NOVEL MULTI-SECTOR PARTNERSHIPS IN DISASTER RISK MANAGEMENT

RESULTS OF THE ENHANCE PROJECT

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Partnership for Risk Reduction

Novel Multi-Sector Partnerships in Disaster Risk Management

Results of the ENHANCE project

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Foreword

This book is the final result of the ENHANCE project. This project aimed at developing and analysing novel ways to enhance society's resilience to catastrophic natural hazard impacts. It analysed and developed new multi-sector partnerships (MSPs) between public and private sectors, with emphasis on the financial sector. MSPs are voluntary but enforceable commitments between partners from different sectors (public authorities, private services/enterprise and civil society), which can be temporary or long-lasting. They are founded on sharing the same goal: reduce risk and increase resilience. The project was carried out by 25 partners from academic institutes, governmental sector, private companies, and international organisations, with emphasis on the financial sector such as insurance.

The ENHANCE project has studied ten case studies on risk reduction, taking place at different geographical and spatial scales in Europe. The case studies are related to heat waves, forest fires, floods, droughts, storm surges, and volcanic eruptions. Based on these case studies the project has assessed current partnerships, and analysed what risk information is needed to enhance risk management.

In order to develop MSPs that can effectively reduce risk, the first step is to widen the risk information basis of stakeholders, through the development of risk assessment models, evaluation tools, a risk catalogue and toolbox, and the provision of an inventory of existing risk scenarios in Europe. Special attention was paid to economic instruments that can complement already existing disaster risk reduction (DRR) measures within MSPs. For example, insurance schemes can be used to compensate losses after a damaging event. However, it can also be used to provide incentives to households to reduce risk, through deductibles and premium setting. In addition, water pricing can be used as an instrument to limit water consumption in drought prone areas, and raise awareness on water scarcity.

Furthermore, ENHANCE has explored the roles of actors and stakeholders, and has systematically examined their successes and failures in increasing resilience to natural hazards and disasters and their associated risks. Accordingly, this book describes indicators for successful and unsuccessful partnerships and recommendations will be provided as to how to improve cooperation to better manage risk. Finally, the regulatory policy framework is analysed, from the global level (e.g. the Sendai Framework for Disaster Risk Reduction 2015-2030) to the local levels, since regulations can steer the development of partnerships and set the financial and administrative boundary conditions for partnerships for developing DRR measures.

01

Introduction

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Trends in disaster risk

During the past decades, the frequency and economic damage of natural disasters has increased sizeably, both worldwide (Munich Re, 2014) and in Europe. **A number of major disasters have left their marks across Europe, prompting high economic damage and losses, casualties, and social disruption**. Examples include the 2010 eruptions of the Eyjafjallajökull volcano in Iceland; earthquakes in Italy in 2009 and 2012; droughts and forest fires in Portugal and Spain in 2012; heavy rainfall that caused record floods in Central Europe in 2013; floods in the UK in the summer of 2007, and the winters 2014/15 and 2015/16; and a hail storm that hit France, Belgium, and Western Germany in 2014, causing approximately €3.5 billion in damages (Munich Re, 2015).

Natural disaster risks and losses in Europe are **expected to continue rising as a result of the projected expansion of urban and economic activities in disaster-prone areas**. In addition, **climate change might increase the frequency and severity** of certain extreme climate and weather related events, such as droughts, heat waves, and heavy precipitation (IPCC, 2012; IPCC, 2014). These phenomena will continue to unfold as human induced climate change will become more pronounced. Hence, it is imperative to take comprehensive action on disaster risk to improve the resilience of European societies to natural hazards.

Increasing resilience to disasters that are caused by natural hazards is a complex task that involves many actors and often cuts across sectors and geographical scales. Effective disaster risk reduction (DRR) options are complicated because disastrous natural hazard events are often **low-probability/high-impact** in nature (e.g. Mechler et al., 2014). Such events, including frequent events, can trigger a chain of disastrous natural and man-made hazard events at different spatial and temporal scales, which are often ill-observed and under-reported. The massive earthquake, tsunami, and nuclear disaster in north-eastern Japan in March 2011 exemplifies such chain event. In addition, risks from catastrophic events are highly dynamic, varying in time and space due to changing patterns of exposure and vulnerability. With climate change affecting extremes from hydro-meteorological hazards, such risks will also become dynamic and more difficult to estimate (IPCC, 2012).

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The Sendai Framework for Disaster Risk Reduction 2015-2030

Global disaster risk reduction activities have been informed by the efforts of the United Nations Office for Disaster Risk Reduction (UNISDR). Until 2015, UNISDR coordinated the implementation of the **Hyogo Framework for Action: 2005-2015 (HFA)**, which was organized around the main challenges that countries face in terms of natural disaster risk management (UNISDR, 2011). These challenges include: (1) improved risk assessment based on a multi-hazard and multi-risk approach; (2) a more vigorous pursuit of multi-sector partnerships (MSPs); and (3) improved financial and disaster risk reduction (DRR) schemes.

As a follow up to the HFA, the Third UN World Conference on Disaster Risk Reduction (WCDRR, 14–18 March 2015, Sendai, Japan) identified new commitments and targets, which led to the **Sendai Framework for Disaster Risk Reduction 2015-2030** (Mysiak et al., 2016). The first four targets of the Sendai Framework aim to reduce the impact of future disasters, mortality, economic damage, and damage to health and educational facilities. Other targets aim to extend local and national DRR strategies, and are an extension of the HFA's call for better coordination of disaster risk activities with development and other sectorial policies (UNISDR, 2015).

In addition, DRR has received increasing attention as a response to climate change. The **Paris Agreement**, negotiated at the end of 2016 under the United Nations Framework Convention on Climate Change (UNFCCC), sets a global goal of adaptation for the first time to build adaptive capacity, strengthen resilience, and reduce vulnerability to climate change. This new policy emphasises that responses must account for local, subnational, national, regional, and international dimensions and actors across scales. One particular issue in relation to disaster risk is the 'loss and damage' discussion, which has also been formally recognised with the inclusion of the **'Warsaw Loss and Damage Mechanism'** into the agreement. This mechanism informs the action of efforts beyond adaptation, and in addition to discussing responsibility and liability, a large part of the debate has focused on bolstering comprehensive DRR (UNFCCC, 2015).

Multi-sector partnerships

An important part of the Sendai Framework guiding principles calls for partnerships to achieve improved risk management. **The challenge is to improve the way that different institutions and sectors (jointly) cooperate to develop and implement DRR measures. To achieve this, the ENHANCE project has specifically studied multi-sector partnerships (MSPs)**.

MSPs are partnerships that involve a mix of actors from the public and private sectors and civil society organisations. MSPs have the potential to significantly improve disaster risk management, but joint action with the aim of lowering risk involves different stakeholders and can also be challenging (Pahl Wostl et al., 2007; UNISDR, 2011). For example, the different responses to heatwaves in Europe in 2003, 2006, and 2010 and the UK floods in 2015 demonstrate that **the roles of public, private, and civil society actors (including individuals) in preparing for and responding to catastrophic impacts are often not clear or effective**. Moreover, actors must often base their risk management strategies on **scarce, limited, or inaccurate risk information**. This is not surprising, since empirical data on low probability-high impact events is not recorded in available datasets. Together, these factors can lead to the development of ineffective and unacceptable disaster risk management measures and an unexpectedly large impact of natural disasters (financial, ecological, health, and social). In preparing for and responding to natural hazard impacts, there is also often **a lack of clarity on financial responsibilities** about who pays for what, how often, and when.

Knowing that the challenge of managing risks that result from natural hazards has increased, it is clear that these risks cannot be handled by the private sector or the government as single actors, and strategies to increase resilience should therefore incorporate all sectors of society (including closer cooperation between sectors). **The main goal, therefore, of the ENHANCE project was to develop and analyse new ways to enhance society's resilience to catastrophic natural hazard impacts**. **The key to achieving this goal is to analyse new multi-sector partnerships that aim to reduce or redistribute risk and increase resilience**. Within ENHANCE, **we define MSPs as:**

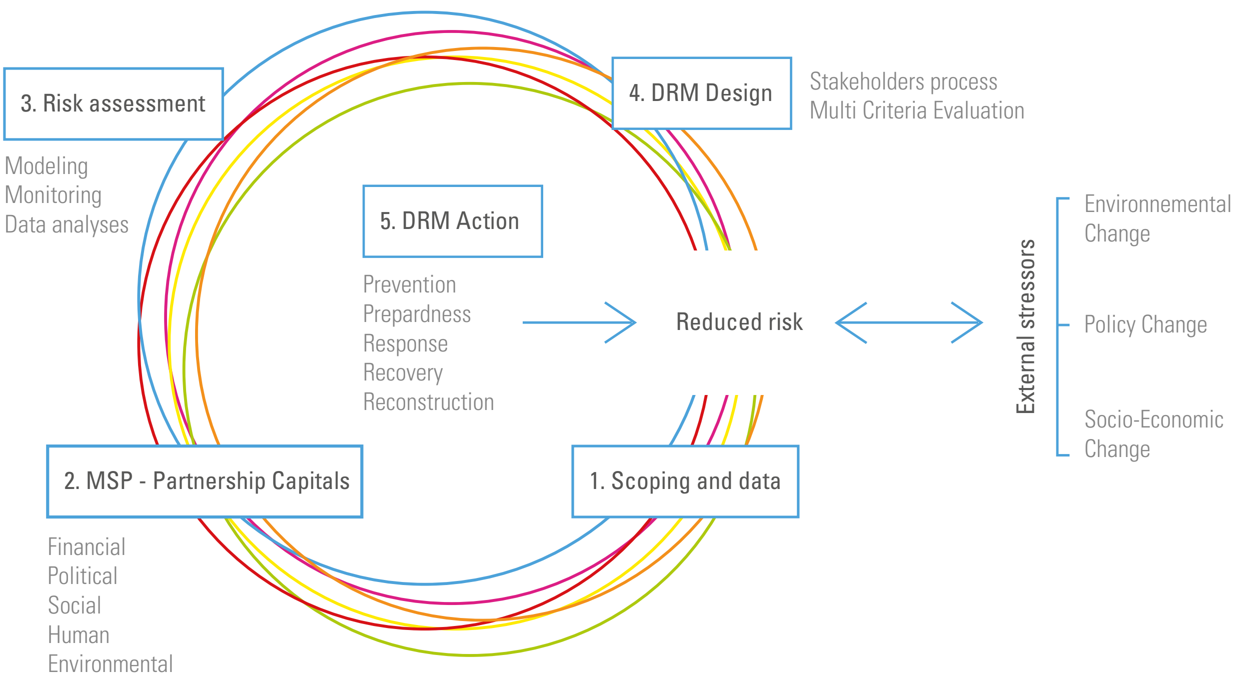
'Voluntary but enforceable commitments between partners from different sectors (public authorities, private services/enterprises, and civil society), which can be temporary or long-lasting. They are founded on sharing the same goal in order to gain mutual benefit, reduce risk, and increase resilience'.

The ENHANCE framework

Figure 1.1 describes the general approach that was followed by ten ENHANCE case studies (See **Table 1.1**). Following the main components of Figure 1.1, the main activities of each case study were (1) to assess the capacity of each existing MSP to reduce or manage risk; (2) to assess current and future risk, including extremes and effects from both climate change and socio-economic developments; and, (3) to explore DRR measures that were developed and governed by the MSP with the aim of reducing risk.

The relationship between resilience and good governance of MSPs is assessed in ENHANCE by **the Capital Approach Framework (CAF)** that was developed during the project to assess governance performance. The CAF

Figure 1.1.
Setup of the ENHANCE framework for assessing the healthiness of MSPs, to assess current and future risk levels, and to reduce and manage risk through DRR design and action.



assesses risk governance performance (See section 1.5) and the influence of risk perception of MSPs on risk management strategies (Chapter 3).

Furthermore, for the risk assessment activities (Chapter 2), different **modelling and statistical techniques** were implemented to assess the magnitude and frequency of extreme events, such as 'extreme value analysis' and joint distribution of risk ('copula's').

Finally, the project explored different **economic instruments** (Chapter 4), such as pricing and insurance (Chapter 5), as part of the different DRR actions, and explored what type of **EU and national policies** are required to develop and maintain such instruments to enhance MSPs (Chapter 6).

Overall, the mix of substantive analysis and application to the ten case studies provided by the ENHANCE consortium served as a rich laboratory for studying the way that MSPs may help to achieve the imperative of DRR, as set out globally by the Sendai Framework, Paris Agreement, and the Sustainable Development Goals (SDGs) debates, to be implemented regionally, nationally, and locally across many hazard-prone contexts. The ten ENHANCE case studies are described in more depth in Part II.

Table 1.1.

Ten ENHANCE case studies on different natural hazards, scales, and multi-sector partnership types.
Note: MSP types: E = Emergency response MSP; R = Risk reduction strategy MSP; F = Financial MSP.

Hazard	MSP	Issue topic	Hazard	Scale	Location	Public and Private Stakeholders
HYDRO	R	Drought management in Júcar River Basin District (Spain)	Drought	Basin	South Europe	Conf. Hidrográfica del Júcar, USUJ, Iberdrola power
	R	Risk culture, perception, & management (North Sea coast)	Storm surge	North Sea	North Europe	Wadden Sea Forum
	F	Flood risk and climate change implications for MSPs (UK)	River flood	Natio-nal-City	West Europe	Insurance Industry, Willis, Greater London Authority, Department for Environment, Food and Rural Affairs, Environment Agency
NON-HYDRO	E	Health preparedness and heat wave response plans (Europe)	Heatwave	EU-wide	EU	HO Europe Bonn and Denmark, EEA
	R	Air industry response to volcanic eruptions (Europe)	Volcanic eruption	EU-wide	EU	Icelandic Aviation Administration
	F	Insurance & forest fire resilience, Santarem District, Portugal	Forest fire	City, local	South Europe	City of Chamusca, City of Mação, CPA, ACHAR, Ch. Firefighters, DRF-LVT, Empremédia
MULTI	E, F	Climate variability & technological risk in the Po basin, Italy	Multi-hazard	Basin	South Europe	Civil Protection Agency, Water Boards, River Basin Authority, Regional Administrations
	R,F	Flood risk management for Rotterdam Port infrastructure (NL)	Multi-hazard	City	North Europe	Port Authority Rotterdam, Municipality of Rotterdam, Rijkswaterstraat, Industry of the Port of Rotterdam
	R	Building railway transport resilience to alpine hazards, Austria	Multi-hazard	National	Alpine, Central Europe	Austrian Railways – ÖBB, WLV
	F	Testing the Solidarity Fund for Romania and Eastern Europe	Multi-hazard	EU	Eastern Europe	EC DG Regio, DG CLIMA, World Bank

Flood in Budapest, Hungary. Copyright: UNISDR.

Assessing the capacity of MSPs to manage risk

In order to assess whether MSPs have the capacity to anticipate natural disaster risk, **the ENHANCE project merged resilience concepts and indicators with a framework for analysing (un)successful governance processes**. While tentative first steps have been made to generate such indicators (e.g. Twigg, 2009), understanding how to properly contextualise resilience indicators for governance and disaster risk management remains challenging. Bahadur et al. (2010) summarised the main components of a resilient societal system, such as: equity, learning, and community involvement. These high-level resilience components are primarily concerned with studying highly integrated systems as a unit of analysis. However, since the ENHANCE project seeks *measurable* resilience indicators for analysing MSPs (often regional and local scales), resilience must be studied in the context of *how* partners cooperate in order to reduce risk.

Another important source for developing indicators to assess the capacity of MSPs is the research by Twigg (2009), who emphasises the importance of stakeholder partnerships that are designed to increase resilience and reduce risk. Twigg (2009) describes 11 factors that may provide a basis for identifying 'healthy' characteristics of an MSP for building resilience or shaping new partnership development: **integration of activities, shared vision, consensus, negotiation, participation, collective action, representation, inclusion, accountability, volunteerism, and trust**.

In order to convert 'resilience – governance factors' into measurable MSP indicators, we developed the **Capital Approach Framework (CAF)**. The CAF is characterised by (a) the understanding of risk as a social construct (Stallings, 1990; Johnson & Coello, 1987); (b) the understanding of governance following the concepts of Fürth (2003), Rhodes (1997), and the more specific risk governance framework (IRGC, 2005); (c) the concept of institutional fit, which is 'the degree of compliance by an organisation with the organisational form of structures, routines, and systems prescribed by institutional norms' (Kondra & Hinings, 1998, p.750); and (d) capital approaches including the capital theory (Smith, 1776), the idea of linking sustainable development to capitals (Serageldin & Steer, 1994; OECD, 2008), and the concept of the five capitals (Goodwin, 2003; OEDC, 2008).

The different capitals provide partnerships with the capacity to react to natural hazards. Capital or capacity is hereby understood as the assets, capabilities, properties, and other valuables, which collectively represent the good functioning of an MSP. **The CAF differentiates between five capitals, which are understood as dimensions of an efficient risk governance performance**: financial, social, human, natural (environmental), and political capital. Political capital has been added to this project and refers to the capability of institutions to enact rules, laws, or frameworks that might change the course of actions. The resilience indicators that are described by Bahadur et al. (2010) and the 11 factors that are described by Twigg (2009) can be allocated within one of these five capitals. The rationale behind this approach is that the maintenance or enlargement of the five capitals will assure the capability of a partnership to react to environmental hazards. In an ideal situation, a sustainable MSP will focus on maintaining and/or enhancing its capitals. The quality of these five capitals is contingent upon existing development and health baselines, as well as the legacy of past disaster impacts.

The five capitals are described as:

- **Social:** the relationships, networks, and shared norms and values that qualify and quantify social interactions, which have an effect on partnership productivity and well-being.
- **Human:** focused on individual skills and knowledge. This includes social and personal competencies, knowledge gathered from formal or informal learning, and the ability to increase personal well-being and to produce economic value. In the case of partnership, the human capital will be the addition of its individual skills and knowledge.
- **Political:** focuses on the governmental processes, which are done/performed by politicians who have a political mandate (voted by the public) to enact policy. It also includes laws, rules, and norms, which are juristic outcomes of policy work.
- **Financial:** involves all types of wealth (e.g. funds, substitutions, etc.) that are provided, as well as financial resources that are bounded in economic systems, production infrastructure, and banking industries. Financial capital permits fast reactions to disasters.
- **Environmental:** comprehends goods and values that are related to land, the environment, and natural resources.

Risk assessment

In order for an MSP to manage risk, **accurate risk assessment and information is critical to any DRR decision**. Risk assessment looks to understand future permutations by constantly updating projections on risk scenarios through risk assessment and reflection (e.g. Tschakert & Dietrich, 2010). Risk assessment can play an important role in measuring the relative influence of an MSP on risk reduction through its actions, for example through applying risk information in decision support, evaluation, and cost-benefit analysis processes (e.g. Watkiss et al., 2014). Risk information also plays an important role in assessing the appropriateness of risk management activities/strategies in anticipation of future risk conditions.

