CHANGING RISKS IN CHANGING CLIMATE

Report

Activity:	4.5
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Version	v0.4
Date	30.12.2014

Content

Glossary

Term	Explanation
Climate change	Climate change refers to 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 such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes (from IPCC, 2014, page 5).
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts. Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (from IPCC, 2014, page 5).

Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Impacts: Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts (from IPCC, 2014, page 5).
Risk	The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. In this report, the term risk is used primarily to refer to the risks of climate-change impacts (from IPCC, 2014, page 5).
Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (from IPCC, 2014, page 5).
Resilience	The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (from IPCC, 2014, page 5).

Scope of the document

According to the latest IPCC report the magnitude and frequency as well as spatial distribution of a number of climate-related natural hazards is expected to change. Climate change adaptation tops the agenda of governments as well as regional and local authorities in most European countries. In order to design climate change adaptation strategies the risk that various natural processes such as heat waves, floods, drought, wildfires and storms pose on communities (population, infrastructure, built environment, economic development) has to be identified. However the risk is dynamic and may change in time. This change is due to changes in frequency, magnitude and extent of natural hazards but also changes of the elements at risk. The SEERISK project focuses on South East Europe. One of the main products of the project is a common risk assessment methodology for the partner countries. In this report, the status quo of future risk assessment is presented together with an extension of this common risk assessment methodology developed in SEERISK to include future change in order to enable risk assessment under future scenarios in synergy with other European projects and programmes.

Executive Summary

Thematic Pole 5 on Climate Change Adaptation within the South East Europe Transnational Cooperation Programme (SEE Programme) consists of projects addressing climate change adaptation. These projects have the common goal of contributing to the development of knowledge, measures, mechanisms, policies (including local and national ones) to address the adaptation to climatic impacts. The Joint Disaster Management risk assessment and preparedness in the Danube macro-region (SEERISK) project as well as its twin project - A network for the integration of climate knowledge into policy and planning (ORIENTGATE) - are part of this Pole.

The general objective of our report is to identify the methodological steps and existing knowledge for extending risk assessment performed in the SEERISK (under present climate conditions) into the future under climate change scenarios. The SEERISK common methodology for risk assessment is the general framework which allows us to take into account the potential for further climate and socio-economic evolutions to assess the risks for climate-related hazards.

Risk is defined by the overlapping of hazard and impact (exposure and vulnerability). Global environmental change (i.e. climate and socio-economic change) should be considered in the risk assessment and in the planning of prevention measures. Improvements in procedures for downscaling climate have to be done in hazard mapping for risk assessment and adaptation. The interaction with stakeholders is essential for developing procedures and tools related to mapping impact for adaptation. The lack of wide spread quantitative information on impact and adaptation is still a challenge in the Danube Macro-region under present conditions.

Assessment of future climate-related hazards can be done using global and regional climate models driven by the scenarios describing external perturbations such as changes in atmospheric compositions due to increasing concentration of anthropogenic greenhouse gases (GHGs) (figure I). Global climate models (GCMs) provide the boundary conditions (typically at a spatial resolution from 50 km to 150 km) for regional climate models (RCMs) which physically downscale the global signals at finer spatial scales (less than 50 km). Besides dynamical downscaling,

statistical downscaling methods are also applied to model results to reach spatial resolutions from near 1 km to 10 km.

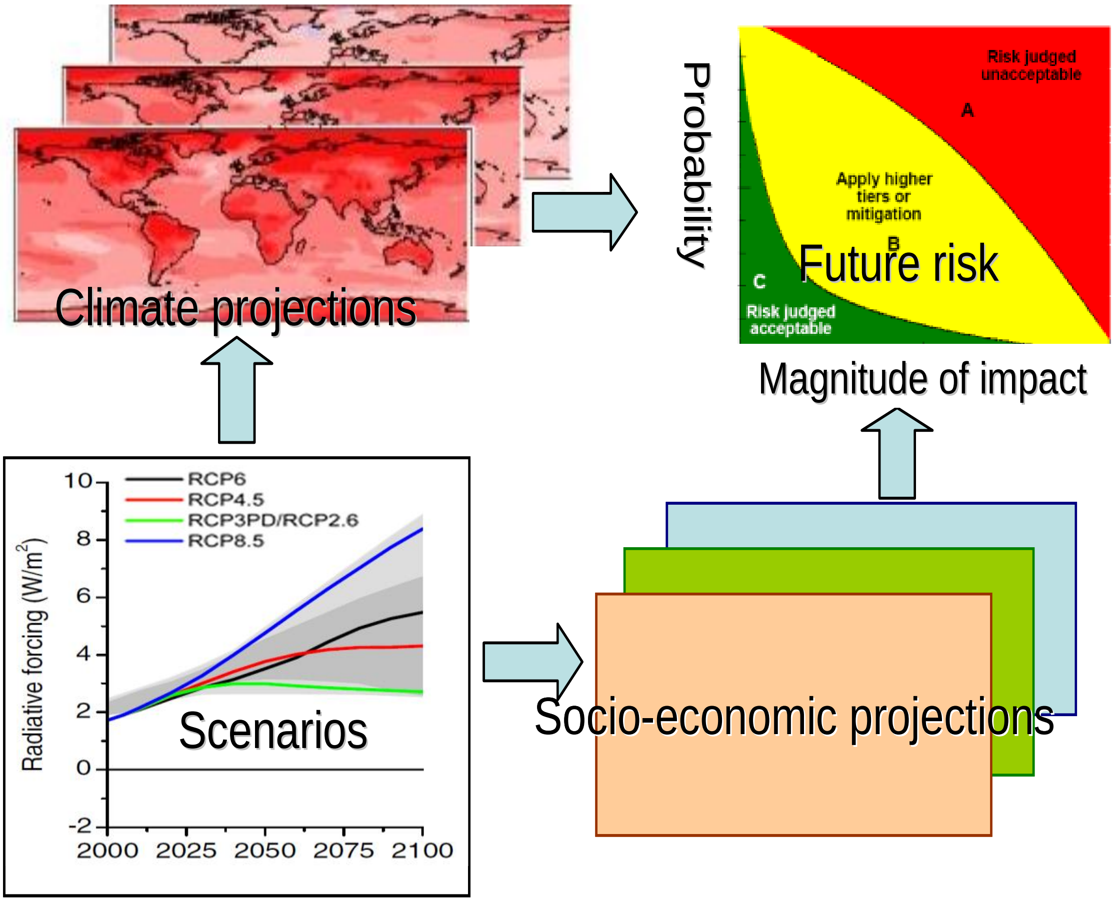


Figure I The concept of quantitative assessment of future risk under climate change.

External factors imposed to climate models such as future GHGs concentrations are derived from different future scenarios. Scenarios do not predict the future but they help in better understanding uncertainties and alternative evolution paths, in order to assess the feasibility of options to be taken in the conditions of possible futures developments. Scientific community has produced global quantitative scenarios of socio-economic changes, including changes in demographics, technology, energy and land-use either as SRES IPCC storylines or others consistent with the

Representative Concentration Pathways (RCPs). RCPs are not linked to any socio-economic scenarios, but each of them is consistent with many socio-economic storylines because different socio-economic futures could lead to similar changes in atmospheric GHGs concentrations. Future impact can be shaped by regionally-modeled future projections in demography, land-use and other socio-economic changes (Figure I). Development plans from municipalities, regional or national governments can provide exposure and vulnerability changes in the risk assessment, too.

The Danube Macro-region has been already strongly affected by climate variability and change. In the future, extreme high temperatures across this area are projected to become more frequent and last longer. As for precipitation, recent results indicate that the amounts of heavy precipitation are projected to increase in both winter and summer. Urban areas are prone to additional constraints due to human-made environment. However, especially in summer, drought and water scarcity will affect a large part of the Danube macro-region too.

Future impact changes in the Danube macro-region are mainly shaped by demographic, land-use and other socio-economic changes like over all Europe. In general, demographic changes are expected in: (1) age composition; (2) population size and growth; (3) population mobility/migration/urbanization. In the Danube Macro-region, as in all Europe, the trend for the future is defined by an aging population. This trend is expected to have a direct impact on the vulnerability of human communities to natural disasters such as those analyzed in SEERISK and ORIENTGATE projects (e.g. heat waves in urban areas, floods). According to the European Environment Agency, the European urban areas are expected to increase by 1% in 2020 in comparison to year 2000. One of the most predominant land-use changes present in Europe (and in the Danube Macro-region) is the increase of soil sealing due to both urbanization and road infrastructure expansions. These expansions affect the exposure and vulnerability of the society to heat waves and floods.

In the case of heat waves over the Danube Macro-region, the hazard component (which is related to the increase in temperature) is expected to change towards more frequent, persistent and strong episodes in the future. The confidence associated to future climate projections based on numerical experiments with climate models is highest for this hazard compared with others analyzed in SEERISK and ORIENGATE projects. As for impact side, a typical indicator of exposure to heat waves that is population census data from the areas affected is expected to increase due to the trend of increased urbanization in the Danube Macro-region. Vulnerability metrics such as the age distribution of population is also expected to contribute to higher level of risk associated to heat waves due to the aging trends present in the Danube Macro-region, too.

For the Middle Danube River Basin, studies show a pronounced increase in flash floods due to more extreme weather events (torrential precipitation) especially in the small basins (e.g. Sava and Tisza). The studies of the Low Danube River Basin indicate an increase in flood frequency, too. Flood events are projected to occur more frequently particularly in winter and spring, although estimates of changes in flood frequency and magnitude remain uncertain. The uncertainty of flood prediction is especially high in small catchments. The uncertainties due to hydrological impact models add to those coming from global and regional models. The risks associated especially to urban floods are expected to increase due to increased flood frequency (climate change), larger exposure (e.g. increased urbanization) and higher vulnerability (e.g. soil sealing trends) in the Danube Macro-region.

Climate change amplifies the frequency and severity of droughts. The common feature across the Danube Macro-region countries is that all of them are sensitive to both the variability and change in precipitation. The expected climate evolution in this region is toward warmer and drier summers. The southern parts of Hungary and Romania as well as the Republic of Serbia, and Bulgaria are likely to face droughts and water stress resulting in water shortages in the following decades (with a stronger manifestation toward the end of this century). A common feature of the Danube Macro-region is that the most vulnerable sector to drought impact is agriculture. The impact of climate change on local agricultural activities can be assessed by crop models coupled to the RCMs. Risks related to food security in the Danube Macro-region are also influenced by exposure (e.g. reduced agricultural areas) and vulnerability (e.g. propriety fragmentation, aging population).

The hazard component of future risk in wild fires could be more reliable compared with other risks as future changes in temperature and related variables have relatively high certainty. The hazard of wild fires is physically-related to drought hazard. How exposure and vulnerability add their effects to that of changes in hazard component to shape the future risks of wild fires in the Danube Macro-region is not very clear in the present available literature.

The wind speeds during storm events increase significantly over large parts of Central Europe by about 5 %. Analyzing extreme wind speeds and the related loss potentials, enhanced speed values and risk of loss are found over the northern parts of Central and Western Europe, whereas significant reductions are found over southern Europe and the Mediterranean. However, the present literature lacks analysis of risk losses due to changing wind under future climate conditions in the Danube Macro-region.

In the SEE Transnational Programme, the SEERISK project mostly targeted the disaster management community while the ORIENTGATE project was more adaptation-orientated. However, the two communities share common interests, too. They are interested in seasonal climate prediction and both use interdecadal climate information for assessing hazards. Also, both communities have to fill the gap between climate experts and stakeholders in understanding of climate change and raise awareness of people on these issues. The involvement of stakeholders in assessing climate-related risks and in finding ways to effectively use climate predictive information is essential for both disaster management and adaptation. Stakeholders have to be involved in an interactive way in the process of climate-related risk assessment, climate prediction and associated activities for risk reduction and adaptation.

1. Introduction

The pace of climate change imposes increasing pressure on the scientific community and on the rest of the society from the need of improved knowledge on physical phenomena across multiple temporal and spatial scales to demands for assessments of socio-economic exposure and vulnerability to climate impacts in order to improve life quality through appropriate adaptation measures (Figure 1.1). In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans (IPCC, 2014). The geopolitical distribution of impacts on human systems attributed to climate change highlights different risks to climate-relating hazards arising from differences in vulnerability and exposure due to non-climatic factors and socio-economical inequalities.

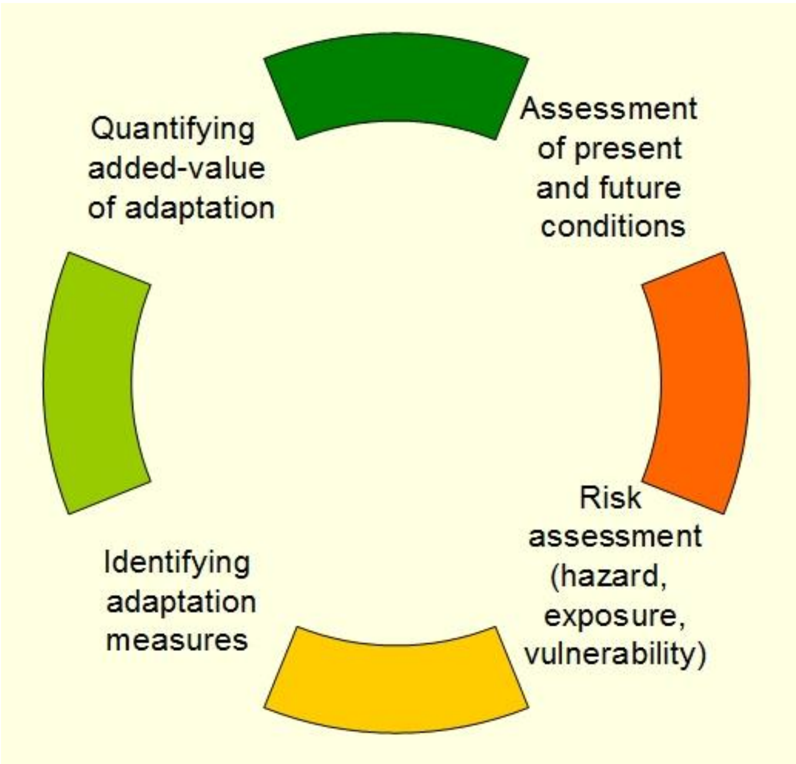


Figure 1.1 Adaptation cycle

An effective management of the risks associated with climate changes and in particular with the changes in the frequency and intensity of weather- and climate-related extreme events (e.g. heat waves, floods and droughts, wild fires) is needed at all decisional levels – global, regional and local communities.

