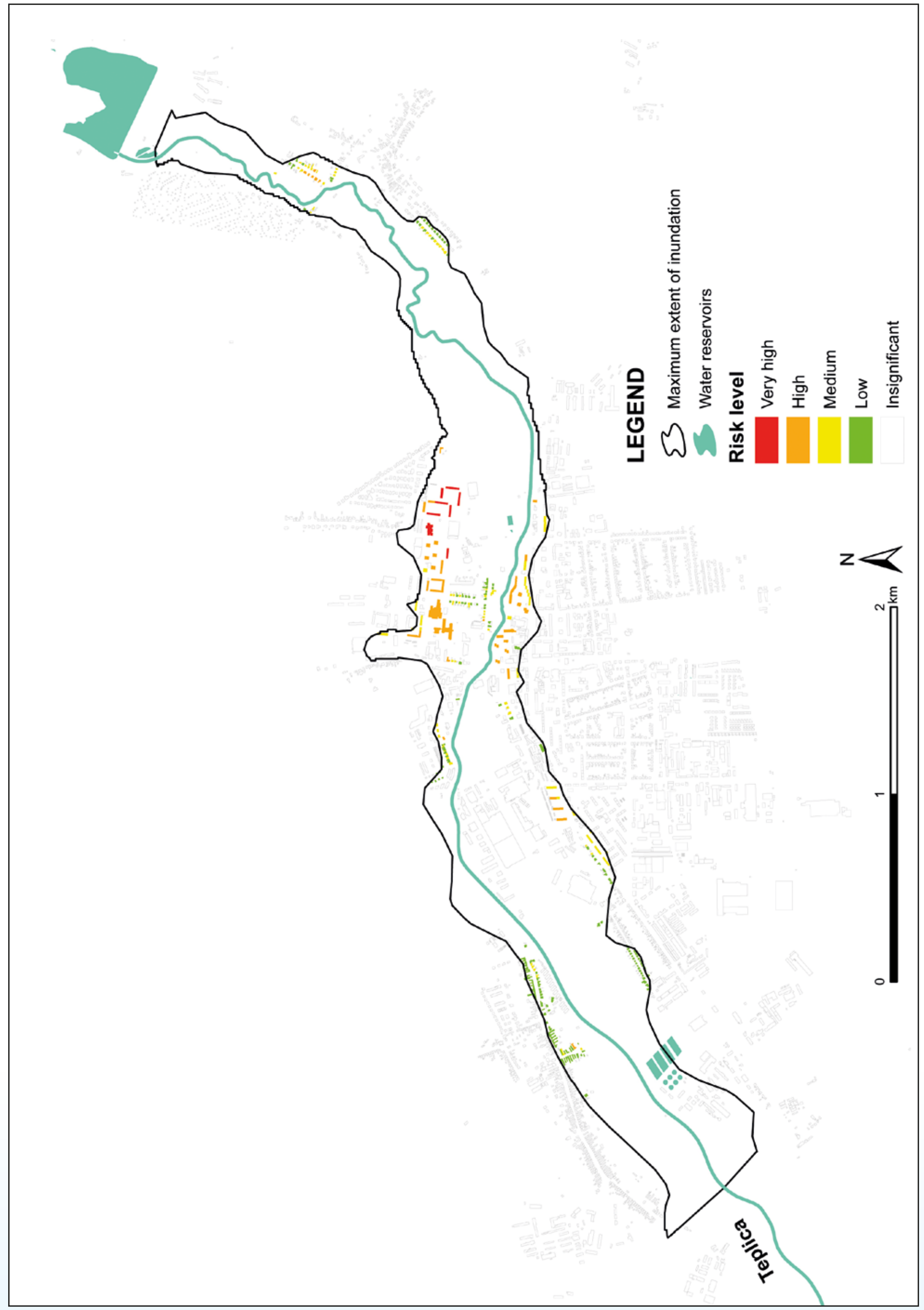

Figure 37. *Flood risk map of Senica, Slovakia*

4.5 ASSESSING AND MAPPING THE CONSEQUENCES OF EXTREME WIND IN SIÓFOK, HUNGARY

Siófok is a town located on the south shore of Lake Balaton. It has a population of 24 662 people, its administrative area covers 1255 km^2. With a 17 km long beach, Siófok is one of the most popular summer destinations for tourists in the county. In the summer,, ten thousand Hungarian and foreign tourists visit Siófok every day. The town lies at 127 m above sea level. The Sió canal flows out of the lake here. South of the town, there is a protected area with small lakes, marshes, meadows and forests. Motorway M7 with heavy traffic borders the town from the south, and a commercial airport is located near the centre. There is a storm warning observatory in Siófok and storm alerts for bathers and sailors are issued by a light signal system along the lake.

Hazard type: The most relevant natural hazard for Siófok is extreme wind associated with thunderstorms. Falling trees (mostly black pines) and branches often cause damage on roofs of buildings, electricity cables and anchored sailing ships. People are directly at risk, which is of utmost importance in the tourist season. There are several past events with registered wind speeds as high as 140 km/h, which could damage roof structures of the buildings. On the open water even a 40 km/h wind speed is to be considered a threat for people swimming or boating.

Risk matrix: An impact matrix for extreme wind was developed for Siófok (Figure 38). The matrix is based on two impact levels: the estimate of residential population and the quality of roofs of buildings.

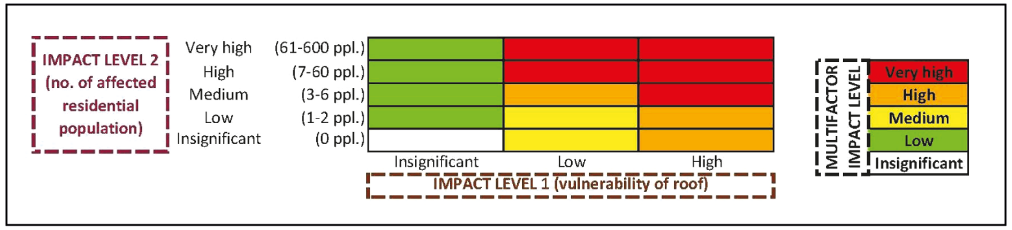

Figure 38. *The impact matrix for extreme wind in Siófok.*

Description of Impact Levels:

Impact Level 1 shows the vulnerability of buildings, especially roofs and is divided in three classes: insignificant (modern roof), low (roof in an acceptable condition, but of older design or surrounded by trees) and high (old roof with loose tiles or damaged) based on expert opinion.

Impact Level 2 consists of five classes defined based on the number of people per building.

Description of Multifactor Impact Level Rating: The multifactor impact level is associated with measures that will be taken when very high or high level is reached e.g. make owners aware of the risk, suggest roof repairs, monitor large trees in the vicinity etc.

Risk scenario: The scenario describes a summer windstorm disaster event on the south shore of Lake Balaton. Extreme wind speed (over 110 km/h, rare worst - case scenario) will cause serious damage in Siófok. The timing of the event is a summer weekend afternoon. The duration of gust peaks is 4 hours. The event will affect the whole municipality (124.66 km^2). The number of people affected on a summer weekend when the resort town is full of tourists is around 100,000. The main vulnerable group is elderly people. People in sail ships, people staying in buildings that are in poor condition or whose build quality is bad, or those who find themselves near trees will be most affected. Expected damage includes damage to buildings caused by falling trees, debris or poor roof quality, damage to power lines and interruptions of traffic flow caused by falling trees.

The preparedness of disaster management and the national authorities may be summarised as follows:

As far as the open water area is concerned, there is a storm warning system in use and information for tourists is available in different languages (Hungarian, English and German). Moreover a frequency (NAVINFO) broadcasts important information for people in sailing boats in the case of high wind speeds. Moreover, rescue teams are on standby from March to October and alert the rest of the year. On land, there are also general warnings and information for the public. Special rules apply in case of large events, the disaster management body is in direct contact with organizers of mass events. The civil protection department of Siófok has 30 experts and the disaster management office has at least 50 experts with the possibility of securing the support of even more professionals in case of an emergency.

Risk mapping: Instead of a risk map, a multifactor impact map has been made for the Siófok pilot area. The reason is that the extreme wind hazard – one basic element of risk mapping – namely extreme wind, could not be mapped on a local scale (on the basis of the provided data set). The multifactor impact map is a synthesis of two base impact maps working with data on the physical and the social attributes of the town: one shows the state of the individual structures (buildings) and therefore their vulnerability, while the other indicates the number of people in the buildings.

The multifactor impact map of Siófok hardly shows (Figure 41) any concentration of buildings marked red or orange, meaning high vulnerability. Magnifying the map, it becomes obvious that there are neighbourhoods where the density of buildings marked red or orange is higher but also areas where there are only few or a single building in these categories.

The neighbourhoods where the density of buildings with medium and high impact values is high are not situated on the banks of the lake but are located inland or in the centre of the town. The area with a high density of highly vulnerable buildings (orange) is in the heart of the town, framed by Sió Canal, the railway, and main road No 7. This is, in fact, the town centre with mostly public buildings. This type of area stretches out to the south over the main road, where the buildings marked orange are 8-10 storey blocks of flats. Another neighbourhood with a high density of residential buildings exposed to a high impact of wind (marked red) is located in the south-east of Siófok. Lower income residents and poorer quality housing characterise this area. The area deserves special attention both for infrastructural and social reasons. In addition to the above-mentioned neighbourhoods where highly vulnerable buildings are concentrated, there are only individual buildings (mainly hotels and public buildings near the beaches) marked orange and less frequently red on the multifactor impact map of Siófok.

The quality and the nature of the input data could be improved for the multifactor impact map. Apart from the general condition of the houses, the type of the roof covering material, the roof area, the building's age and height could be also included in the scope of the mapping exercise. The condition of other elements at risk could be also considered such as trees and power lines which are potential source of threats in time of thunderstorms. By taking into account data on hazard factor, such as wind direction and wind speed (which would prerequisite particular measurements and modelling of local wind conditions), full-fledged risk maps could be prepared.

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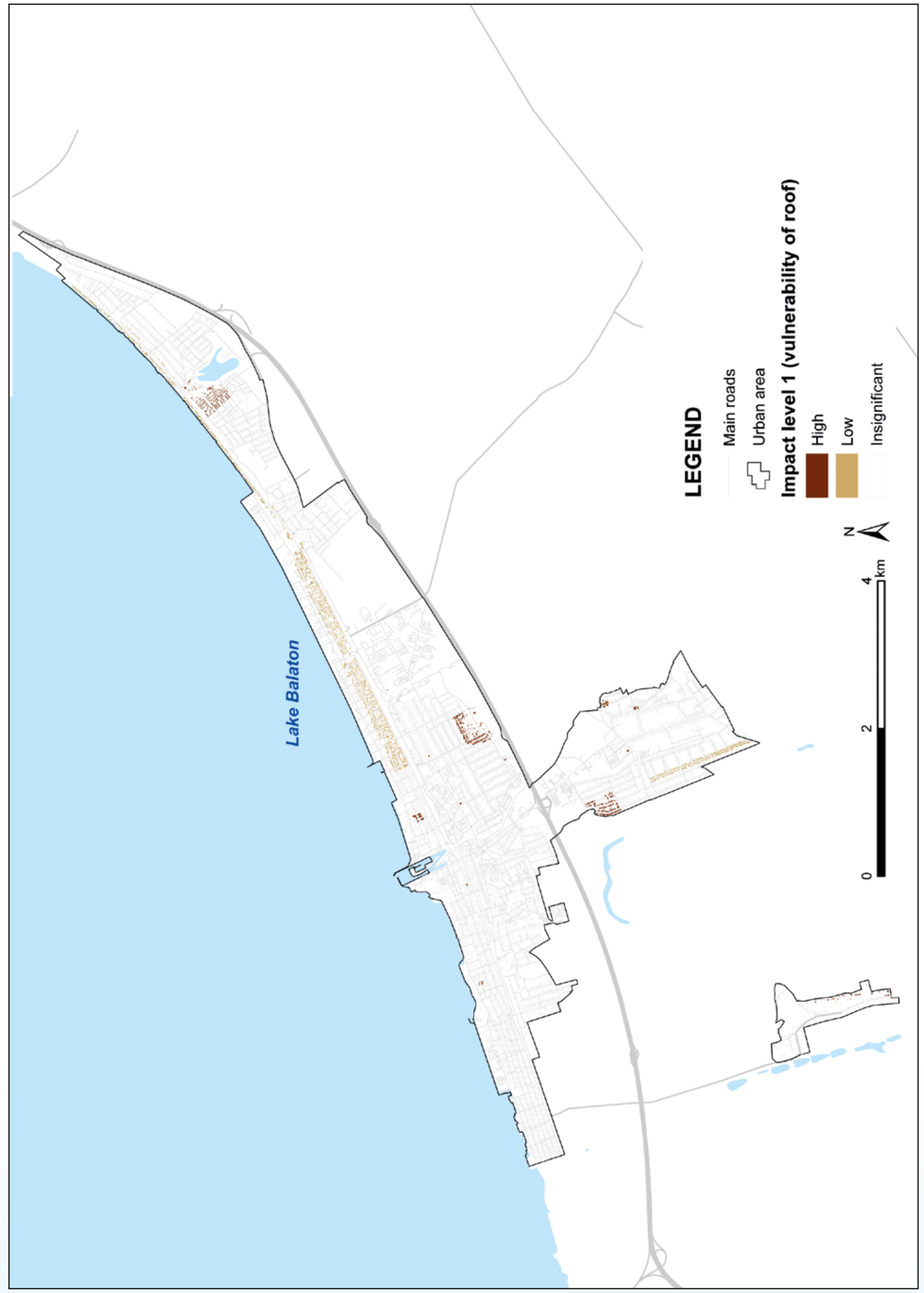