Generally speaking, there are two approaches to arriving at distributions of natural disaster risks: **statistical risk assessments** and **catastrophe models**. The first approach looks only at the past and estimates risk from historical loss data using extreme value theory (Embrechts et al., 1997). A fundamental challenge is how to model the rare phenomena that lie outside of the range of available observation. While much real world data approximately follows a normal distribution, which implies that the estimation of distributional parameters can be done based on such assumptions, for natural hazard extremes, the tails (rare outcomes) are much fatter than normal distributions predict. This is accounted for in extreme value theory, according to which, natural disaster risk distributions are estimated using, for example, Gumbel, Weibull, or Frechet distributions. Typical steps in such an assessment are provided in ENHANCE for all case studies for which sufficient hazard or loss data is available. In the second approach, catastrophe models are applied, which are computer-based models that estimate the loss potential of natural disasters (Grossi & Kunreuther, 2005). This is usually done by overlaying the properties or assets that are at risk (exposure module) with hazard and vulnerability information.

For a sound analysis of current and future natural hazard risks, it is important to understand the **dynamics of the underlying causes of risk**. For example, the projections of climate variability and change should ideally be based on an ensemble of (regional) climate models that capture a broad spectrum of underlying uncertainties. Moreover, **information about exposed economic assets and their vulnerability to hazards** is needed. Combining these three dimensions is a non-trivial task, especially for the assessment of extremes. **In ENHANCE, a new approach was developed to avoid the underestimation of such low-probability/high-impact events**.

DRR and economic instruments

Economic instruments, such as risk financing instruments, water pricing and water markets, private-public partnerships, taxes, and others, can produce incentivising behaviour and increase the uptake and efficiency of adaptation measures by MSPs. The effectiveness of these instruments at reducing risk is frequently debated in the policy and science spheres. Yet, the evidence base on their effectiveness remains limited (even for insurance-related instruments) and there are few conceptual and numerical analyses (Agrawala & Fankhauser, 2008; Kunreuther & Michel-Kerjan, 2009; Bräuninger et al., 2011). For example, the White Paper on the adaptation of the European Commission (EC; EC, 2009) calls for 'optimising the use of insurance and other financial services products, specialised Market-Based Instruments (MBIs) and public-private partnerships with a view to the sharing of investment, risk, reward and responsibilities between the public and private sector in the delivery of adaptation action'.

There is an increasing interest in the use of such economic instruments, which are currently at the heart of the debate on novel approaches to managing risk. The literature suggests that **risk transfer** could play an important role in risk reduction by incentivising the take-up of risk reduction measures (Herweijer et al., 2009; Maynard & Ranger, 2011). Risk transfer removes or reduces the risk of experiencing an uncertain financial loss. However, if designed and operated appropriately, it can also play a role in physical risk reduction and adaptation. There is a semantic challenge that one must consider when analysing the links between risk transfer and risk reduction on one hand, and adaptation on the other: stakeholders do not always speak the same language, and may use many terms in different contexts, such as loss prevention, risk engineering, risk reduction, vulnerability reduction, and climate adaptation. Assessing the effectiveness of a risk transfer scheme at incentivising risk reduction goes beyond pure economic cost-benefit analysis, and must include recognition of the different stakeholder objectives, such as vulnerability reduction, commercial viability, affordability, and the financial sustainability of a scheme in the context of changing risk levels. Measuring this effectiveness remains a challenge, particularly in the context of public-private partnerships because success or failure often only becomes evident after another risk event, and it requires in-depth data collection on the ground.

ENHANCE analysis identified three channels through which economic instruments can contribute to risk management: (1) direct risk reduction: for example, risk financing provides direct compensation payments, which reduce follow-on impacts from an event; (2) indirect risk reduction: incentives for risk management and increased resilience help to reduce and manage risks, (3) managing systemic risk: both down-and upside risk are managed; the insurance takes the down-side (bad risks) risks out of investment decisions, and focuses on harnessing upside risks (good risks).

ENHANCE examined the scope of different economic instruments for enhancing resilience and managing risk, and applied a common framework based on multi-criteria analysis to assess economic instruments in the case studies, in order to specify the suitability of those instruments. The criteria (and associated) indicators comprised the following aspects: economic efficiency, including the link to incentivise disaster risk management, social equity, political and institutional applicability, and environmental effectiveness. Operationalising the criteria universe with a multi-criteria decision-making approach allowed ENHANCE analysts to apply a qualitative scoring matrix to economic instruments across five ENHANCE case studies.

Flood in the UK, 2006. Copyright: UNISDR.

DRR and insurance

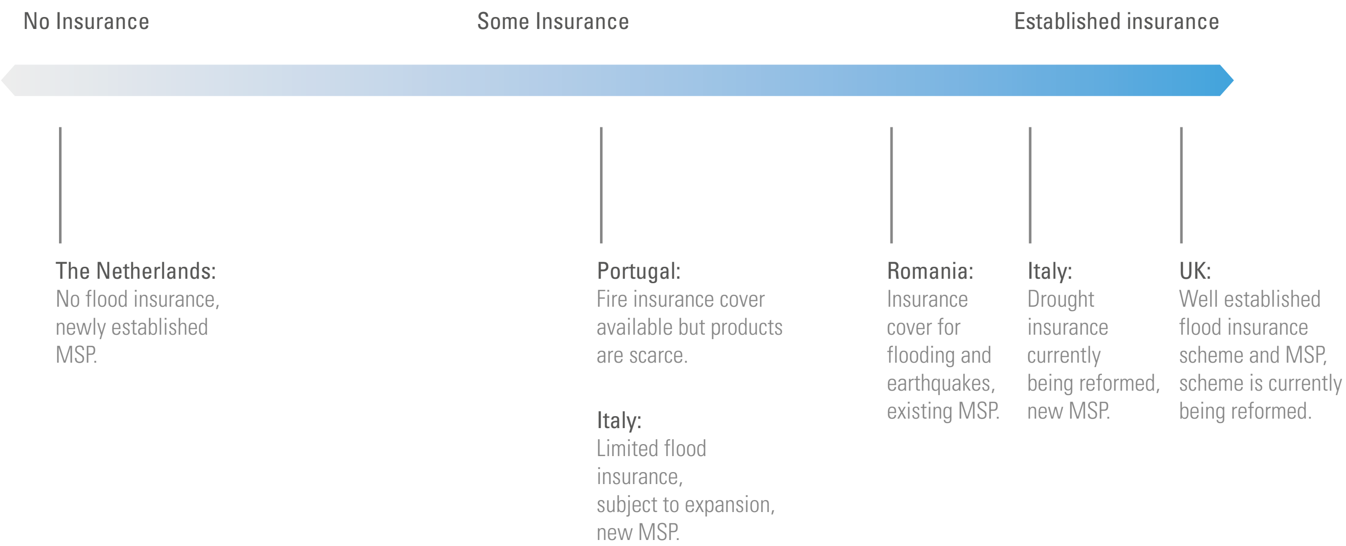
Insurance is a key economic instrument in the context of DRR, offering a shift in the mobilisation of financial resources away from ad hoc post-event payments, where funding is often unpredictable and delayed, toward more strategic and, in many cases, more efficient approaches that were arranged in advance of disastrous events (Linnerooth–Bayer & Hochrainer-Stigler, 2015). The main function of insurance is **the financial transfer of risks and compensation for losses. However, if correctly designed and implemented, it can also support disaster risk reduction (DRR) and climate adaptation** (see Surminski et al., 2015 for an overview). Within this context, insurance may be delivered using a range of approaches, such as risk pools, private insurance, or public insurance schemes, addressing different hazards at different scales, including property, agriculture, and sovereign risk insurance. Feasibility, effectiveness, and the potential for incentivising behavioural change vary across the different types and forms of insurance. Methodologies for comparing and assessing these characteristics are currently starting to emerge (for Europe see Paudel et al., 2012; for developing countries see Surminski & Oramas-Dorta 2014).

While it is clear that insurance can contribute to disaster risk management, a range of challenges also exists, including a lack of comprehensive information and cognitive biases, as well as financial constraints and moral hazard. **The ENHANCE project considers two key questions in the context of natural disaster insurance and risk reduction**: (1) How to assess existing insurance offerings, and (2) how to design new insurance schemes that strengthen and incentivise DRR.

ENHANCE introduces six different methodologies for assessing the linkages between insurance and risk reduction: Stress testing, investigation of flood insurance and moral hazard, estimation of effectiveness of household-level flood risk mitigation measures, assessment of risk-based insurance pricing incentives for flood risk mitigation, analysis through a risk reduction framework, and investigation of the design principles of insurance.

Based on the case studies, **our analysis reveals a range of important insights that are relevant to individuals who consider, design, operate, or participate in insurance schemes**. An area of particular interest is **the role of MSPs for the provision of disaster insurance**. Here, our case studies (Figure 1.2) highlight the importance of increased evidence and understanding of underlying risk issues, enhanced collaboration of stakeholders, and openness about limitations and costs. The issue spans many dimensions, which makes innovation and reform challenging for political decision-makers and private companies. Chapter 5 outlines our findings in the context of the ENHANCE case studies that focus on insurance.

Figure 1.2.
The different ENHANCE insurance case studies.



Risk perception

Human beings understand risk broadly from two points of view: The **analytic view** and the **experiential view**. The first view is normative and requires conscious control that brings logic, reason, and scientific deliberation to dealing with hazard management. The second view refers to the intuitive reactions to danger. This latter view remains today as one of the most common ways to respond to risk (Slovic et al., 2004).

Experiences determine, in many cases, the responses to current risks, and these experiences are closely related to the perceptions of risk. Perception is our sensory experience of the world around us; that is, the way we think about or understand something. It involves the recognition of environmental stimuli and actions in response to these stimuli. Hence, risk means different things to different people. Actions and understanding of risks are learned by socially and culturally structured conceptions and evaluations of the world and how it might be. Important aspects are identifying the cultural and social embedding of risk, and identifying which characteristics are in place when individuals and communities act and deal with the risk of natural hazards. This is important in the context of individuals and social groups, such as multi-sector partnerships.

Since risk perception is important in risk management, and the way that risk is perceived may shape further action towards risk reduction, risk management is largely influenced by the perceived, subjective probability of risk. From a sociological perspective, risk is defined as an inherent characteristic of human decisions in the context of hazardous events (e.g. Renn, 2008). However, risk can also be defined as a result of different mental constructions that result from the perception of each affected group, as well as their interpretations and responses which depend on social, political, economic, and cultural contexts and judgments (Luhmann, 1993; IRGC, 2005). This has also been recognized in the Paris Outcomes of the European Forum for Disaster Risk Reduction, which recommended better inclusion of risk perception in the understanding of how local cultures identify and manage risk. **Within the ENHANCE framework (Figure 1.1), MSPs undergo a learning process, upgrading their knowledge of risk information and potential for DRR actions**. This may represent the capacity or ability of actors (institutions and individuals) to have risk awareness of future disaster risks and/or to better understand the likelihood of the current impact.

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02

Risk assessment & information

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Introduction

During the past decades, the frequency and worldwide impacts of natural disasters has increased rapidly (Munich Re, 2014; 2015). A number of major disasters have occurred in Europe, prompting high economic damage and losses, casualties and social disruptions. Examples are the 2010 eruption of the Eyjafjallajökull volcano in Iceland; earthquakes in Italy in 2009 and 2012; droughts and forest fires in Portugal in 2012; and heavy rainfall that caused record floods in Central Europe in 2002 and 2013.

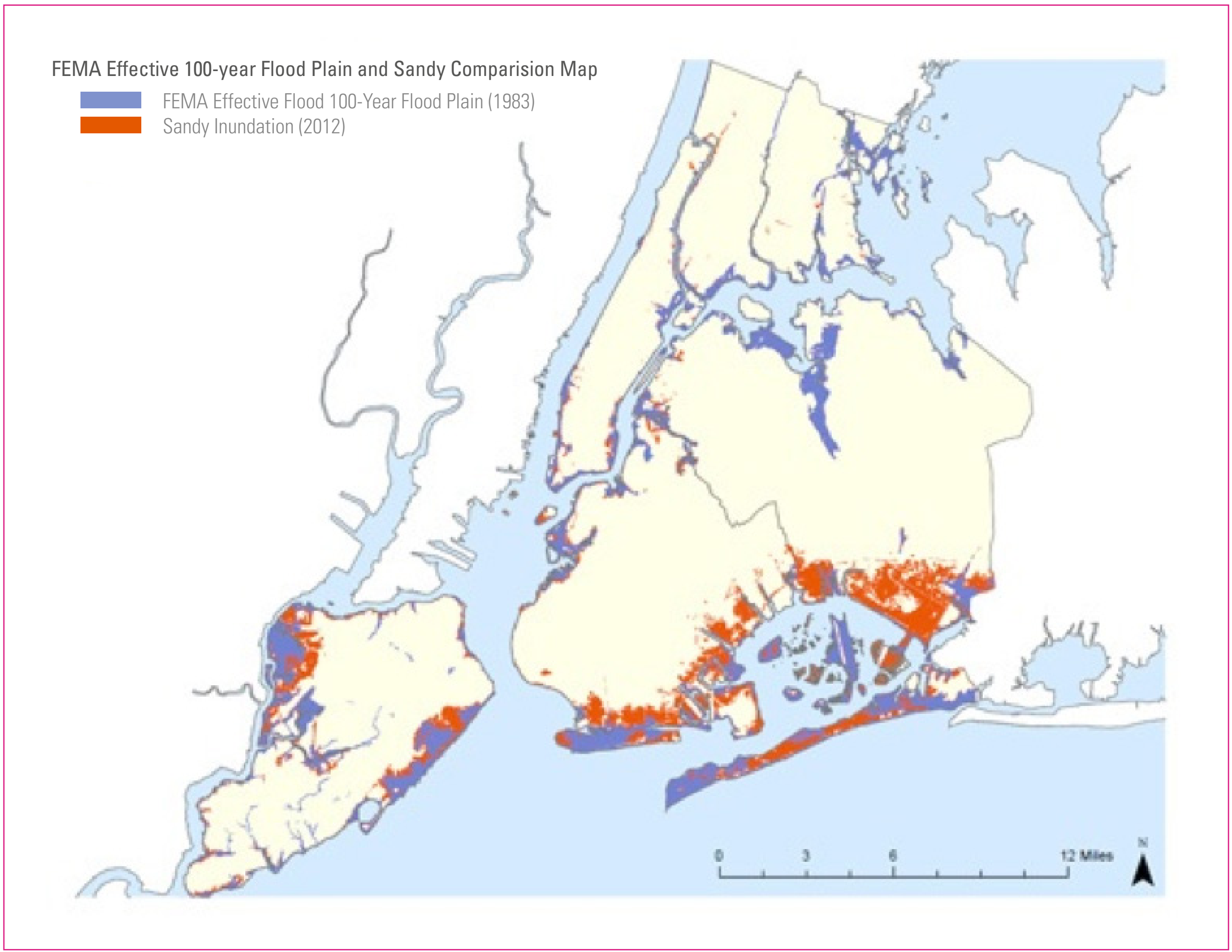
Natural disaster risks are of high policy and citizen concern in Europe. They are expected to rise further as a result of projected demographic development and land use change, with expansion of residential and production activities in hazard-prone areas. Climate change will further exacerbate risk from natural hazards, and it has been demonstrated to have already increased the frequency and severity of certain extreme climate and weather related events, such as droughts, heat waves and heavy precipitation (IPCC, 2012; IPCC, 2014).

Knowing the increasing trends in natural disasters and losses, it is imperative to take action on disaster risks to improve resilience of European societies to natural hazards. The main goal, therefore, of the ENHANCE project is to develop and analyse innovative ways to manage natural hazard risks. Key is to develop new multi-sector partnerships (MSPs) that aim at reducing or redistributing risk, and increase resilience of societies. For several reasons, **comprehensive and accurate risk information** is important for MSPs and for policy-making in general. First, a better understanding of natural hazard risk is important **for preventing excessive socio-economic stress** at levels from local to national to international, and in order **to plan for reducing risk from extreme events in the future**. For example, measures that reduce risk (e.g. levees to prevent flooding) require a certain design level or elevation, which can be derived from historical water level data or hydrological simulation models. Second, post-disaster information on the losses from a natural hazard event is important, in order **to prepare (emergency) aid to the region**. In addition, accurate post-event loss information is needed **to estimate whether financial support is needed** in terms of compensation or new investments to recover the area and develop the economy back to its original state.

An example of where inaccurate risk information can lead to is exemplified in **Figure 2.1**. This figure shows a map for NYC, for the actual flooding due to hurricane Sandy in 2012 (red color) and the official 1/100 flood zone (blue colors) provided by the Government before the hurricane occurred. **The figure shows that many of the actual flooded areas are outside the official flood zone. Inaccurate perception of flood risk for an area may lead to the development of urban areas in unprotected areas, or to under-designing levees for protecting people against extreme events**.

Figure 2.1.