Recently, the scientific community has made significant advancements in assessing climate predictability and associated uncertainties on various spatial and temporal timescales. However, these advancements do not cross immediately the screen of computers to measurably increase the quality of people lives and socio-economic cohesion of the European Union and of the world. The need for integration of climate information in the decision process at policy-makers levels as well as in the long-term planning activities in the private/industry sectors is nowadays well accepted and important steps have been made in this direction during the last years. Human society has three different response approaches to climate change: mitigation, adaptation and acceptance of a certain level of climate-related damages. The best solution is probably a mixture of all these approaches. At global and regional levels, efforts have been taken towards improving people awareness on climate changes and potential effects, identifying and implementing measures to mitigate negative impacts and/or exploit new opportunities associated with these changes. From web-based platforms presenting climate-related information in an easy-to-use manner (e.g. www.climateadaptation.eu) to web-based tools designed to address specific societal challenges in relation to climate change, a variety of user-oriented applications aims to deliver climate information in a form fitted for the decisional process.

Under present climate, knowledge about local features of climate variability and change demands an integration of standard meteorological observations, other in situ information, and satellite and weather radar data. As for the future climate conditions, the challenge is to downscale model results to finer temporal and spatial scales relevant to local analysis to deliver climate products, services and plan adaptation. Last but not least, the spatially-detailed mapping of climate-related hazards in local area have to be fully coupled with exposure and vulnerability of population and infrastructure in order to continually assess the climate related risks to which one has to adapt for a sustainable development.

The general objective of our report is to identify and review the state of art in the methodologies for extending risk assessment performed in the SEERISK (under present climate conditions) into the future under climate change scenarios. The common methodology for risk assessment developed in the SEERISK project (SEERISK Consortium, 2014) is the general framework which allows us to take into account the potential for further climate and socio-economic evolutions to assess the risks for climate-related hazards.

As the document of the Thematic Pole 5 on Climate Change Adaptation reveals, the South East Europe Transnational Cooperation Programme (SEE Programme) consists of a number of projects that shared a concrete approach towards climate change adaptation measures, a cross-cutting theme to several projects and Areas of Intervention. The SEE projects which address the climate change adaptation had the common goal of creating knowledge, measures, mechanisms, policies for coping with climatic episodes that endanger environment and human society through local and national climate-related policies. The projects from the Thematic Pole 5 on Climate Change Adaptation addressed different sectors (forestry and agriculture, drought, water & coasts, urban adaptation and health, floods, disaster management). They are aiming at streamlining their results towards strategies and policies that address climate change adaptation to strengthen the value of their outcomes (http://www.southeast-europe.net/en/achievements/capitalisation_strategy/pole7/thematicpole5climatechangeadaptation).

The present report aims to respond to the challenges identified by European Commission and viewed as priorities in the SEE work programme, in synergy with the results from the Thematic Pole 5 on Climate Change Adaptation, in particular to the one concerning the need to increase Europe's resilience to crises and disasters. The outcomes based on a risk assessment approach will provide support for the development of innovative adaptation and long term risk reduction options, fine-tuned to specific natural and socio-economic conditions across Danube Macro-Region.

2. Concept and approach

Methodological steps for extending risk assessment (under future climate change) which has been performed in the SEERISK (under present climate conditions) are based on (1) the EU guidelines for risk assessment and mapping (EU, 2010); (2) the ISO31010 (IEC/FDIS 31010 2009); (3) Climate change, impacts and vulnerability in Europe; (5) Adaptation in

Europe Addressing risks and opportunities from climate change in the context of socio-economic developments; (4) common risk assessment methodology for risk assessment and adaptation in the Danube macro-region (see figure 2.1).

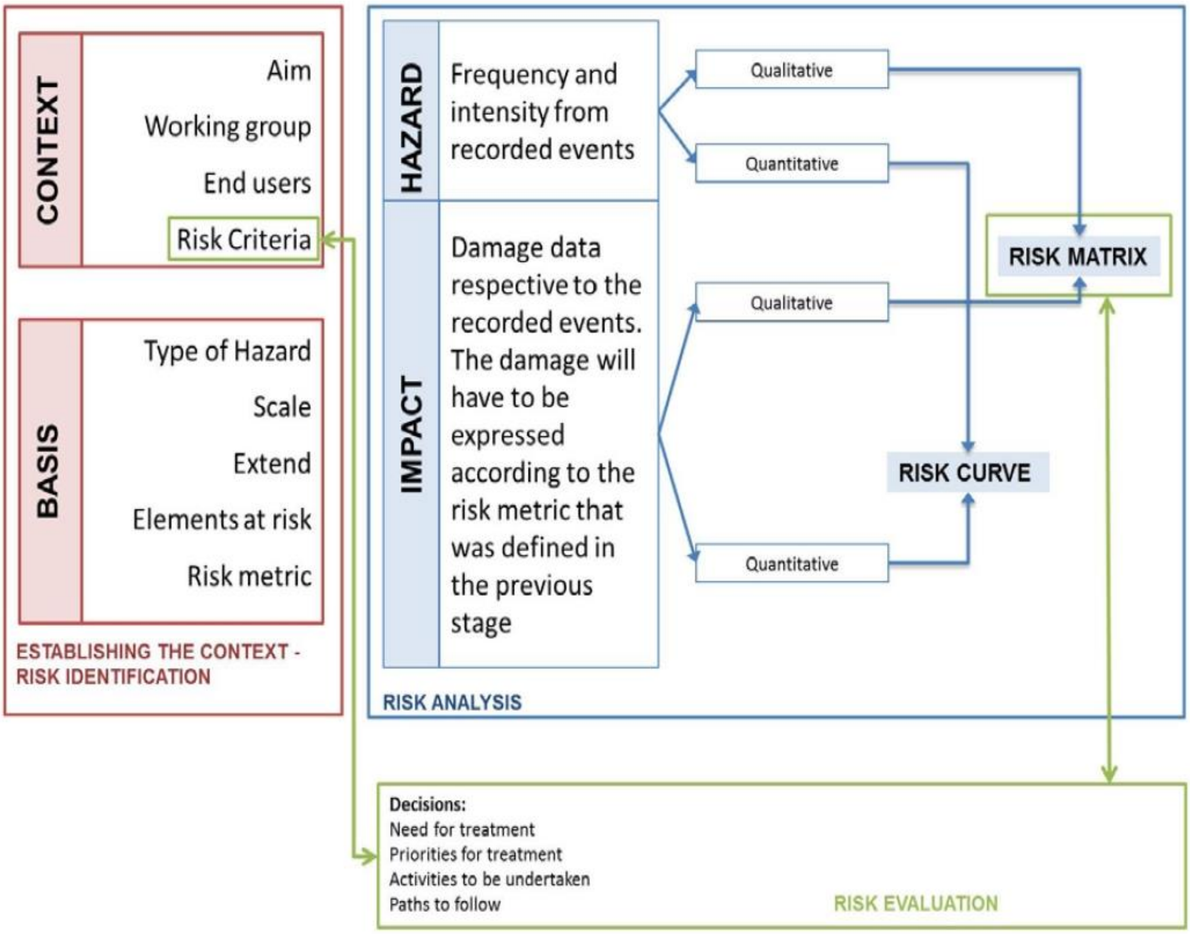


Figure 2.1 The structure and workflow for SEERISK common risk assessment methodology (SEERISK Consortium, 2014).

One of the main products of SEERISK is the common risk assessment methodology for risk assessment and mapping (SEERISK Consortium, 2014). The Common Risk Assessment Methodology (Figure 2.1) incorporates three steps: 1. establishing the risk context and risk identification, 2. risk analysis and 3. risk evaluation. The hazard and impact analysis which are the two main components of risk analysis are based on data from previous events. However, the spatial and temporal patterns of hazards as well as the socioeconomic context are subject to change in the future.

According to the latest report of the Intergovernmental Panel for Climate Change (it is likely that the frequency and the magnitude of some hazard types might change in the near future (IPCC, 2012). In more detail, according to the IPCC report “a changing climate leads to changes in the frequency, intensity, spatial extent, duration and timing of weather and climate extremes and can result in unprecedented extremes” (IPCC, 2012, p.111). As a consequence weather related phenomena are also expected to change. However, the severity of the impacts does not depend only on the process itself but also on the level and spatial distribution of vulnerability and exposure. Risk is the overlapping area from hazard and vulnerability (figure 2.2), so changes in the later will lead to changes in risk. Global environmental change (i.e. both meaning climate and socio-economic change should be considered in risk assessment and in the planning of prevention measures.

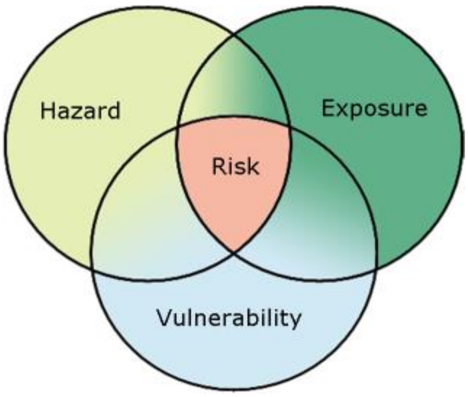


Figure 2.2 Definition of risk in relation with hazard and exposure and vulnerability (i.e. impact).

Figure 2.3 illustrates how global change is taken into consideration in the common risk assessment methodology. The inner frame describes the current situation, whereas the outer frames describe the situation for future scenarios (for instance, targeting on time horizons of 2050 and 2100). In order to assess the change in hazard, climate models that can simulate the weather variables (e.g. precipitation, temperature etc.) may be used. On the other hand, the changes in vulnerability will depend on the socio-economic (e.g human-made changes in land use 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. If model data or information required for assessing the change in hazard and/or vulnerability are not available, the exit strategy has to be used, which is based on expert judgment (Figure 2.4).

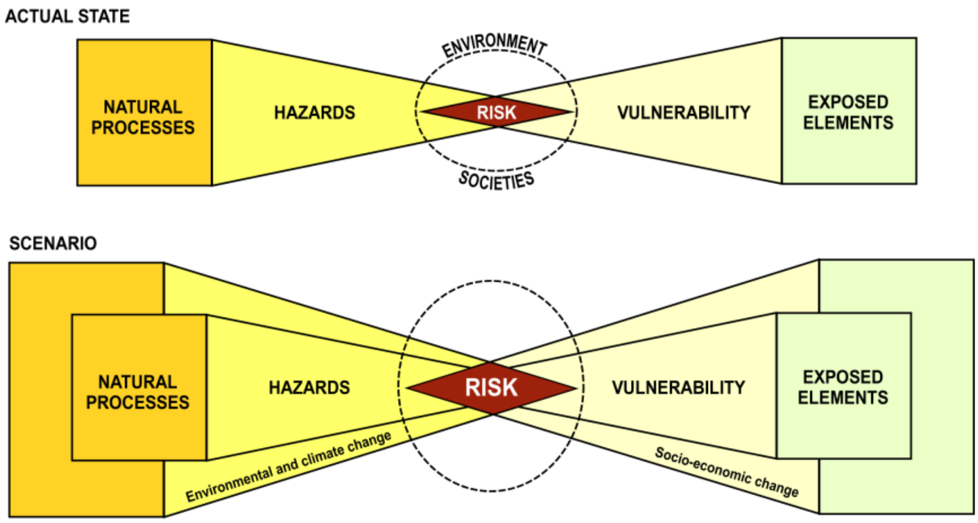


Figure 2.3 Consideration of changes in climate and in socio-economic change are essential in risk assessment (Source: Malet et al., 2012).

Special procedures and tools are needed to couple downscaled weather and climate with impact data for risk assessment. Improvements in integration of observations and model results will support downscaling procedures in hazard mapping for risk assessment and adaptation. The interaction with stakeholders is essential for developing procedures and tools related to climate-related hazards and impact and adaptation. The lack of wide spread quantitative information on impact and adaptation is still a challenge.