Figure 39. *Impact map of Siófok, Hungary based on building (roof) quality of residential buildings*

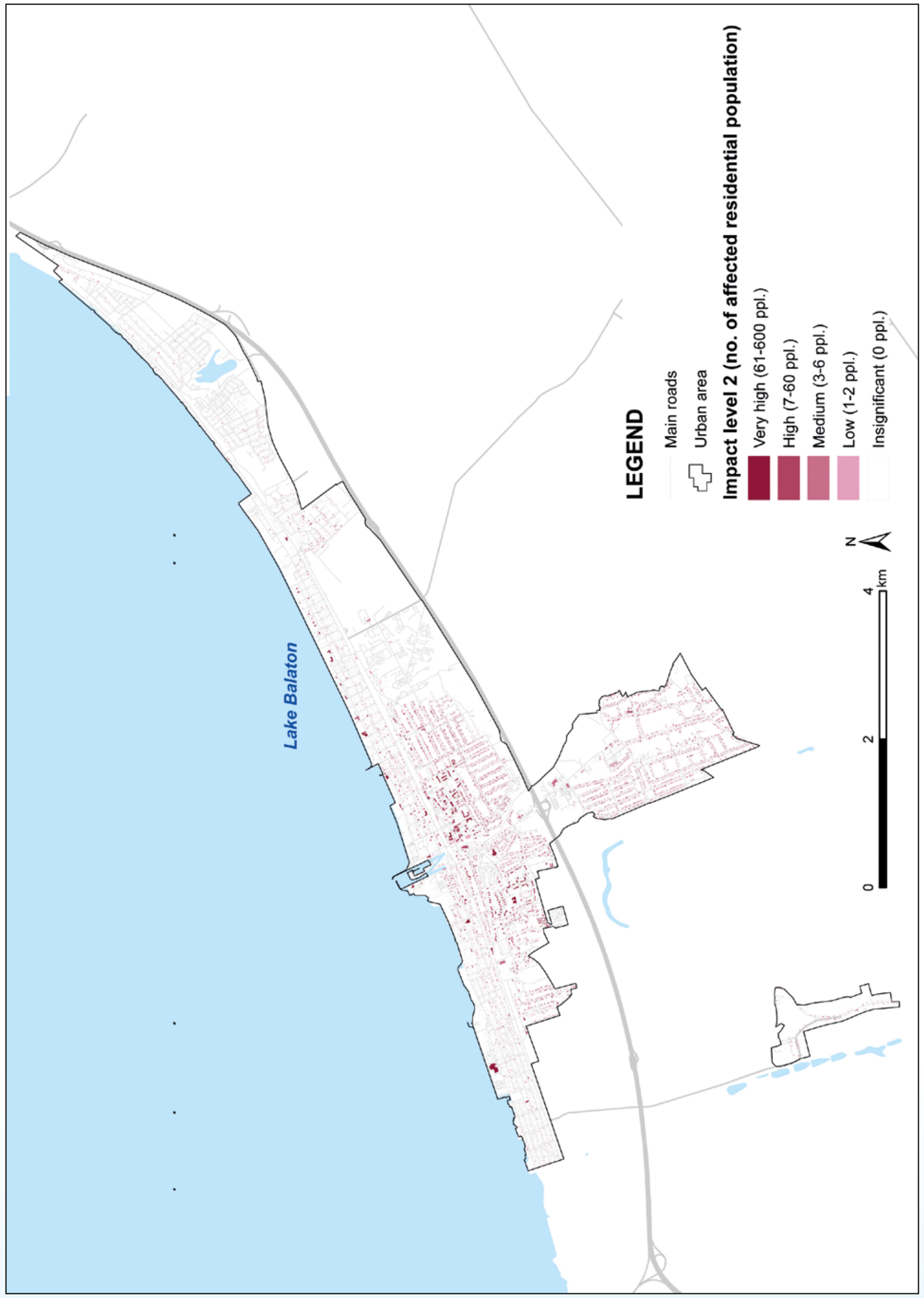

Figure 40. *Impact map based on residential population in Siófok, Hungary*

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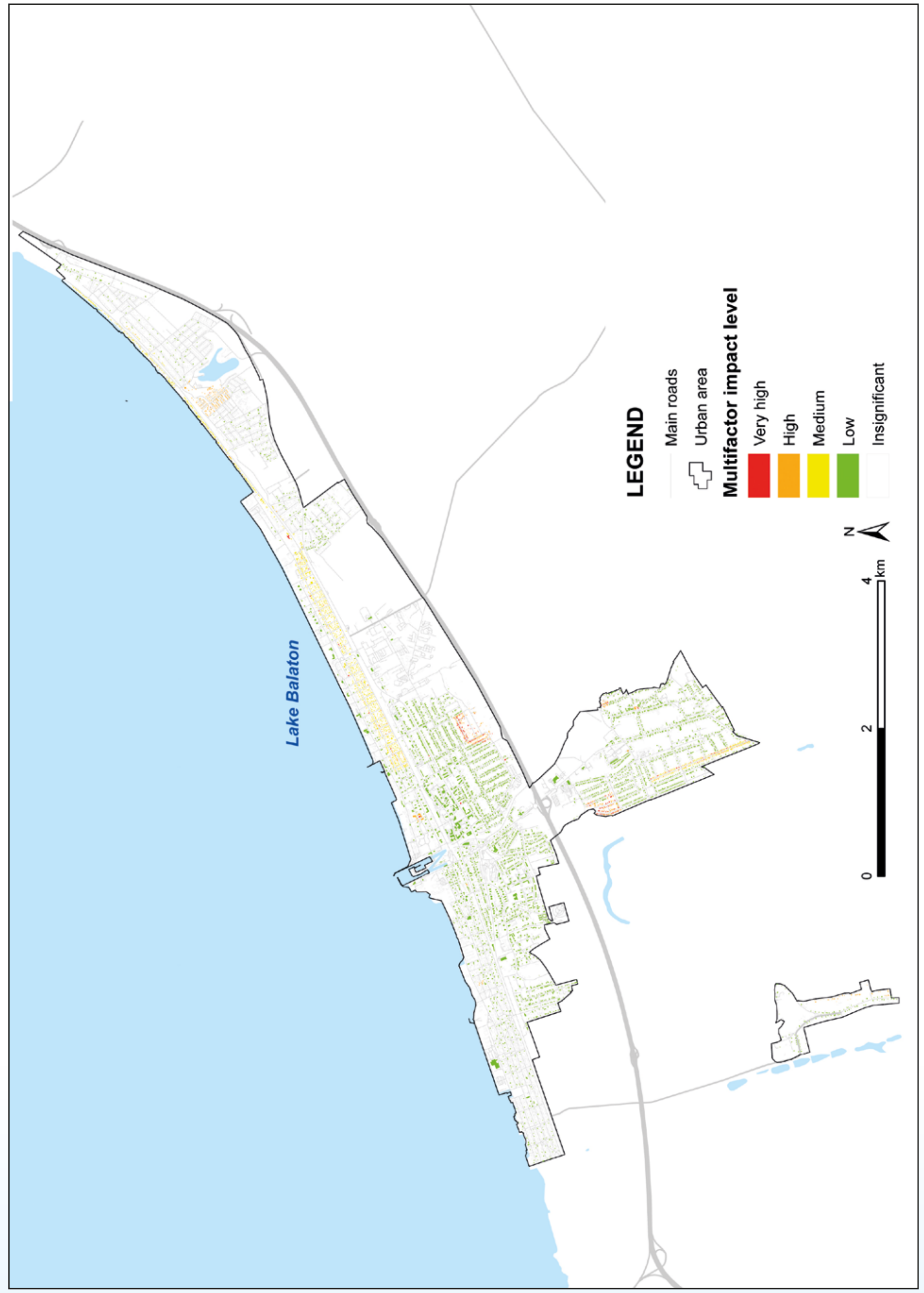

Figure 41. *Multifactor impact map on extreme wind in Siófok, Hungary based on both roof quality and residential population estimate*

4.6 ASSESSING AND MAPPING WILDFIRE RISK IN VELINGRAD, BULGARIA

Velingrad is the largest municipality in Pazardzhik Province in Southern Bulgaria. The municipality consists of two towns, Velingrad and Sarnitsa, as well as 22 villages. It covers an area of 818 km^2 with a population of 40,707 people and its administrative area Velingrad is located in the Chepino valley in the Rhodope Mountains at an altitude of 755 m a.s.l., while the average altitude is 1,300 m a.s.l. in the region. The climate is mountainous with a high number of sunny days. Broad - leaved and coniferous forests occupy 83% of the total territory of the municipality, which also boasts five protected areas. There are around 80 mineral water springs in Velingrad. Excellent natural conditions have made Velingrad a famous spa and wellness resort.

Hazard type: The territory of the municipality is covered with forest to a large extent, mainly with inflammable pine trees. Rising spring and summer temperatures, together with human negligence increase wildfire hazard. During the summer, wildfires occur almost every day. Fires frequently erupt in the vicinity of roads or settlements, in most cases, caused unintentionally by tourists or woodcutters. Yet, wildfires are becoming more and more devastating, destroying the ecosystem and precious timber. The mountainous terrain makes it difficult for fire engines to reach the site in danger. In 2002, almost 250 hectares burned down, while in 2007 all the surrounding municipalities were affected by wildfires.

Risk matrix: The flammability of different forest types and the distance of the forest from the road network and settlements were used in order to develop a risk matrix for wildfires in Velingrad (Figure 42).

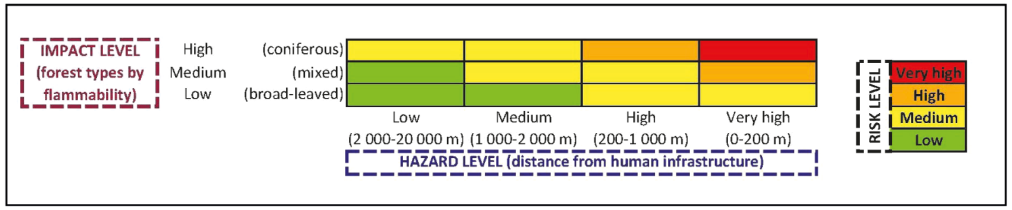

Figure 42. *The risk matrix for wildfires in Velingrad, Bulgaria*

Description of Hazard Levels: Description of hazard levels was based on the distance of the fire from roads and settlements.

Description of Impact levels: Description of impact levels was based on the type of trees (forest type) and their flammability. High impact is expected when a coniferous forest burns, a medium impact in the case of a mixed forest and a low impact when in a broad-leaved forest.

Description of Risk Rating: Very high: Fire is destroying a huge part of a coniferous forest and s less than 200 m away from roads and settlements. Evacuation is needed at the affected residential areas. High: Fire is destroying a mixed type of forest. The fire is less than 1000 m away from roads and settlements. Serious efforts are needed for it to be distinguished. Medium: Fire can destroy any type of forest. Its distance from roads and settlements varies. Low: Fire is destroying mainly broad-leaved forest and partly mixed forest and it is more than 1000 m away from roads and settlements).

Risk scenario: Wildfires in the area are very common (they occur once a month) and cause damage to the forest and ecosystems. Due to the characteristics of the geography of the municipality (mountainous terrain) fire brigade vehicles frequently cannot easily reach the fire. The worst case event is likely to happen every 6 years. The risk scenario is based on the 2002 wildfire that lasted for 34 hours and destroyed more than 0.25 km^2 of coniferous forest (pines) and more than 0.17 km^2 of deciduous forest. The area that will be affected is situated west of the town of Velingrad – the pilot area's administrative centre. The area consists of 0.25 km^2 of coniferous (pine tree) forest. The distance of the wildfire from the urban area (hotels, houses, hospital, school and a local family centre) is nearly 200 meters. The altitude of the terrain of the wildfire affected area varies from 800 m to 900 m above sea level. The timing of the event is in early summer, early in the morning. The fire is expected to reach its peak in four hours.

The affected elements at risk are: 500 people, 10 residential buildings, two hotels, one hospital, and one social services family centre. In more detail, the following consequences are expected:

- Physical impacts: no casualties and two injured; The main city potable water tank that is used by the whole city of Velingrad is located within the fire zone.
- Economic impacts: loss for business – spa tourism in the nearby hotels; loss for forest management – loss of timber;
- Environmental impacts: pollution of the environment, smoke, deforestation, soil erosion, changes in biodiversity in the fire-affected area..
- Social and psychological impacts: threat to residential buildings situated nearby with about 190 people, 30 children, 60 staff in hotels, 20 patients and medical staff

The Authorities responsible for the design and implementation of disaster management measures are: the mayor of the municipality, regional governor, the bodies of the Chief Directorate for Fire Safety and Civil Protection, the Bulgarian Red Cross, the Executive Forest Agency of the Ministry of Agriculture and Food.

There is an annual order (order of the regional governor of the Pazardzik region regarding prevention of fires in the forests and their timely extinguishing in the Pazardzik region) that is issued in the beginning of April. The following action plans are in use:

- Action plan of Velingrad municipality in case of fires.
- Action plan of the Regional service of fire safety and civil protection in case of fires.
- Plan for prevention of fires in the forests for every forest management area and state-owned hunting ground in the territory of Velingrad municipality - in this case, the state owned forest management area of Alabak. The plan is signed every year and after that it is approved by the chief of the Regional Service for Fire Safety and Civil Protection– Velingrad and the director of the Regional Directorate of Forestry Pazardzik.
- Plan for interaction between the Regional service fire for safety and civil protection – Velingrad and the state owned forest management area of Alabak - the plan is singed every year.