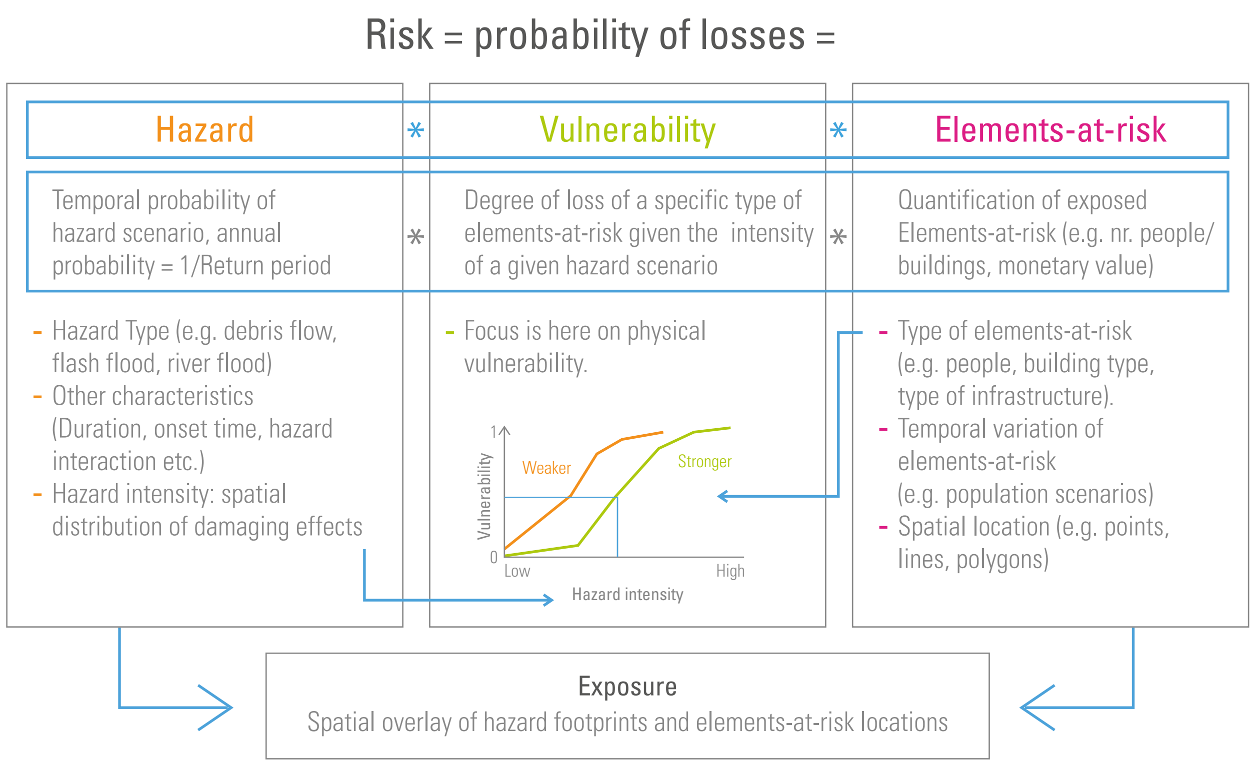
A map for NYC, for the actual flooding due to Hurricane Sandy in 2012 (red color) and the 1/100 flood zone map (blue colors) provided by the Government before the event (Source: NYC, 2013).



A risk-based approach

Within the ENHANCE project, we have followed **a risk-based framework** (see e.g. Kron, 2005) which has several components displayed in **Figure 2.2**: (1) Exposed assets ('Elements at risk'): These are the assets at risk, such as people, buildings and infrastructure. (2) Hazard: the potential magnitude and frequency of hazards that threaten those assets, (3) Vulnerability: the level of protection and preparedness to reduce risk of the exposed assets. Losses can be calculated by combining the hazard information with exposure and vulnerability data. For example, a flood depth and extent map (hazard) can be overlaid with information on exposed buildings with their value (exposure).

Figure 2.2.
Schematic figure of risk as a function of hazard, vulnerability and elements-at-risk (Source: Van Westen, 2015).



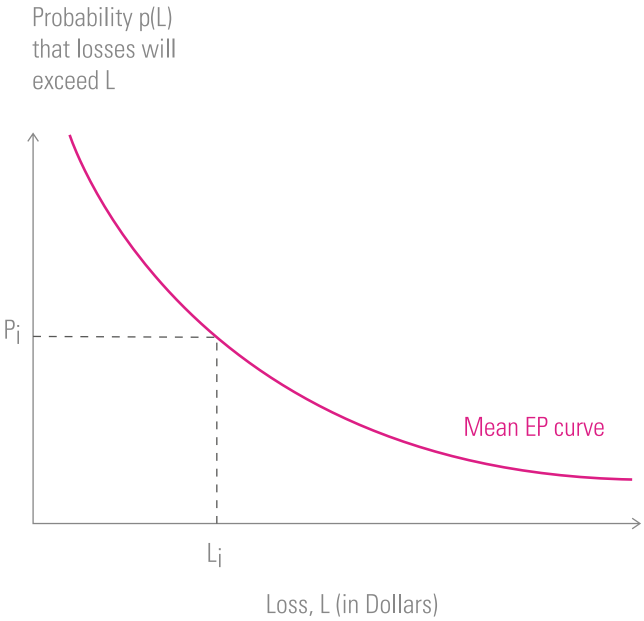
Furthermore, each exposed asset can be further characterised by its vulnerability. For example, for exposed buildings, we can use information on building codes, or use data on empirical losses to buildings from historical records. Losses can be measured in terms of dollars of damage, fatalities, injuries, or some other unit of analysis.

In order to derive risk estimates from calculated losses per event, we also need the probability for each of these events. In this way we can plot the exceedance probability against the potential loss per event, summarised as an **exceedance probability-loss (risk) curve** (EP curve, **Figure 2.3**), where the risk is approximated by the area under the curve (Meyer et al., 2009). The EP curve in Figure 2.3 shows that for the specific loss Li, the likelihood that losses will exceed a certain threshold level of losses Li, is given by Pi. There is some debate on the number of data points needed to construct the curve. For example, Merz and Thieken (2009) used seven return periods to produce risk curves for Cologne, Germany, which is relatively many data points compared to most other studies.

Photo by Donald Bowers/Shutterstock.

Figure 2.3.

Mean Exceedance-Probability curve, showing for a specified event the probability Pi that losses exceeding Li (Source: Grossi and Kunreuther, 2005).



Calculating losses: example Austrian railways and flood risk

The railway transportation system of the Alpine country Austria plays an important role in the European transit of passengers and freights. In total, 11.7 million tons of goods were transported across the Austrian Alps in 2013, which is 28 % of the total volume recorded for the inner Alpine Arc. Also the Baltic-Adriatic Corridor, which is one of the priority axes (No 23) of the Trans-European Transport Network (TEN-T), runs from Gdansk in northern Poland through Austria to northern Italy. It is one of the most important north-south routes in Europe and the easternmost crossing of the European Alps. It connects three other EU member states (Poland, Czech Republic, and Slovakia) with economically important areas in Austria and Northern Italy and also provides a link to other Trans-European Transport Networks – TEN-T priority axes from Eastern to Western Europe, such as the one running from Paris via Vienna to Bratislava (No 17). Moreover, the Austrian railway network is essential for the accessibility of lateral alpine valleys and is thus of crucial importance for their economic and societal welfare. If traffic networks are (temporarily) disrupted, alternative options for transportation are rarely available.

The mountainous environment, in which around 65 % of the national territory of Austria is situated, poses a particular challenge to railway transport planning and management. Relief energy and steep slopes limit the space usable for permanent settlements and infrastructure, e.g. amounting to only 15 to 20 % of the whole Alpine Convention territory. Hence, railway lines often follow floodplains or are located along steep unsteady slopes, which considerably exposes them to flooding and in particular to alpine hazards, e.g. debris flows, rockfalls, avalanches or landslides. As a result, **railway infrastructure and**

operation has been repeatedly impacted by alpine hazards. For example, in June 2013, floods and debris flow events caused substantial damage to the railway infrastructure in Austria. The national railway operator ÖBB reported a total damage of about EUR 75 million to its railway network.

In order to better plan, negotiate, and decide on investments in protection measures, reliable models for estimating potential flood losses to railway infrastructure are needed. Such models are, however, rare and their reliability is seldom investigated. Therefore, the ENHANCE case study 'Building railway transport resilience to alpine hazards' aimed at developing an **empirical modelling approach for estimating direct structural flood damage to railway infrastructure and associated financial losses**. Via a combination of event data, i.e. photo-documented damage on the Northern Railway in Lower Austria caused by the March river flood in 2006, and simulated flood characteristics, i.e. water levels, flow velocities, and combinations thereof, the correlations between physical flood impact parameters and damage occurred to the railway track were investigated and subsequently rendered into a damage model.

After calibrating the loss estimation using recorded repair costs of the Austrian Federal Railways, the loss model was applied to three synthetic flood hazard scenarios with return periods of 1/30, 1/100 and 1/300 years along the March River (see **Figure 2.4**). Next, flood losses were calculated for these three flood hazard scenarios (**Table 2.1**).

Photo by LeksusTuss/Shutterstock.

Figure 2.4.

Estimation of potential structural damage at the Northern Railway for three synthetic flood scenarios: a) a 30-year event, b) a 100-year event, and c) a 300-year event. In damage class 1 the track`s substructure is (partly) impounded, but there is no or only little notable damage. In damage class 2 the track section is fully inundated and significant structural damage has occurred (or must be expected), while in damage class 3 additional damage to substructure, superstructure, catenary and/or signals occurred so that a full restoration of the cross-section is required. The damage classes are estimated for each 100 m-segment (Source: Kellermann et al., 2015).

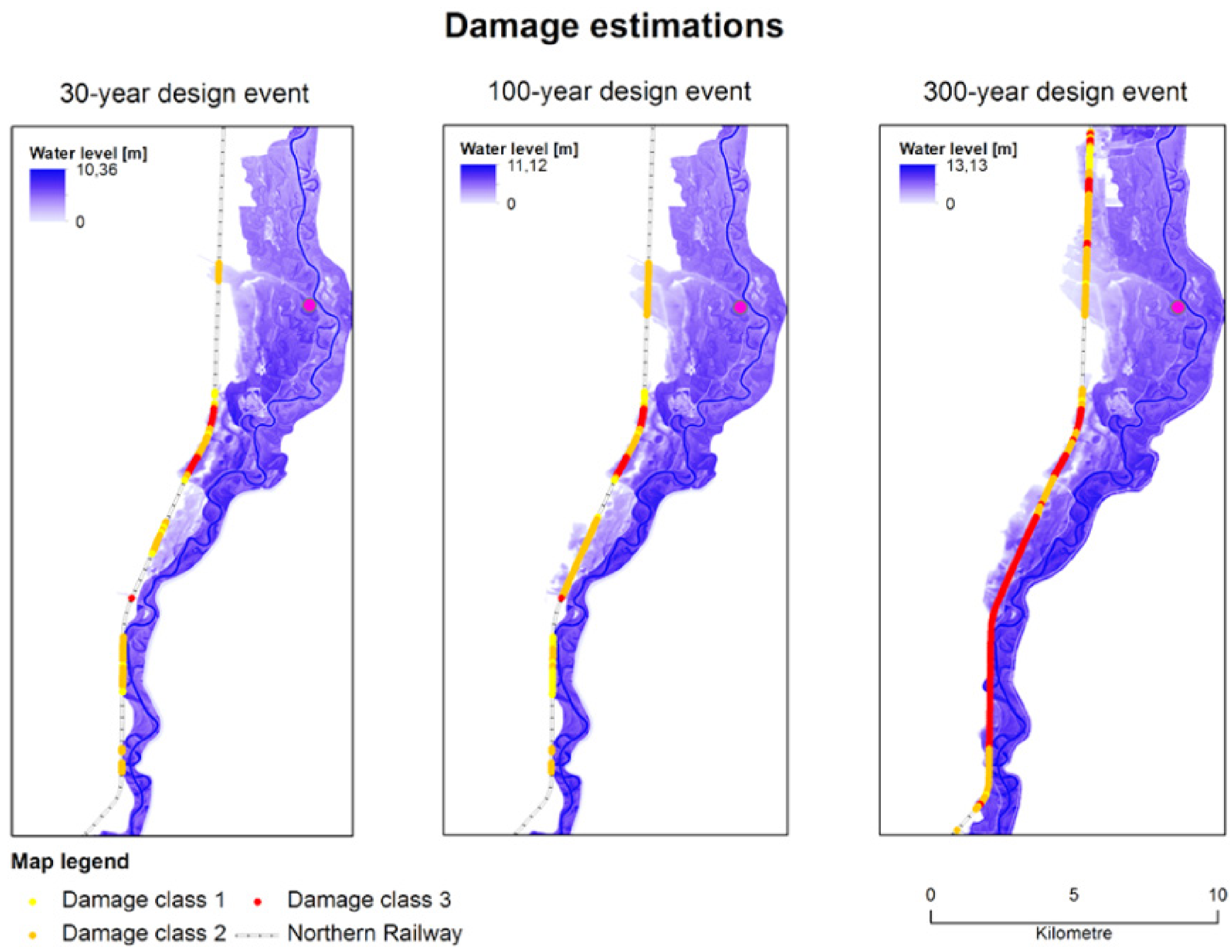


Table 2.1.

Estimated repair costs for different hydraulic scenarios along the March River (Source: Kellermann et al., 2015).

Flood scenario and probability	Repair costs estimated by the RAIL model (euro)
1/30	17.698.600
1/100	21.511.600
1/300	93.168.900

Finally, it was applied to the whole catchment of the river Mur to identify hot spots of flood risk in this part of the railway network (Kellermann et al. 2016).

Example of damage and vulnerability calculations: Port of Rotterdam and flood risk

The port of Rotterdam in the Netherlands is the second largest in the world and the Largest Port in Europe. The harbor is situated in the south-western river delta of the Netherlands and is prone to natural hazards (wind storms, flooding) and the impact of climate change on these natural hazards. Potential elements at risk are industries, energy plants, port facilities, railways, tunnels, and container terminals. In addition, a large section of Rotterdam's working population is employed in the port area, and many businesses are highly dependent upon port activities. Severe economic damage can occur from long-term closures of the port and its industry.

Similar to the Austrian case study, **flood inundation maps** with different return periods (probabilities) were used to estimate potential flood losses. This was done by first overlaying the flood maps for the Port with the exposed assets ('buildings') of the area. This database is shown in **Figure 2.5.** Next, we applied so-called **stage-damage curves (SDC)** to represent the vulnerability to flooding for each of the exposed assets classes (**Figure 2.6**). A stage-damage curve for flooding shows how much percentage damage of the total potential damage occurs for a certain flood depth. For example, Figure 2.6 shows that for asset type 'liquid bulk storage', more than 85% of the total damage occurs with a flood depth of 1m.

Figure 2.5.
The six types of exposed assets in the Port of Rotterdam. Photo by Port of Rotterdam Authority, 2012.

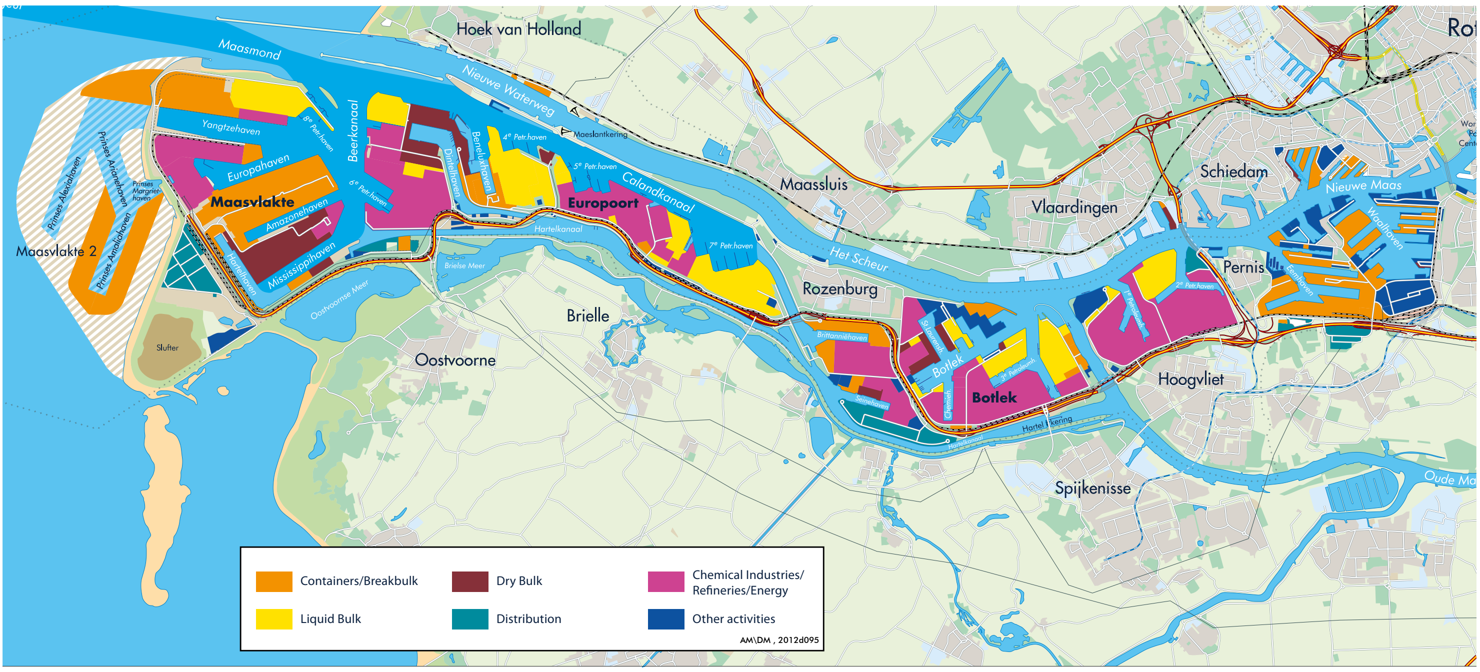
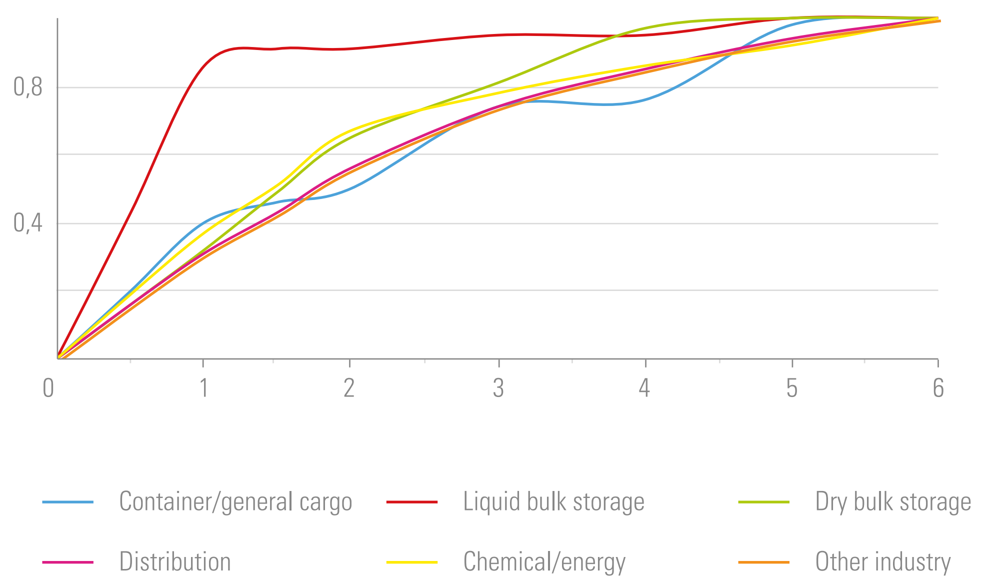


Figure 2.6.

Stage-damage functions for the Port of Rotterdam. The functions show the relation between the exposed assets (6 types), and the % damage of flooding as a function of the flood depth.