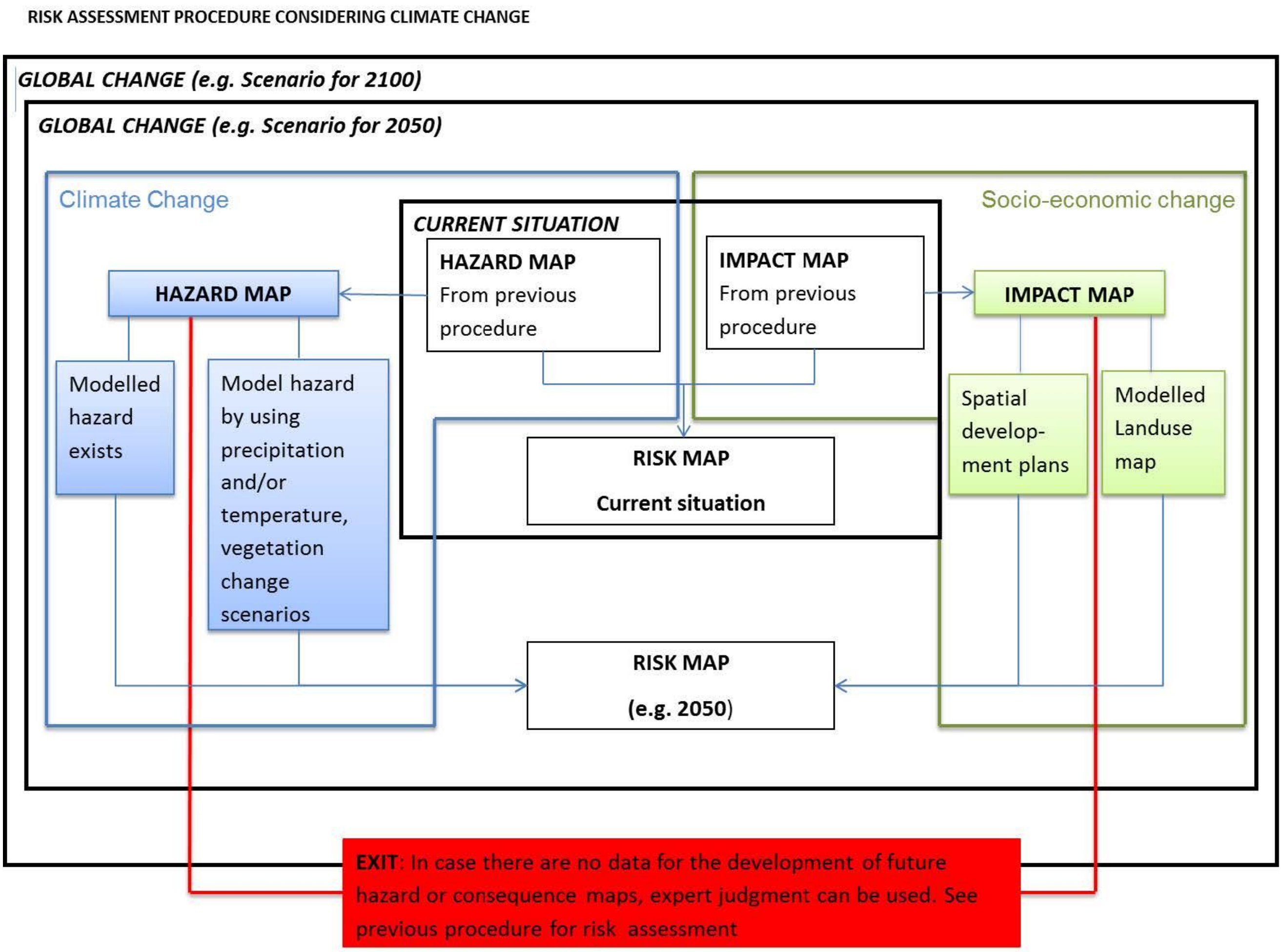


Figure 2.4 The extension of the SEERISK common assessment methodology to include global environmental change.

3. Future Risk Assessment and associated Uncertainties

3.1 Earth system modelling and associated uncertainties

In order to describe the future evolution of the climate variables (e.g. air temperature, precipitation) for further assessing climate-related hazards, most of studies use global and regional climate models driven by the scenarios describing external perturbations, such as changes in atmospheric compositions due to increasing concentration of anthropogenic greenhouse gases (GHGs). Generally, a climate model describes in mathematical language, based on physical laws, the behavior of the analyzed system starting from an initial state and constrained by external and boundary conditions. The climate system of the Earth consists of interacting components: the atmosphere, the hydrosphere (planetary ocean and continental hydrological network), the cryosphere (e.g. continental snow, glaciers, permafrost, ice caps and sea-ice), the land surface and the biosphere. In order to model the Earth system is not enough to separately describe its components, but one has to simulate the processes linking them, too (e.g., Peixoto and Oort, 1992). Due to the synergy between its components, the response of the Earth system to external perturbation differs from the sum of individual responses provided by the above-mentioned subsystems. Climate modelers have brought separate components together, firstly as coupled models of atmospheric and oceanic circulation (with sea ice dynamics), and secondly as Earth system models (ESMs) which interactively add biological and geochemical processes (including the carbon cycle) to coupled ocean-atmosphere component (Foley et al., 1998). Global climate models (GCMs) provide the boundary conditions (typically at a spatial resolution from 50 km to 150 km) for regional climate models (RCMs) which physically downscale the global signals at finer spatial scales (less than 50 km). Besides dynamical downscaling, statistical downscaling methods are also applied to model results to reach spatial resolutions from near 1 km to 10 km.

External factors imposed to climate models - such as future GHGs concentrations - are derived from different future scenarios. Scenarios of GHGs emissions/concentrations and other drivers are used to assess the impact of a range of human activities on Earth system components. However, one has to take into account that changes in climate are major drivers of changes in both natural and human systems (through changes in technology, economies, lifestyle and policy). Scenarios do not predict the future but they help in better understanding uncertainties and a range of evolution paths, in order to assess the feasibility of options for adaptation to climate change.

The first approach in designing scenarios was a linear one consisting of the following steps: (1) producing socio-economic scenarios that lead to different future GHGs and aerosol emissions (i.e. the IPCC SRES scenarios); (2) evaluating the effects of those emissions on concentrations; (3) describing the influences on the climate system, and (4) assessing the implications of those climate changes, along with socio-economic futures and other environmental changes, on natural and human systems (figure 3.1.2 a).

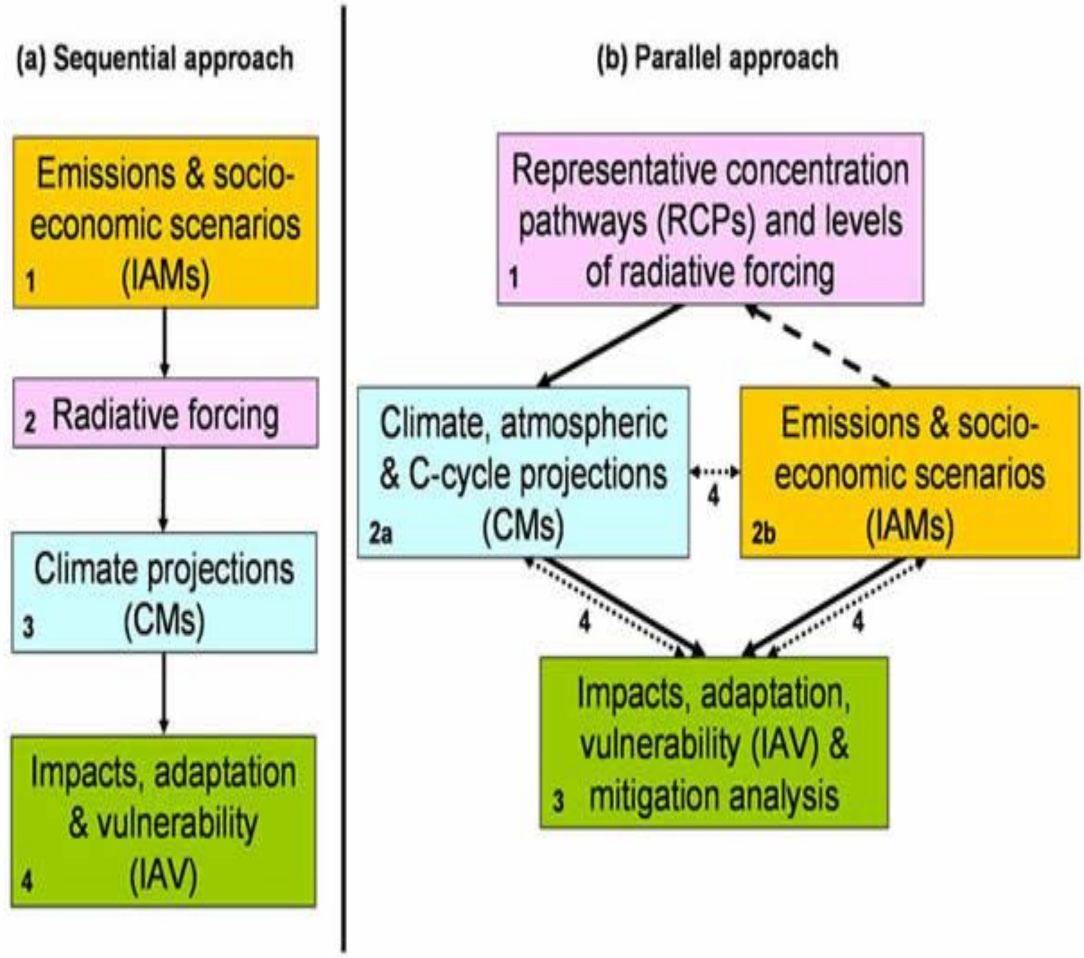


Figure 3.1.2 Approaches to the development of global scenarios: (a) previous sequential approach; (b) proposed parallel approach. Numbers indicate analytical steps (2a and 2b proceed concurrently). Arrows indicate transfers of information (solid), selection of RCPs (dashed), and integration of information and feedbacks (dotted). Source: Moss et al. (2008).

The IPCC SRES scenarios are based on different driving forces of GHGs emission changes, including population growth and socio-economic development. These drivers span a range of future scenarios that might influence GHG sources and sinks, such as the energy system and land use change. The SRES team defined stories (named A1, A1T, A1F1, A1B, A2, B1 and B2), describing the relationships between the forces driving GHGs and aerosol emissions and their evolution during the 21st century (Nakicenovic al., 2000). Each story represents different demographic, social, economic, technological, and environmental developments that increasingly diverge with time (http://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf).

Another recent approach is designed for a better integration between socio-economic driving forces, changes in the climate system, and the vulnerability of natural and human systems. Instead of starting from socio-economic scenarios that lead to different GHGs emissions, the new scenarios start with future GHGs and aerosol concentrations (figure 3.1.2b).

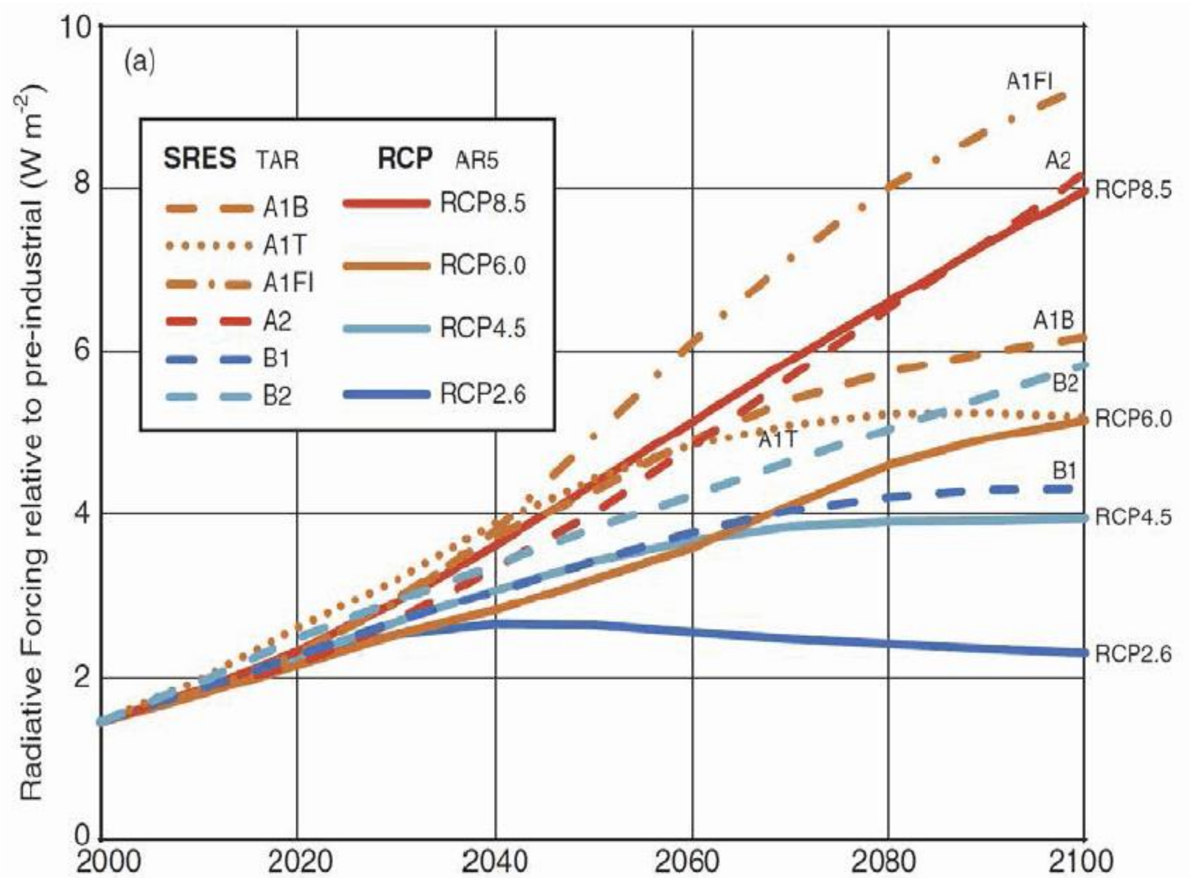


Figure 3.1.3 Projected radiative forcing (W ^m-2) over the 21st century from the SRES and RCP scenarios. Figure from IPCC AR5 WGII, Chapter 1.

These new scenarios described in the Moss et al. (2008) are the Representative Concentration Pathways (RCPs). The RCPs can be simultaneously used either by Earth System Models (ESMs) to explore future changes in physical and biogeochemical responses to changing atmospheric composition and radiative forcing, or by Integrated Assessment Models (IAMs) to explore alternative socio-economic conditions that would result in such future atmospheric composition changes (figure 3.1.2b) (Moss et al., 2008). During the parallel stage of the new approach, climate modelers are performing new climate experiments with their models to produce climate projections using the time series of concentrations and land use from the four RCPs. These model projections will be used to construct new climate scenarios for application in Impacts, Adaptation, and Vulnerability (IAV) and IAM studies (figure 3.1.2b) (Moss et al., 2008).