There are also decrees specifying safety measures against forest fires, which are given to the tourists, loggers, mushroom and herb pickers. Moreover, the places suitable for firing up barbeques in forests are marked.

Risk mapping: While the land cover in the municipality consists mainly of forests (coniferous, broad-leaved and mixed forests), there are also meadows and urban areas.

The hazard map (Figure 43) clearly shows that hazard is higher within buffer zones around settlements and roads. However, the impact of a potential wildfire shown on the impact map (Figure 44) has different spatial patterns, since it is based on forest types of characterized by different flammability levels. Higher impact is to be expected in the coniferous forest, situated mostly in the southern part of the municipality. The risk map (Figure 45)shows that the highest risk occurs in places where the coniferous forest overlaps with high hazard zones, namely in the vicinity of the road network in the south, in the north-western part of the municipality and on western and southern edges of the town of Velingrad. This map can be used by emergency services, local authorities and volunteers in order to identify the areas where emergency actions should be concentrated and patrols prior to the start of a wildfire should be intensified.

However, the risk map is basically accurate, for fulfilling its aims and designations, it is needed to be more precise and detailed. The basic data should be more up-to-date, without missing items with a better quality. Weather conditions (at least wind speed and direction) during the fires and topography should also be taken into consideration.

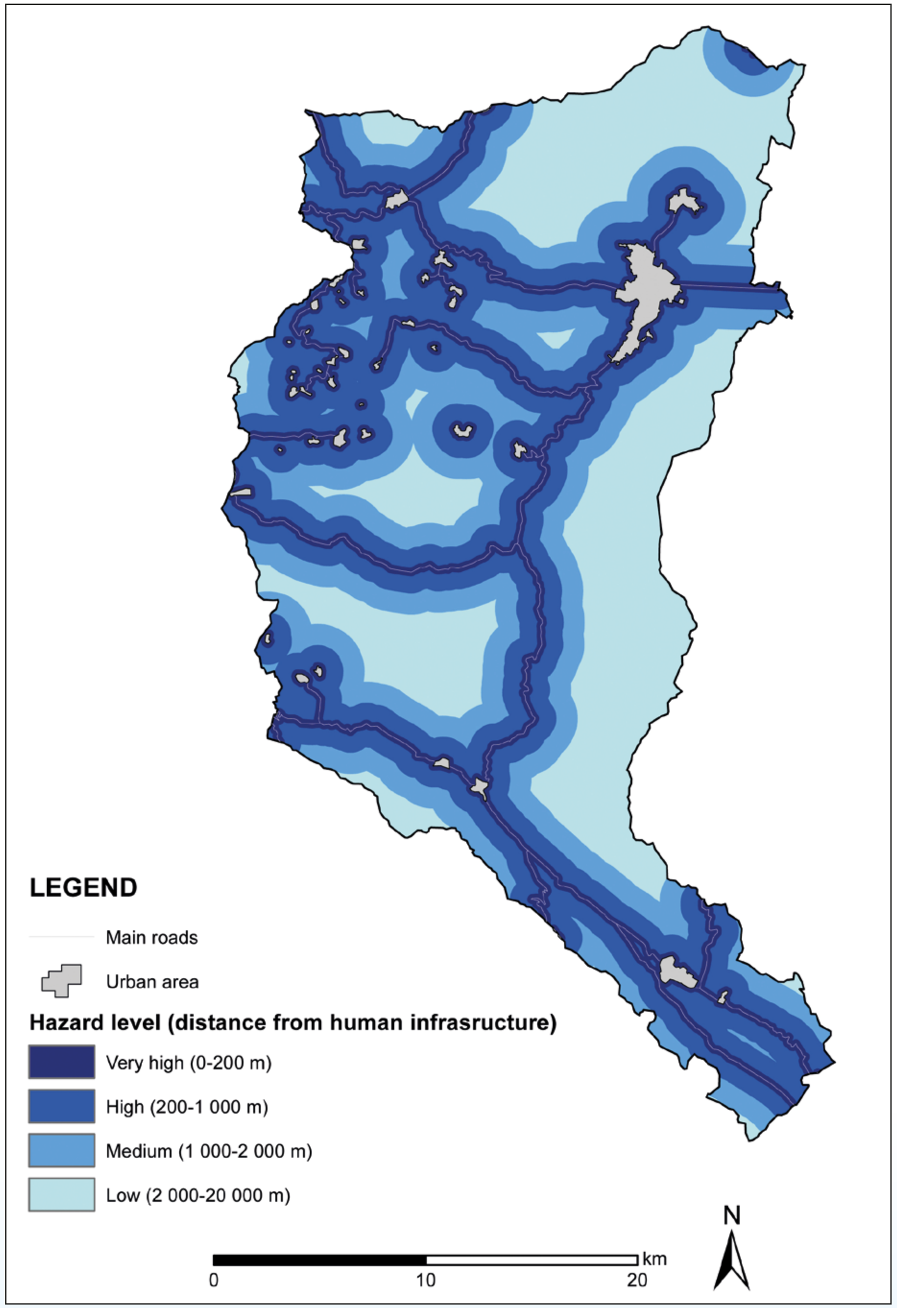

Figure 43. *Hazard map based on distance from human infrastructure in Velingrad, Bulgaria*

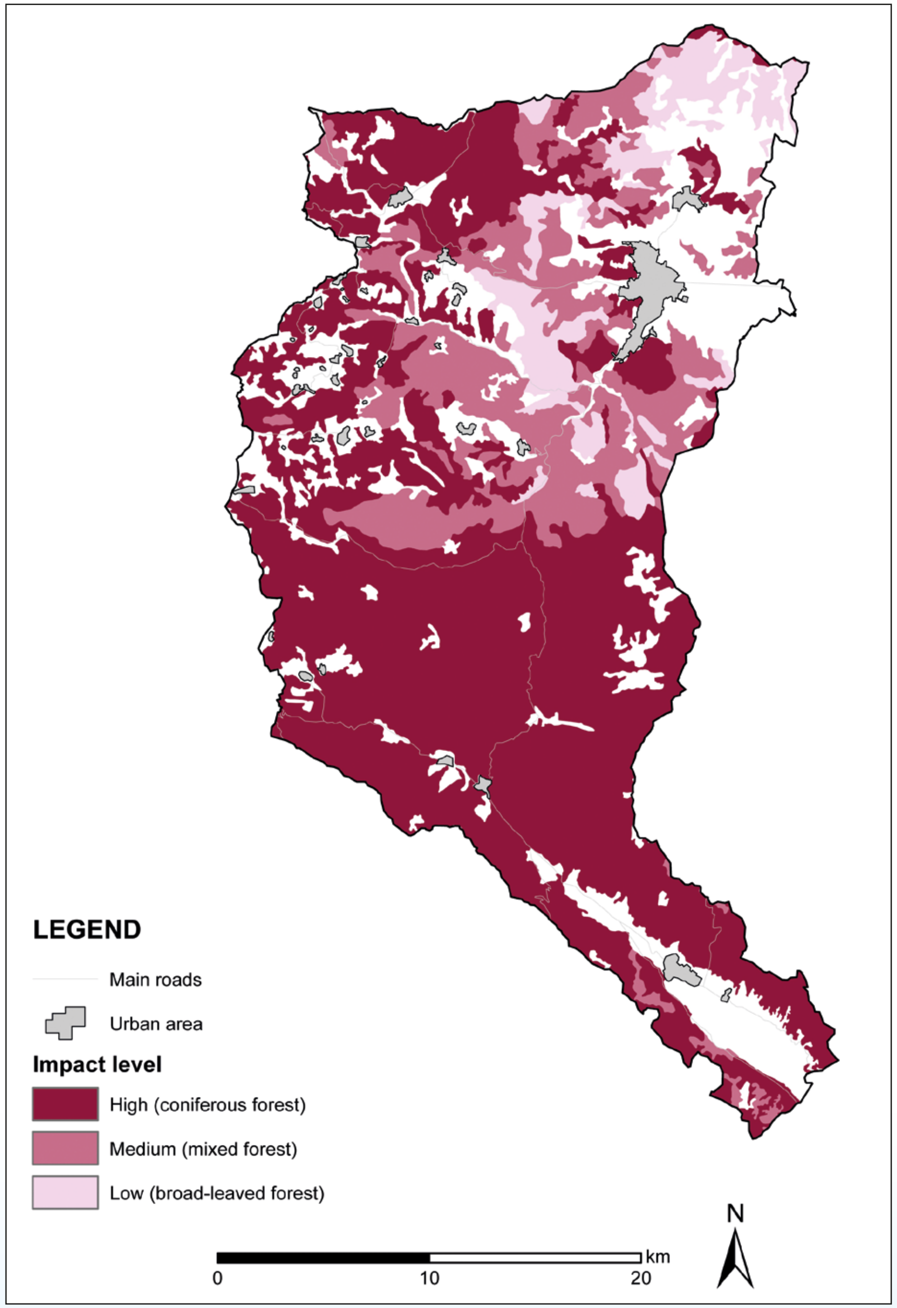

Figure 44. *Impact map based on flammability of forest types in Velingrad, Bulgaria*

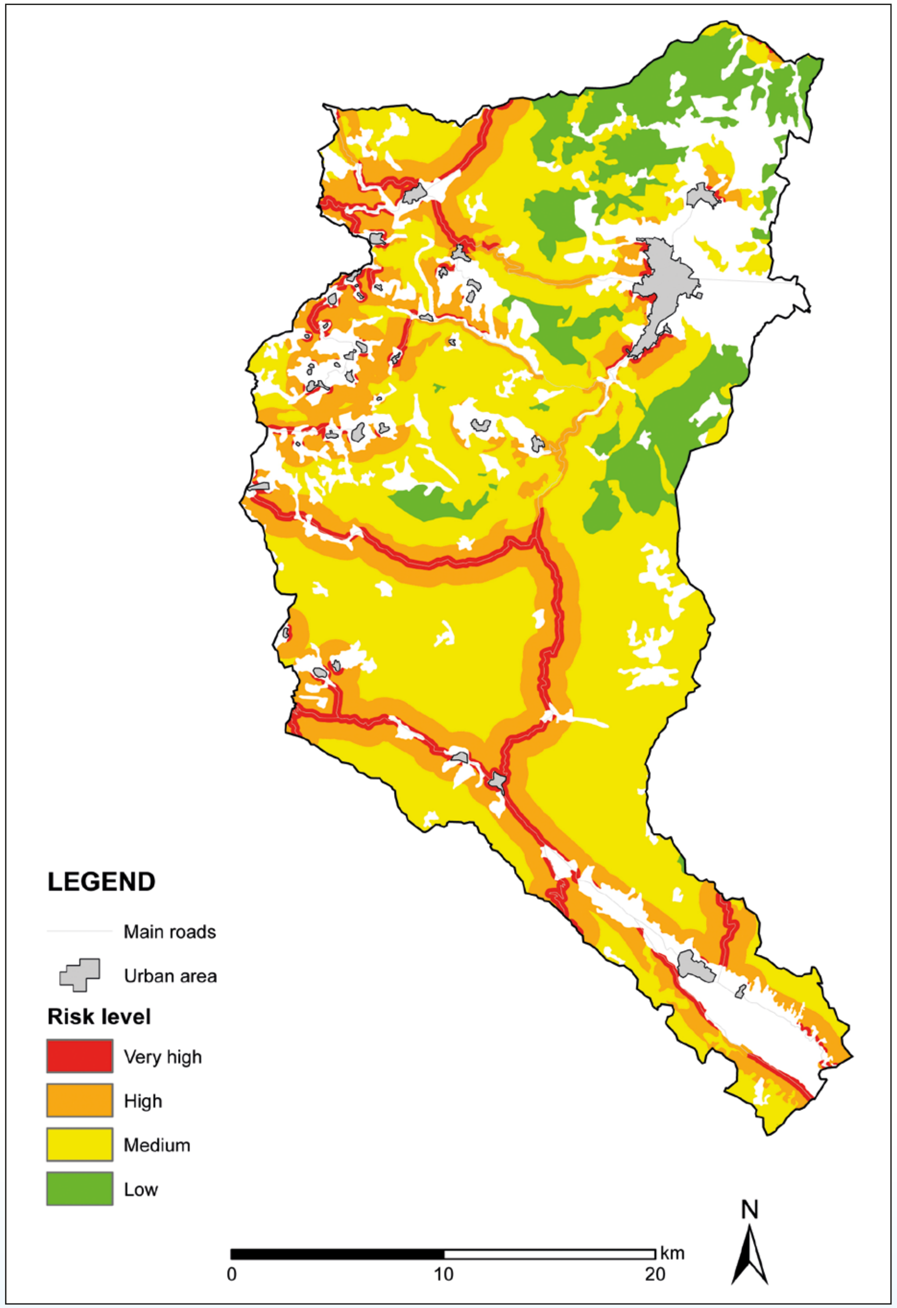

Figure 45. *Impact map based on flammability of forest types in Velingrad, Bulgaria*

4.7 FEEDBACK FROM PROJECT PARTNERS AND LESSONS LEARNT

The Common Methodology for Risk Assessment is a newly introduced product that is open to improvements and changes. The purpose of this chapter is to present the initial feedback of the partners on the methodology that may be used as a basis for improvement and further development. In more detail, the lessons learnt aim to identify the advantages and disadvantages of the methodology, the needs for future development and intensions for dissemination.