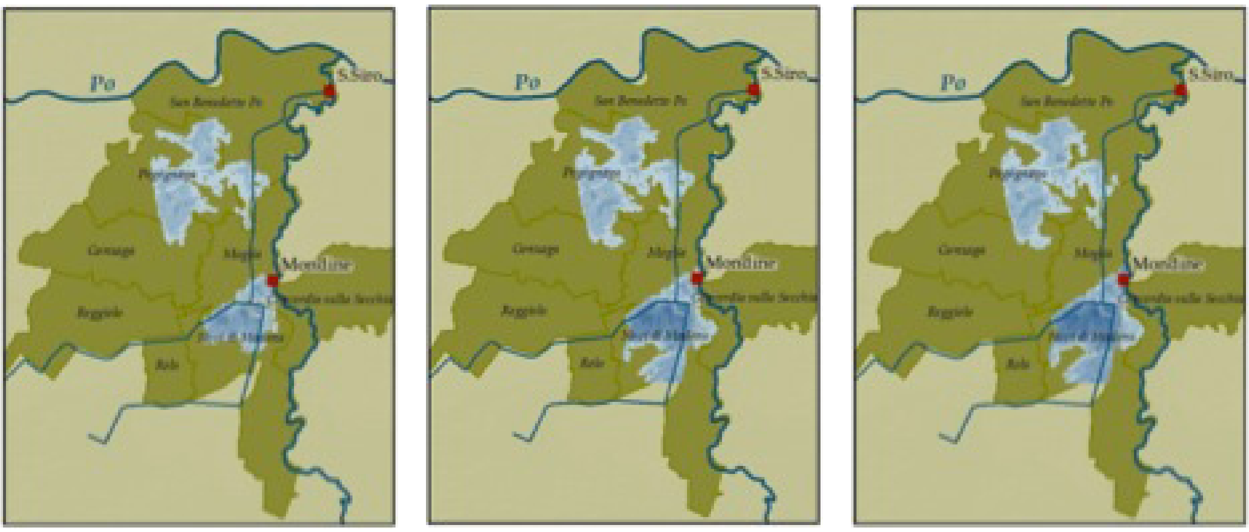


Case study Italy: controlled floods to reduce risk

The flood risk analysis conducted in this case study was compelled as a result of the severe earthquake that hit the Emilia Romagna region (Northern Italy) in 2012, causing a total loss of €16 billion. Among other consequences, the earthquake disrupted the otherwise well-functioning drainage system (DS) protecting the area against flooding. Flood risk increased consistently in urban, industrial, and agricultural areas. To prevent larger impacts, in 2012 a multi-sector partnership was installed between the Civil Protection Agency (CPA), the Land Reclamation and Irrigation Boards (LRIB), and the Regions Lombardy and Emilia Romagna. The partnership, promoted and overseen by the Po River Basin Authority (PRBA), was endorsed as an inter-regional emergency management plan.

The risk assessment delineated the areas exposed to higher flood risk as a result of inoperable DS under different precipitation and disruption scenarios, and estimated economic losses caused by uncontrolled floods in terms of capital stock damage and foregone production losses. First, the simulated volume of drained water and timing of its outflow were analysed using a 2D hydrodynamic model and high-resolution digital elevation model to produce **flooding maps** for each scenario (**Figure 2.7**). Altogether 25 scenarios were analysed, including four network disruption and five rainfall intensity configurations. As in the Port of Rotterdam case, economic losses were estimated using **stage-damage curve model**. The SDC method estimated capital stock damage that ranges between €20 million under normal functioning conditions to around €300 million under catastrophic floods. The analysis also included the effects of climate change and land conversion.

Figure 2.7.
Flood scenarios for the Po River Basin case study, for return periods 1/1, 1/10 and 1/50 years.



Rp1 Rp10 Rp50

Example of EP curve: case study wildfires in Portugal

A key hazard in Portugal is wildfire with many major episodes over the recent past. In 2003, Portugal had the worst ever recorded fire season, with about 450 thousand hectares burned. The central part of the Portuguese mainland was most affected, including the district of Santarém where the ENHANCE case studies, the municipalities of Chamusca and Mação, are located. Chamusca and Mação were especially affected in 2003, and empirical risk data from 2003 were used to study the major drivers that led to the catastrophic fires.

The assessment of wildfire risk was performed in two different complementary components: **spatial** and **temporal**. First, wildfire hazard maps were created showing the extent of the burned areas. Next, each of those hazard maps was translated into losses using a wildfire model. This model integrates the following variables: land cover (CORINE Land Cover data, the exposed assets), slope (Digital Elevation Module 80m) and previously burnt areas (historical data of burnt areas). The model derives fire loss maps by combining the forest fire hazard maps with the economic value of the elements at risk (different types of forests) and their vulnerability. Finally, each fire loss map was assigned a probability that could be statistically derived from a fire database. Using the unit values for losses included in the National Forest Strategy of 2006, an **exceedance-probability loss curve** (**Figure 2.8**) was established indicating loss information for the two most extreme years of 2003 and 2005. It shows that values of estimated losses for the district of Santarém can be higher than €100 million.

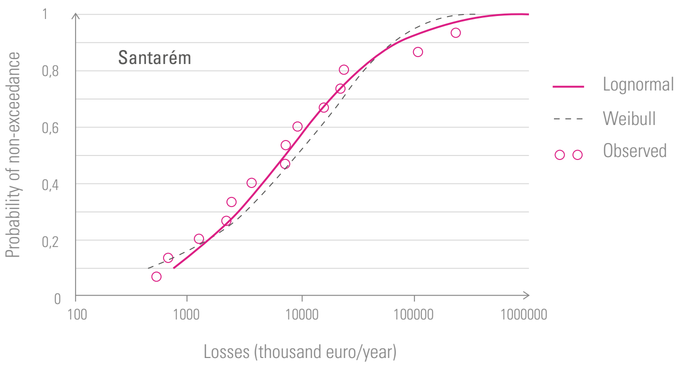


Figure 2.8.
Exceedance probability-loss curve for wildfires in the district of Santarém, showing the relation between forest fire losses and their probability.

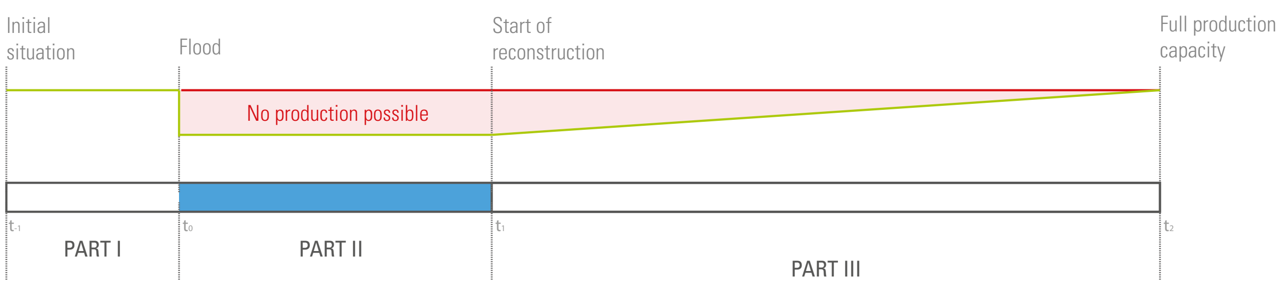
Alternative vulnerability indicators: drought indicators

In the ENHANCE project, we have performed two drought case studies: (1) a **global analysis** on past drought trends and projections of future drought conditions due to climate and socio-economic changes, and (2) a **regional case study in the Júcar Basin** in South Eastern Spain, where we have assessed drought impacts in view of global change and evaluated the effectiveness of drought adaptation.

Drought and water scarcity are two manifestations of water-related risk that are both connected to the deficit of freshwater resources. **Drought** is a natural phenomenon that refers to a deviation from the historical record (Logar & Van den Bergh, 2012; Pereira et al., 2009; Wilhite, 2005). **Water resources scarcity** refers to the overuse of water resources and is often seen as strongly modified by human use. Two hazard indicators often used to assess global and regional scale water scarcity are the **Water Crowding Index (WCI)** and the **Water Scarcity Index (WSI)** (Falkenmark, 1986; Falkenmark et al., 2007). The WCI quantifies water scarcity as the yearly water availability (measured in runoff or discharge) per capita at a country or basin-level. The WSI uses a ratio between withdrawals and resources availability as an indicator for water scarcity conditions.

The Júcar Basin, for example, **uses a combination of indicators for the assessment of current and future drought risk, and for operational use**. Synthetically generated information on streamflow and reservoir storage levels are combined with knowledge on sectoral water needs and costs of potential water shortages to assess the probability of hazardous drought conditions and their associated (economic) impacts. Vulnerability to drought and water scarcity conditions in the Júcar Basin is mainly determined by the portfolio of different water uses being dependent on the same source of water and by the operational management of drought conditions. At this operational level, drought risks are governed by monitoring multiple drought indicators (reservoir volumes, aquifer storage, streamflow, rainfall) and the timely declaration of emergency states if necessary (Monteagudo et al., 2013).

Both global scale indicators and local scale indices for risk assessment and operational use depend heavily on the availability of reliable observations or simulations of meteorological and hydrological conditions (precipitation, evaporation, streamflow, reservoir levels) **and socioeconomic information** (population, water needs, land use, vulnerability). Continuous investments are needed and taking place to assimilate and improve the (open-source) availability and quality of this meteorological, hydrological and socioeconomic information at different spatial scales, for example within the Inter-Sectoral Impact Model Inter-comparison Project (ISI-MIP), the EartH2Observe project (E2O), the Global Runoff Data Centre (GRDC), and the European Drought Observatory (EDO).



Direct and indirect damages

In risk assessment studies, one can distinguish between direct and indirect effects (Koks et al., 2012). **Direct effects** can be defined as the impacts that occur due to direct effects from hazards to properties or people. In the economic literature, direct losses are often referred to as stock losses, which are defined as losses that occur at a given point in time. **Indirect effects**, on the other hand, are often caused by the direct impacts, but are the result of interferences within industrial supply chains (Okuyama and Santos, 2014). Most importantly, indirect effects may also occur outside the hazard area: e.g., companies that are not flooded, but that have economic relations with households and industries that are flooded, cannot supply or demand their goods and services, and therefore, indirectly suffer from the flood.

Numerous studies have developed approaches to estimate flood damage. Many of these studies, often originating from the engineering community, address mainly direct losses of flooding using stage-damage curves, such as illustrated for the cases of Rotterdam and Po (Penning-Rowsell et al., 2010; Kreibich et al., 2010). Estimating indirect losses has mainly been the domain of the economic community, using macroeconomic models such as input-output models or generalised equilibrium models (e.g. Steenge and Bockarjova, 2007; Hallegatte, 2008). A few studies have proposed a more integrative approach for the calculation of both direct and indirect flood damage. For instance, Jonkman et al. (2008) proposed a framework for the combination of direct and indirect losses and FEMA (2009) developed two modules within the HAZUS-FLOOD model to assess direct and indirect losses. However, an integrative model, able to consistently integrate both direct and indirect losses, which gives the total flood risk in terms of expected annual damage, is in our opinion, still missing.

In the ENHANCE project, we have applied an **integrative flood risk model** for the Port of Rotterdam. The framework consists of multiple steps. First, a direct loss assessment (using a direct flood damage model) is conducted in the port region, specifically differentiating the direct damages to various industrial sectors. Second, we simulate indirect losses using an input output model, and calculate how direct losses translate into the loss in economic production per sector (Koks et al. 2014). Next, the input-output model is used to show the time and costs required to reach the pre-disaster state of the economy in the area.

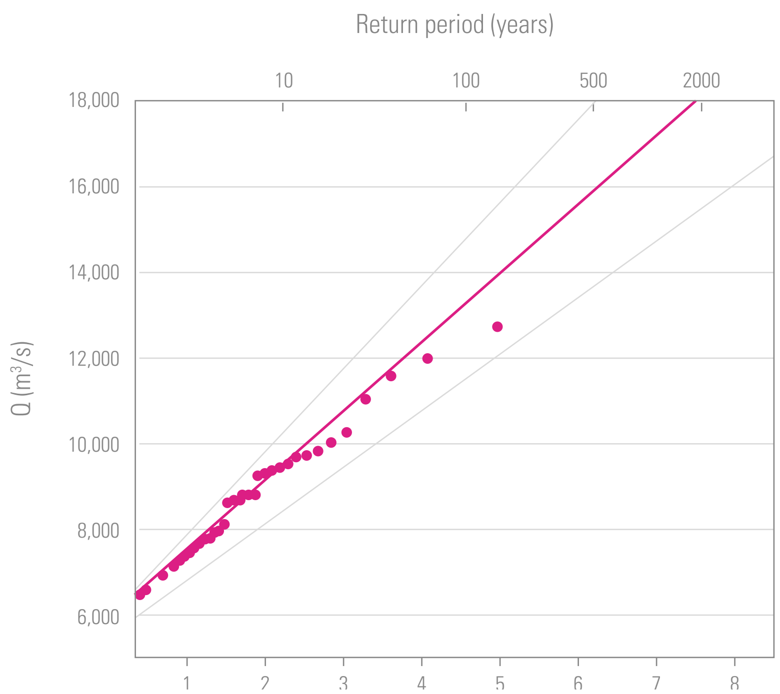
Figure 2.9.
Overview of the different model parts for the indirect risk model: pre-flooding situation; shock to the economy because of a flooding event; post-event situation with the recovery of the economy until initial production is achieved.

Extreme events and statistics

In risk assessment, it is often difficult to attach a probability to a certain hazard event. This pertains especially for low probability events for which there is little or no empirical data. For these situations, **extreme value theory** is needed to model statistical properties of extreme events that lie outside the range of observed data. The usual statistical techniques focus on average events, and have a great bias in estimating extremes. One reason for this is that standard estimation techniques only serve well where there is a large density of observed data. Furthermore, most data is (naturally) concentrated toward the center of the distribution (the average) and so, by definition, extreme data is scarce and therefore estimation is challenging.

Figure 2.10 shows an example of fitting extreme value statistics (A so called 'Gumbel plot') through measured data of river discharges for the river Rhine in the Netherlands (the black dots). Since only ~100-150 years of measurements are available, the rarest event is the maximum discharge in that period: ~12500 m3/s, with a probability of ~1/100. However, for policy reasons, we would like to estimate an extreme discharge that has a probability of 1/1000. Therefore, we need to extrapolate the measured data using extreme value statistics, which gives us a discharge of ~16000 m^3/s.

Figure 2.10.
Fitting an extreme value Gumbel plot through measured discharge data for the Rhine Basin.



A further complication is the dependency between extreme events which is now tackled within the ENHANCE project via a 'Copula approach'. Copulas are useful for modelling dependencies between continuous random variables. Using a copula model allows to separate the selection of the marginal distributions (e.g. the risk in form of loss distributions) from the selection of the copula (e.g. the dependency between risks). In other words, while the marginal distributions contain the information of the separate risks, the copula contains the information about the structure of the dependency. Using flood as an example, the application of a copula approach makes it possible to estimate loss distributions between selected regions and countries, explicitly taking their dependency into account (Jongman et al. 2014).

Flood in York, UK, 2007. Copyright: UNISDR.

Risk information and policy implications

The importance of the quality-assured, systematically collected and thorough datasets on impacts of natural hazards, the loss data systems (LDS) have been highlighted by the Sendai Framework for Disaster Risk Reduction 2015-2030 and the OECD.

Currently, empirical data on losses from natural hazards in Europe are fragmented and inconsistent. Because open and accessible records on disaster impacts and losses are prejudiced by data gaps, European policy-makers have little choice but to resort to proprietary data collection.

The Sendai Framework calls on the national and regional government **to better appreciate the (knowledge of) risk**. Empirical and evidence-based risk analysis and assessment are a vital part of the disaster risk reduction efforts (e.g. JRC, 2015). The open-ended intergovernmental expert working group (IEWG) was instituted to develop a set of indicators for measuring global progress.

The Sendai Framework is not alone in this quest. The OECD invited the member countries to better prepare for catastrophic and critical risks (OECD, 2010, 2014). The draft Sendai Framework indicators focus currently on direct damage and structural/physical losses. However, the OECD recommended **considering the whole distributional and implied ripple or spillover effects of natural hazards**, which is now also discussed between countries and UNISDR.

The European Union Civil Protection Mechanism (EC, 2013) compels the EU member states **to conduct risk assessments**, where possible also in economic terms, at national or appropriate sub-national level. They also have to make a summary of the relevant elements thereof available to the Commission by December 2015 and every three years thereafter. For both purposes, the Joint Research Centre (JRC) is developing loss indicators that should be part of operational disaster loss databases (De Groeve et al., 2013; 2014; 2015).

Photo by hotblack/Morguefile.