The new approach means that scientific community has to produce quantitative scenarios of socio-economic changes, including changes in demographics, technology, energy and land-use consistent with the RCP pathways. RCPs are not linked to any socio-economic scenarios, but each of them is consistent with many socio-economic stories because different socio-economic futures could lead to similar changes in atmospheric composition. The socio-economic stories produced by the scientific community can then be used as a common set of assumptions by the IAM and IAV communities. The IAV community combines these with results from the ESM community based on RCPs to examine climate change impacts, adaptation options, and vulnerability to climate change. Both SRES and RCPs scenarios are illustrated for comparison in figure 3.1.3. RCP8.5 was developed to represent a high-end concentration scenario while RCP2.6 represents a GHGs concentrations due to extremely strong mitigation scenarios (van Vuuren et al., 2011a). RCP 4.5 is a medium GHGs concentration scenario (Thompson et al., 2011).

Society has three different response approaches to climate change: mitigation, adaptation and acceptance of unavoidable climate damages. The best solution seems to be a combination of these approaches. For elaboration of climate change policy is necessary to produce information on: (1) what mitigation actions might be required in order to produce a climate outcome; (2) what will be the potential for adaptation; (3) what unavoidable impacts might occur for a range of climate change projection are important information. In the process of the policy elaboration, one must trade off between the relative costs, benefits, risks, and unexpected side effects of various levels and rates of climate change when planning climate change policy.

In the context of climate risks assessments little distinction is been usually made between long and short term needs for responding to climate impact. Climate variability is important on short time horizon (usually, on intraannual and interannual scales) while climate change is acting on longer term, beyond decadal scale. The SEERISK project focused especially on the short term climate due to the fact that its products were designed mainly for disaster management community. On the other hand, the ORIENTGATE project addressed more the issues related to long term climate. However, planning adaptation requires information on both variability and climate change and the SEERISK and ORIENTGATE approaches have to be merged.

Few policies are designed to operate on interdecadal timescale because one would avoid committing resources for which there is no short term return and partially due to the uncertainties in the future projections. Although observed trends in climate change are expected to continue, there is considerable uncertainty about the precise rate of change and its concrete impact. For example, there are uncertainties associated with using different models, scenarios and downscaling methods as well as differences in the scales, projection periods and domains of interest where they are applied (Tiago et. al, 2014).

The climate change is the result of the interaction of the natural Earth system with anthroposphere (consisting of human systems). Changes in ecosystems, natural resources, economic activities and infrastructure, and human well-being, depend not only on climate change, but also on other changes in the environment (depicted in environmental scenarios) and the capacity of societies and economies to buffer and adapt to impacts (addressed in scenarios of vulnerability and adaptive capacity). Closer integration of scenarios is required to address feedback loops and other issues, such as the ecological and economic implications of different sets of adaptation and mitigation policies (Tiago et. al, 2014).

From the adaptation perspective, it is important to assess the range of all possible changes in relation to their associated uncertainties. A part of uncertainties in future projections are due to theoretical limitations in modeling climate and its feedbacks with ecosystems and human systems. They are intrinsic to science, so certain levels of uncertainties will be always present and those must be included in decision-making processes. Adaptation to climate change raises the challenges for long-term policy planning under these unavoidable levels of uncertainties (Tiago et. al, 2014).

3.2 Future climate-related hazards in the Danube macro-region

Europe is strongly affected by climate variability and change (e.g. IPCC, 2012; IPCC 2013; IPCC, 2014). European Environment Agency reveals that since 1880 the average length of summer heat waves over Western Europe doubled and the frequency of hot days almost tripled (http://www.eea.europa.eu/data-and-maps/indicators/global-and-european-temperature/global-and-european-temperature-assessment-8).

Number of combined tropical nights (minimum temperature greater than 20ºC) and hot days (maximum temperature greater than 35ºC) are projected to become more frequent and last longer during this century (Fischer and Schär 2010, IPCC 2013) in the Danube macro-region as figure 3.2.1 shows.

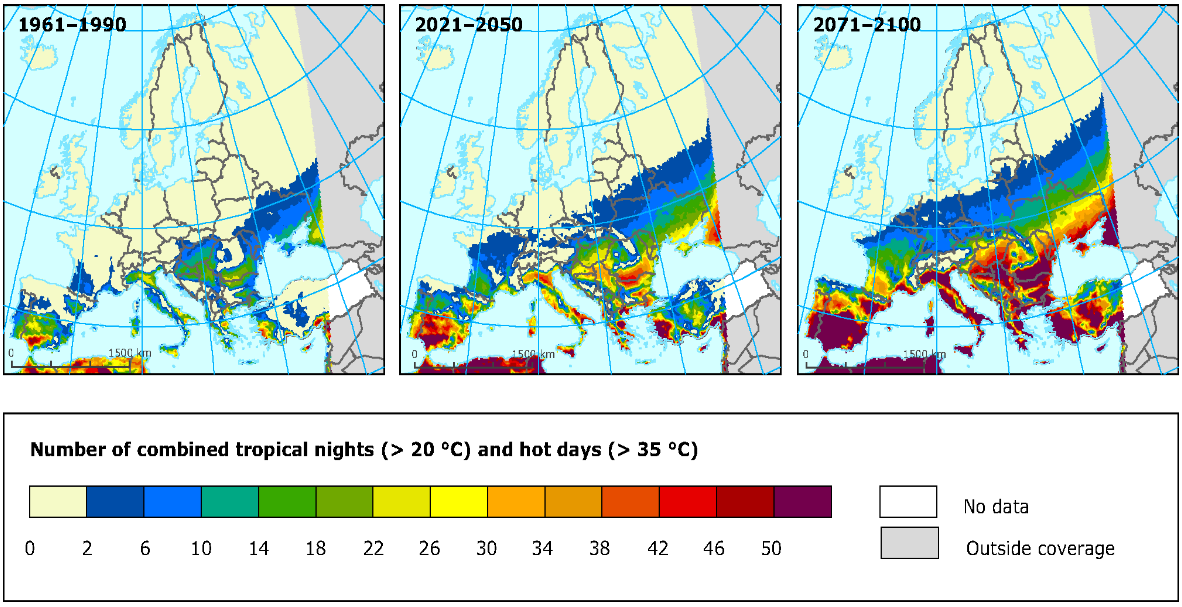


Figure 3.2.1 Changes in extreme temperature for two future periods, relative to 1961-1990. Extreme temperatures are represented by the combined number of hot summer (June-August) days (TMAX>35°C) and tropical nights (TMIN>20°C). All projections are the average of 5 Regional Climate Model simulations of the EU-ENSEMBLES project using the IPCC SRES A1B emission scenario for the periods 1961-90, 2021-2050 and 2071-2100 (Fischer and Schär, 2010. Maps and caption from Environment Protection Agency. http://www.eea.europa.eu/data-and-maps/figures/projected-average-number-of-summer-1).

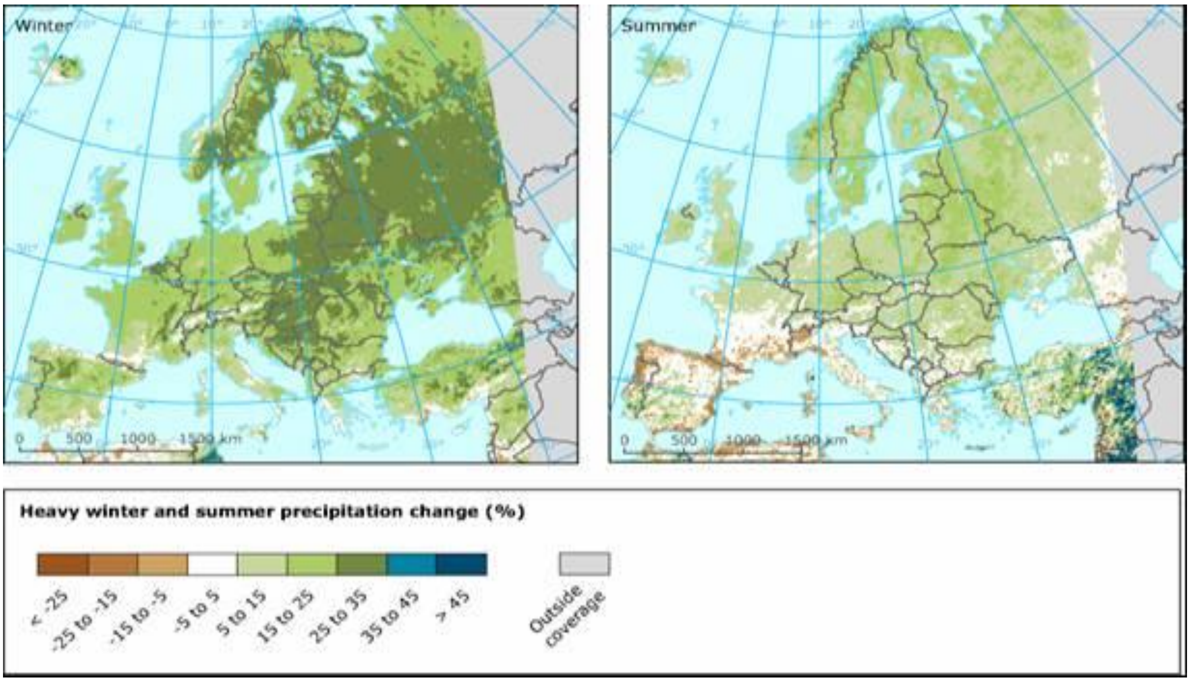


Figure 3.2.2 Projected changes in heavy precipitation (in %) in winter and summer from 1971-2000 to 2071–2100 for the RCP8.5 scenario based on the ensemble mean of different regional climate models (RCMs) nested in different general circulation models (GCMs) obtained in the EURO-CORDEX initiative (http://www.euro-cordex.net/). Maps and caption from Environment Protection Agency (http://www.eea.europa.eu/data-and-maps/figures/projected-changes-in-20-year-2).

As for precipitation, recent results indicate that the ensemble mean projects show a statistically significant increase in large parts of central Europe and northern Europe of up to about 30 % and a decrease (up to 40 %) in southern Europe between 2071-2100 and 1971-2000 (Jacob et al., 2014). Furthermore, the amounts of heavy precipitation are projected to increase in both winter and summer over a large part of Europe and in the Danube macro-region (figure 3.2.2). Urban areas are prone to additional constraints due to human-made environment. As for as extreme winds, the model results do not suggests significant changes over the Danube macro-region under climate change scenarios (figure 3.2.3).

The new scenarios mentioned in section 2.1 (RCPs) show a consistent picture with the SRES scenarios, even though the details are different due to different radiative forcing. Examples based on temperature and precipitation projections for Danube Macro-region under RCP 4.5 scenario are illustrated in figures 3.2.4, 3.2.5, 3.2.6, and 3.2.7. Climate model results reveal mean temperature increase in winter (up to 2ºC for 2012-2050 vs. 1971-2000) and summer (reaching 2.5ºC for 2012-2050 vs. 1971-2000) over our region of interest (figure 3.2.5 and 3.2.7). Under RCP 4.5 scenario, climate projections indicate summer precipitation reductions up to 9% in 2021-2050 compared to 1971-2000 over the Danube macro-region (figure 3.2.6).

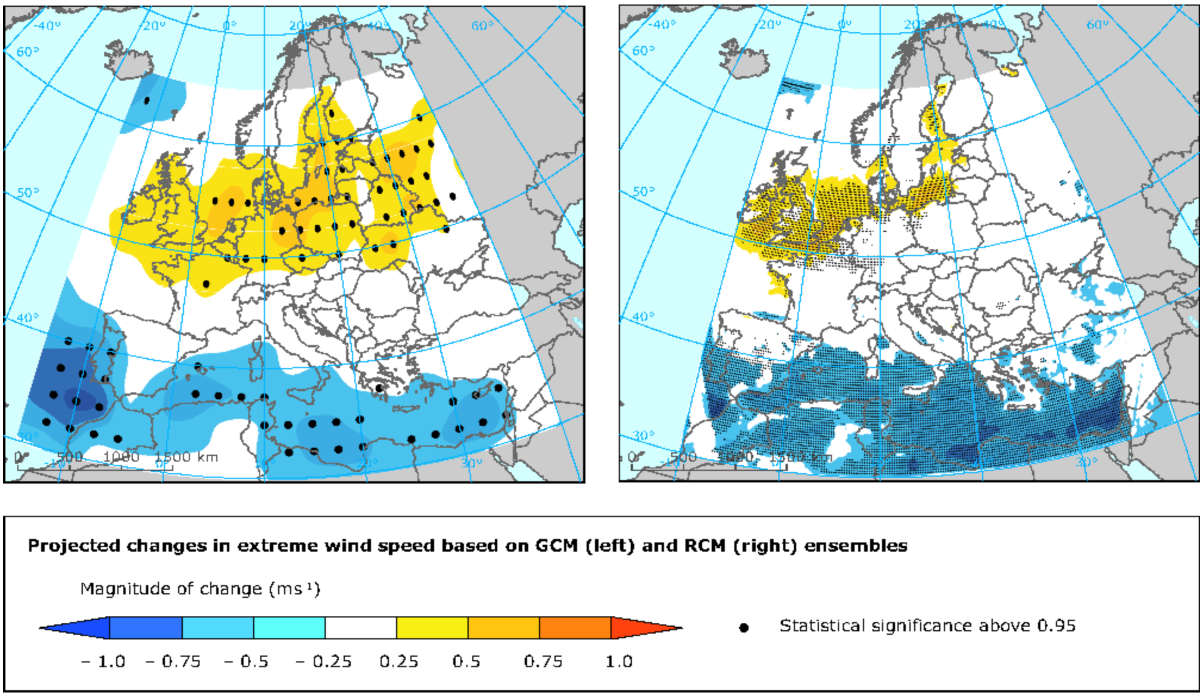


Figure 3.2.3 Ensemble mean of changes in extreme wind speed (defined as the 98th percentile of daily maximum wind speed) for A1B (2071–2100) relative to 1961–2000. Left: based on 9 GCMs. Right: based on 11 RCMs. Coloured areas indicate the magnitude of change (unit: m s−1), statistical significance above 0.95 is shown by black dots. Maps and caption from Environment Protection Agency (http://www.eea.europa.eu/data-and-maps/figures/future-changes-in-european-winter).