This chapter may be used by practitioners, local authorities or other decision makers wishing to introduce improvements and modifications into the methodology or it may be used as a basis for further research as part of future projects.

The Common Methodology for Risk Assessment has been developed based on a questionnaire that was given to SEERISK partners where they were asked to describe their needs, expectations, and wishes, as far as the common methodology was concerned. In the same questionnaire the partners provided information regarding the existing methods that have been used in their area until now to assess or simply to visualise the risks, legal requirements in this field and the available data that can be used for the development of risk maps, matrices and scenarios. Having considered data gaps, UNIVIE developed a common risk assessment methodology. Each partner was required to develop a risk scenario and a risk matrix based on the existing data on past events that would provide information on the frequency of the events and their consequences. The partners also provided a detailed description of a risk scenario, based on a past event. Finally, the GIS team of NDGDM developed the risk maps. Since this is the first time that the methodology has been applied, it was essential to collect feedback from the partners, in order to concentrate on the points that need further development or improvement. The partners evaluated the common risk assessment methodology using a feedback form that included the following sessions:

- Comprehension and completeness
- Applicability/Products/Advantages/Disadvantages
- Future developments (Improved data collection)
- Dissemination

As far as the **comprehension and completeness** of the common risk assessment methodology is concerned, all partners appear to be satisfied with the product and have no problems understanding how the methodology works as well as comprehending the different terms and definitions that are featured in it. However, partners indicated that a more detailed description of the methodology for the development of risk matrices would be needed, particularly as far as risk rating is concerned. Risk rating indicates which level of risk is acceptable, furthermore it associates risk levels with the corresponding risk management actions or decisions that have to be taken. For this reason, risk rating has to be implemented by decision makers, and can be only set if the institution has a decision-making powers to rate the risk.

As shown in the box bellow, as far as the **advantages and disadvantages** of the methodology are concerned, more advantages than disadvantages were pointed out.

Partners recognized that the common methodology has many advantages such as:

- "Wide applicability, covering different scenarios" (Serbia)
- "It works without a mathematical model and completed data sets" (Slovakia)
- "It can be used for a wide range of hazards" (Bulgaria)
- "There are various risk evaluation options intended for different the end users" (Hungary)
- "Modular and flexible architecture allows the use of basic concepts, not only with complete datasets, but also with sparse data" (Romania)

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The partners pointed out that the use of the methodology is expected to increase the level of preparedness in the area where is applied and that different stakeholders may find a common approach to risk identification, assessment and evaluation. Moreover, the methodology will effectively transfer climate knowledge to disaster managers, decision makers, media and the general public. Besides, almost all the partners have the required staff and technology to implement the methodology and use the existing data to produce risk maps in the future.

The partners also highlighted a limited number of disadvantages, such as flexibility that allows too much space for criteria definition making comparison of products impossible.

All the partners underline that the fact that methodology can function in absence of completed datasets is an advantage. However, as far as the methods proposed for improving future data collection are concerned, they point out the drawbacks that have to do mainly with the lack of communication and access to data between agencies and administration and the lack of data in the electronic and spatial form (e.g. GIS data).

All partners strongly believe that they are able to develop all the products needed (risk matrices, scenarios and maps). Nevertheless, the Serbian partners stress that there is a problem of incoherence between the proposed common methodology and the existing methodology for risk matrices. There were generally no significant problems in developing the products, apart from some difficulties in risk rating, setting thresholds for high/medium/low risk and the use of data on extreme events to make the risk matrix.

Risk maps were prepared by the SEERISK GIS Team, coordinated by NDGDM. The UNIVIE methodology can be viewed as a theoretical framework for risk assessment. Therefore, the step-by-step tutorial of risk map preparation will be included in the GIS Best Practices document.

Not all partners plan to use the methodology in the future for different types of hazards, and elements at risk. However, there are plans for its future use for hail, storms and blizzards in Serbia, wildfires, the impact of drought on agriculture and water management in Romania. The Bulgarian partners are planning to use the methodology in other regions or at other levels in Bulgaria.

Only a few partners suggest that the methodology may be used for future scenarios (Serbia, Bulgaria) although in some cases more research will be needed (Romania), whereas others find it impossible due to the lack of climatic models for the future (Slovakia).

The majority of the partners plan the dissemination of the methodology at the national level through meetings and workshops. In more detail, the partners plan to disseminate the methodology to other agencies, such as disaster management and environmental sector, local authorities, municipalities, ministries (e.g. the ministry of agriculture), universities, administration at different levels (local or regional) and protected area managers. The dissemination may be achieved through workshops, bilateral meetings, emails, or introduction of the methodology in national platforms (e.g. in the case of Bulgaria, in the national Climate Change discussion platform).

The Common Methodology for Risk Assessment should be disseminated and, based on the feedback from end-users, improved and expanded to include more hazards such as hail, landslides, debris flows, and flash floods. The users may improve their data collection methods in the future by following the recommendations included in the methodology document. In this way, they may be able to produce higher quality risk maps in the future. The methodology should serve as a common platform for end-users and stakeholders, allowing them to collaborate and to reduce disaster risk to a minimum.

5. THE SOCIAL ASPECTS OF CLIMATE CHANGE: ASSESSMENT OF PUBLIC AWARENESS AND PREPAREDNESS

In the previous chapters of this guideline the Common Risk Assessment Methodology were introduced, along with the practice of assessing risks generated by climate change related natural hazards at the local level. It is also important, in a complex research project, such as SEERISK, to focus on the social (human) aspect of climate change and the consequences, in the communities, as well. People living in different socio-economic circumstances, who have different social and educational backgrounds, understandably, react to the impacts of climate change in various ways. Being aware of and being prepared for the impacts of climate change has become indispensable for communities and their institutions looking after the welfare and safety of people. The social aspect of climate change is revealed via an assessment of the level of awareness and preparedness of the local inhabitants and institutions in the pilot area. The identification of gaps between risk exposure and the actual preparedness of local communities can be completed in this way and the possible solutions in the form of recommendations become easier to find.

In the framework of the SEERISK project, the approach and behaviour of the inhabitants were studied by using the survey method (non-representative questionnaire survey), while the approach of the institutions and decision makers was revealed by conducting interviews and scrutinizing planning documents of the local communities (municipalities, regions).

5.1. SOCIAL AWARENESS QUESTIONNAIRE SURVEY IN THE PILOT AREAS

5.1.1. AIMS AND METHODOLOGY

The aim of the questionnaire survey in the pilot areas was to gain an insight into the awareness of and preparedness of the local population for climate change and the related risks. Each pilot area conducted its own survey and prepared an analysis applying a list of criteria that was the same for all project partners. The data gained from the questionnaires were all entered into a Microsoft Excel file in the pilot areas. All the pilot area analyses, as final products of the questionnaire surveys, are text–based but also include lots of diagrams and data tables.

Both pilot studies and the overall, synthesizing analysis (based on survey analyses of six pilot area) were structured in the same way:

- raw results: the distribution of the responses among the possible replies (in %),
- special aspects: studying the distribution of Yes or No responses,
- territorial approach: comparison of the natural and social environment of the survey units within one pilot area,
- combined analyses: horizontal connection between certain questions and the different contexts of the respondents.

BASIC SURVEY PARAMETERS

The total sample of the SEERISK project exceeded 1600 completed questionnaires in the six pilot areas. At the project level, the survey covered 27 survey units in the six pilot areas and the surveying was completed by almost 90 assessors, during more than ninety working days. (Table 2.). In each pilot area, 0.1% of local inhabitants were contacted. The total number of questionnaires was distributed among the surveying units, according to their share in the total population of the pilot area. The pilot area meant one settlement e.g. town of Siófok or an area with more than one settlement e.g. Velingrad Region.

Country	Number of questionnaires	Pilot area	Number of survey units	Number of assessors	Time of the survey
Bosnia and Herzegovina	200	Sarajevo – Ilidža	4	4	16.09 - 20.09.
Bulgaria	407	Velingrad Region	5	11	13.06.- 04.07.
Hungary	247	Siófok Municipality	5	12	17.06.- 14.07.
Romania	300	Arad	6	52	10.06.- 22.06.
Serbia	274	Kanjiža Municiality	4	8	01.07.- 30.07.
Slovakia	216	Senica	3	1	21.06.- 30.07.
Total	**1644**		**27**	**88**	**Min. 90 working days**

Table 2. *Basic parameters of the questionnaire surveys in the pilot areas, 2013*
Source: SEERISK questionnaire surveys (n=1644)

The international questionnaire survey does not represent the population of the pilot areas in terms of age or educational level for. The explanation is that there are immense differences in the total population of the pilot areas (Siófok vs. Arad) and also that the availability of the census data - which e.g. age representatively could have been based on - differs considerably on the settlement level by the partner countries.

SUMMARY OF THE PROCEDURE OF THE QUESTIONNAIRE SURVEYS

General impressions of the assessors (people carrying out the survey):

- about the attitude of people: friendly, response rate is more than 80%,
- about circumstances in which the questionnaire is actually filled in: usually a standard on-street interview process, taking 25-30 minutes on average,
- about the difficulties of conducting the survey: In some cases, demographic features (e.g. low educational level, older age) could affect the understanding of the different questions and terms. The majority of difficulties were rooted in the following:
- terms and definitions of the different natural hazards (e.g. floods, flash floods, inland excess water) understanding were not so easy for the respondents to understand;
- sometimes respondents found it difficult to evaluate the level of safety.
- In each country, interviewers underwent special training, with a short discussion of the questionnaire clarifying instructions, terms, definitions etc.

By summarizing the results of the questionnaire surveys many common and pilot area specific conclusions could be drawn about people's attitude to natural hazards and climate change in general. The international comparison does not evaluate and examine the results but simply presents the differences among the pilot areas.

Country	YES responses (%)	NO responses (%)
Bosnia and Herzegovina	100	0
Bulgaria	83	17
Hungary	92	8
Romania	98	2
Serbia	99	1
Slovakia	97	3
Average	95	5

Table 3. *Rate of Yes and No responses to the question "Have you ever heard about global climate change?" (percentage), 2013.*[3]
Source: SEERISK questionnaire surveys (n=1644)

5.1.2. SYNTHESIS OF THE QUESTIONNAIRE ANALYSES OF THE PILOT AREAS – A SUMMARY

Knowledge about global climate change and information channels through which it is transfered

According to the survey results, people in the pilot areas mostly have already heard about global climate change (Table 3). Among those who claimed not to have heard about the topic, elderly people, respondents with no academic qualifications or those who have not completed primary school domimate..

For those who have already heard about global climate change, the most important source of information is broadcast media, particularly television. Internet and newspapers also appear among other important sources of information. The frequency of use of modern means of communication (mainly the Internet) is the highest among people under 50 and those who have at least secondary school level education. The role of institutionalized education as a source of information is more relevant for people with a high and higher than average educational level, but it is a weak source of relevant knowledge for elderly people. Organizations such as disaster management and the authorities are sources of information about climate change for the smallest group of respondents. The role of schools is even less frequently acknowledged in this context, which proved to be a common gap identified in almost every pilot area.

Among those who have already heard about climate change, the majority rate its influence on everyday life as *strong* or *very strong* (Figure 46). In most pilot areas, respondents rate the connection between climate change and its influence on their everyday life as average: they do not deny the possible effects but they are still uncertain about it.

[3] Indication of the year in title of all figures in this chapter is a common methodological tool in order to report the date when the survey was conducted. This way information can be defined by the actual figure regardless of the text.

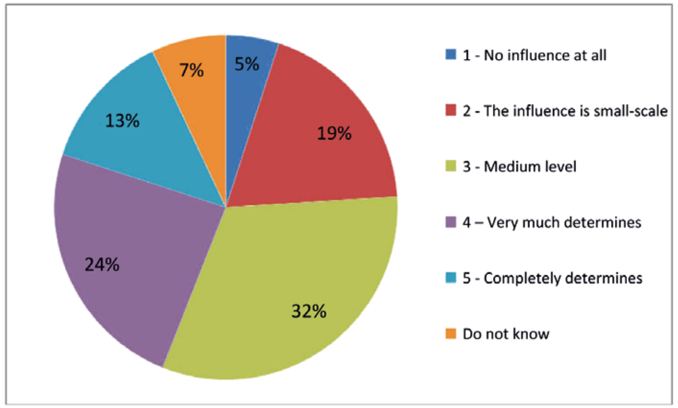

Figure 46. *Evaluation of the influence of global climate change on everyday life for the whole sample (percentage), 2013.*
Source: SEERISK questionnaire surveys (the segment of the respondents who have already heard about global climate change)

More than a half of all respondents think that weather has changed or completely changed in the past 20-30 years and there are less people who are unsure about it (Table 4). The number of people who completely deny changes in weather is rather low in all pilot areas. Young people – mainly under the age of 35– have uncertainties and they more frequently think that climate change has no effect on their everyday life. Older people recognize the signs of climate change. The tendency in each pilot area is such that the higher the educational level, the higher the number of respondents who see the consequences of the changes in climate.

Country	No change has happened (1)	Change has been small-scale (2)	Medium level (3)	Weather has changed (4)	Weather has completely changed (5)	Do not know
Bosnia and Herzegovina	2	4	30	36	27	1
Bulgaria	3	21	34	24	13	5
Hungary	1	20	46	15	6	12
Romania	3	8	19	17	53	0
Serbia	4	7	19	25	45	0
Slovakia	4	14	23	26	22	11

Table 4. *Responses to the question "According to your personal experience has the weather changed in the past 20-30 years / since your childhood?" (percentage), 2013.*
Source: SEERISK questionnaire surveys (n=1644)

EVALUATION OF THE SENSE OF SAFETY AND THE THREAT OF NATURAL HAZARDS

Most age groups are not able to determine precisely whether natural hazards affect their sense of safety or not, but the feeling of insecurity is growing with age. More than 30% of respondents feel rather safe with regard to natural hazards (Figure 47). Also 30% of respondents rate the impact of natural hazards on their sense of safety as very or fully influential, especially in the group of people over 40-45. Generally people over 60 feel more vulnerable.