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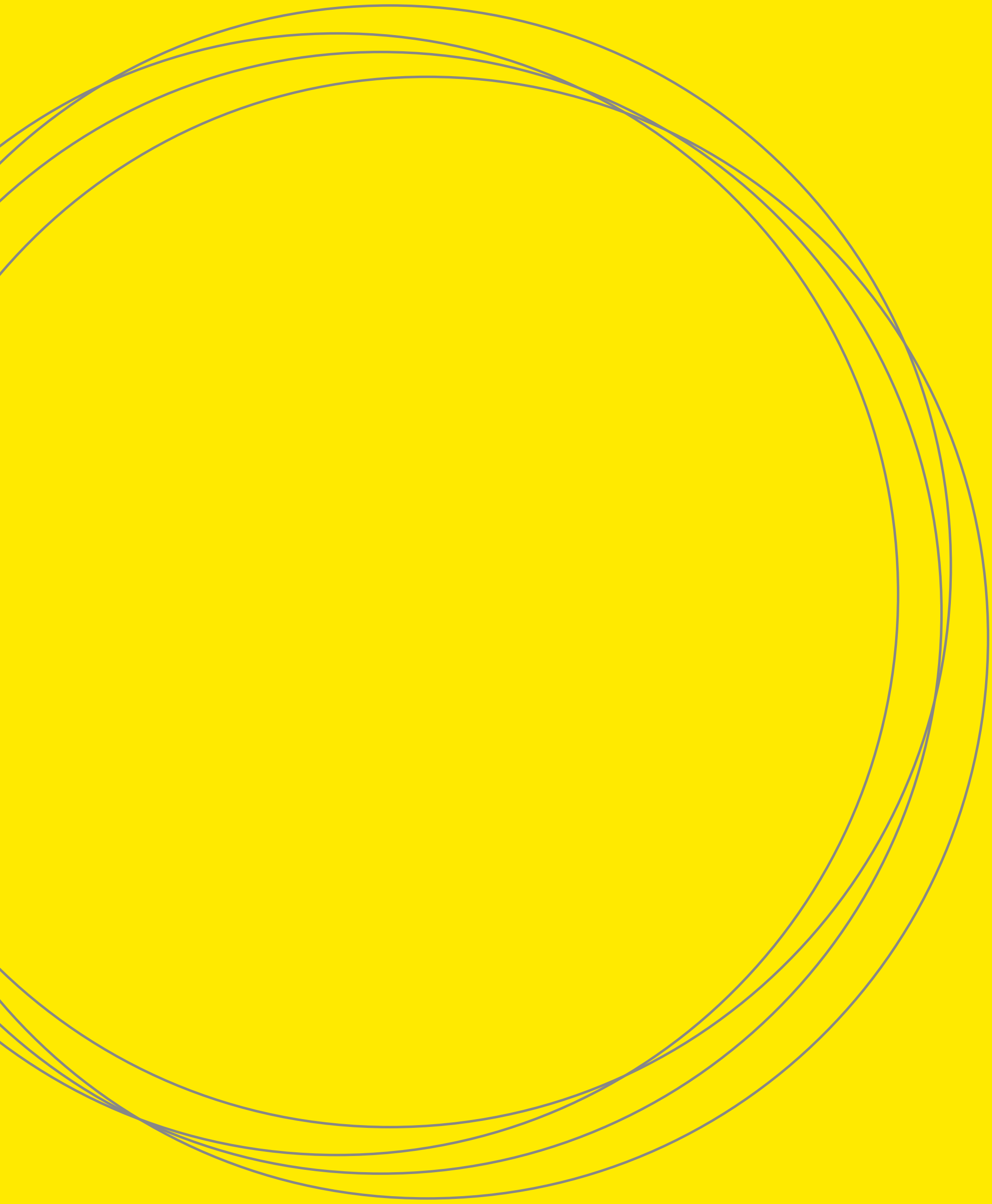

03

Risk perception

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Introduction

Risk perception plays an important role in disaster risk management (DRM). In cases in which people have poor or no perception of a particular risk, their reaction might be inappropriate or even harmful (e.g. building houses in flood-prone areas). In other cases in which the perception of risk is framed by historical and social events, risk awareness and perception are high, and people and institutions show enhanced preparedness in order to reduce potential harms. Literature shows that **risk perception largely influences risk management** and therefore determines whether risk management is successful in reducing vulnerability (e.g. Bubeck et al, 2012).

In the ENHANCE project, the goal has been to enhance multi-sector partnerships (MSPs) to manage catastrophic natural disasters in Europe. In order to enhance risk management, we need to understand what kind of risk management cultures exist, and identify and assess indicators that represent cultures of risk.

The project followed the following approach:

(1) We developed the basis for providing criteria to analyse the regionally and culturally embedded perception of natural hazards and (economic and human) resources, as well as to analyse the recent handling of risk events. These criteria might help other areas in Europe with similar contexts and risks to develop similar risk management strategies.

(2) We developed and implemented a standardised online survey to find out how risk management practices are shaped by risk perceptions in MSPs. More specifically, we investigated experiences with past risk events and assumptions about future risks, how these relate to concrete policies and measures adopted within individual organisations and in the MSPs, and which risk management cultures can be identified. The survey targeted, particularly, representatives of organisations dealing with natural hazard risks.

Factors influencing risk perception

To understand how risk perceptions shape risk management, we follow the **Cultural Theory of Risk** by Douglas and Wildavsk (1982) and the **Protection Motivation Theory** by Rogers (1975). As a basis for determining the objective risk, the IPCC (2012) and UNISDR (2009) definitions of risk can be followed, which define risk as a combination of **hazard, vulnerability** and **exposure** (see also Chapter 2). However, these definitions fail to include the perception component, i.e. including **risk as a mental construction** (IRGC, 2005). A mental model is an individual's internal, personalised, intuitive and contextual understanding of how something works (Kearney, 1997), acquired over time through social interactions and experiences. When an event repeats, the model is used as a lens through which the individual arrives at perceptions or evaluates new information (Jungermann et al., 1988). This is related to the psychological side of risk and consequently to the perception of the risk.

Several factors determine how risk is seen by people and organisations. Individuals, institutions, communities or societies may perceive risks differently due to diverse cultures or beliefs. Risk can be seen as a **collective and cultural construction** (Douglas, 1982).

Perception of risk goes beyond the individual, and it is a social and cultural construct reflecting values, symbols, history, and ideology (Weinstein, 1989). This represents institutions in the sense of Ostrom (1990). In some cases in which the population is used to particular extreme events, they might have internalised them and might not consider the events as a risk. For these people, it is not risky to live with e.g. droughts: it is a situation that they are living with for many years or centuries and which they have encapsulated in their daily lives. It is for this reason that we cannot only consider the natural hazards as a risk, but understand risk through **the perception and meaning given to it by the people living in a particular area**. Such consideration provides a useful perspective for developing risk management strategies that are tailored to the local needs of stakeholders.

Figure 3.1 shows factors determining the perception of risk, which is **a complex combination of innate biases and experience**, i.e. cultural-, socio-political- and emotional factors (Renn, 2000). These factors are both collective and individual. Although we focus on the collective dimension, it is important to know that the individual dimension influences the collective. Thus, the factors on the individual side are important for determining the global risk perception factors. Perception is our sensory experience of the world around us and involves both the recognition of environmental stimuli and actions in response to these stimuli. Cognitive psychologists state that factors underlying perceptions are, e.g., personal risk experience, social communication and cultural traditions (Aven, 2010).

Figure 3.1.
Factors determining risk perception (Source: Adapted from Renn and Rohrmann, 2000).

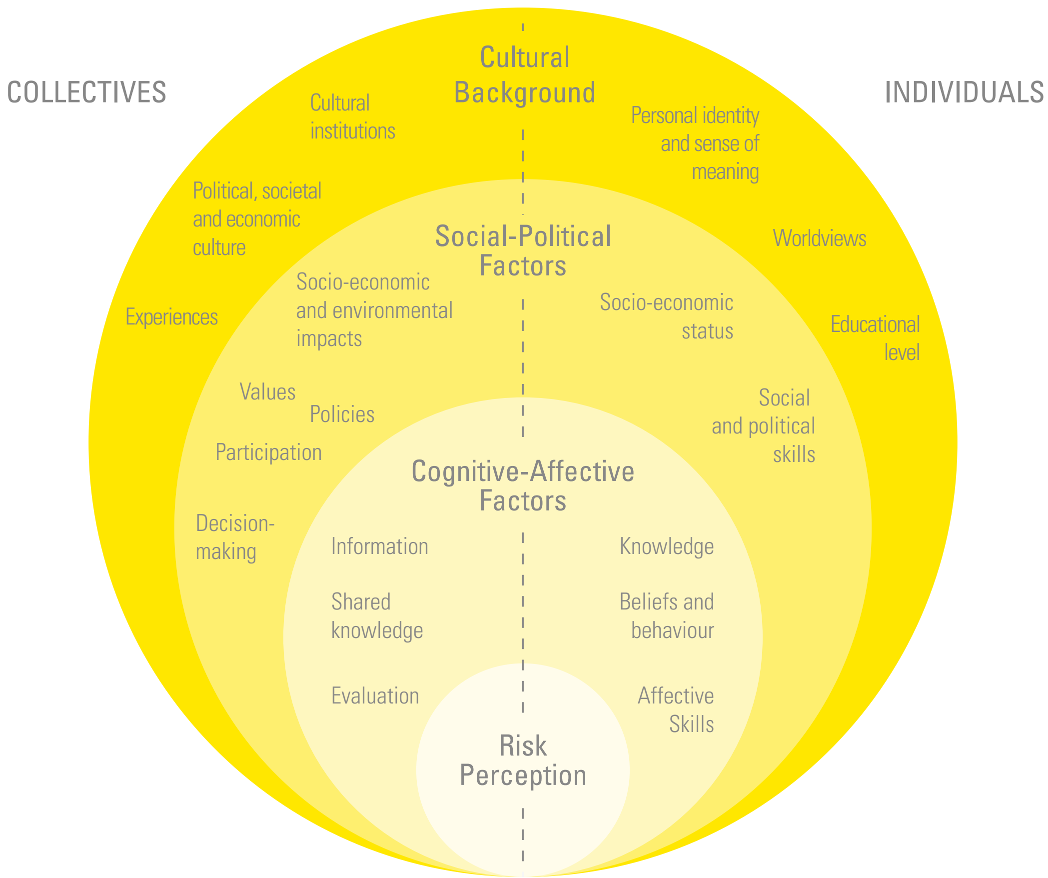
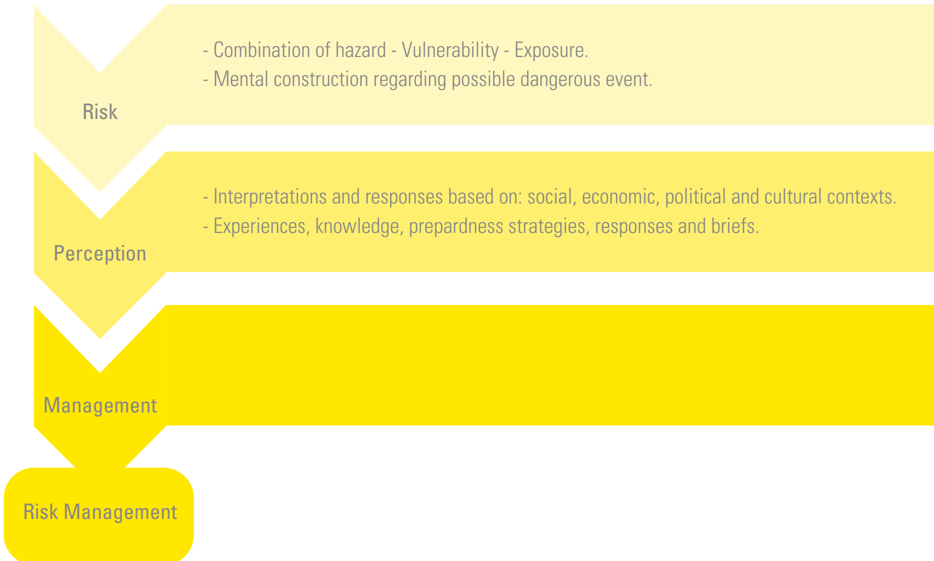


Figure 3.2.
Risk management and risk perception.



Risk management and risk perception

Risk management is a more or less systematic approach that includes the identification, assessment and understanding of a risk in order to define a collection of management actions. The aim of risk management is **to minimise the potential harm of a risk event by implementing strategies and actions to control and reduce risk** (UNISDR, 2009).

Risk management in the context of natural hazards has rapidly evolved over the last decades, from protective ex-ante strategies and ex-post focused strategies, such as insurance solutions, to a recently emerging, more holistic focus related to the concept of resilience (Ghesquiere et al., 2006). Approaching disaster risk management from a resilience perspective entails the integration of physical, social, financial, technological and human capitals (as we described in chapter 1) across all components of the risk management cycle (recovery, assessment, prevention and mitigation, preparedness).

Since risk is perceived differently by people, **risk management approaches are influenced by what people perceive as 'risky'**. If within an MSP a hazard is perceived as a potential risk, the respective actors will take action to manage it. Often preparedness in the face of a threat influences the degree of risk perceived, e.g., the higher the preparedness, the lower the perceived risk. This is also referred to as **the 'levee effect'** (Tobin, 1995). A good example is the Wadden Sea Region case study (Chapter 11), in which a high confidence in the preparedness measures (dykes) results in a low risk perception. Another important factor influencing risk perception is **past experiences of extreme events**. This can enhance risk perception for a period of several years after the event, as was shown after the Hurricane Katrina in New Orleans, and is even capable of generating debate in risk management in other countries such as the Netherlands. On the other hand, a long-term high risk, such as the frequent periods of droughts in the Júcar River Basin in Spain, have lowered the perception of the risk faced. In this latter case, stakeholders might follow the previously used strategies to face the event and/or use existing knowledge and experiences from previous episodes to create new risk management strategies.

Even within one MSP or institution, we find an internal mix of cultures. Therefore, an MSP which shares the same goal of reducing risk and gaining mutual benefit could achieve this goal through very different views on how to do it. According to the **Protection Motivation Theory** (Rogers, 1975), people or MSPs follow the appraisal of the threat and coping strategies, and might first decide whether a threat in the area is relevant or not (**Figure 3.2**). If this is the case, they will determine which actions to take. In other words, risk management strategies adopted by MSPs are highly steered by the individual actors' subjective perceived probabilities of adverse extreme events, i.e. their risk perception and risk preferences. The subjective probability as the perceived risk is usually responsible for people's behaviour and shapes risk management (Wauters et al, 2014).

In our analysis we tried to capture: 1) the understanding of risk and the perceived probability of adverse extreme events; 2) social and cultural interpretations of risks as well as experiences and traditional strategies, and 3) the resulting management.

Assessing the relation between risk perception and risk management

Following two features, risk perception determining risk management and the consideration of risk as a natural hazard and its consequences, we used a qualitative research method to analyse and compare different case studies. **An online questionnaire** was made available to all MSPs in the ENHANCE project (see **Table 3.1**) for gathering data from organisations dealing with natural hazards. Furthermore, we have described the risk cultures of such organisations avoiding focussing on individuals. We were particularly interested in organisations that are creating alliances with other organisations and are pursuing a common objective. **We assessed which elements enhance risk management practices within the cooperative action of an MSP**.

The challenging aspect is that these common perceptions are shaped by different individuals with different points of view, but probably sharing a common risk culture. Through the questionnaire responses, it was possible to introduce an overall description of cultures of risk within different case studies. The questionnaire development was based on **Cultural Theory** (Douglas and Wildavsk, 1982), which asserts that structures of social organisation endow individuals with perceptions, reinforcing those structures in competition against alternative ones. Furthermore, we used a revised list of criteria obtained from the **Protection Motivation Theory** and the **Framing Theory** (Slovic et al. 2004).

Table 3.1 shows how information was categorised from the questionnaire. The ENHANCE case studies addressed floods, forest fires, droughts, earthquakes and their natural consequences (e.g. volcanic eruption).

Table 3.1.

Survey categories for assessing cultures of risk across European MSPs.

<table>
<tr><th>Section</th><th colspan="2">Elements</th><th>Criteria</th></tr>
<tr><td rowspan="5">Characteristics of the institution</td><td colspan="2" rowspan="3">Information</td><td>Knowledge</td></tr>
<tr><td>Pattern of behaviour</td></tr>
<tr><td>Experiences</td></tr>
<tr><td colspan="2">Values</td><td>Trust</td></tr>
<tr><td colspan="2">Political issues</td><td>Decision-making</td></tr>
<tr><td rowspan="6">Natural Hazard (Risk description)</td><td colspan="2">Hazard</td><td>Typology</td></tr>
<tr><td colspan="2" rowspan="2">Impact</td><td>Socio-economic</td></tr>
<tr><td>Environmental</td></tr>
<tr><td colspan="2" rowspan="3">Event</td><td>Frequency</td></tr>
<tr><td>Intensity</td></tr>
<tr><td>Data (observation/recorder)</td></tr>
<tr><td rowspan="6">Management (Risk management)</td><td colspan="2" rowspan="2">Resources</td><td>Financial</td></tr>
<tr><td>Skills</td></tr>
<tr><td rowspan="4">Coping capacity</td><td rowspan="4">Policies</td><td>Assessment</td></tr>
<tr><td>Prevention/mitigation</td></tr>
<tr><td>Recovery</td></tr>
<tr><td>Preparedness</td></tr>
<tr><td rowspan="5">Participation (Partnership)</td><td colspan="2" rowspan="3">Participation</td><td>Partners</td></tr>
<tr><td>Cooperation</td></tr>
<tr><td>Communication</td></tr>
<tr><td colspan="2">Policy</td><td>Regulation</td></tr>
<tr><td colspan="2">Evaluation</td><td>Improvement/review</td></tr>
</table>

Survey results

Most ENHANCE MSPs surveyed are generally voluntary. An exception were some partnerships focussing on civil protection, and almost 60% of the MSPs are regulated by official legislation.

The risk perception characteristics of the Wadden Sea Region and Júcar River Basin case studies are outlined below. **The analysis of risk perceptions across European MSPs showed important factors that brought the MSPs of ENHANCE to put risk management practices in place** (**see Figure 3.3**). Almost all respondents indicate that risk management would be enhanced following an increase in the frequency of disasters, mainly due to increase/decrease of precipitation (depending on the region and natural hazard observed); sea level rise; increase in climatology intensity; increase of human settlement in some areas and also human abandonment in others; deficiency in infrastructures; and climate change.

RISK PERCEPTION in the trilateral Wadden Sea Region

The Wadden Sea Forum (WSF) is an independent platform of stakeholders from different sectors (Agriculture, Energy, Fisheries, Industry and Harbour, Nature Protection, Tourism) as well as representatives of local and regional governments in Denmark, Germany and the Netherlands. Once established to foster sustainable development of the trilateral Wadden Sea Region (WSR), the ENHANCE project investigate the WSF's potential as a MSP in the trilateral coastal risk management processes, supporting the target to enhance risk management as people-centred, social processes.

Embanked foreland at Sönke-Nissen-Koog, German Wadden Sea coast. Photo by Birgit Gerkensmeier.

Stakeholders of the WSF perceive storm surge events as a major risk in the WSR. These perceptions correspond with scientific discussions in coastal research highlighting the need to enhance resilience against natural hazards, such as storm surges, along European coast lines. However, stakeholders' awareness of the currently applied storm surge risk management measures in the WSR does not correspond to this tenor: In fact, stakeholder discussions disclosed that storm surges represent a major risk – but this risk is currently well managed and therewith reduced to a societal tolerable degree in all the three countries. Much more important, however, for stakeholders of the WSF are risks deriving from socio-demographic changes –for these issues stakeholder express a most urgent need for action and improvement of risk management in the WSR. Furthermore, *risks resulting from conflicting spatial uses between different user interests in the WSR are perceived as important risk in the area* which is, following stakeholders' awareness, of high priority for enhancing risk management activities.