Climate model results presented here and others such as those provided by ORIENTGATE, ENSABLES, and EuroCORDEX are the base for mapping future hazards in the limits shaped by the unavoidable uncertainties. Future changes in temperature and related variable have highest certainty. The certainty related to the future evolution of precipitation is less reliable than temperature changes (ICPDR, 2013). The certainty of changes in the water storages snow and ice is relatively high, too. Changes in winter precipitation from snow to more rain are very likely, but the quantitative projected changes are less reliable.

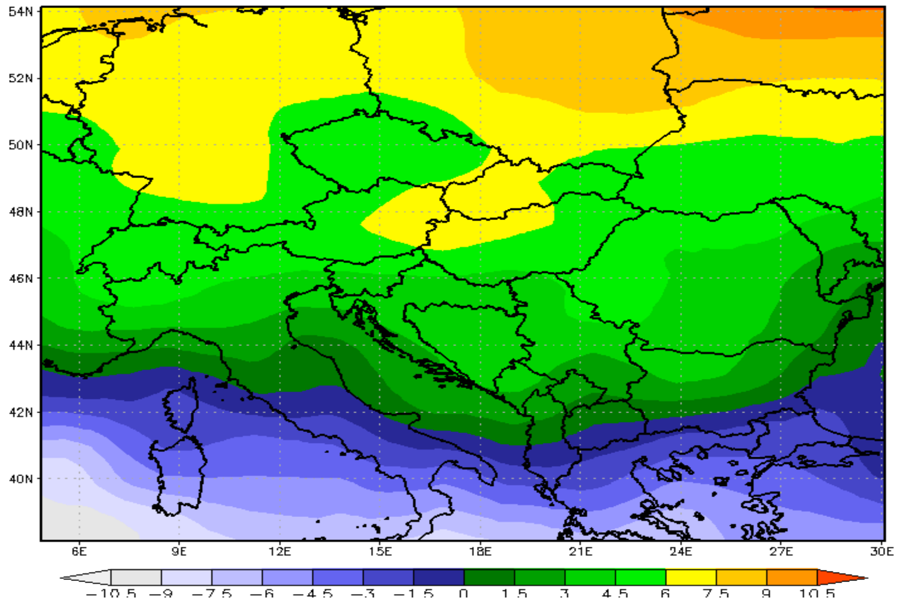


Figure 3.2.4. Differences in the ensemble mean of winter precipitation (in %) between the intervals 2021-2050 and 1971-2000 using conditions of RCP 4.5. The ensemble means were computed using 25 numerical experiments with global climate models taken from CMIP5 database.

The future-projected runoff, evapotranspiration and groundwater are all rather uncertain. Future changes in water availability depend largely on precipitation, which might decrease in summer, especially in the southeast of the Danube basin with a strong tendency to water stress (ICPDR, 2013). Projections of extreme hydrological events are generally more uncertain than changes in the mean water availability. Although there are uncertainties in climate change impacts on low flows, droughts and water scarcity, these are more reliable than changes in floods which show larger uncertainty.

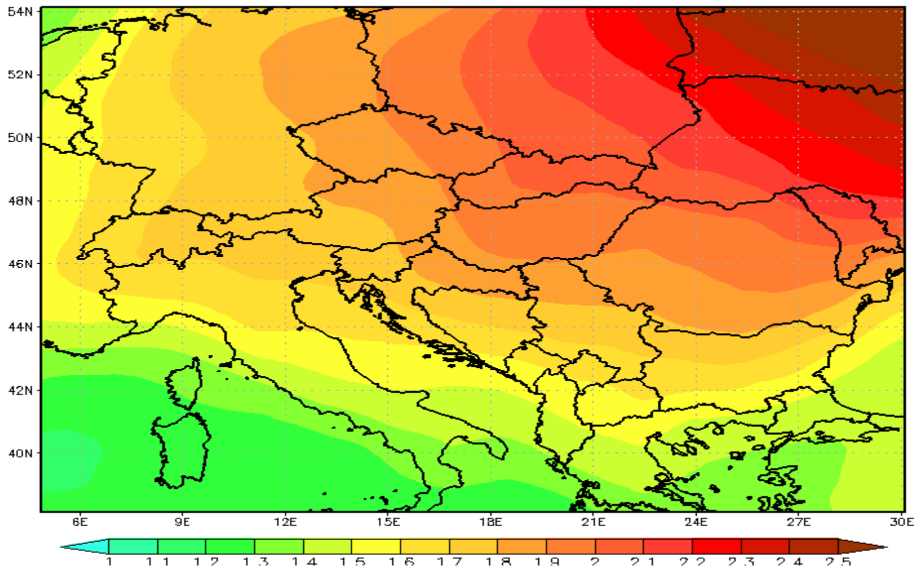
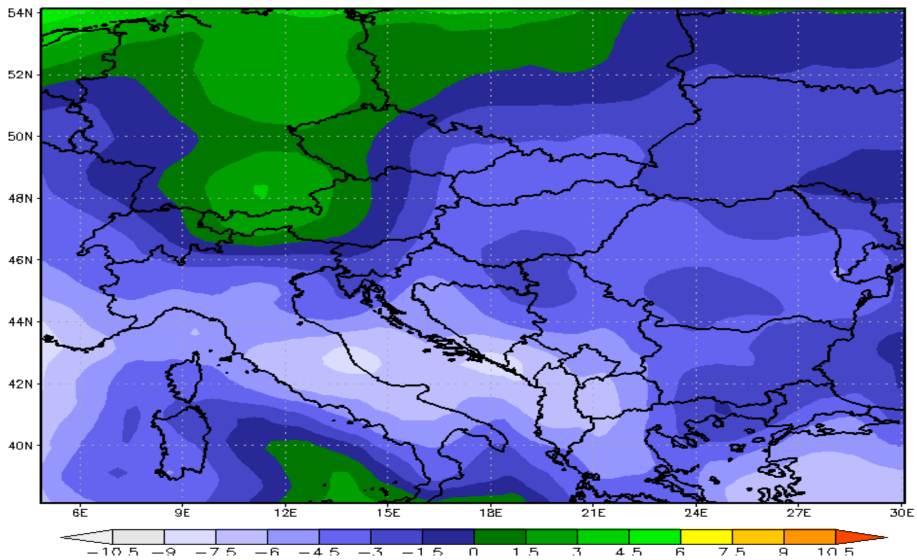


Figure 3.2.5. Differences in the ensemble mean of winter temperature (in °C) between the intervals 2021-2050 and 1971-2000 using conditions of RCP 4.5. The ensemble means were computed using 25 numerical experiments with global climate models taken from CMIP5 database.



Fgure 3.2.6. Differences in the ensemble mean of summer precipitation (in %) between the intervals 2021-2050 and 1971-2000 using conditions of RCP 4.5. The ensemble means were computed using 25 numerical experiments with global climate models taken from CMIP5 database.

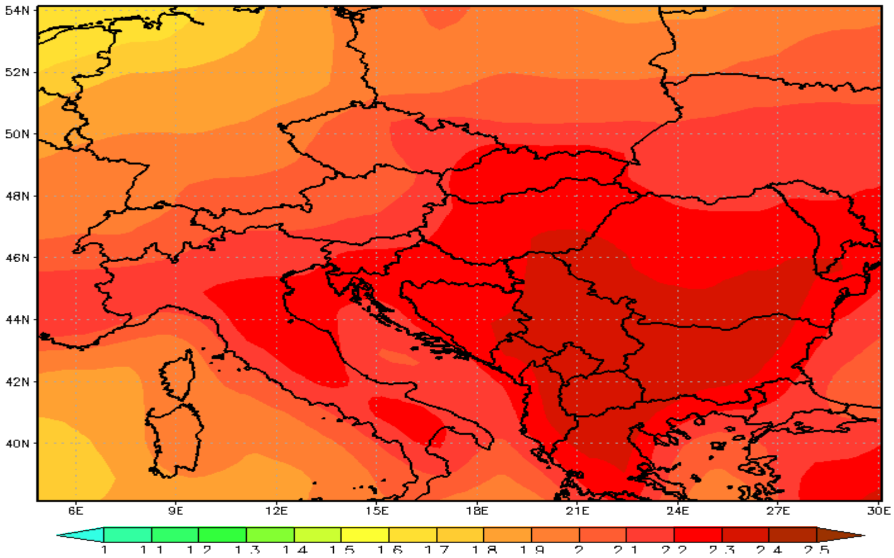


Figure 3.2.7. Differences in the ensemble mean of summer temperature (in °C) between the intervals 2021-2050 and 1971-2000 using conditions of RCP 4.5. The ensemble means were computed using 25 numerical experiments with global climate models taken from CMIP5 database.

Through the innovative approach of coupling predictive climate information with specific socio-economic background (impact assessment) one could provide support methods and tools for a better climate- risk management at various time-scales and on a more coherent basis at the Danube macro-region level.

3.3 Changes in socio-economic context

The assessment of socio-economic changes usually requires socio-economic scenarios. A socio-economic scenario is a combination of quantitative projections and qualitative information (such as storylines) that define a plausible future (Carter et al., 2007). Historically, scenarios of global futures were mostly used to assess the plausible evolution range of global GHGs emissions and concentrations imposed on climate models as external conditions. The impact/adaptation/vulnerability (IAV) research community has rather analyzed the consequences of a certain local increase in a climate variable (e.g., 1°C increase in air temperature compared with a reference interval), without using the global socio-economic scenarios.

Producing regional, national and sub-national scenarios at long time scales is a complex endeavour (e.g. Gaffin et al., 2004; Theobald, 2005; Lempert et al., 2006; Grübler et al., 2007; Groves and Lempert, 2007; Hallegatte et al., 2010; Van Vuuren et al., 2010b). In some cases there are local scenarios - such as city scenarios designed to support urban planning. However, these scenarios are not connected to global ones, in which global environmental change could be fully represented. Moreover, they usually consider time horizons of less than 30 years. Urban scenarios with a 2100 time horizon are not generally available now, yet such scenarios would be of relevance to the understanding of urban - scale climate change impacts. Thus, in our context is difficult to exemplify with socio-economic scenarios for Danube macro-region to assess the impact part of future risks in our domain of interest. What we can present from the available literature is some qualitative information about future impacts in the region based on identified European trends in the indices of exposure (e.g. total population, urban areas, etc) and vulnerability (e.g. age distribution, land use, etc) that partially shape the socio-economic impact.

3.3.1 Demographic changes

Demographic changes are expected in: (1) age distribution; (2) population size and growth; (3) population mobility/migration/urbanization. In more detail and as far as the age distribution in Europe is concerned, the main characteristic and trend for the future is an aging population which is expected to have a direct impact on the vulnerability of societies to natural disasters. In contrast with the high birth rates of the decades following the Second World War, since the 1970's negative trends in the population structure have been observed (Stula and Linz, 2010).

The low birth rates in combination with low mortality rates have led to an ageing population. This ageing population may be more vulnerable to some hazard types (e.g. heat waves) and less able to adapt to climate change (low adaptive capacity) (ESPON, 2013). The percentage of elderly in Europe is expected to increase from 17.1% to 30% in 2060 whereas the percentage of people more than 80 years old will triple by 2060 (Eurostat, 2008 and EEA, 2012). Even though the available literature does not provide us quantitative estimates, these European trends are expected to take place in the Danube macro-region, too.

Population growth and urbanization may also have an indirect impact on the vulnerability to natural hazards since the urban sprawl will be responsible for more paving of surface, and higher temperature in cities (heat island effect).

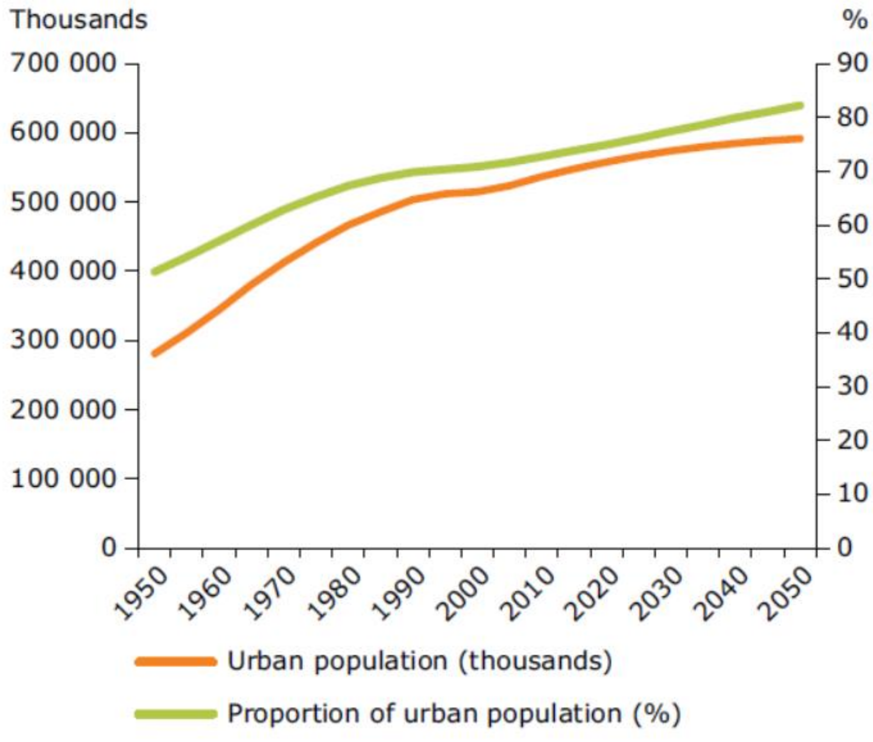


Figure 3.3.1 European urban population trends (EEA, 2012)

Increasing urban land intake and urbanization have resulted in the increase of vulnerability of European cities to climate change related hazards such as heat waves, flooding and drought. This has been obvious through the consequences of events such as the flooding of river Elbe in 2002 (EEA, 2012) The European urban population trends are demonstrated in Figure 3.3.1 According to the United Nation Global Report on Human Settlements - Cities and Climate Change (UN-Habitat, 2011) although the percentage of people living in cities of less than 500,000 will slightly decrease, the percentage of people living in megacities (more than 10 million people will increase (from 8.2% in 2000 to 10.4% in 2020 (UN-Habitat, 2011).