Among those who faced the dangers of natural hazards in their lives, there are more people who think natural hazards affect them completely or significantly.

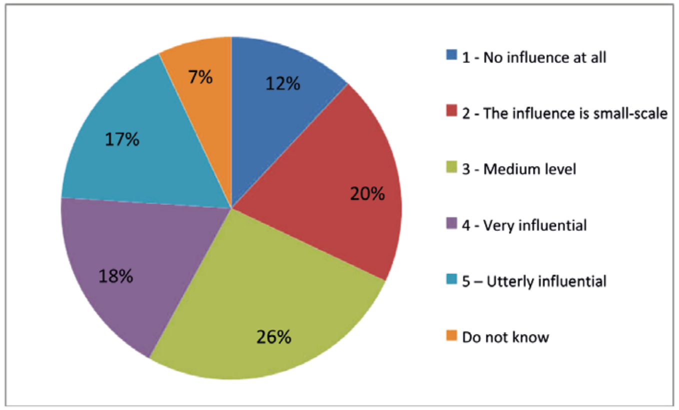

Figure 47. *Average level for the whole sample about the evaluation of the influence of natural hazards on the sense of safety (%), 2013.*
Source: SEERISK questionnaire surveys (n=1644)

Sometimes there is a marked difference between the natural hazards indicated by the respondents and the types of hazards which have been selected to be in the focus of the risk assessment process in the pilot areas or are identified in interviews and planning documents (e.g. in Bosnia and Herzegovina, Bulgaria and Slovakia) (Table 5).

Country	1	2	3
Bosnia and Herzegovina	Floods 42%	Flash flood 33%	Inland excess water 25%
Bulgaria	Floods 22%	Flash flood + Hail 21%	Inland excess water 17%
Hungary	Extreme thunderstorms + windstorms 20%	Extreme heat waves 18%	Hail 10%
Romania	Extreme heat waves 36%	Extreme thunderstorms + windstorms + cold waves 31 - 32%	Drought 30% Extreme snowstorms 29%
Serbia	Extreme thunderstorms + windstorms + heat waves + hail 45- 47%	Extreme snowstorms+ droughts 26 - 27%	Floods+ inland excess water 23%
Slovakia	Extreme thunderstorms + windstorms 46%	Extreme heat waves 39%	Hail + drought 32 - 33%

Table 5. *The most important natural hazards which can influence the sense of safety according to the respondents' opinion (%), 2013.*
Source: SEERISK questionnaire surveys (n=1644)

Sometimes also marked differences can be observed between the type of natural hazards influencing the sense of safety and the type of natural hazards causing serious consequences. Damage to the economy and destroyed homes are the most serious tangible impacts according to the surveys.

EVALUATION OF THE PREPAREDNESS FOR NATURAL HAZARDS

The most important measures/precautions to be taken by the local people are almost the same in all the pilot areas. At least 40% of people in all pilot areas are taking the following preventive measures: *refraining from dumping waste in public spaces* and *storing hazardous materials safely*. The most frequently indicated measures/precautions aimed at mitigating the possible impacts of climate change show that personal competences and the financial resources of households (especially income) are the most determining factor for respondents' actions and future plans.

The real effects of climate change on people's lives can be observed in the responses such as *putting in roller blinds / shutters on windows* or *installing air conditioning in the house/flat*. There is a high number and rate of respondents in all countries who regularly control the physical condition of the house/flat, or have installed weatherproof doors and windows, air conditioning, thermal insulation, or have reinforced the roof.

Fully prepared respondents – or at least those who feel fully prepared – are mostly middle-aged people who received secondary school education, living in the centre of pilot settlements.

In order to have a higher level of protection from natural disasters, the respondents have taken or are planning to take certain measures. Among those, who responded that they *planned to carry out actions within a year* the most important options for measures/ precautions are:

- *reinforcing the roof,*
- *careful selection of the construction site for a residential building,*
- *careful selection of building materials for a residential building,*
- *installing air conditioning in the house/ flat*

People are very aware of the fact that they should not store hazardous materials in their homes in an unsafe way.

Thus, at least 50-60% of respondents are somehow prepared for a disaster. The most common practices are following the official weather forecasts and warnings; storing survival tools, keeping medication and first aid kit at home.

DISSEMINATION OF INFORMATION AND MEANS OF COMMUNICATION

The people contributing to the economy (aged between 18 and retirement age) are less informed about the ways to obtain information and to get prepared.

The majority of people feel they do not get enough information from the official sources about the potential natural hazards and about the ways to get prepared for them, and feel the need to get more information about civil protection duties/actions and about the ways of preparing for disasters. People also pointed out that they would like to get more information.

The majority of interviewees rely on communication channels, such as *state and commercial broadcast media* to get information about the potential dangers and civil protection measures.

In addition to state/national broadcast media, local TV, radio or newspapers are also important information sources for the communities.

The weakest sources of information (less than 15%) are forums/presentations at schools and workplaces. The role of modern communication channels, like the Internet, social media or electronic messages, as ways of obtaining information decreases with the age of respondents. In view of the age structure of the whole sample, it is to be expected that modern means of communication will be less commonly used.

VOLUNTEERING

The majority of the respondents (more than 80% of the whole sample) find it important to take an active part in disaster prevention or rescue efforts: there are no marked differences by demographic features. However, more than 60% have never taken part in any prevention-oriented activities. 18-35 year-old male and elderly respondents indicated to have taken part in such activities. The majority of the people surveyed (more than 70%) are not members of any volunteer civil protection organisation. Their members are mainly young and middle-aged men. More than 50% are ready to take part in relief operations when a real disaster strikes: middle-aged men in particular have confirmed their willingness to participate.

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HIGHLIGHTS

DEMOGRAPHIC ASPECTS:

- The depth of knowledge about climate change depends on age structure and educational level;
- The majority of people rely the broadcast media as their source of information - age or educational level do not make any difference in this respect;
- Younger people are often unsure when evaluating the influence of climate change – personal experience is also a dominant factor in addition to educational level,
- Volunteering differs by gender, as dominantly men take part.

NEIGHBOURHOOD-SPECIFIC ASPECTS:

- People living in poor housing conditions or in a disadvantaged social environment feel more threatened by natural hazards;
- The role of local media as a special source of information for people living in rural areas.

SPECIAL ASPECTS:

- Education system and the authorities are considered to be weak sources of information;
- Climate change appears as a factor in the decisions to take measures/precautions aimed at mitigation of the possible damage e.g. putting in roller blinds / shutters on windows or installing air conditioning in the house/flat;
- Personal competence,, based mainly on educational level and the material resources (income) of household members typically influences the level and type of prevention.

COMBINED ASPECTS:

- Among those who regularly use the Internet to get information, there are more people evaluating the effects of climate change as strong;
- There is a connection between personal experience of natural hazards and the evaluation of the sense of safety – the ones having gone through such an event are more sensitive to the issue;
- Among those who have been threatened by natural hazards and who evaluate the effects of climate change as strong, there are more people who have taken steps to ensure a higher level of protection against natural disasters.

5.2. ANALYSIS OF THE INTERVIEWS WITH LOCAL STAKEHOLDERS AND LOCAL PLANNING DOCUMENTS

In the followings segment of this guideline, the findings regarding the level of awareness of stakeholders, along with a preparedness analysis based on qualitative research methods, namely interview and document analyses, will be presented. The application of these methods contributed to a better understanding of the institutional level approach to climate change and preparedness for it and its local consequences. It helped to indentify not only progress, but also shortcomings in these fields.

The interviews and document analysis were consistently conducted at the local level in the six pilot areas of the SEERISK project following the same methodology. The partners conducted a minimum of four interviews for each pilot area, mainly with heads of different organisations, experts on disaster management and local decision makers e.g. mayors.

The interviews centred on the issues of disaster management/civil protection and climate change. The objective was to see the general approach and viewpoint of the ones occupying higher positions in the local society, who have the right and the obligation to formulate decisions on the priorities in the domain of local activities and budget spending. The interviews were semi-guided (a list of questions was provided, which did not prevent gaining information beyond the given scope) and the analysis was structured by five core issues that the summary below follows.

Document analyses focused on local level regulatory and development-oriented planning documents, such as the disaster management plan, the urban land use/regulation plan, urban development concept and strategy, special planning documents on environmental protection. The focus of the analysis was climate change, namely, finding out whether this globally pressing issue appears in the local documents, as a factor influencing daily life, future development objectives, measures and prospects.

5.2.1. INTERVIEW ANALYSES

SUBJECTIVE EVALUATION OF RISK EXPOSURE IN EACH PILOT AREA

The opinions of interviewees about the tangible impacts of climate change vary by partners. In Siófok, Arad, Kanjiža and Ilidža, they agree that impacts of global climate change are detectable, they highlight the palpable changes regarding various weather phenomena. They also clearly link all this to global climate change. In Velingrad and in Senica, however, the interviewees attribute changes to natural cycles in weather and express the need for more thorough research which would prove the link between changes in local weather and the classic interpretation of global climate change.

None of the people interviewed stated that there were natural hazards related to climate change. Their observations were about natural cycles and not about a stable tendency towards climate change. (Analysis of the Local Level Planning Documents p. 8., Velingrad, Bulgaria).

LOCAL REFLECTIONS OF THE NATIONAL LEVEL ORGANISATIONAL CHANGES IN DISASTER MANAGEMENT

Legislative changes occurred in each partner country recently, which resulted a substantial transformation of the organisation of disaster management and the fire departments introducing integration and centralisation aimed at making the system more efficient. Nevertheless some partner interviewees expressed worries that the new management system slows down decision making from top to bottom.

In all the pilot areas, local powers remained in the hands of municipalities, but in extreme cases they need to turn to the higher authorities.

Volunteering has become a key issue. Some partners feel that people are poorly motivated for volunteering, while others found it easier to recruit people.

PROVISION OF INFORMATION ON CLIMATE CHANGE AND PREPARING LOCAL PEOPLE FOR EXTREME WEATHER SITUATIONS

The provision of relevant information to citizens is normally multi-actor based. Centrally determined and locally initiated actions (presentations at schools, leaflets, exercises, life-guarding at the lake) are ideally combined. Cooperation between actors is also a must. However, actual actions and efficiency differ strongly from one pilot area to another. The main target groups are children as they can be reached in an institutionalized form. Annual evacuation simulations are common practice, but barely provide any information, while specific information sources (clubs, extra lessons) are less accessible to children in the pilot areas. Climate change is mostly included in the curriculum but the local aspects and the consequences are hardly ever integrated into teaching.

Middle aged people are the most difficult to reach according to the interviewees. National and local media might reach them, but this method is not effective enough. Municipalities have a little competence in action, they print leaflets, advertise in local newspapers, though they all have a person in charge of civil protection. All partners share the view that preventive activities need to be enhanced and more efficient and include a range of partners from public institutions such as schools, health centres into the local disaster management unit and even workplaces.

„Local-level hazards generally belong to the topics of form master's classes. For us it is something important as we have 550 pupils and the staff is round 100. We all need to know that various unexpected events can happen – it can be an earthquake, extensive fire or any other kind of event which cannot be foreseen. All these issues are to be part of discussions moderated by the form master allowing the participants to learn what is and what is not to be done in these unexpected situations." (Director of József Beszédes Secondary School, Kanjiža,* Serbia).

EVALUATION OF THE PREPAREDNESS OF CITIZENS FOR DISASTER SITUATIONS

There is general agreement among the interviewees that local people are not interested in the awareness about and preparedness for climate change-related natural hazards.

„People are surely not prepared for that (climate change), only a small percentage of the people are interested in this subject, most live in the moment and they are not interested in the future and the issues like destruction of tropical forests, desertification, shortage of drinking water, acid rain, etc. Here, people are not worried about that, they have not experienced it first-hand." (Head of the Department of Civil Protection and Crisis Management District Office Senica, Slovakia).

These hazards are exceptions, existing only potentially, they will affect their lives the most if experienced. According to the interviewees, the population is not sufficiently prepared for any emergency event.

"We believe that neither local authorities, nor the population are properly prepared to fight the consequences of climate change. We found differences between people of different ages and educational level. Younger and more educated people are more interested in this phenomenon than older or less educated individuals." (a NGO, Arad, Romania).

Irresponsible behaviour of people is evident in their actions, such as building structures that do not conform to the rules stated in local regulations or simple negligence in private properties, which poses a threat to other people's lives in case of natural disasters.

All partner countries consider raising the awareness of local people and increasing their sense of responsibility to be of crucially important.

THE IMPACT OF CLIMATIC ATTRIBUTES AND CLIMATE CHANGES ON URBAN DEVELOPMENT AND MAINTENANCE

The opinions on this issue vary the most among partner interviewees due to the different assets of the pilot areas. There is general agreement among them though that the elements of critical infrastructure (e.g. provision of water and electricity, roads to ensure accessibility) have to be given priority. Siófok and Senica especially emphasized this in relation to water courses and bodies of water (the importance of protective dams, protective works). In Siófok sometimes the large-scale projects are often parts of strategic infrastructure (water management of Lake Balaton, or the national railways) all vulnerable to unprecedented storms. Other partners, Arad, for example, pointed out the significance of the thermal insulation programme for residential buildings and also stressed the need for a coherent policy on green belts and their role in the protection against heat waves. In regions like Kanjiža, the interviewees expressed their concern for agriculture and the related infrastructure. They found projects aimed at construction and repair of irrigation systems, cleaning and extension of irrigation channels to be the most important of all. There were extreme situations, like in Sarajevo-Ilidža, which have been recently resolved, but were still listed as a problem to be dealt with.