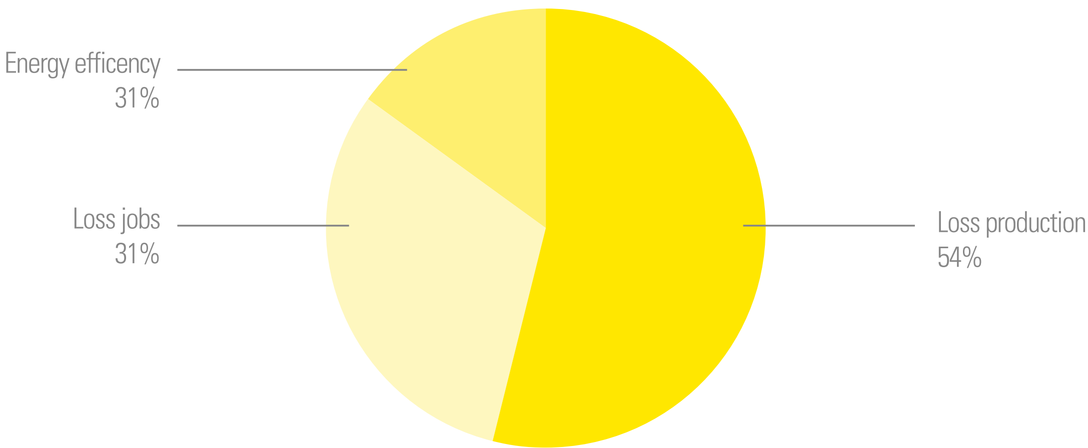
This insight of stakeholders' risk perceptions and their awareness of management needs reveal that the WSR is facing a multitude of risks, including urgent need for improved risk management processes beyond storm surge risk management issues. Focusing on only one of these risks would not meet stakeholder expectations and risk management requirements. In practice, the necessary consequence is to include an expansion and adjustment of the risk management aims to the MSPs requirements, as it was done in the ENHANCE cases study. In this regard, the WSR findings underpinned the importance to acknowledge and to include stakeholders' (and societies') concerns and keep risk management processes flexible enough to adapt to changing or new conditions in the management process.

RISK PERCEPTION in the Júcar River Basin

The Júcar River Basin Partnership (JRBP) manages the water issues in the basin. The Permanent Drought Commission (PDC) is a MSP (apart from the JRBP) decreed by Royal Decree (Spanish legislation) when the drought special alarm system detects drought in the basin. The PDC is shape by governmental authorities, private enterprises, partnerships of water users, NGOs and union representatives.

Stakeholders' perceptions vary from one water use to another e.g. *agricultural associations for irrigators perceive the loss of production and jobs as risk due to the reducing water in irrigation during a drought episode while the drinking water supply enterprise considers risk the poor quality of the water for human consumption*. Also there are variations between the different regions in the JRB, e.g. historical Royal Rights have determined the priorities to use the water of the river, building conflicts between territories and developing also perceptions. Those perceptions and the risk culture created during centuries in the basin make possible to have a consistent management to deal with risks. Stakeholders in JRB are not self-consider vulnerable in the face of droughts due to the high preparedness and planning to mitigate them. There are not droughts exactly the same but the long time dealing with them has developed scenarios well regulated, nevertheless one of the bigger uncertainties perceived by the stakeholders to face risk are the measures which imply economic expenses, if they will be able to face them, or the increase of drought episodes in short period due to climate change.

Socio-economic impacts perceived



Source: Risk perception assessment (D4.2. ENHANCE)

Xirivella irrigation canal. Photo by M. Carmona.

In addition, respondents gave their perceptions of **existing measures and their effectiveness**. The measures they considered most effective in regard to risk assessment are represented in **Figure 3.4a. Risk mapping and regular monitoring** are considered as the most effective and are mandatory in many cases. In some MSPs, measures are anchored as part of their risk culture, and examples of their use can be found already since the first half of the last century. Other measures are: knowledge and technology transfer, information and networking, and applying future climate scenarios and simulations. It is remarkable that economic monitoring of losses does not form part of their usual instruments for monitoring risk. This is most likely due to the fact that economic losses are normally accounted long after the catastrophic events have taken place. In addition, due to the continuous improvements in risk minimisation in many cases, economic losses vary from one event to the next both in quantity and location complicating the monitoring process.

Regarding the **measures implemented as part of risk preparedness plans**, most institutions have some form of risk management and risk emergency plans (**Figure 3.4b**). Most of these plans, however, are older than 10 years, and in 60% of the cases they are considered mandatory. Emergency plans are considered mandatory in all the cases (100% of the cases analysed).

Regarding **action to support prevention and mitigation** (**Figure 3.4c**), awareness raising is implemented for more than 10 years in 50% of the cases. 92% of the analysed cases implement this measure. On the other hand, insurances are used only by 17% of the cases.

Long-term post-disaster policies and compensations funds are the most implemented **measures to ensure recovery after a disaster event** (**Figure 3.4d**). 25% of the respondents considered the management of economic support out of the scope of their work.

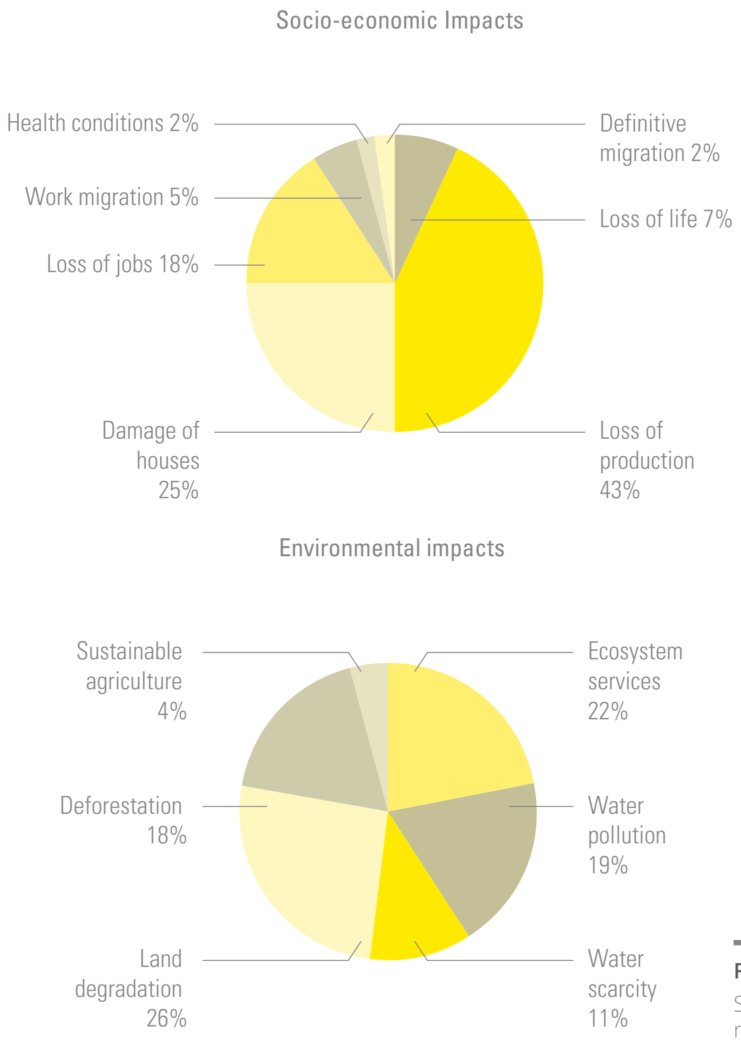


Figure 3.3.
Socio-economic and environmental factors that drive risk management across the ENHANCE case studies.

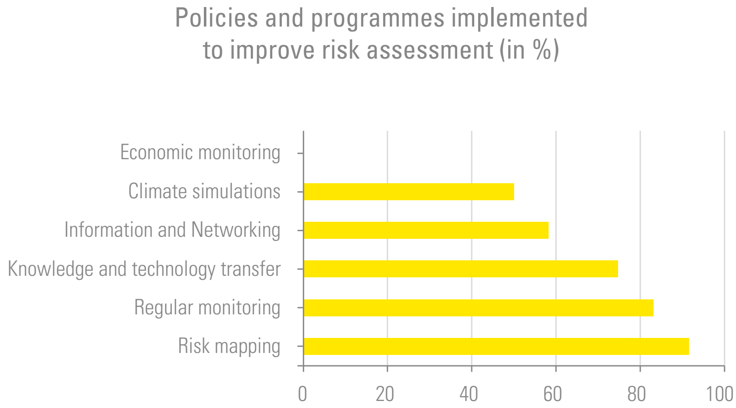


Figure 3.4.a.
Measures considered by MSPs as being effective for improving risk assessment.

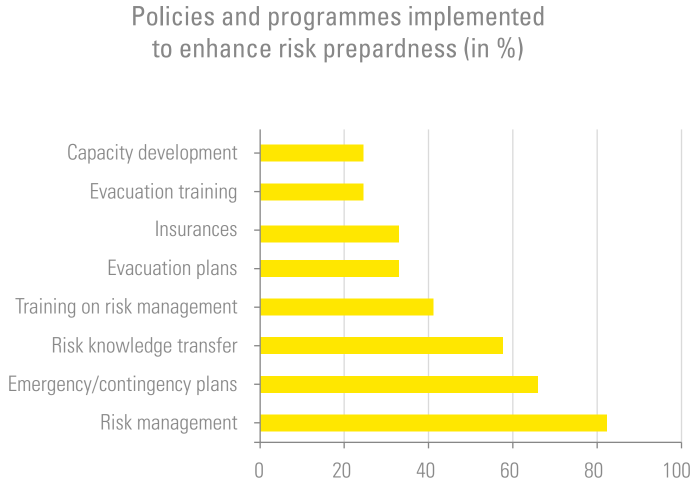


Figure 3.4.b.
Policies and programmes implemented to enhance risk preparedness.

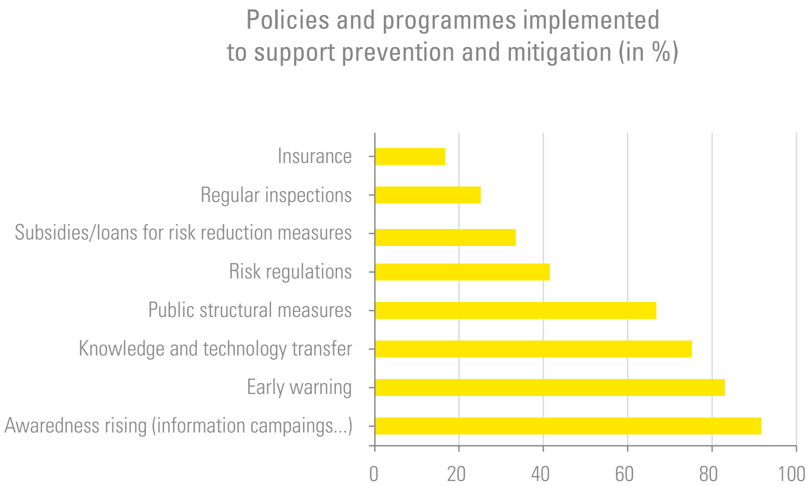


Figure 3.4.c.
Policies and programmes implemented to support prevention and mitigation.

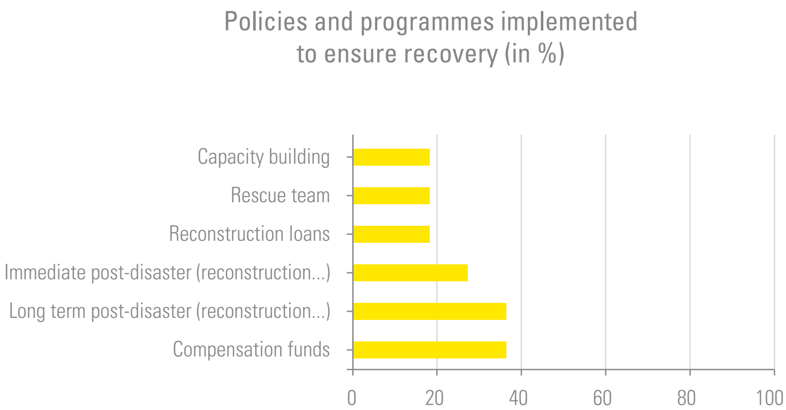


Figure 3.4.d.
Policies and programmes implemented
to ensure recovery.

Together with UNISDR, ENHANCE provided input on the theme of risk perception at the European Forum for Disaster Risk Reduction 2015. During this conference, representatives of national platform for disaster risk reduction for different EU countries were also present. As a follow up, we asked our survey respondents on the activities of those national platforms. It appeared that 70% of the respondents confirm that they have a **national platform for disaster risk reduction** in their country, involving public and governmental entities, civil protection departments, universities, infrastructure businesses and environmental agencies, among others. These national platforms are responsible for the coordination of actions oriented to develop guidelines for monitoring and management, to foster agreements between stakeholders, elaborate information and its dissemination, and to provide financial support for the implementation of all tasks at the regional and local level. This implementation process is usually done through conventions, project evaluation, monitoring committees, governmental funds and mandatory insurance of properties. Regional and local platforms are responsible for the identification of needs, definition of measures and distribution of the financial support for their implementation.

The survey showed the main characteristics of risk cultures being:

- Decision-making processes made on a consensus basis.
- Involvement of all members of the partnership in the risk management process.
- Expert knowledge as a predominant key value.
- Importance of historical knowledge: experiences in the past help with subsequent events. E.g. creation of risk management models, defence programs, etc.
- Activities to prepare for risk management: data collection and empirical analysis including systematic monitoring. E.g. warning systems, sensing networks and remote sensing, GIS, systems of indicators, etc.
- Key policies to improve risk assessment include risk mapping and regular monitoring.
- Most partnerships are involved in national platforms for disaster risk reduction carrying out coordination and being responsible for finance and information.
- Key measures to support prevention and mitigation are awareness raising (around 71%) and early-warning systems (around 80%).
- Long-term post-disaster policies and compensations funds to ensure recovery after a disaster event.

Policy implications

Multi-sector partnerships have proven to be a very effective mechanism for managing risk events. They have often evolved around a long-standing culture of risk management, tailored to particular locations suffering from recurring natural hazards. With the results of our analysis we can confirm the main characteristics of a risk culture that are beneficial to risk management. Those characteristics are partly shaped by the perception of risk of the people involved in the partnership.

There is a need to support these MSPs and governments should assist the creation of multi-sector partnerships to manage risks and take advantage of the synergies between stakeholders. This support should also be reflected in the legislative field, for example, through including guidelines and criteria for the creation of MSPs that will in turn help to further analyse the effectiveness of MSPs.

Nevertheless, we have to recognise that there is no 'one-size-fits-all' solution and that MSPs are shaped by the hazard they face and also by the social, political and historical background. For example, the creation of an MSP in areas facing the same hazard for many consecutive years will be easier than in areas where no tradition of a particular hazard's management exists. MSPs are very likely to occur even in an informal way in regions where a certain hazard has a recurrent nature (e.g. droughts in the Júcar River Basin District). Thus, it is important or even necessary that these informal MSPs are further legalised, stimulating a good governance structure to optimise the risk management process.

Another possibility is that risk management is done in a very local/individual basis. Our work shows that MSPs are the epitome for proper risk management, so there is an evolution from the individual to the partnership approach.

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04

Economic instruments

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Introduction and overview

Economic instruments (EI), such as **subsidies**, **taxes** and **insurance-related options** are at the heart of discussions regarding novel approaches for managing risk and adapting to climate change, including in the context of multi-stakeholder partnerships (MSP) between the private and public sectors (Agrarwala and Fankhauser, 2008; Chambwera et al., 2014).

Although the attractiveness of reducing and managing disaster risk has long been demonstrated (e.g., Foresight, 2012), **there is underinvestment into disaster risk management** (DRM). A number of factors, such as a lack of comprehensive information and cognitive biases are important. In particular, financial constraints and moral hazard, i.e. adverse incentives provided by current arrangements for dealing with disasters play a large role (Chambwera et al., 2014).

In this line of thinking, instruments that provide a price signal for risk management and incentivise behavioural change hold high appeal by policymakers including in the EU (see Bräuninger et al., 2011). Yet, little is known about such economic instruments, their mechanics, links to risk management and concrete application in the field of disaster risk management (and climate adaptation) (see Chambwera et al., 2014). Knowledge gaps exist particularly with regard to conditions that create enabling environments for innovative market-based and risk financing instruments. Among these are, e.g., the attractiveness for stakeholders in the context of MSPs or institutional settings that are required to successfully and efficiently apply the EI.

This chapter discusses the **potential of EI for managing and incentivising risk management in the context of the ENHANCE project**. The analysis debates how economic instruments may support risk management, including new partnerships between the private and public sectors. Based on an inventory, it applies different assessment techniques to the most promising options by way of case studies, and finally gauges the potential of key economic instruments for incentivising risk management generally via multi-criteria assessment.

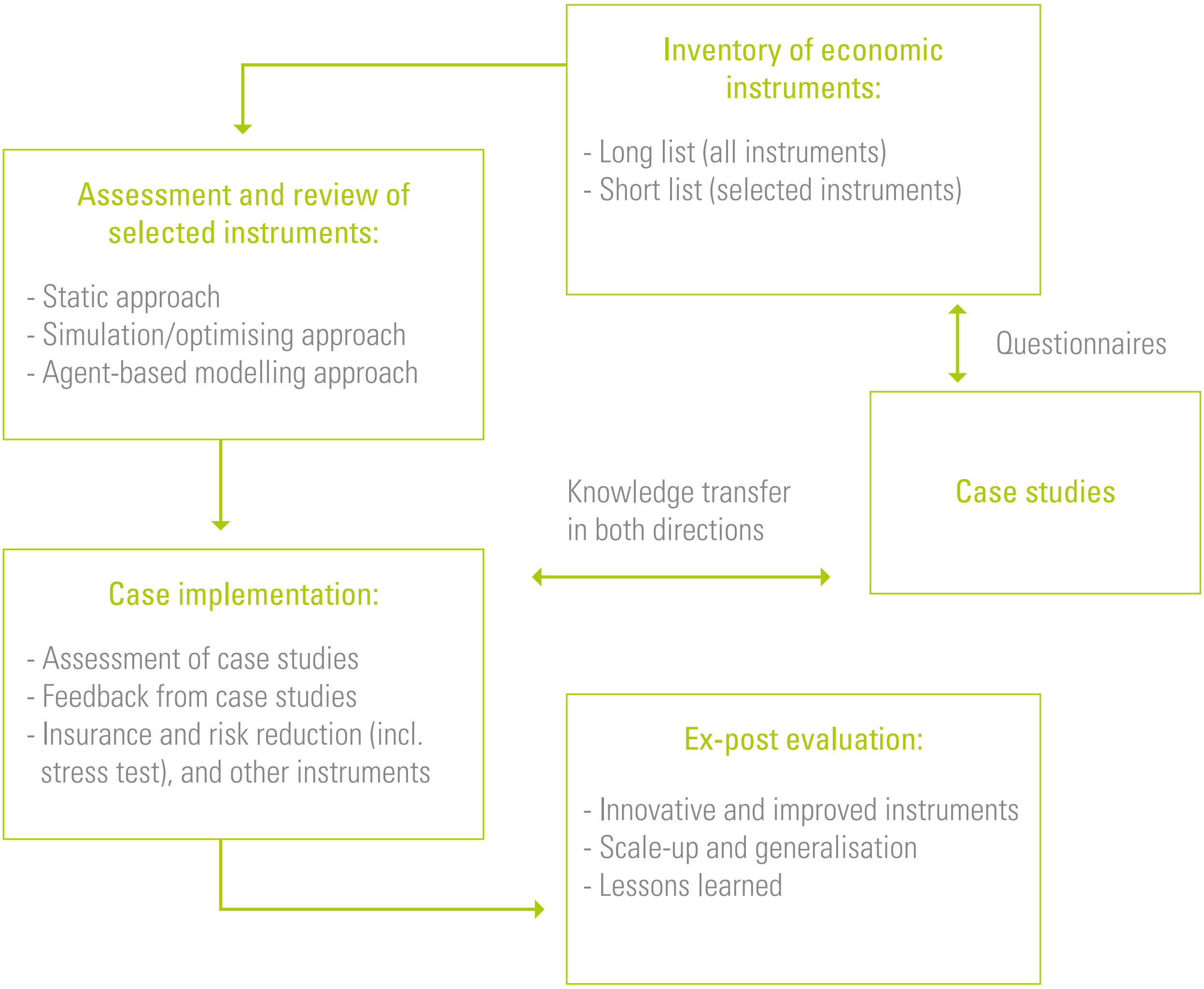
The guiding questions for this part of the ENHANCE project have been:

- What innovative economic instruments exist for managing disaster risk?
- How do they contribute to risk management?
- How do case studies discuss and assess economic instruments?
- What can be learned from the case study application using a common assessment framework?