3.3.2 Land use change

The European Environment Agency (EEA) has produced a report on land use in Europe with a focus on land-use outlooks for the year 2020. More specifically, the land-use outlooks cover two dimensions: changes between different land-cover categories and changes within land cover categories. According to this report urban areas are expected to increase by 1% in 2020 in comparison with the 2000 level. Agricultural land use is expected to decrease in contrast to the forest area which is expected to increase by 5% between 2000 and 2020 (EEA, 2010). The study of Pérez-Soba et al. (2010) presents modelling approaches of land-use for Europe together with theirs associated uncertainties.

As far as land cover change and the impact on the consequences of natural hazards are concerned, one of the most predominant changes is the increase of soil sealing. Soil sealing is “the permanent covering of an area of land and its soil be impermeable artificial material such as asphalt and concrete” (EC, 2012). The impact of soil sealing on the hydrological cycle is schematically shown in Figure 3.3.2. Soil sealing in built up areas may decrease the water storage capacity of the floodplain leading to an increase of flood risk and flood damage. Some European examples may highlight the size of the problem: for example, the Rhine and the Elbe have lost four 80% and 86% of their natural floodplains (EC, 2012). It is clear that the problem will continue since everyday an additional 27 hectares of land is sealed in Europe, primarily due to the steady expansion of the transport network (IASS, 2013). Soil sealing plays also an important role in the urban temperature and the development of the urban heat island. Soiled surfaces in cities may be up to 20% warmer than unsealed or vegetated ground (IASS, 2013).

3.3.3 Other socio-economic change

Other socio-economic changes such as unemployment, financial crisis, changes in the Gross Domestic Product (GDP) can affect the overall impact of natural hazards in a community. According to Kriegler et al (2012), only a limited number of studies based on socio-economic scenarios have been developed to support climate change adaptation. Studies that have considered socio-economic scenarios include the work of Arnell et al. (2004) and Rounsevell et al. (2006).

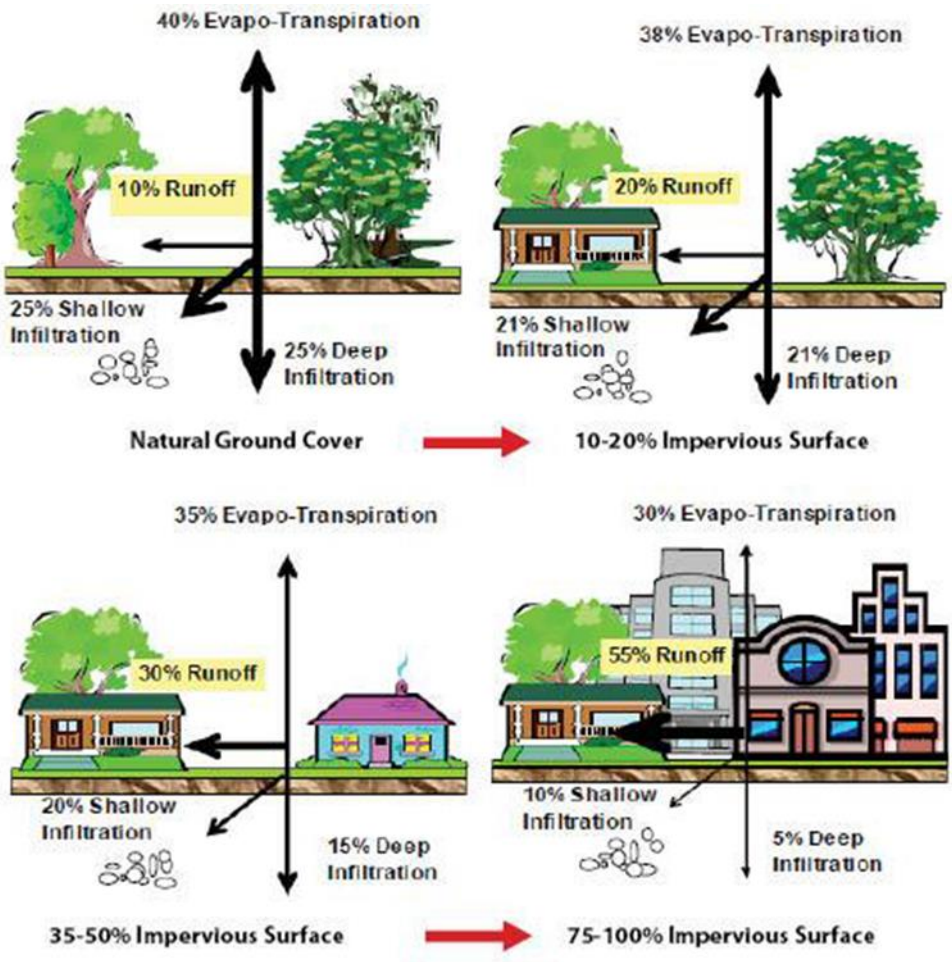


Figure 3.3.2 Impact of soil sealing on the hydrological cycle (EC, 2012)

4. Risk changes for selected hazards under future climate

4.1 Heat waves

Heat-waves defined as prolonged spells of anomalous high temperature that lasts from several days to weeks have a strong impact on the society including a rise in mortality and morbidity. Heat waves also affect infrastructure (power, water, and transport). The heat wave has no universal definition. The term is relative to the usual weather in the analyzed region (Lass et al., 2011). The World Meteorological Organization recommended as the definition of heat wave the interval when the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5 Celsius degrees, the reference period being 1961–1990 (Frich et al. 2002). In some cases, there are definitions implemented in national legislation such as the Romanian regulation that indicates the socio-economic measures for heat wave intervals defined as two consecutive days with maximum air temperature greater than 37º C (or with the maximum daily value of thermal comfort index greater than 80). In Hungarian regulation a heat wave is defined as the interval of three consecutive days with the day average temperature above 27ºC.

In the case of heat waves, the hazard is the increase in temperature. Future changes in temperature and related variable have relatively high certainty (ICPDR, 2013) that is why investigating future changes to heat wave-related hazards lead to results with a low level of uncertainty. The main problem in building hazard maps for heat wave at the urban scale is the lack of high resolution air temperature measured there. Downscaling methodologies are needed for different urban areas in the Danube macro-region to describe how they respond to climate variability and change. Usually, this type of methodologies are based on regional climate simulations with limited-area models running at resolution finer than 10 km coupled with the Town Energy Balance (TEB) (Mason et al., 2000) scheme as described in the paper of Hamdi et al. (2014). In order to downscale the regional climate data to an urban scale of 1-km resolution, a standalone surface scheme including TEB has to be used. The results of this type of simulations can add insights in the interactions between climate change and the urban heat island and allow the study of the UHI during heat-wave episode under both present and future conditions.

The hazard component of the future changes in heat wave risk can be derived using the high-resolution dynamical downscaling methodology developed by Hamdi et al. (2014) applied to climate projection results such those exemplified in the Chapter 3, section 3.2. These results from climate projections are taken from both CMIP 3 data (under SRES scenarios) and CMIP 5 (under RCPs). The CMIP 3 and CMIP5 are the results of numerical experiments with global climate model. Another approach could be to start the fine downscaling procedure from the results of regional climate models (e.g. ENSEMBLES for CMIP 3 and EuroCORDEX for CMIP 5).

As for impact side, exposure refers to the inventory of elements at the location at which hazard events may occur. A typical indicator of exposure to heat waves is population census data from the areas affected.

Vulnerability metrics is defined by the lack of material or social resources to cope with or mitigate the effects of extreme heat. The vulnerability depends on factors such as: (1) physical exposure (working outside, living in a home without air-conditioning in urban area etc.); (2) sensitivity to a given heat exposure (e.g. age - children and elderly people are more vulnerable, sex - women tend to be more vulnerable to heat stress than men, health condition due to pre-existing respiratory and cardiovascular diseases, and body mass); (3) access to treatment (such as lack of information or medication due to poverty) (Buscail et al. 2012).

The final risk map is generated from the combination of the hazard index, and the exposure and vulnerable index. In the concrete case of Arad municipality, the future risk mapping could follow the present qualitative approach by using a risk matrix to superimpose the hazard and impact components. We could imagine a range of scenarios in which we assume, for instance, that (1) total population, city skyline and built areas remain roughly the same (i.e. the exposure), but with changes in hazard (more frequent, persistent and strong heat waves) and vulnerability (e.g. aging population trend) – the business as usual scenario; (2) the total population remain the same, city skylines and built area are modified to adapt to a stronger thermal stress but with higher level of hazard occurrence and higher vulnerability – the adaptive scenario. The two scenarios demand different risk matrices to reflect levels of (no) acceptable risks.

Also, in order to better map the future risks, the impact should be decomposed into exposure and vulnerability to use their modeled projections. This was not the case for the risk mapping of heat wave risk in Arad (Romania) performed in the SEERISK project under the present climate conditions. In this regard, ORIENTGATE project offers examples of good practices in using exposure and vulnerability assessment under climate change scenarios for their case studies of Veszprem city and 13th district of Budapest.

The downscaled data from model results can help in identifying a quantitative relation between hazard and impact (e.g. Michelozzi et al., 2010). These elements together with scenario-derived data on impact can provide risk curves instead of risk matrices. Furthermore, based on business as usual and adaptive scenarios one could estimate the costs of feasible adaptive measures and the benefits in downgrading health population vulnerability.

4.2 Floods

In the flood case, the future changes projections of hazard are more uncertain than in the case of heat waves due mainly to the fact that the level of certainty related to the future evolution of precipitation is less reliable than temperature changes (ICPDR, 2013). Also, projections of extreme hydrological events are generally more uncertain than changes in the mean water availability. Furthermore, impact assessment of climate variability and change on floods requires projections on both high spatial resolution and short-duration precipitation extremes. The relevant time scales can be very short, which needs effective statistical downscaling of climate model results (Arnbjerg-Nielsen, 2012). Stochastic weather generator and regression-based downscaling methods are usually applied to generate high resolution climate data both in time and space. Vulnerability and risk mapping and adaptation approach which are developed for flood cases have to take higher uncertainties into account. Most of the available future projections are based on the IPCC SRES scenarios A1B and A2 (e.g. ICPDR, 2013). The 4th IPCC assessment report predicts that climate change will increase the occurrence of flash floods across the EU river basins, too. In contrast with the SEERISK flood case studies which were performed under present climate conditions (for Senica in Slovakia and Sarajevo Bosnia & Hertzegovina; see SEERISK Consortium, 2014), hazard assessment of future floods needs hydrological models coupled to downscaled climate results to simulate changes in future stream flows and other local hydrological processes.

For the Middle Danube River Basin, studies based on IPCC SRES scenarios show a pronounced increase in flash floods due to more extreme weather events (torrential rainfall) especially in the small basins (e.g. Sava and Tisza). The studies of the Low Danube River Basin indicate an increase in flood frequency, too. Flood events are projected to occur more frequently particularly in winter and spring, although estimates of changes in flood frequency and magnitude remain uncertain. The uncertainty of flood prediction is especially high in small catchments (ICPDR, 2013). The scale and frequency of floods are likely to increase due to climate change - which will bring higher intensity of rainfall but inappropriate river management and construction in flood plains which reduces their capacity to absorb flood waters contribute to amplify the natural hazard. Also, the number of people and economic assets located in flood risk zones continues to grow. This leads to a number of new challenges to flood risk management.

Urban areas are also prone to floods. Heavy precipitation induced by climate change could cause significant damage in urban areas. In urban areas, if this rainfall is combined with thunderstorms, additional problems such as electrical failures could worsen the consequences because pumping facilities may stop. Low intensity rainfall events would cause no direct harm to the urban drainage system. However, they may worsen the effect of events that follow due to saturation of the area. Extreme rainfall events would be likely to cause increased basement floods and surface floods, as well as sewer overflow. The impact of increased surface water flood risk in urban areas is likely to be compounded by urban creep (which results in faster runoff from impermeable areas and less infiltration) and the increasing value of the assets likely to be affected. To manage urban floods in view of climate change, specific consideration are required in relation to the design and dimensions of water run off systems, and management of reservoirs and infrastructure such as underground parking.

Suggested actions for adaptation consist of (1) assessment of the projected increase in maximum rainfall intensity across Danube basin due to climate change; (2) understanding the disaster potential of surface water flooding in both river basins and urban areas to promote awareness of local communities and local and national administration; (3) guidance or examples of good practice on adaptation for both river basins and urban areas.

4.3 Drought

Droughts are defined by the decrease of average water availability mainly due to rainfall reduction. Droughts can occur anywhere in Danube macro-region, in both high and low rainfall areas and in any seasons. The impact of droughts can be exacerbated when they occur in a region with low water resources or where water resources are not being properly managed resulting in imbalances between water demands and the supply capacity of the natural system (EC, 2011). There are three basic types of droughts: meteorological, agricultural and hydrological. Although there are uncertainties in climate change impacts on low flows, droughts and water scarcity, these are more reliable than changes in floods which show larger uncertainty (ICPDR, 2013).