"Unlicensed housing construction occurred particularly just after the end of the war in Bosnia and lasted between 1992 and 1995. The population was exposed to the hazards due to unplanned construction of their homes" (Gap analysis, Sarajevo-Ilidža, Bosnia and Herzegovina).

5.2.2. DOCUMENT ANALYSIS

As the pilot areas differ according to size and territorial, administrative coverage, the examined documents consequently have different coverage and sometimes cannot even be interpreted in the same manner.

Disaster management plans (named differently in the pilot areas, according to the scope of the document) exist for each pilot area. They are all stem from the obligations defined in the legal framework to which they must conform in terms of scope and content. The documents are operative by nature and consequently action-oriented allowing to act in case of disasters of various origins. The analysed documents of Kanjiža and Senica focus specifically on flooding and groundwater, while that of the Velingrad region discusses the what is to be done about natural hazards in general. The plans of Arad County and Siófok Municipality have a wider approach and including man-made hazards, as well. All of the documents have been revised and updated in the past 3 years. These documents are not analytical in a that they do not look for cause and effect relations. The plans of Arad County, Kanjiža, Sarajevo-Ilidža and Siófok mention the concept of climate change, but they deal with the issue in general introductions and treat climate change as the cause of changes which require a new strategy. Each and every document attach increasing importance to prevention, namely, field exercises and stress the significance of cooperation with the relevant authorities (e.g. water management authority) and organisations. The disaster management plans have hardly any cross references with other planning documents – and if a document exists , it is the regulation/land-use plan.

The urban and territorial and land use/regulation plan(s) do not deal with cause-effect relations either (no explanations are provided as to land use regulation in an area) but use the types of data determined by the relevant construction-related legislation From the documents and the interviews with chief architects, it turned out that the impacts of climate change appear in the local regulatory planning documents indirectly and with considerable delays.. Experience shows that the process of amending land use plans requires a lot of time. Land use plans and local construction regulations specify what not to do in a particular area and understandably include no provisions about what to build and how. That is the task of development-oriented local plans, which need to take into account and be based on land use and constriction regulations.

The relevant development-oriented local planning documents (concepts, strategies, programmes) have the same structure for the pilot areas, which consists of the following sequence of steps: situation/status analysis, SWOT, overall objectives, specific objectives (development targets), interventions and projects. Impact analysis, among others, the kind focusing on environmental impact is still not that widespread. Local consequences of climate change are not a prominent topic in these planning documents. The issue appears in the chapters on general *environmental* issues, dealing with both locally and the globally defined problems e.g. air pollution, emissions, deforestation etc. The interventions and projects are hardly ever structured around the issue of local impacts of climate change. Climate change and the environmental consequences rarely appear even as a horizontal issue, although the European Union directs the attention of the member states to the issue and respects the related investment needs of the partner countries in the 2014-2020 period. The conclusion is that the development-oriented documents need to take into account and incorporate the concept of climate change and conscientiously formulate investment projects with regard to function, location, capacity, energy consumption with a thorough general and local knowledge of climate change.

Local people are supposed to be prepared for the various extreme weather events and should be aware of the term and meaning of climate change. However, there are individuals in the local community, who commit the same irresponsible mistakes year after year, in spite of the negative experiences. Most typical of these is that they fill up the rain water drainage system in front of their properties and build parking places on them. When there is an extreme rainfall producing a lot of water the buildings are flooded and the same people ask for help from the municipality. This irresponsible behavior is repeated and causes damage in other properties too. (Dr. Árpád Balázs, the mayor of Siófok).

Climate change is a specific topic of sectoral plans of environmental protection. In the SEERISK project, not all the pilot areas indicated to have one. As to the cause-effect relation, these documents focus on the cause side, when talking about the interventions and measures, which is the control over human intervention affecting the natural cycles (e.g. decrease of CO_2 emission resulting in global warning). The local adaptation strategy is not a core issue, nevertheless even the national strategies (if they exist) have started to deal with climate adaptation only recently. If local communities have these specific plans, they rely on the relevant national strategy, conforming to EU regulations (objectives) and policy recommendations.

6. GAP ANALYSIS: COMPARISON BETWEEN RISK ASSESSMENT AND RISK PERCEPTION OF LOCAL COMMUNITY

The so-called "gap analysis" has been chosen as a working method to identify intervention areas where massive adaptation measures are needed. Gap analysis focuses on **the gap between the challenges imposed by the natural hazards related to climate change and the level of overall preparedness of the society.** Hence, gap analysis not only shows the extent to which local communities are able to deal with potential disasters, but also how efficient authorities have been so far in taking preventive actions. Better prevention and preparedness will obviously make communities more resilient to climate-related disasters.

Gap analysis shows the missing link between the challenges imposed by the natural hazards related to climate change and the level of overall preparedness of the society for climate-related disasters.

The gap analysis has been be carried out by comparing the products previously prepared at the pilot area level. One part of these products are related to an assessment of the identified hazards, such as risk matrices, risk maps and risk scenarios, while the other part of the products are related to the outcomes of the social awareness surveys, like questionnaire analysis; the analysis of the local planning documents and interviews with the local stakeholders. On the basis of these products and by adopting a stepwise approach, the pilot areas prepared their own gap analyses of the actual and the perceived risk profile, as shown in Figure 48 below:

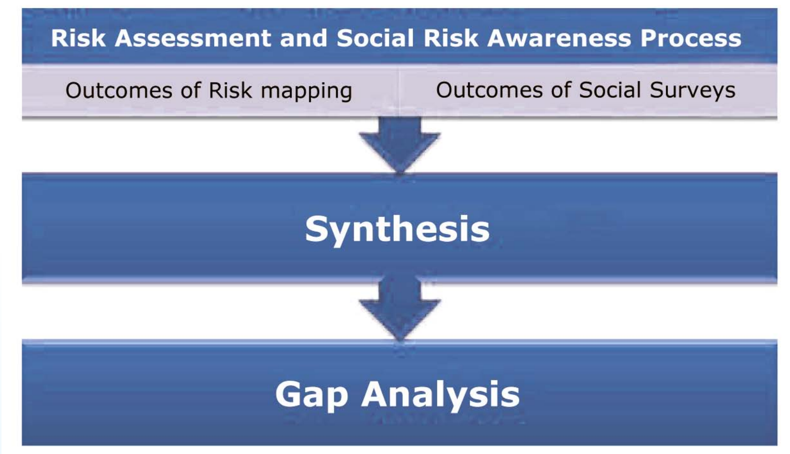

Figure 48. *Gap analysis workflow*

The actual risk profiles of the pilot areas in the event of a disaster have been defined on the basis of risk matrices risk scenarios. Through these risk matrices and risk scenarios partners gained information on the hazard (frequency, duration, intensity, extent of the hazard), vulnerability (the distribution of the exposed people, buildings, infrastructure and environment), and the possible impacts and consequences of the disaster (the number of affected people, buildings, infrastructure and environment; expected losses).

Spatial distribution and the level of risks has been visualised via risk maps which identify the exact locations of areas exposed to the highest risk inside the pilot areas.

The risk perception in the population, people's awareness of the risks they are exposed to and their preparedness has been analysed through a questionnaire survey presented in Chapter 5.1. The survey has been complemented by an analysis of the local planning documents and by interviews conducted with representatives of the local disaster management, the municipality and local public institutions. This latter has given us an important insight on how locals perceive the risks, and whether their perception is similar or not to the results of the risk assessment exercise.

The gap analysis prepared for each pilot area in particular examined the preparedness of the local disaster management organisations, local government and other local public institutions regarding climate change-related natural hazards. It took into account various aspects of the present institutional arrangements of a municipality, and showed the efficiency of the measures taken in the affected target population.

The gap analysis determined proper, sufficient, tolerable, insufficient and zero level of preparedness, according to the following subdivision:

Aspects of institutional preparedness:
Information flow from the national level
Human capacity
Financial capacity
Other means (machines, course books, etc.)
Preparation of local leaders and institutions
Urban planning

Table 6. *Institutional aspects in the gap analysis*

The gap analysis identified the actions already taken and the efficiency of those actions amongst local inhabitants per age group:

Affected target groups :
Local inhabitants (under 18)
Local inhabitants (between 18-60)
Local inhabitants (over 60)
Special target groups: local businesses
Special target groups: tourists

Table 7. *Local target groups in the gap analysis*

Finally, the identified gaps have been assigned the appropriate level of priority and the possible solutions proposed by each pilot area, based on a discussion with the local stakeholders. The summary table in Annex I shows the problems that have been identified; highlights have been added where a gap is shared by more than one pilot area. A gap that is shared amongst various pilot areas has been considered to be a common challenge,, which requires urgent intervention.

The various challenges revealed by the gap analysis have to be met with sensible responses that can later be translated into disaster prevention measures. In order to determine what a sensible response is, the consortium partners found it crucial to schedule meetings with local decision makers and their advisors. The responses should obviously be conceivable and potentially acceptable for the policy makers in the local institutions, in order to be followed up, later on. For example, an alternative activity module to remedy shortage of information among students under 18 cannot be introduced into the schools without the consent of educational institutions; awareness raising campaigns to remedy the lack of information facing middle aged people cannot be introduced without the consent of the local municipality, etc. Ideally gaps are discussed and responses are formulated in close cooperation of the local municipality and the local disaster management with the fire department or civil protection units. Involving other stakeholders – such as research institutions and civil society actors – into the discussion process is also desirable, since they play an important role in improving the efficiency of measures by facilitating data provision, interpretation, awareness raising programmes etc. The recommendations shown in the next chapter have been drawn up based on the compiled results of the discussions with stakeholders held in the pilot areas.

7. POLICY RECOMMENDATIONS FOR EFFECTIVE ADAPTATION TO CLIMATE CHANGE

▲ (orange triangle)	Local disaster management (incl. civil protection organisations, fire brigades, municipal emergency services)
■ (red square)	Local municipality
▲ (blue triangle)	National disaster management (incl. civil protection organisations, fire brigades, municipal emergency services)
▼ (light blue triangle)	Educational institutes (incl. primary and secondary schools, universities and vocational schools)
● (green circle)	NGOs: non-governmental organisations
■ (orange square)	Ministries

Table 8. *Each symbol represents an organization/institution that could be responsible for executing specific policy recommendations introduced in this chapter.*

The possible solutions to the issue of adaptation to the challenges imposed by the changing climatic conditions have been drafted by the pilot areas through roundtable discussions. The most important, common findings have been formulated in this chapter. However, the choice of the specific measures to be implemented in a town, in a municipality, in a region or in a country will be a matter of further discussions among stakeholders.

The section below takes stock of the identified satisfactory institutional setting, measures and actions at the local level.

Each symbol shown in table 8. represents an organization/institution that could be responsible for executing specific policy recommendations introduced in this chapter.

HUMAN CAPACITY FOR DISASTER PREPAREDNESS IS SUFFICIENT

The public awareness survey showed that all pilot areas evaluated the human capacity of the local disaster management organisations, the local government, and the local public institutions (mainly educational institutions) as "appropriate"* or "sufficient".

INFORMATION FLOW FROM THE NATIONAL TO LOCAL INSTITUTIONAL LEVELS IS SATISFACTORY

The majority of the pilot areas evaluated information flow from national-level institutions to the local level, namely, to local disaster management organisations, local government units, and other local public institutions as "appropriate" or "sufficient"; though the types of institutions which received the highest rating varied among municipalities (information flow in all three types of institutions was described as appropriate" or "sufficient" only in Hungary and Romania).

AVAILABLE TOOLS RELATED TO DISASTER PREVENTION ARE RELATIVELY SUFFICIENT

Equipment and material like machines, course books etc. were deemed to be "sufficient", although inadequate in half of the pilot areas.

DECISION MAKERS ARE RELATIVELY PREPARED TO DEAL WITH CLIMATE CHANGE ISSUES

The level of personal preparedness and informedness of local leaders of disaster management organisations and local government units regarding climate change was evaluated to be 50% "appropriate", while decision makers in other local institutions were evaluated to be sufficiently knowledgeable about climate related issues by only the 1/3 of the pilot areas.

SOME AWARENESS RAISING ACTIVITIES CARRIED OUT BY LOCAL INSTITUTIONS ARE RELATIVELY EFFECTIVE

A few kinds of ongoing activities aimed at informing people about the consequences of climate change related natural hazards proved to be useful. Beyond the obvious positive results of these activities, it was found that climate change aspects were not incorporated into information exchange. These activities are: courses organised by local disaster management organisations in schools; emergency evacuation simulations in schools and local public institutions; presentations of disaster drills in public forums.

AUTHORITIES HAVE BEEN RELATIVELY SUCCESSFUL IN REACHING SPECIAL TARGET GROUPS

As good examples of reaching special target groups, the following actions were reported from some of the pilot areas: public seminars on protection intended for special target groups, highly affected by potential natural hazards (e.g. owners of holiday resorts in the areas where the level of flood risk is high, namely, in Senica, farmers in Kanjiža; safety education programme for the elderly, including information on emergency situations and first aid (Senica); leaflets containing information on natural hazards and emergency situations distributed in schools (Arad); publications for tourists on hazards and emergency situations in foreign languages (Siófok). Nevertheless, aspects of climate change were again not associated with these actions.