Approach

Figure 4.1 shows the main tasks carried out for this line of work. A review of the available literature leads to a long list of potential instruments and their general applicability. Screening of anticipated uptake of the instruments in key ENHANCE case studies via a questionnaire submitted to our case study partners produced a short list of instruments, which were implemented and further assessed via modelling and empirical analysis. As the final step, a common framework based on multi-criteria analysis was applied to the case study instruments to assess their specific suitability.

Figure 4.1.
Workflow for assessing economic instruments for managing disaster risk in the ENHANCE project.



Review of economic instruments for disaster risk management

Private and public sector agents are tasked with managing disaster risks. While significant efforts of reducing and managing risk are being carried out throughout many regions, recent evidence suggests less than optimal adaptation levels to current hazards and future changes therein, e.g. through climate change (Agrawala and Fankhauser, 2008; IPCC, 2014) across all regions, sectors and societies. In fact, as discussed in IPCC (2014), given a diverse set of risks and manifold preferences, constraints and perceptions of risk, there is no such thing as 'optimal' adaptation. Yet, there is ample scope for 'better' adaptation and risk management. Risk management may happen autonomously or through policy intervention and policy instruments – the focus of our attention for this chapter.

Apart from insurance-related instruments, few adaptation instruments work ***directly*** via economic principles and using markets to adapt to impacts and risks. On the other hand, economic instruments can be used to ***indirectly*** incentivise behaviour and increase the uptake and efficiency of adaptation measures. As one important reference, Agrawala and Fankhauser (2008) distinguish the following incentive-providing instruments relevant for key sectors:

- insurance schemes (all sectors subject to extreme weather events);
- price signals / markets (water; ecosystems);
- financing schemes via Public-Private Partnerships or private finance (flood defence, coastal protection, water);
- regulatory measures and incentives (building standards, zone planning);
- research and development incentives (agriculture, health).

Synthesising this, and in line with recent literature, we consider two broad types of instrument categories (see also Chambwera et al., 2014; Bräuninger et al., 2011):

1. **Market-Based Instruments (MBI)** are instruments administered by government regulators that provide a monetary/economic incentive promoting risk management and adaptation. According to the EU white paper, the definition of MBI is broad (see EU Commission, 2009) and in the interpretation of this chapter it includes natural resource pricing, taxes, subsidies, marketable permits, payments for ecosystem services, licences, property rights and habitat banking.
2. **Risk Financing Instruments (RFI)** comprise all instruments that promote the sharing and transfer of risks and losses. They generally can be classified as pre-disaster arrangements, and comprise insurance, weather derivatives and catastrophe bonds, and many of those are indeed market-based as well.

Three channels through which EI can contribute to risk management can generally be identified (see Bräuninger et al., 2011; Chambwera et al., 2014):

1. **Direct risk reduction**: as one example, risk financing provides direct compensation payments, which reduce follow-on impacts from an event.
2. **Indirect risk reduction**: incentives for risk management and increased resilience help to reduce and manage risks.
3. **Managing systemic risk**: both down and upside risks are managed, i.e. insurance takes down-side ('bad risks') risk out of investment decisions, which overall focus on harnessing upside risks ('good risks').

Our inventory is presented in the form of a long list (see **Table 4.1**) and reflects instruments applied in the case studies. The EI are split up into the key groups mentioned above (see also Bräuninger et al., 2011).

Table 4.1.

Overview of economic instruments with applicability for managing disaster risk.

Economic instrument	Description
I. Market-based instruments	
Subsidies	Subsidies can be defined as a financial support/incentive from a government to an entity for implementing a practice or performing a specified action.
Grants	Direct payments or grants constitute the purest form of a subsidy. An economic entity receives an amount of money, which is supposed to induce the recipient to undertake a specific action bound to that payment.
Price supports	Price supports belong to the group of indirect subsidies although some direct payment is usually associated with them. In its most common form, the government defines a price floor for a good and pays the differential amount to the producers of the good as soon as the market price falls or is below this minimum level.
Pricing (taxes and fees)	Besides generating government revenue allowing public expenditures e.g. for a public adaptation policy, taxes can also be used to direct private behaviour towards a socially optimal behaviour.
Land use taxes and fees	Land use taxes –we understand them as a tax on land and buildings – represent a payment either for the land ownership itself or for its kind of use. Land use fees are similar in nature, but they would by definition require some type of service from the collecting (public) institution in return.
Water pricing	Price to be paid for a certain amount of water or water/sanitation services. Double role, as financial instrument for cost recovery of water services and as economic instrument, acting as incentive for a more efficient water use. The EU Water Framework Directive requires the recovery of financial, environmental and resource cost of water services, considering the Polluter Pays Principle. The resource cost has been related with the opportunity cost (social welfare losses) of not using water for the most socially beneficial use. Efficient water pricing should incorporate a signal of the marginal value of water to the users. The design of the final tariffs for residential water supply involves the consideration of conditions of revenue sufficiency, efficiency, equity and affordability.
Licenses, permits and variations	Environmental markets are based on the generation of demand for tradable units through regulatory decision. This demand then triggers the supply of units.
Project-based offsets	A project-based adaptation offset could be generated by projects in regions where adaptation is relatively easy to generate, but where no governmental adaptation commitment exists.
Advance market commitment	The government guarantees a certain income to the entity providing a desired activity, making this instrument comparable to a subsidy.
Other market-based instruments	These instruments specifically address the problem of overuse of natural resources, partially picking up some of the broader concepts, like taxation.
Payments for ecosystem services	As long as the benefits from changing the ecosystem instead of conserving it are larger, a payment would be needed in order to avoid e.g. conversion of forests to pasture.

Water markets	An intensification of unevenly distributed water resources and extreme events such as droughts, together with increasing average temperatures, calls for the efficient use of scarce water supplies. Voluntary win-win trades of water can contribute to reallocate scarce resources to the high-value uses, improving the economic efficiency and promoting the adoption of water saving technologies. There is a broad range of options (permanent transfers, temporary transfers, option contracts, spot markets, etc.), and even water quality trading schemes.
Habitat banking	Habitat banking aims at conserving the ecosystem services of land, including biodiversity. Credits are given for the creation, restoration and enhancement of habitats, while debits occur when ecosystems are unavoidably degraded or destroyed.
II. Risk financing instruments	There are many instruments for dealing with the financial burden imposed by disasters. At the most general level, we distinguish risk financing from loss financing instruments. The important distinction is that risk financing is purchased/ organised by persons or a community at risk purposefully and in anticipation of risk, whereas loss financing is arranged by people, governments and the state, often ad hoc, after an event.
Insurance-related instruments	Insurance helps to finance losses caused by extreme events. Insurance has the potential to be useful for adaptation in incentivising and enabling and risk reduction as well as enabling recovery and economic development.
Catastrophe bonds	A catastrophe bond is an instrument whereby disaster risks are packaged (securitised) in the financial markets. The investor receives an above-market return provided a specified catastrophe does not occur during the contract, but sacrifices interest or part of the principal if the event does occur.
Weather derivatives	Weather derivatives are contracts where pay-outs are linked to physical 'triggers', e.g. number of days with temperatures below or above a specified threshold, or rainfall above or below a specified level.

Application to the case studies: instruments and methods

During the ENHANCE analysis a questionnaire was used to identify the type and scale of economic instrument use across the case studies. This was then refined through detailed discussions with case study partners about key instruments and the type of analytical methodologies applied in the different case studies. **Table 4.2** summarises the set of economic instruments and assessment methodologies used for the different case studies.

Table 4.2.
Overview of assessment of EI and methodologies used in case studies.

Economic Instruments	Empirical approach	Simulation and optimisation approach	Agent-based modelling approach
Grants, tax reductions	Santarém, tax-financed subsidies	--	London, subsidies for flood proofing Rotterdam, subsidies for flood proofing
Land use taxes & fees	Santarém, land-use tax	--	--
Market commitments	Santarém, market commitments	--	--
Water pricing/markets		Júcar, water pricing/markets	--
Property insurance, crop and forest fire insurance	Santarém, insurance Romania/Eastern Europe, sovereign and private market insurance market insurance	--	London, property insurance Rotterdam, property insurance, incentives for flood proofing
Sovereign insurance and related instruments	Romania/Eastern Europe/EU	EUSF	--

Simulation and optimising approach of water pricing and markets

Through simulation the economic impact of different policies/scenarios can be obtained for a particular set of a priori rules. In contrast, optimisation models directly provide the best solution in terms of the objective function and the constraints, recognising the opportunity costs and economic trade-offs inherent in any decision-making. This approach has been applied to the **Júcar River Basin drought case study** and focuses on water pricing and water markets as strategies for drought risk management (see also box below). It was also used for assessing **European-wide risk sharing via the European Solidarity Fund**.

Agent-based modelling approach

Agent-based models (ABM) are useful as they provide a bottom-up approach for understanding systems and their behaviour, and are advantageous for visualising the effects of changing behaviours. ABMs can be used to characterise different stakeholders in a risk sharing arrangement. Simulation of the hazard and losses can be used to assess the effect of different risk sharing options, and arrangements which encourage overall risk reduction. This approach has been applied to the **London and Rotterdam flooding case studies**, which focus on the role of insurance. These EI were found to be highly attractive for MSP stakeholders with a significant link to risk management. There is also a high level of experience and evidence with regard to their application for risk management and adaptation.

Mixed methods approach

Other cases used a mix of qualitative and quantitative empirical techniques. The **EUSF/Romania case study** focused on low-probability but high-consequence flood events and investigated the performance of the EUSF, including robustness, solidarity and risk reduction considerations. Beyond providing a detailed assessment of the Fund itself, the main goal was to explore if the formulation of an EU-wide multi-sector partnership that could enhance the financial resilience of the Community. The case study followed a probabilistic risks analysis method for assessing flood risk on the Pan-European level, leading into stress testing of the EUFS. Beyond the stress testing, the case study investigated the Fund's performance in terms of solidarity and promotion of disaster risk reduction by conducting a modelling exercise and a detailed analysis of relevant EU policies. The MSP of Chamusca and of Mação performed qualitative and a quantitative empirical analysis, which entailed identifying a long list of economic instruments, relevant criteria and a description for each criterion, and participatory deliberation with key the stakeholders of the MSPs.

Assessing water scarcity in the Júcar River Basin

Issue and instruments

The Júcar River Basin is a complex water resources system located in eastern Spain, highly regulated and with a high share of water for crop irrigation (about 83%), in which water scarcity, irregular hydrology and groundwater overdraft cause droughts to have significant economic, social and environmental consequences. The basin has been used as a test case to apply scarcity-based water pricing policies and water markets as potential instruments to manage drought risk. Scarcity-based water pricing policies are based on the marginal economic value of water (Pulido-Velazquez et al., 2013, Macian-Sorribes et al., 2015). When water storage is high, the marginal value of water is low, while low storage (drought periods) is associated with high marginal values.

Models and methods

In order to assess the impacts of these economic instruments, two new tools were developed and applied to allocate available water resources through simulation and optimisation approaches. The **simulation tool** (SIMGAMS) allocates water resources according to system priorities and operating rules, evaluating the scarcity costs through economic demand functions. The **optimisation tool** (OPTIGAMS) allocates water resources to maximise net benefits (or minimise total water scarcity cost plus operating cost at river basin scale). SIMGAMS allows for simulating incentive-based water pricing policies based on water availability in the system (scarcity pricing), while OPTIGAMS is used to simulate the effect of ideal water markets by economic optimisation.

As the Júcar River Basin has a high share of water use for crop irrigation (around 80%), we also assessed the impact of drought on irrigated agriculture production using an **econometric approach** (Lopez-Nicolas et al. 2015). For this purpose, a two-stage approach has been applied (Gil-Sevilla et al., 2010 and 2011): first, an econometric model has been fitted to explain the impacts of water resource availability and crop price volatility on the agricultural production value. Monte-Carlo algorithms are then used to consider the contribution of the variability of the hydrology on drought risk and impacts.

Lessons and insights

The results show the potential of applying economic instruments to deal with drought risk management. Water pricing policies and water markets have a positive impact on drought risk management, reducing the total scarcity cost during drought periods. Scarcity-based water pricing policies send a scarcity signal to water users (when the storage decreases water price increases). So this works as an incentive towards a more efficient water use, promoting high-value uses during

MCA assessment of economic instruments for adaptation

Overview of synthesis assessment using MCDA framework

In choosing an approach to assess the costs and benefits of a number of economic instruments, four major decision-techniques can be identified: cost benefit analysis (CBA), cost effectiveness analysis (CEA), multi-criteria decision analysis (MCA), and robust decision-making approaches.

We utilise an MCA methodological framework in this work to discover and quantify stakeholder and decision-maker considerations about various non-monetary factors in order to compare different courses of action (Huang et al. 2011). As described by Belton and Stewart (2002), MCA approaches **'seek to take explicit account of multiple criteria in helping individuals and groups explore decisions that matter'**.

MCA is appealing and practically useful as it tries to take account of multiple conflicting criteria, provides a model that can serve as a focus for discussion, and a process which leads to rational and explainable decisions (ibid). MCA methods are desirable for analysing complex problems, as they deal with a mixed set of both quantitative and qualitative data, including expert and stakeholder opinion. The process of application is structured to enable collaborative planning and decision-making, as it accommodates the involvement of multiple experts and stakeholders (Mendoza & Prablu 2003). While there are numerous MCA methods, they all follow a similar basic approach. For any alternative, its total value score is calculated as a linear weighted sum of its score across several criteria. Alternative approaches have hierarchical structures, which break dimensions into several sub-dimensions (criteria to indicators) (Keeney and Raiffa, 1976).

Regardless of the specific MCA approach, the selection of criteria and indicators for assessment is vital, and we build on analysis conducted by Bräuninger et al. (2011), which defined and populated a set of indicators to assess economic instruments for the EU, based on qualitative scoring and expert opinion. The criteria are outlined below, with the introduction of a fourth, which deals with the environmental dimension of economic instruments.
Regardless of the specific MCA approach, the selection of criteria and indicators for assessment is vital, and we build on analysis conducted by Bräuninger et al. (2011), which defined and populated a set of indicators to assess economic instruments for the EU, based on qualitative scoring and expert opinion. The criteria are outlined below, with the introduction of a fourth, which deals with the environmental dimension of economic instruments.

Table 4.3.

Criteria used in MCDA analysis of economic instruments, and motivating questions and indicators for analysis.

Economic criterion: Efficiency	Social Criterion: Equity	Political and institutional applicability	Resources, biodiversity and sustainability
What is the balance between costs and benefits?	What distributional consequences will arise? Will they be negative, i.e. regressive? Will the instrument be affordable and cover a high percentage of those affected?	Which types of adaptive activities can be incentivised by the instruments?	Does the measure reduce the quality or quantity of resources?
What transaction costs will accrue?	Are there any specific barriers or conditions that are not covered?	Have policymakers applied similar instruments? What have the experiences been?	Does it incentivise more sustainable management of resources, or encourage biodiversity protection?
How well does the instrument incentivise disaster risk management?		Are interest groups likely to oppose such instruments?	Do measures decrease negative externalities related to human health? Do they encourage the use of linked resources?

For this assessment, we strongly relied on expert opinion, i.e. on ENHANCE analysts' perspectives on the pros and cons of the different instruments, while involving stakeholder views where possible. Scoring was jointly taken forward by the team involved in this line of work of the ENHANCE project in order to give broader insight into the instruments as they are supposed to support DRM. Several issues emerged while doing the analysis. These include level of generalisation of the results across case studies as well as questions regarding the context-specific nature of each case and instrument, as well as differences in relevance of the criteria and indicators. The comparability of results across different cases remains very questionable, and therefore the results should not be necessarily viewed as a comparison across case studies but of viewing the case study in a more holistic manner.

MCA analysis of instruments: results

The MCA analysis covered five case studies, of which four dealt with insurance-related instruments, and one, the Júcar case, with water markets and pricing. We present results separately for the analysis of water markets and water pricing as well as insurance cases.

Water markets and scarcity-based water pricing in the Júcar River Basin

Two instruments were compared in the Júcar River Basin case for dealing with water scarcity: water markets and scarcity-based dynamic water pricing. The following section provides a qualitative comparison of the two options assessed, followed by results of the MCDA process (see Figure 4.2).

Economic criterion

In theory, both water pricing policies and water markets move water to the highest-valued uses, providing an efficient water allocation with a positive impact on drought risk management, reducing the total scarcity **cost** during drought period. Water pricing would also reduce the demand in scarcity periods increasing the storage in drought conditions, which could avoid potentially larger future losses.