Expected future climate evolution in this region is directed towards warm and drier summers under both types of IPCC SRES and RCP scenarios (see also Section 3.2). Significant part of the Danube Macro-region is already vulnerable to frequent occurrence of droughts that have adverse effects on the people living in drought-prone areas due to impacts on water scarcity, land degradation, agricultural production and ecosystems degradation. In addition, climate change amplifies the frequency and severity of droughts in the all region as climate model results based on IPCC SRES scenarios have shown (figure 4.3.1). The common feature across the Danube Macro-region countries is that all of them are especially sensitive with respect to both variability and change in precipitation.

The study of ICPDR on Danube climate change adaptation (2013) based on IPCC SRES scenarios indicates that within the Danube River Basin, drought and low flow events as well as water scarcity are likely to become more intense, longer and more frequent. Thereby, frequency could increase especially for moderate and severe events. Due to less precipitation in summer these extreme events will be more severe in this season, whereas they will become less pronounced in winter. In some parts of the Danube Macro-region, the drought risk will increase drastically in the future leading to possible economic loss, increase in water conflicts and water use restrictions. The southern parts of Hungary and Romania as well as the Republic of Serbia, Bulgaria are likely to face severe droughts and water stress resulting in water shortages. In Alpine areas, e.g. some parts of Austria, no clear trend or even a slight improvement of the low flow and drought situation were identified. Therefore Alpine watersheds remain important for downstream areas during drought periods. The future low flow situation depends also on changes in water use, which could worsen or improve the general trend (ICPDR – Danube study – Climate change adaptation, 2013). Effects of droughts occurrences are: (1) degradation of surface water quality; (2) urban water supply shortages; (3) groundwater deplition; (4) economic losses in agricultural, tourism and industrial sectors.

A common feature of the Danube Macro-region is that the most vulnerable sector to drought impact is agriculture. The SEERISK pilot study on drought was chosen to take place in Kanjiza (Serbia) – in a predominantly agriculture area (SEERISK Consortium, 2014). Impact assessment of future drought on agriculture needs crop models coupled to downscaled climate results to simulate changes in future local crops and associated costs and benefits. Biophysical processes of agro-ecosystems are strongly affected by environmental conditions. The projected increase in GHGs will affect crops either directly (primarily by increasing photosynthesis at higher CO2 (Drake et al., 1997) or indirectly through effects on drought which in turn affect ecosystem dynamics (Olesen and

Bindi, 2002). The exact responses depend on the sensitivity of the particular agro-ecosystem and on the relative changes in the controlling factors. ORIENTGATE project presents examples of crop modeling approach for maize and winter wheat in Romanian case studies (National Meteorological Administration, 2014). In this context, it is also noteworthy to mention that agriculture is not only sensitive to climate change, but its activities are also among the contributors to global warming through emissions of several greenhouse gases (primarily carbon dioxide, methane, and nitrous oxide).

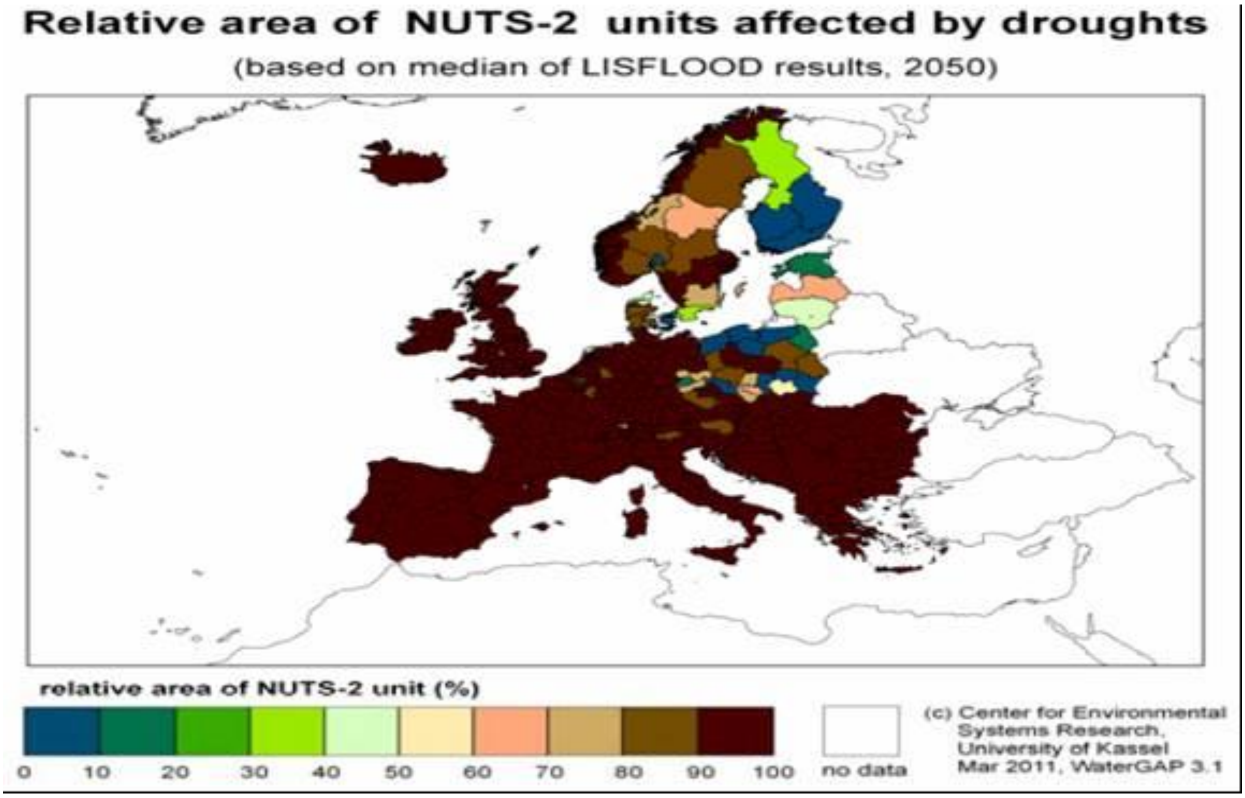


Figure 4.3.1 Share of NUTS-2 area affected by sever drought event; MQD10future < MQD50base in the 2050s. Median of ensemble drought results as calculated by LISFLOOD (Source: EC report, 2011).

The effects of drought are related not only to physical nature of the hazard, but also depend on the society's ability to manage the associated risks. Drought monitoring, early warning, prediction are all necessary because the associated risk under climate change is affecting and will affect the entire Danube macro-region (figure 4.3.1). The EC report

(2011) shows that although most countries from the Danube Macro-region have well developed meteorological and hydrological monitoring, these systems have to be used more via synergetic efforts to support decision makers in sectors such as agriculture, tourism etc. Even though countries (with a strong tradition of agriculture production) have developed robust agro-meteorological monitoring and drought warning systems, preparing for the future climate change is still a challenge in the Danube macro-region. Transnational integrated approach is needed for successful tracking of drought, comparing its impacts using common methodology and for assessing vulnerability of various sectors to drought occurrence.

The main guiding principles for drought risk reduction include: (1) political commitment; (2) knowledge development; (3) drought policies that focus not only on reactive approaches but also on proactive approaches like adaptation strategies development; drought monitoring, risk assessment, identification of appropriate risk reduction measures; (4) developing policy mechanisms to enforce drought reduction strategies; (5) long-term investments (WMO, 2011).

4.4 Wild fires

The hazard component of future risk in wild fires could be considered more reliable compared with other risks due to the fact that future changes in temperature and related variable have highest certainty (ICPDR, 2013). Rising average summer temperatures are associated with an increase in area affected by wild fires. As the climate get hotter, moisture and precipitation levels are changing, with wet areas becoming wetter and dry areas becoming drier (IPCC, 2013). Higher spring and summer temperatures and earlier spring snow-melt (expected to occur in the Danube macro-region) typically cause reduced soil moisture, increasing the likelihood of drought and a longer wild fire season. These hot, dry conditions also increase the likelihood that, once wild fires are started by lightning strikes or human error, they will be more intense and persistent. Forests are the most likely areas to face greater risks from wild fires as conditions grow drier and hotter. Dry grassland areas may be at lower risk due to the fact that strong aridity is likely to prevent this vegetation from growing at all, leaving grasslands without potential “fuel” for wild fire. The hazard of wild fires is physically-related to drought hazard and the SEERISK pilot study in Kanjiza (Serbia) demonstrates that. Another wild fire risk assessment was performed in the mountain region of Velingrad (Bulgaria) (SEERISK, Consortium, 2014).

Long-term trends indicate the costs and dangers associated with defending homes in the wild land/forest - urban interface will increase. However, how exposure and vulnerability add their effects to that of changes in hazard component to shape the future risks of wild fires in the Danube Macro-region is not very clear in the present available literature.

The society needs to adapt to higher risks for wild fires means by creating buffer zones between human habitation and susceptible forests, improved integration of wild fire mitigation plans into local regulations. At national level, there are administrative solutions such as: (1) grant benefits to incentive for improved local land use planning; (2) providing assistance for land use planning to local administration; (3) improving firefighter safety through improved public education and active participation in local land use planning; (5) mapping fire risk using national standards, with incentives for added detail by local administration.

4.5 Windstorms

Windstorms regularly cause heavy property damage in the European infrastructure. The windstorms are the most costly insured hazard in the Europe (Haseemkunju et al., 2014). The analysis made by Donat (2010) shows that the intensity of extra-tropical cyclones associated with wind storm in Central Europe is increased by about 10 % in ensemble mean in the Eastern Atlantic and in the North Sea. Furthermore, the wind speeds during storm events increase significantly over large parts of Central Europe by about 5 %. Analyzing extreme wind speeds and the related loss potentials, enhanced speed values and risk of loss are found over the northern parts of Central and Western Europe, whereas significant reductions are found over southern Europe and the Mediterranean (Donat, 2010).

However, global and regional model results suggest that the extreme wind speeds does not show significant changes under global warming scenarios over the Danube macro-region (see Section 3.2). The location of SEERISK pilot case of risk assessment for extreme winds was in Siofok (Hungary). The hazard component of the risk related to extreme wind episodes seems to remain dominated by the natural climate variability in the coming decades in this region, too.

The present literature lacks analysis of risk losses due to wind storms under future climate conditions in the Danube Macro-region (e.g.

Schwierz et al, 2010; Donat, 2010). Even though, climate adaptation efforts for reducing future risks related to windstorms need to include adequate settlement planning, establishment of appropriate construction standards and the development of early warning systems.

5. Synergies, conclusions and follow up

5.1 Thematic Pole 5 on Climate Change Adaptation in the South East Europe

Thematic Pole 5 on Climate Change Adaptation within the South East Europe Transnational Cooperation Programme consists of projects addressing climate change adaptation which have the common aim of creating knowledge, measures, mechanisms, policies to address the adaptation to climatic events that might endanger ecosystems and human systems.

Forecasting the evolution of such hazards under climate change conditions and assessing related risks for adapting local and national policies to the effects of climate change are important themes of the projects within Thematic Pole 5 on Climate Change Adaptation. SEERISK is part of this pole. One of the main aims of SEERISK was developing and testing a Common Risk Assessment Methodology for the Danube macro-region of which the most tangible outcomes are risk maps. Also, the SEERISK project investigated and revealed the gaps between knowledge provided by risk experts and the awareness of local communities related to climate change. The SEERISK project contributed to close the gap between risk exposure and preparedness in the Danube macro-region.

Another component of this Pole is the project "A network for the integration of climate knowledge into policy and planning" (ORIENTGATE). The ORIENTGATE project fosters concerted and coordinated climate adaptation actions across the SEE region by (1) exploring climate risks faced by coastal, rural and urban communities; (2) contributing to a better understanding of the impact of climate variability and change on water regimes, forests and agro-ecosystems; (3) analyzing specific adaptation needs in the hydroelectricity, agro-alimentary and tourism sectors. The principal ORIENTGATE results relevant for our report on future risks include six pilot studies of specific climate adaptation exercises, a data platform connected to the EU Clearinghouse on Climate Adaptation, dashboard based monitoring system, policy guidelines which ensure the improvement of climate change policy. ORIENTGATE aims at the implementation of concerted and coordinated climate adaptation actions across south east Europe. Its consortium focuses on case studies in urban, rural and coastal regions. It is a two and a half year project which was launched at the same time with SEERISK project. The project has also developed a methodology for risk assessment for risks related to climate variability and change. The methodology was developed in order to harmonize existing methodologies but also to enable the communication on the part of hydro-meteorological services. Moreover, the project encouraged the use of acquired climate adaptation knowledge and experience in territorial planning and development and it also enhanced the capacity to reconcile the risks and opportunities in environmental changes. The two projects (ORIENTGATE and SEERISK) took the opportunity of exchanging experiences through presentations of results from one project to the other.

The DANUBE FLOOD RISK project, part of the Thematic Pole 5 on Climate Change Adaptation, focused on the most cost-effective measures for flood risk reduction: risk assessment, risk mapping, involvement of stakeholders, and risk reduction by adequate spatial planning, by jointly developing a scalable system of flood risk maps for the Danube River floodplains under present climate conditions. Another Thematic Pole 5 project is the Drought Management Centre for Southeastern Europe (DMCSEE) project which coordinated development and application of drought risk management tools and policies with the goal of improving preparedness and reducing drought impacts. The DMCSEE monitors and provides regional information on drought situation in the SEE regions. Using common methodology in drought analysis and impact assessment the DMCSEE obtained regionally comparable results enabling better overview of drought situation for sectors economically dependent on water availability, such as agriculture, energy and tourism. Anther component of the Thematic Pole 5 on Climate Change Adaptation is the MONITOR II project which aimed to transnational coordination of hazard mapping and contingency planning. This project produced a common methodology and a CSA ("Continuous Situation Awareness") system. The integration of monitoring systems facilitates periodic update of hazard maps and contingency plans and thus makes them usable in real-time for disaster situations. The CC-WARE project which improved knowledge about the vulnerability of the water resources under climate change in SEE regions is part of the Thematic Pole 5 on Climate Change Adaptation, too. The CC-WaterS project within Thematic Pole 5 identified and evaluated resulting impacts on availability and safety of public drinking water supply for several future decades. It elaborated measures to adapt to those changes build the ground for a Water Supply Management System regarding optimization of water extraction, land use restrictions, and socioeconomic consequences under climate change scenarios for water suppliers in SEE. The EU.WATER project contributed to the Thematic Pole 5 by shaping a common macro-regional answer to increase agricultural output based on water-wise approach and scientific-oriented patterns rooted on traditional agricultural practices. Other contributors to the Thematic Pole 5 on Climate Change Adaptation are the SNAP-SEE project which promote recycling of secondary aggregates, aiming at keeping the natural resources with a positive effect of climate change mitigation and BE-NATUR which addresses the issue of the wise, sustainable use of natural resources in the context of climate change.