Intervention areas where more attention needs to be paid to make the population and infrastructure resilient when it comes to dealing with the consequences of climate-related disasters in the Danube macro - region are listed below:

INFORMING THE POPULATION UNDER 18 ABOUT CLIMATE CHANGE PHENOMENA

The lack of specific information for the population under 18 has been identified in most pilot areas. This age group is particularly important if we take into account the long lasting impacts of climate change on human health and property. Education of this age group can be secured in a variety of ways:

- Include more information about climate change phenomena and the risks derived from them into national curricula. Competence level: Ministry of Education
- Train the responsible educational institutions about climate change, and introduce the theme slowly into the local curriculum. Competence level: local, national and regional ED, meteorological institutions
- Make learning modules available in primary and secondary schools, especially use films and visual material along with the traditional education system. Competence level:
- Incorporate knowledge on climate change in pre-school and extra-curricular educational activities at the level of the primary schools and vocational schools developing pupils' interest in the topic through games and contests. Competence level:
- Establish cooperation of educational institutes with professional organizations (disaster management, municipal authorities, and the non-governmental sector) dealing with the issue of climate change. Competence level:

INCREASING THE LEVEL OF PREPAREDNESS OF PEOPLE IN GENERAL AND RAISING THEIR AWARENESS ABOUT NATURAL HAZARDS

The majority of our six pilot areas have demonstrated that the existing level of awareness and preparedness of local people to deal with natural hazards does not guarantee a response that would be efficient enough, regardless of age groups. People have some general knowledge about hazards; still they are prone to behaving inconsistently in unusual situations, due to lack of preparedness. As the interviews conducted with local institutions have shown, middle-aged people are the most difficult to reach. The outreach of national media is vast, yet the information they provide has low impact when it comes to local issues and conscientious behaviour. The following measures are suggested to be introduced:

- Make publicly available information about environmental challenges more efficient. To enhance information efficiency, parents should be involved along with children into school programmes and activities related to climate change. Compared to national media outlets, local media (TV and print) should be more involved in the provision of information. Different social groups should be approached differently. The elderly, youth groups and people with lower level of education and status in particular need more attention. Competence level: media
- Organise local disaster management exercises more often, covering remote locations, and having a varied scenario. Exercises shall include not only practical skills, but also transfer of knowledge on climate-related issues. Competence level:

> *"Evacuation simulates only fire in the buildings and in practice it cannot be expected that everybody knows what to do." – Velingrad, Bulgaria.*

- Organise or increase membership of civil protection and/or fire fighter volunteer groups and include aspects of climate change in the training. Competence level:
- Acknowledge the solidarity of the citizens through thanking people, giving honorary awards, etc. Competence level:
- Organise public seminars with instructions on self-protection and the protection of community property (e.g. fire protection, encouraging the population to maintain irrigation channels). Competence level:
- Train the elderly to help them to become more resilient. Competence level: health care institutions.
- Place leaflets or posters, showing how to deal with a hazard, in public spaces (e.g. make brochures available in outpatient's clinics and doctor's surgeries;

make guides on how to behave during heat waves available in tourist spots: instructions on how to prevent forest fires) Competence level:

> *"The Executive forest agency puts up forest signs: Protect forests from wildfires. Signs alone are not enough to make tourists aware of the danger." – Velingrad, Bulgaria.*

- Encourage the exchange of information with municipalities in other regions or countries and inform the local population about the results. Competence level:

INFORMING DECISION MAKERS ABOUT CLIMATE CHANGE EFFECTS

The decision makers of at least two pilot areas have reported that they would need fresh and concise information about local effects of climate change. This need could be satisfied by taking some of the following measures:

- Secure continuous exchange of information between disaster management authorities, local leaders and their advisors. Competence level:
- Establish forums for informing decision makers about the recent findings of climate change related research and its local aspects. Build a multi-actor strategic partnership with scientific institutions, the local disaster management unit, local institutions, NGO and the private sector. Competence level:
- Involve all competent authorities in the risk assessment process, using GIS tools. Competence level:
- Establish continuous exchange of information with national-level authorities (e.g. Ministry of Environmental Protection, national DM organisation) in order to obtain more information on the effects of climate change at the national level. Competence level: Ministries,

IDENTIFYING LOCAL HAZARDS CONSEQUENCES OF THE CLIMATE CHANGE

Several partners reported that even though global climate change is part of the core curriculum in schools and receives national media coverage, its local aspects and consequences are not sufficiently understood. Even though the frequency of extreme and unexpected natural disasters is increasing, there is a certain reluctance to relate those to climate change and to acknowledge personal responsibility. The following can be done to remedy these shortcomings:

- Initiate public discussions, backed up by data and statistics to illustrate direct correlation between natural hazards and climate change. Competence level: Local experts, decision makers, meteorologists,
- Program activities on the local aspects of climate change to be carried out as after-school activities in a form agreed with school management. The internet should be used as a dissemination tool. Competence level:
- Disaster management institutions should closely cooperate with scientific institutions conducting climate related research and risk assessment and should show the link between extreme natural events with climate change. Competence level: media,

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PREPARE SEGREGATED NEIGHBOURHOODS FOR A POSSIBLE DISASTER EVENT

Several partners reported that communities in disadvantaged neighbourhoods (ghetto-like neighbourhoods) are not prepared for disasters; although these areas would be easily damaged by an unforeseen event, such as sudden flooding or a storm. The following can be done to enhance the preparedness of the segregated neighbourhoods:

- Use evidence-based, scientific risk mapping relying on GIS data on urban structures and surrounding infrastructure to determine the most vulnerable sites. Competence level:
- Work out a neighbourhood-specific approach to the dissemination of publicly available information, paying special attention to the people living in areas exposed to the highest level of risks. Competence level:
- Teach members of the population social solidarity and self-help techniques through educational programmes aimed at people of all ages – children, adults seniors. Competence level:
- Continuously improve basic infrastructure in the segregated (e.g building and regular maintenance of the sewer systems) possibly with the involvement of the local community. Competence level:

TAKE CLIMATE CHANGE INTO ACCOUNT IN LOCAL DEVELOPMENT DOCUMENTS

Local development documents (such as drafts, strategic plans) specify general development objectives and needs of a particular town, urban region etc. It has been reported from the examined pilot areas that the documents pay little attention to climate change and its local consequences. Climate change as a buzzword appears mostly in the analytical part of these documents, instead of being viewed as one of the most important horizontal factors, influencing all aspects of urban and rural life. Ignoring climate change in this way threatens social and environmental sustainability of local communities in the long run. The following are recommended:

- Take into account the effects of climate change as a locally tangible phenomenon in the status analysis of development plans when planning the future of an urban or rural area. Competence level:
- Consider climate change adaptation aspects (location, energy, water efficiency) as a horizontal factor in all possible development objectives stated in the development plans. Competence level:
- Identify scientifically infrastructural investments clearly resulting from the impacts of climate change (e.g. need for reinforcing a protective dam has to be preceded by risk assessment and a cost-benefit analysis). Competence level:
- Environmental impact analysis of entire urban development plans is recommended to be done by an expert team, which is independent from strategy planners. Competence level:
- Examine innovative solutions on the strategic and project level regarding the function, location, capacity, energy consumption of the establishments adapted to local circumstances. Competence level:
- Revise locally relevant sector-specific planning documents (environmental protection, water management, agriculture,

forestry, etc.) in the light of risk assessment results and integrate the necessary measures, based on the maps in sector-oriented plans. Competence level:

INTEGRATE THE CONSEQUENCES OF CLIMATE CHANGE IN NATIONAL DISASTER MANAGEMENT PLANS

Being part a high security sector, an institution in charge of disaster management is often centrally managed and its responsibilities are always, regulated by law and an action plan that is approved by the government. Although climate change does influence disaster prevention and intervention measures, the documents laying down the principles of disaster management rarely rely on a comprehensive assessment of climate change effects to the region, which impedes proper sectoral planning. The following is recommended:

- Take into account the consequences of climate change in the national disaster management plans, always based on scientific research (GIS risk mapping, climate modelling, and the lessons learnt from climate adaptation projects). Competence level:

INTEGRATE CLIMATE CHANGE ADAPTATION PRINCIPLES IN CONSTRUCTION REGULATIONS

Land use and building regulation plans are common tools for keeping urban development within a relatively controlled framework. However, almost all partners have reported deficiencies in urban construction. There is lack of discipline of people and investors to observe construction regulations. Even though building regulations at the local level take possible climatic impacts into account, the evolution of regulations cannot keep the pace pace with the changing climatic and hydrological situations. The examples from pilot areas show that roofs in poor condition expose buildings to damage in the case of extreme wind, filled drainage ditches in public areas are endangering houses; there is a lack of funds for thermal insulation; unlicensed construction hinders flood protection: there is a lack of green areas in towns. Possible solutions to overcome these specific shortcomings are as follows:

- Conduct a detailed vulnerability and risk assessment for urban construction elements (residential buildings, public institutions, elements of critical infrastructure) with the identified natural hazards in mind. Competence level:
- Revise urban land use regulation plans with the aim of replacing deficient land cover types (e.g. constructing permeable surfaces, instead of those made of concrete; extending urban green spaces). Competence level:
- Update the local building/construction regulation plan, on the basis of the risk maps (e.g. height of buildings, building materials, max. concrete coverage of building sites). Revise construction regulations in order for new public buildings to become more climate-friendly and climate-resistant (e.g. insulation rules of public institutions. Competence level:
- Introduce stricter controls by the municipal inspection service regarding construction regulations or find the right way to make local people and investors conform to the rules. Competence level:

SECURE FUNDING FOR CLIMATE-SENSITIVE DEVELOPMENT PLANS AND PROJECTS

Planning and securing the future of any place in a climate-conscious manner requires new competences and substantial financing. In the partner countries public financing is still scarce regarding these investments. Securing funding opportunities is a key issue, which can be solved in the following manner:

- Provide financial and material support for small-scale remodeling projects from the municipal budget, with the help from sponsors and volunteers (e.g. planting trees, renovating buildings and public infrastructure). Competence level:
- Search for alternative financial resources and the know-how in order to implement climate adaptation projects (e.g. European funding, private sector investments). Competence level:
- Prioritise and support from the existing budgets projects providing long-term innovative and comprehensive urban solutions (e.g. water retention; innovative flood adaptation facilities instead of only control). Competence level:

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9.ANNEXES

ANNEX I - GAP ANALYSIS SYNTHESIS

Summarized Gap analysis table

Colouring code:

Gap only in one pilot	
Gap shared by 2 pilots	
Gap shared by more than 3 pilots	

Theme 1. Climate change		
Gap	**Shared by**	**Solutions proposed by the pilot areas**
There is a common understanding that climate change is not a factor. The link between natural hazards and climate change is not demonstrated.	Velingrad	There has to be a large discussion backed up by data and statistics to illustrate direct correlation between natural hazards and climate change. (Local experts, meteorologists, municipal disaster management vice-mayor, the chief of the fire brigade)
Decision makers are not fully informed about the effects of climate change.	Ilidža, Velingrad	Prepare media campaigns; revise the plans for preparedness by including climate change effects. Joint work with local leaders and/or their advisors needs to be done.
Population under 18 is not informed about climate change in general.	Ilidža, Velingrad, Senica, Arad	The Ministry of Education and other responsible institutions have to include in their educational programmes issues related to natural hazards and climate change. The responsible institutions need to be informed and trained about climate change so that the topic could be slowly integrated into the local curriculum. (Local educational institutions especially those exercising higher level (e.g. national or regional) level of control of education) Incorporating knowledge and information on climate change in pre-school and extra-curricular educational activities and in school curricula of primary and vocational schools and developing pupils' interest for this issue through educational games and contests. Cooperation with organizations that professionally deal with the issue of climate change. (Local educational institutions – primary schools, vocational schools, paid by sponsors)
Local aspects and consequences are not dealt with or only as part of voluntary courses.	Siófok, Arad	Local aspects of climate change and the link to basic disaster management skills could become elements that are included into the programme

		of the afternoon activities in schools (obligatory in Hungary for pupils under 15). Internet as a tool for dissemination of information. A massive cooperation of school staff, local DM organisation and the local municipality is required.
Theme 2. Preparedness and awareness – natural disasters		
Gap	**Shared by**	**Solutions proposed by the pilot areas**
People are not informed in any way, there are **no special information campaigns** on hazard management for the local population.	Velingrad	Media could be involved; also different clubs for different social groups and interests – pensioners, youth groups, people with lower education and people with low status need to be reached. Informal meetings could be involved (municipality, local media.)
People are inefficiently informed. Citizens know the risks, but in extreme situations behave inconsistently.	Siófok, Ilidža, Senica, Arad, Kanjiža	Public information must be provided in more efficient way. Parents could be more involved (via incentives) in school programmes. Organize local preparedness exercises more often and cover more areas of the municipality, especially remote ones. Provision of information is to be solved through regional media – regional TV and printed media. Manifestations of citizen solidarity should be given priority. Provide financial and material support for the construction of flood control facilities from the city budget, state budget (Crisis fund), sponsors and volunteers. Create an urban financial fund for preventive measures, which would decrease negative impacts of climate change. Preparing field activities for transferring knowledge on climate related issues and disaster management (Local DM unit, local municipality, educational institutions (primary schools, secondary schools). Organising public seminars providing participants with specific instructions on self-protection and the protection of property (e.g. fire protection, encouraging the population to maintain the irrigation channels). Health care institutions should be included in order to help senior citizens.
Educational institutions are not sufficiently involved in educating the population about the effects of	Kanjiža	LM and DM should encourage educational institutions to provide educational and practical training for people belonging to different age