5.2 Synergies with other European programmes

The aims and outcomes of the Thematic Pole 5 on Climate Change Adaptation within the South East Europe Transnational Cooperation Programme are in synchronicity with other European Programmes dedicated to improve knowledge on climate change and transfer it to adaptation and disaster management communities. CHANGES (Changing Hydro-meteorological Risks as Analyzed by a new generation of European Scientists) is a Marie Curie Initial Training Network funded by the European Community's 7th Framework Programme. It includes 11 partner institutes and 6 associate partners of which 5 private companies, representing 10 European countries. The aim of the project is to develop an advanced understanding of how global changes (related to environmental and climate change as well as socio-economical change) will affect the temporal and spatial patterns of hydro-meteorological hazards and associated risks in Europe; how these changes can be assessed, modeled, and incorporated in sustainable risk management strategies, focusing on spatial planning, emergency preparedness and risk communication. UNIVIE, who is a very active partner is SEERISK, is also one of the full partner institutes in the CHANGES network, Work Package Leader (WP2 - Evaluating changes in exposed elements at risk and their vulnerability) and host institution for the Early Stage Researcher (ESR) involved in the research team of this project proposal. UNIVIEs contribution to the project focuses mainly on uncertainty quantification in vulnerability assessment of infrastructure and buildings exposed to hydro-meteorological hazards. Knowledge acquired during this project regarding vulnerability but also regarding future scenarios and changes has been also used for the development of the common risk assessment methodology of SEERISK. The two projects run almost parallel and although CHANGES has a strong scientific focus, exchange of experiences and findings were possible due to the common participation in both projects by UNIVIE.

MOVE stands for Methods for the Improvement of Vulnerability assessment in Europe. It was an FP7 European which involved 13 European partners. MOVE's main objective was to create knowledge, frameworks and methods for the assessment of vulnerability to natural hazards in Europe. By identifying gaps in existing methodologies it used indices and indicators to help improve societal and environmental resilience placing emphasis on clear, capable measurement and accounting for uncertainties. One of its final products was a conceptual framework that is independent of scale and hazard type. The methodologies developed aimed at the analysis of physical, technical, environmental, economic, social, cultural and institutional vulnerability measured for specific hazards and at different geographical scales and were applied in 7 European case study areas. MOVE focused mainly on one part of the risk assessment process (vulnerability) it formed a basis for the development of the risk assessment methodology of SEERISK. Synergies between the projects were ensured by the common participation of UNIVIE.

ChangingRISKS is an EU-funded project which aims at the definition of potential impacts of global environmental changes on landslide hazards, the analysis of consequences in terms of vulnerability and the implementation of a strategy for quantitatively investigating and mapping indicators of mountain slope vulnerability exposed to landslides. UNIVIE was an active partner in that project and the knowledge gained was transferred in SEERISK.

Austrian Panel on Climate Change (APCC) is a Project which is financed by the Climate and Energy Fund (Klima-und Energie Fond). The results of the projects are presented in the Austrian Assessment Report 2014-AAR14". The report suggest that due to the foreseeable socio-economic changes in combination with the expected climate change the loss potential in Austria will increase for the future. For this reason Austria adopted in 2013 a national adaptation strategy in order to cope with the consequences of climate change. However, the strategy has not been fully evaluated yet. Nevertheless the report is an excellent example of an assessment of the future changes and consequences for a specific country which could be used also for other countries or even regions in order to assess the future impact of climate and global environmental change (APCC, 2014).

The EUPORIAS (EUropean Provision Of Regional Impact Assessment on a Seasonal-to-decadal timescale) is a FP7 ongoing project which aims to develop end-to-end impact prediction services on seasonal to decadal scales. Together with the results of FP7 project SPECS which provides new climate prediction systems, EUPORIAS products are intended to enhance ability of European Union regional and national authorities to make effective decisions in climate-sensitive sectors of economy and society at large. Seasonal to decadal scales are most relevant to climate-related disaster reduction and adaptation communities. However, barriers and limitations to the use of seasonal to decadal prediction, identified by EUPORIAS, relate mainly to issues of skill and predictability on these scales. Hindcast results indicate that in the particular case of predicting summer temperature with a couple of months in advance there are predictability and skill for the SEE regions (). In this context, we identified synergies rising from EUPORIAS, SPECS and SEERISK projects in the particular field of heat wave related risks for health population. A case study in EUPORIAS investigates the relationship between climate variables and mortality rates during the warm season in the recent observational period and infers the future evolution of mortality from climate/mortality relationships and climate model projections. Results will be expressed as a function of adaptation scenarios, additionally including estimates about the change in society's demographic profile, such as population size and age (http://www.ic3.cat/detail_topic.php?menu=95&tema=2). Starting from the SEERISK pilot study in Arad and using EUPORIAS together with SPECS advancements in the field of seasonal to decadal prediction, we will better assess risks related to heat wave for health in SEE urban areas and include this assessment in preparedness planning of disaster reduction and in adaptation strategies. Synergies between the projects are ensured by the participation of Meteo-Ro team in both SEERISK and EUPORIAS.

5.3 Conclusions and follow up

Improving the use of climate risk assessment and/or prediction in decision making related to disaster reduction and adaptation requires identifying the specific opportunities for management to take an appropriate action and intervene within the specific community. In order to use climate information one needs an initial understanding of the impact of climate variability and change within the community of interest and, especially, to seek to understand where in functioning of that community climate issues are of paramount importance.

Then it is important to determine the opportunities for tactical or strategic measures in response to climate risk assessment and/or prediction.

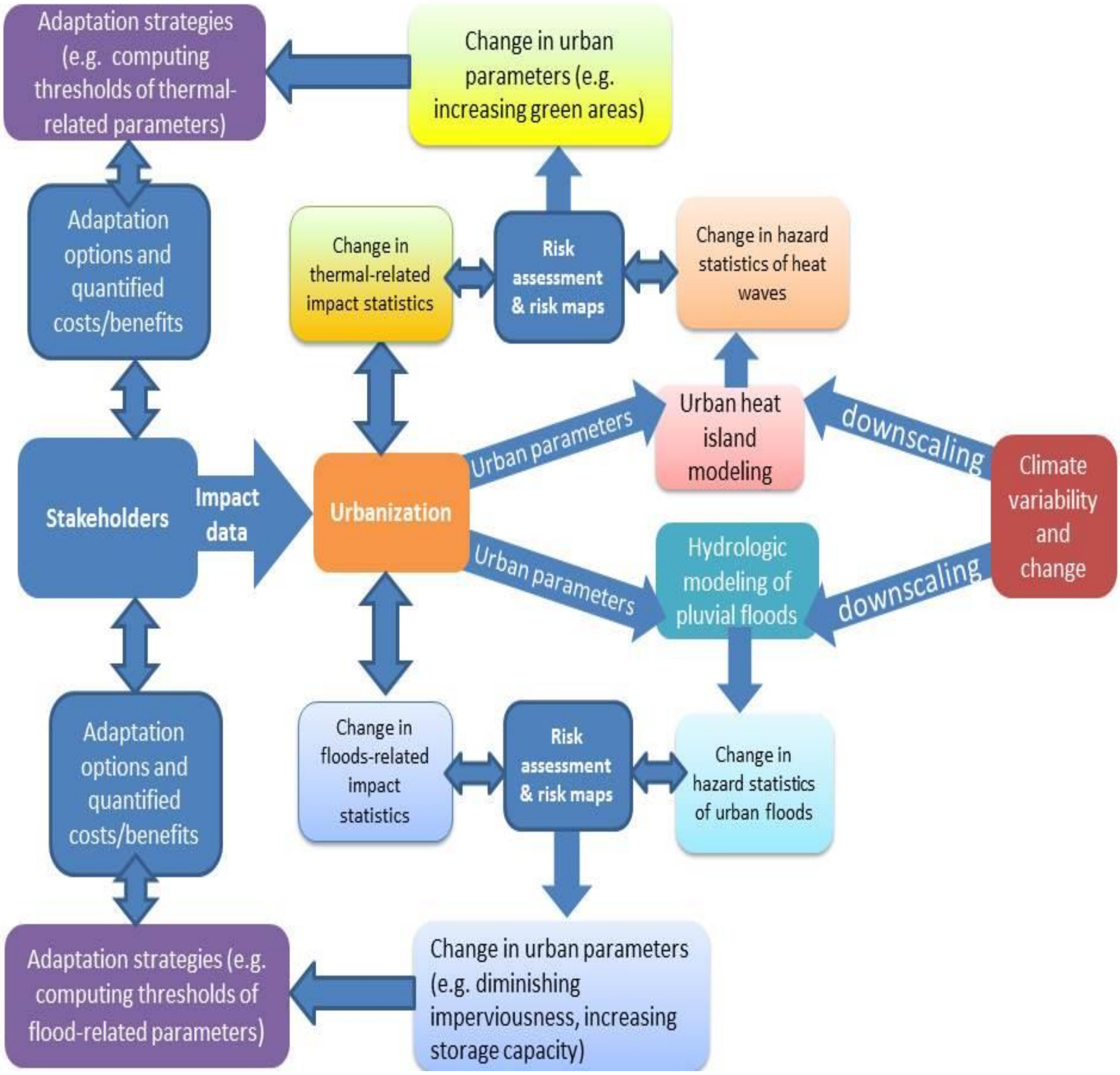


Figure 5.3.1 Examples of synergies in linking climate-related risk assessment with adaptation for specific climate-related hazards.

In this respect, it is then important to identify what possible options there may be at relevant decision points within risk reduction or adaptation communities and how decisions might be changed in response to climate prediction and/or climate risk assessment. Also, within this framework, it is important to identify what lead - time is required for management decisions in a particular climate-affected community. Risk reduction community tends to focus on shorter time scales of climate such as those of seasonal prediction, while adaptation community concentrates more on longer time scale from decadal climate prediction to interdecadal climate projection.

In the SEE Transnational Programme, the SEERISK project mostly targeted the disaster management community while the ORIENTGATE project was more adaptation-orientated. However, the two communities share common interests, too. They are interested in seasonal climate prediction and both use interdecadal climate information for assessing hazards. Also, both communities have to fill the gap between climate experts and stakeholders in understanding of climate change and raise awareness of people on these issues. The involvement of stakeholders in assessing climate-related risks and in finding ways to effectively use climate predictive information is essential for both disaster management and adaptation. Stakeholders have to be involved in an interactive way in the process of climate-related risk assessment, climate prediction and associated activities for risk reduction and adaptation (see figure 5.3.1).

Acknowledgements

We acknowledge the World Climate Research Programme's Working Group on Regional Climate, and the Working Group on Coupled Modelling, former coordinating body of CORDEX and responsible panel for CMIP5. We also thank the climate modelling groups for producing and making available their model output. We also acknowledge the Earth System Grid Federation infrastructure an international effort led by the U.S. Department of Energy's Program for Climate Model Diagnosis and Intercomparison, the European Network for Earth System Modelling and other partners in the Global Organisation for Earth System Science Portals (GO-ESSP)

Annex 1 List of cited projects and programmes

No	Programme	Project Acronim	Project Name	Web address
1	Klima- und Energie Fond	APCC	Austrian Panel on Climate Change	http://www.apcc.ac.at/
2	SEE	BE-NATURE	Better management of Natura 2000 sites	http://www.be-natur.it/
3	SEE	CC-WARE	Integrated transnational strategy for water protection and mitigating water resources vulnerability	http://www.ccware.eu/
4	SEE	CC-WATERS	Climate Change and Impacts on Water Supply	http://www.ccwaters.eu/
5	FP7 Marie Curie Actions	CHANGES	Changing Hydro-meteorological Risks as Analyzed by a new generation of European Scientists	http://www.changes-itn.eu/
6		ChangingRISKS	Changing pattern of landslide risks as response to global changes in mountain areas	http://eost.u-strasbg.fr/omiv/ChangingRisks.html
7	SEE	DANUBE FLOODRISK	Danube Floodrisk	http://www.danube-floodrisk.eu
8	SEE	DMCSEE	Drought Management Centre for Southeastern Europe	http://www.dmcsee.org/
9	FP7	EUPORIAS	EUropean Provision Of	http://www.eupori

			Regional Impact Assessment on a Seasonal-to-decadal timescale	as.eu
10	SEE	EU.WATER	Transnational integrated management of water resources in agriculture for the EU WATER emergency control	http://www.eu-water.eu/
11	SEE	MONITOR II	Practical Use of Monitoring in natural Disaster Management	http://www.monitor2.org/
12	FP7	MOVE	Methods for the Improvement of Vulnerability assessment in Europe	http://www.move-fp7.eu/index.php?module=main
13	SEE	ORIENTGATE	A network for the integration of climate knowledge into policy and planning	http://www.orientgateproject.org/
14	SEE	SEERISK	Joint Disaster Management risk assessment and preparedness in the Danube macro-region	http://www.seeriskproject.eu
15	SEE	SNAP-SEE	Sustainable Aggregates Planning in South East Europe	http://www.snapsee.eu/
16	FP7	SPECS	Seasonal-to-decadal climate prediction for the improvement of European climate services	http://www.specs-fp7.eu/

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