natural disasters, prevention and relief measures.		and gender groups who received different levels of education. (national and local, educational institutions, municipal emergency services, local media, civil organisations.) DM should draw up a programme of seminars and exercises. Printed material should be handed out periodically (before the possible disasters), prior to droughts. LM should use possible solutions from other countries or municipalities.
Frequent high water level of the river Tisa and insufficient awareness of local inhabitants for preparing a defence.	Kanjiža	DM will organize lectures in cooperation with Vode Vojvodine (water management authority in the autonomous province) in order to educate the local population, especially people who live in the vicinity of Tisa Rriver.
Theme 3. Specific territorial aspects of preparedness in the pilot areas		
Gap	**Shared by**	**Solutions proposed by the pilot areas**
People in disadvantaged neighbourhoods would require specific activities aimed at developing their preparedness.	Siófok Senica	A neighbourhood-specific approach is needed in the provision of public information. Paying special attention to people living in the pilot area that is exposed to the highest level of danger of flooding, and also in other, less vulnerable, parts of the city (see risk maps). Education on social solidarity at all levels – children, adults, seniors.
Theme 4. Aspects of urban planning		
Gap	**Shared by**	**Solutions proposed by the pilot areas**
Local development documents pay little attention to climate change and its local consequences.	Siófok, Velingrad	The issues of climate change and the possible consequences, along with the related projects are to be made an integral part of the development-oriented documents. (Local and national government)
Theme 5. Urban development and environmental (urban – countryside) issues		
Gap	**Shared by**	**Solutions proposed by the pilot areas**
Some buildings (roofs) are in poor condition.	Siófok	The delivery of construction licences should be linked to the regulations included in construction regulations, for example. The regulations should specify the required material, state of the roof, etc.. Incentives are needed for renovating roofs or planning and constructing weather-proof roofs as part of new construction projects
Concrete actions (such as block thermal insulation) cannot be efficient unless there is a unique approach, consistent with the local plan of adaptation to climate change impacts.	Arad	Developing short-, medium- and long-term local adaptation plan; identifying human and financial resources for concrete actions such as block thermal insulation. (Local municipality)
Unlicensed construction of housing	Ilidža	(Particularly after the war in Bosnia, its population was exposed to hazards due to unlicensed construction of housing.) Stricter control by municipal inspection service, inclusion of unlicensed construction in regulation plans. (Municipal inspection service and planning department of Ilidža municipality)
Deficiencies in urban solutions. (Concrete surfaces which do not capture water, water runs down the drain and to the watercourse, which is not enough to convert large amounts and outpours. Another drawback is a small number of waer retention sites, etc.)	Senica	Future construction investments should include growing lawns, concrete parking lots to replace the parking areas with perforated bricks. Structural measures should be taken, which would help to retain water and ensure its gradual outflow. (city, building investors)
Floods in the city engender a flash-flood domino effect.	Senica	Consistently updating the cropping plans for thickly sown cereals and crops. Ploughing up the fields so that the water is trapped and does not leak on the roads and the house yards. (the city and farms which cultivate the land.)
Reforestation projects have not been implemented.	Kanjiža	LM in cooperation with Vojvodina šume(forest management authority in the autonomous province) should implement a reforestation project. The local population could implement a reforestation project with the help of Vojvodina šume". ("They will start at once. All they need is trees").

ANNEX II – GLOSSARY OF TERMS

Acceptable risk

Degree of human and material loss that is perceived by the community or relevant authorities as tolerable in actions to minimize disaster risk (UNDHA, 1992).

Capacity

The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals (UNISDR, 2009).

Catchment area

Drainage basin, an extent of land where water from precipitation drains into a body of water (Source: http://www.wikipedia.org).

Climate change

A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2012).

Climate change adaptation

In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (IPCC, 2012).

Climate extremes (see also extreme weather event)

The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as "climate extremes" (IPCC, 2012).

Consequences

Negative effects of a disaster expressed in terms of human impacts, economic and environmental impacts, and political/social impacts (EC, 2010).

Coping capacity

The ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters (UNISDR, 2009).

Critical infrastructure

Assets, systems or parts thereof which are essential for the maintenance of vital societal functions, the health, safety, security, and economic and social well-being of people, and the disruption or destruction of which would have a significant impact (EC, 2008).

Danube macro - region

The area covered by the EU Strategy for the Danube Region stretches from the Black Forest (Germany) to the Black Sea (Romania-Ukraine-Moldova) and is home to 115 million inhabitants (Source: http://www.danube-region.eu).

Disaster

Severe alterations in the normal functioning of a community or society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread hum, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs that may require external support for recovery (IPCC, 2012).

Disaster simulation exercise

Decision making exercise and disaster drills within threatened communities in order to represent disaster situations to promote more effective coordination of response from relevant authorities and the population (UNDHA 1992).

Disaster risk management

Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, resilience, and sustainable development (IPCC, 2012).

Disaster risk reduction

The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events (UNISDR, 2009).

Drought

Drought can be defined as a condition of abnormal dry weather resulting in a serious hydrological imbalance, with consequences such as losses of standing crops and shortage of water needed by people and livestock (Alexander, 2003).

Economic and environmental impacts

The sum of the costs of cure or health care, cost of immediate or longer-term emergency measures, costs of restoration of buildings, infrastructure, property, cultural heritage, costs of environmental restoration and other environmental costs (EC, 2010).

Elements of risk

The population, buildings and civil engineering works, economic activities, public services and infrastructure, etc. exposed to hazards (UNDHA 1992).

Emergency management

The organization and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and initial recovery steps (UNISDR, 2009).

Exposure

People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. (EC, 2010)

Extreme weather event

See under Climate extremes.

Flash flood

Flash floods are an extreme, though short-lived, form of inundation. They usually last less than 24 hours but the resulting rainfall intensity greatly exceeds infiltration capacity (Alexander, 2003).

Flood

The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged (IPCC, 2012).

Forecast

Definite statement or statistical estimate of the likely occurrence of a future event or conditions for a specific area. In meteorology a forecast refers to a future condition, whereas a warning refers to a potentially dangerous future condition (UNISDR, 2009).

Gap analysis

The process through which a company or other organization compares its actual performance to its expected performance to determine whether it is meeting expectations and using its resources effectively. (Source: http://www.investopedia.com/terms)

GIS

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.

Global change

Global change refers to planetary-scale changes in the Earth system. It encompasses planetary scale changes to atmospheric and ocean circulation, climate, the carbon and nitrogen cycle, the water cycle, sea-ice and sea-level changes, food webs, biological diversity, pollution, health, fish stocks, and more. Civilization is now a large driver of global change so the term includes population, the economy, resource use, energy, development, transport, communication, land use and land cover, urbanization, globalization (Source: http://www.igbp.net).

Hazard

A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (EC, 2010).

Hazard assessment

Hazard assessments determine the probability of occurrence of a certain hazard of certain intensity (EC, 2010).

Hazard map

Type of a map that portrays levels of probability of a hazard (or hazards) occurring across a geographical area (EC, 2010).

Heat waves

A period of abnormally and uncomfortably hot and unusually humid weather. Typically a heat wave lasts two or more days (NOAA, 2012).

Human impacts

The quantitative measurement of the following factors: number of deaths, number of severely injured or ill people, and number of permanently displaced people (EC, 2010).

Hydro-meteorological hazards

Process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR, 2009).

Impacts

Consequences on natural and human systems. Depending on the consideration of adaptation, adaptive and coping capacity one can distinguish between potential and residual impacts (Armonia EU FP6 project No: 511208 modified after ESPON 1.3.1 Hazards-project).

Impact assessment

See under Vulnerability assessment

Land use planning

The process undertaken by public authorities to identify, evaluate and decide on different options for the use of land, including consideration of long term economic, social and environmental objectives and the implications for different communities and interest groups, and the subsequent formulation and promulgation of plans that describe the permitted or acceptable uses (UNISDR, 2009).

Level of risk

The level of risk is its magnitude. It is estimated by considering and combining consequences and likelihoods (ISO 31000:2009).

Multi-risk assessments

To determine the total risk from several hazards either occurring at the same time or shortly following each other, because they are dependent from one another or because they are caused by the same triggering event or hazard; or merely threatening the same elements at risk (vulnerable/ exposed elements) without chronological coincidence (EC, 2010).

Natural hazards

Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR, 2009).

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Pilot area

Pilot study is an abbreviated version of a research project in which the researcher practices or tests procedures to be used in a subsequent full-scale project. Pilot area means where the results are tested and implemented (HAY, I. 2005).

Political/social impacts

Usually rated on a semi-quantitative scale and may include categories such as public outrage and anxiety, encroachment of the territory, infringement of the international position, violation of the democratic system, and social psychological impact, impact on public order and safety, political implications, psychological implications, and damage to cultural assets (EC, 2010).

Preparedness

The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions. (UNISDR, 2009)

Prevention

The outright avoidance of adverse impacts of hazards and related disasters (UNISDR, 2009).

Public awareness

In a sense of disaster risk management: The extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken individually and collectively to reduce exposure and vulnerability to hazards (UNISDR, 2009).

Qualitative research methods

Qualitative research is a method of inquiry employed traditionally in social sciences. Its aim to gather an in-depth understanding of human behaviour and the reasons that govern such behaviour. The qualitative method investigates the why and how of decision making. Hence, smaller but focused samples are more often used than large samples. The three main types of qualitative research methods: the oral (primarily interview-based or surveys e.g. questionnaire method), the textual (e.g. analysis of planning documents), the observational (e.g. participant observation) (DENZIN, N. K.–LINCOLN, Y. S. 2005, HAY, I. 2005).

Questionnaire survey

A method using questionnaire which is a research instrument consisting of a series of questions and other prompts for the purpose of gathering original data about people, their behaviour and social interactions, attitudes, opinions and awareness of events. Questionnaires are often designed for statistical analysis of the responses (MCLAFFERTY, S. 2003, BABBIE, E. 2010).

Recovery

The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors (UNISDR, 2009).

Representative sampling

Sampling is the process of selecting units (e.g., people, organizations) from a population of interest so that by studying the sample one may fairly generalize his results back to the population from which they were chosen (Source: http://www.socialresearchmethods.net).

Samples are representative when they have a quality of the same distribution of characteristics as the population from which it was selected. By implication, descriptions and explanations derived from an analysis of the sample may be assumed to represent similar ones from the population (BABBIE, E. 2010).

Response

The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected (UNISDR, 2009).

Resilience

The capacity of a system, community or society potentially exposed to hazards to adapt resisting or changing in order to reach and maintain an acceptable level of functioning and structure (UNISDR, 2004).

Risk

A combination of the consequences of an event (hazard) and the associated likelihood/probability of its occurrence (EC, 2010).

Risk analysis

The process to comprehend the nature of risk and to determine the level of risk (EC, 2010).

Risk assessment

The overall process of risk identification, risk analysis, and risk evaluation (EC, 2010).

Risk criteria

Risk criteria are the terms of reference against which the significance of a risk is evaluated (EC, 2010).

Risk evaluation

The process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable (EC, 2010).

Risk identification

Risk identification is the process of finding, recognizing and describing risks (EC, 2010).

Risk map

Type of a map that portrays levels of risk across a geographical area. Such maps can focus on one risk only or include different types of risks (EC, 2010).

Risk management

The systematic approach and practice of managing uncertainty to minimize potential harm and loss (UNISDR, 2009).

See also under Disaster risk management

Risk matrix

A graphical representation of risk relating the relative likelihood of occurrence and the relative impact (human, economic/environmental, political/social) of a hazard or risk scenario (EC, 2010).

Risk scenario

A representation of one single-risk or multi-risk situation leading to significant impacts, selected for the purpose of assessing in more detail a particular type of risk for which it is representative, or constitutes an informative example or illustration. It is a plausible description of how the future may develop (EC, 2010).

Semi-guided (semi-structured) interview

Semi-structured interviewing is commonly associated with qualitative research. Semi-structured interviews have a flexible and fluid structure, unlike structured interviews, which contain a structured sequence of questions to be asked in the same way of all interviewees. The structure of a semi-structured interview is usually organized around an interview guide. This contains topics, themes, or areas to be covered during the course of the interview (LEWIS-BECK, M. S.–BRYMAN, A.–LIAO, T. F. 2004).

Single risk assessments

To determine the singular risk (i.e. likelihood and consequences) of one particular hazard (e.g. flood) or one particular type of hazard (e.g. flooding) occurring in a particular geographical area during a given period of time (EC, 2010).

Stakeholder

A person or an organisation that has a legitimate interest in a project or entity, or would be affected by a particular action or policy (IPCC 2007b).

Urban planning

A technical and political process concerned with the use of land and design of the urban environment, including transportation networks, to guide and ensure the orderly development of settlements and communities. It concerns itself with research and analysis, strategic thinking, architecture, urban design, public consultation, policy recommendations, implementation and management (Source: http://www.wikipedia.org).

Vulnerability

The characteristics and circumstances of a community, system or asset that make it susceptible to, or unable to cope with the adverse effects of climate change (hazard). It expresses the part or percentage of exposure that is likely to be lost due to a hazard (EC, 2010) (UNISDR, 2009).

Wildfires

Wildfire is a generic term for uncontrolled fires fuelled by natural vegetation. In general, high temperatures and drought following an active period of vegetation growth provide the most dangerous conditions (Smith, 2004).

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