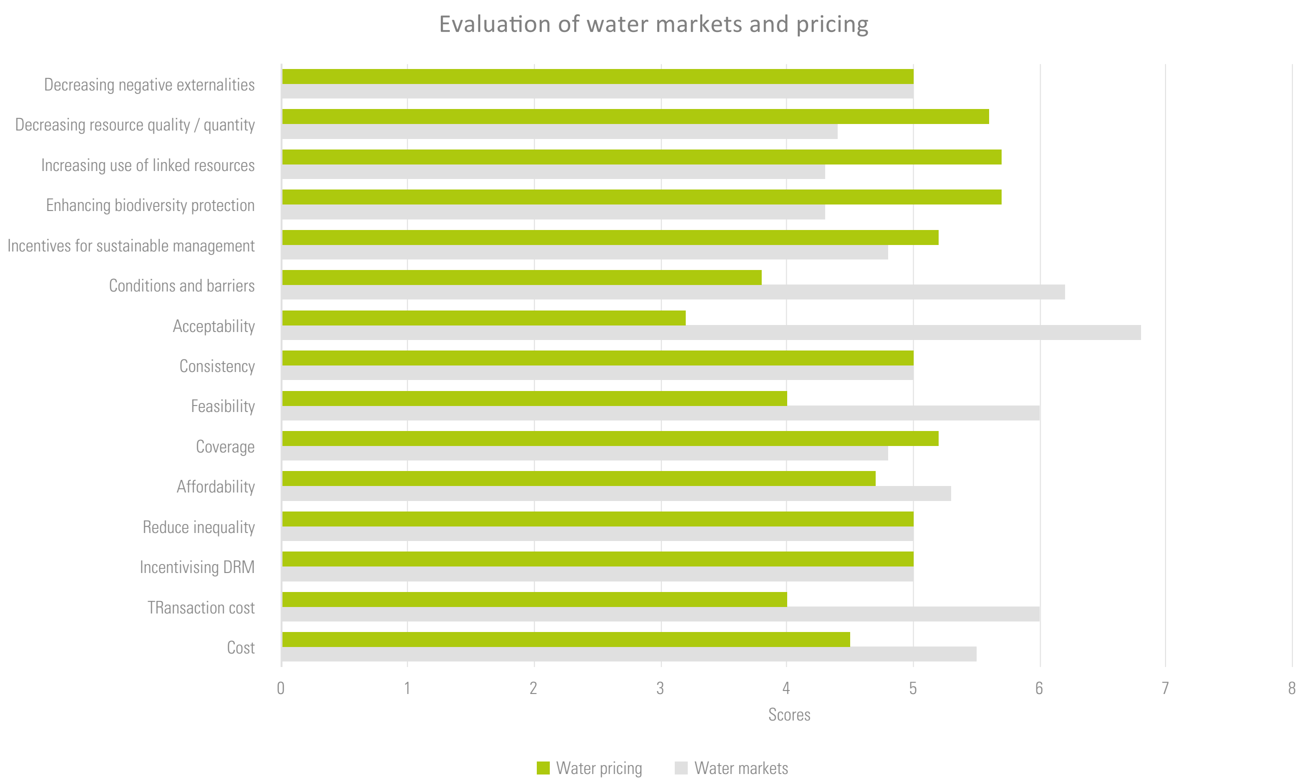
Scarcity-based water pricing policies are pricing policies linked to water availability in the basin (represented by available storage) that integrate the marginal value of water (MROC), sending the users a signal of the economic value of the resource and the opportunity costs. When water storage is high, the MROC is low, while low storage (drought periods) will be associated to high MROC and therefore, higher prices. So this works as an incentive towards a more efficient water use, promoting high-value uses during drought periods, reducing the total water scarcity cost (forgone benefits due to deficits in water deliveries). The results for the Júcar Basin show that a significant reduction of water scarcity can be achieved with an efficient scarcity-based water pricing policy, up to a 60% reduction of total scarcity cost (see Box above).

A perfect water market (results provided by the optimisation) could further reduce the total scarcity cost of the system. Results for the Júcar basin show transfer of resources from low to high value uses during drought conditions, although with implications on environmental conditions that should be regulated in order to prevent this. Transaction costs might hinder the efficiency of water markets.

Transaction costs associated with water pricing vary across methods and locations, and involve a fixed component (installing measuring devices, setting up administration etc.) and a variable component that increases with water proceeds (monitoring and collection) (Tsur, 2000). Beyond administrative costs, others can be substantial and difficult to value (Johansson et al., 2002), and may render pricing policies unfeasible. Since water scarcity pricing is based on marginal water values and use, accurate pricing would require assessing volumetric use, which may not be implemented for some uses (e.g. agricultural demands for use in irrigation), resulting in higher costs. While generating insufficient revenue is obviously not sustainable in the long run, strategies can be implemented to guarantee revenue sufficiency. Markets also involve transaction costs, and can bring costs due to the economic and environmental externalities the transfer can generate. Generally, transaction costs of water markets are higher than of pricing policies, as it might require developing new infrastructure to transfer water between sellers and buyers. When considering bargaining and information costs (also transaction costs), water markets might become more appealing.

In terms of **incentivising DRM**, instruments were not assessed to have a large direct effect, although scarcity-based water pricing policies may indirectly provide an incentive towards more efficient use of water resources by promoting high-value uses during drought periods, and providing users with a signal of the economic value of the resource and opportunity costs. Economy wide macroeconomic impacts of water pricing (e.g. effects on GDP or GVA) are difficult to account, but there are some examples in the literature using input-output tables or computable general equilibrium models (e.g. Perez-Blanco et al., 2016).

Figure 4.2.
Unweighted scoring of water pricing and water markets in the Júcar River Basin case.



Social criterion

Both instruments, pricing and markets, would contribute to the reallocation of resources to high value uses during water scarcity periods. Additional revenues generated by water pricing could be used to **compensate low-value users for some of the losses** they might face due to the price increase during drought periods using financial compensation mechanisms (e.g., Tilmant et al. 2009). The additional financial resources generated could be also employed to **develop adequate infrastructure** to increase water security (for example, by financing desalination plant that reduces water scarcity). Water exchange in water markets is voluntary and represents a win-win situation for both buyers and sellers, but control mechanisms need to be implemented in order to avoid third party effects.

Political and institutional criterion

Both approaches lead to high scores in terms of addressing political and institutional criteria, as they are legally and administratively **feasible** in the setting of the case study, although some legal and institutional reforms are required for implementation in other contexts. Both instruments are **consistent** with other regulatory or incentive-based instruments. However, in some cases water markets might face **physical barriers** to implementation, as it may be necessary to construct additional infrastructure connecting users. Scoring diverges in regards to **acceptability** by other interest groups. In the case of scarcity pricing, acceptability will depend upon the perceived equity and the affordability of the rate structure. Water markets are expected to be more easily acceptable for farmers, since they would increase their income by buying and selling the water, while water pricing policies would penalise them. But it is also true that experience shows that water markets face many practical challenges for their implementation.

Environmental criterion

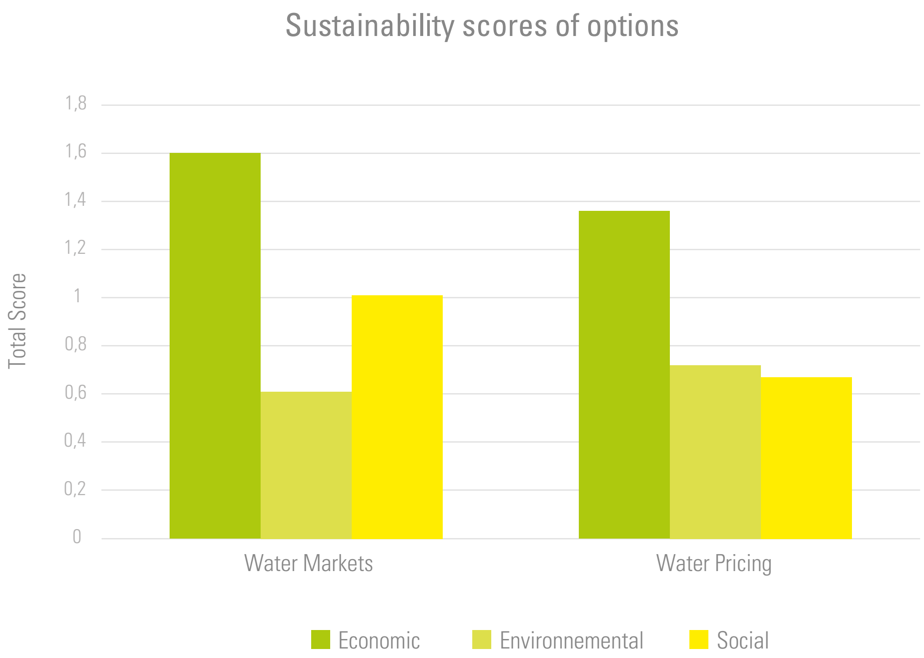
Both instruments score high in regards to environmental indicators; scarcity-based water pricing policies work to promote **more efficient water use**, enhancing **high-value uses** during drought periods. In this way, water pricing can contribute to improving economic efficiency and social equity and, by using less of the resource more efficiently, lead to environmental enhancement. However, we can be more efficient and use more water as well

Photo by Tobias Arhelger/Shutterstock.

(as have been discussed in the case of the modernisation of irrigation systems, Ward and Pulido, 2008), and therefore, have a negative environmental impact. Water markets can also lead to a more **sustainable use of water** through **water reallocation** to (1) more productive soils in more suitable locations, (2) more efficient water users, (3) higher-valued uses, and (4) new developments and the consolidation of water into more viable units, increasing employment and economic activity, and producing environmental benefits (Bjornlund, 2004). However, unless explicit consideration is given to non-market uses or reserves set aside for the public good, markets may not deliver on broader societal goals, requiring to include adequate information on environmental needs, delivering water to meet these needs, and designing an adaptive process to manage these requirements with changing conditions and circumstances (Grafton et al., 2011). Scarcity-based water pricing policies, by reducing water demand and reallocating water use, can also have an impact on environmental flows that need to be considered in the design of the pricing policy.

Results of MCDA analysis

Figure 4.3.
Average sustainability scores of water markets and water pricing for the Júcar River Basin case.



Results of this analysis are shown in **Figure 4.3**, which displays a breakdown of the scores in what it terms 'sustainability scoring', assessing options by separating indicators into economic, social, and environmental factors.[1] **While water pricing is scored as being slightly better in terms of environmental effects, water markets are seen to outperform water pricing in terms of both social and economic indicators**. In any case, this evaluation only refers to the specific pricing policy (scarcity-based marginal cost pricing) and water market scheme that was considered for the Júcar River Basin case study. There are many alternative options for pricing and water trading with many different economic, environmental and social implications. This comparison does not intend to be exhaustive nor can be further generalised. Moreover, the two instruments are not necessarily exclusive and can act as complementary options for mitigating drought impacts.

[1] Political and institutional factors are not discussed separately as they would lead to the same scores for both instruments, as discussed above.

Insurance-related instruments

The following section assesses insurance instruments analysed by the case studies of Portuguese forest fires, Rotterdam and UK flooding, and the EU Solidarity Fund. Instruments were assessed qualitatively according to each criterion, with **Table 4.4** providing a short overview (see annex for a more detailed version, outlining the specifics of each case study) of instruments using the criteria defined previously to structure analysis. The table uses a colour shading system to indicate the strength or weakness of an instrument with regards to the given indicator, as assessed by expert judgment, i.e. building on researchers' insights using quantitative and qualitative analysis. Green indicates that an option is perceived as scoring highly for a given criterion, with yellow indicating moderate ability to meet the ambition set out by the respective indicator, and red being very little or no ability. Grey indicates areas of ambiguity or indicators that are not applicable to the option.

Due to the diversity of cases and analytical tools the findings should not be seen as a comparison between different cases, but rather as a stand-alone analysis of each case.

Table 4.4.

Synthesis assessment of insurance instruments for DRM (see Annex for a more detailed version, outlining the specifics of each case study).

Criteria	Indicator	London Flood Insurance	Fire Insurance and market commitments	Rotterdam property insurance	EU Solidarity Fund
Economic	Cost	Ambiguous	Low	Ambiguous	High
	Transaction cost	Ambiguous	N/A	Moderate	Moderate
	Incentivise DRM	Moderate	High	Ambiguous	Moderate
Social	Reduce inequality	Moderate	Low	Low	Low
	Affordability	Moderate	Low	Moderate	High
	Coverage	Moderate to high	Low	Low to moderate	Moderate to high
Political and institutional	Institutional feasibility	N/A	Moderate	High	High
	Consistency	Moderate	Low	Ambiguous	High
	Acceptability	High	Moderate	Ambiguous	Moderate
	Conditions and barriers	Ambiguous	High	High	Low
Environment dimension	Decrease resource quality	N/A	High	Low	N/A
	Decrease resource quantity	N/A	Moderate	Low	N/A
	Incentivise sustainable management	Moderate	High	Moderate	N/A
	Enhance biodiversity protection	N/A	High	Low	N/A
	Decrease negative externalities	N/A	High	Low	N/A
	Increase use of linked resources	N/A	High	Low	N/A

Economic criterion

Most cases diverged widely in their assessment of economic indicators; the **cost** indicator - indicating how costly experts regard the instrument to be for the economy - varies on a case-by-case basis. The expansion of insurance can promote the growth of the insurance sector or facilitate the development of economic activity; in which case it is a boon. The Rotterdam ABM shows that strengthening the link between DRM and insurance can result in the number of households buying insurance increasing by up to 63%, a rapid expansion of the sector (Haer et al., 2015). As insurance is a transfer of resources from one economic agent to another in a mutually acceptable trade, a high premium cost is not a cost to society, as the price of the premium sends a viable signal of risk, allowing potential policy holders to make a more informed decision regarding the risk faced. However, insurance schemes tend to require (in)direct government support, which can be quite expensive, as vouchers to correct for unaffordability could cost billions of euros if offered at the national level (Hudson et al., 2016). These burdens may be balanced out with lower overall risk faced by society. For instance, in France and Germany the risk reduction potential of all households by 2040 would exceed the costs of providing insurance vouchers to correct for unaffordability (Hudson et al., 2016).

Beyond the cost of the instrument, cases generally reported moderate or low **transaction costs** for the general provision of insurance, due to the well-developed insurance markets in which most of the cases operate. However, the aspects of the cases involving a greater connection to risk would possibly entail higher transaction costs due to the increased costs of monitoring DRM activities that specific policyholders conduct[2]. Private insurers commonly state transaction costs as a major reason for not strengthening the direct link between premiums and DRM (Hudson et al., 2016). Competitive markets can help to keep transaction costs as low as possible. Moreover, in a period of increasing risk the insurers must keep increasing their reserves to meet legal solvency requirements; resulting in more resources being invested in liquid assets with higher management costs.

Most of the measures assessed showed a moderate ability to **incentivise DRM**, even though in some cases, it was not part of the initial design of the instrument, and is seen as being very context dependent. For instance, the ABM in Rotterdam shows that premium discounts could increase the share of households employing DRM by, up to, 55% (Haer et al., 2015). On the whole, the incentivising ability is ambiguous and context dependent, as highlighted by the UK flood insurance mechanism which emphasises that depending on its design and implementation, an insurance scheme can send signals to policy makers in support of flood risk management policies which would address risk levels, e.g. via changes in the planning system and building regulations. The new Flood Re scheme does not enhance this policy link nor the incentivisation of home resilience, which is a missed opportunity (Jenkins et al., 2016). The Portugal forest fire case provides a slight juxtaposition to the other cases, as experts asserted a high amount of incentivising DRM, since insurance application requires a Forest Management Plan and a Plan for Forest Fire Defence. The EUSF also found that recent reforms better linked the Fund to DRM measures, but only for flood risk, leaving more potential for strengthening the link to DRM.

Social criterion

The finding from most cases was that insurance had little to no effect on social indicators such as **inequality reduction**. The Rotterdam case emphasised that it is not a role of insurance to directly reduce inequality; insurance may have a minor role in preventing the worsening of inequality by providing compensation payments but this would only come into play after a disaster, limiting the role of instruments in this regard. Both the Portuguese and EUSF cases also saw minimum potential to reduce inequalities, with the former instrument only benefitting owners of large properties, with no subsidies in place for support, with similar results for the EUSF, as significantly more aid is allocated to countries most able to withstand a disaster's financial impacts. However, for the Flood Re instrument the scheme is shown to alleviate unaffordable premiums, which has a marginal effect on the number of instances in which mortgage payments become unaffordable and houses are repossessed (foreclosed) by the bank (Jenkins et al., 2016), thus slightly influencing inequality.

Responses on the **affordability** of instruments were mixed. Evaluators considered the Solidarity Fund as quite easily affordable for most member states, as they contribute based on economic performance, while for forest fire insurance, the instrument is affordable only for large properties with strong economic standing. The Rotterdam and London cases also showed mixed results; in Rotterdam, affordability can prove problematic for some (potential) policyholders if the link with risk is increased as proposed then high-risk households (with risk adverse insurers) will face

[2] German insurers, for instance, find the transaction costs of offering and monitoring household level DRM are sufficiently high to prevent an active insurer based financial incentive for DRM (Hudson et al., 2016).

very high premiums (Hudson et al., 2016). However, the increased use of risk-based pricing means less cross-subsidisation and lower insurance premiums for those at lower risk. In the UK, Flood Re is understood to achieve the provision of affordable insurance. As technical risk prices increase (reflecting increased flood risk), Flood Re reduces average premiums from approximately £650 to £280 in the baseline scenario. Even under future climate change scenarios average premiums are limited to £450 - £550 by year 30. Experiments without Flood Re illustrate much higher and steeper increases in average flood insurance premiums, upwards to £1700 under the 2050 high scenario. However, this also presents a clear challenge for the aim of using Flood Re as a temporary measure, before allowing risk based pricing after 25 years. As the technical price and the subsidised price for insurance are expected to diverge more and more it remains highly unclear how the system would lead to affordable risk based premiums after Flood Re stops its operation.

Institutional and political criterion

In terms of institutional and political indicators, cases varied widely. Insurance can score highly on aspects such as **feasibility**, and several countries have developed the required institutions for a viable insurance market with risk-based premiums. The EUSF, for example, is fully feasible and is in operation, whereas the Flood Re scheme is not yet operational, so its feasibility cannot be adequately assessed. In Portugal, a legal framework for fire insurance exists, but is not associated to any support from EU or domestic institutions to decrease premium costs.

However, cases diverged on how their instruments were scored with regard to **consistency**. The Rotterdam case emphasised that assessing consistency is ambiguous as it is dependent on the link with DRM. The stronger the overall link with DRM, the more able insurance is to increase resilience against natural hazards. The London case observed that investment in sustainable drainage system (also in combination with property-level protection measures) can help to stabilise insurance premiums over time – a clear indicator that surface water risk management is essential to maintain the viability of flood insurance.

The overall **acceptability** of instruments can be regarded as mostly high and moderate among cases, with some caveats. The Flood Re instrument study highlighted that both property developers and the local government could contribute to flood risk reduction, but are not part of the flood insurance MSP. One aspect that warrants further investigation is how Flood Re could be strengthened or expanded to contribute more significantly to flood risk reduction. The Portuguese fire insurance instrument was seen to have high acceptability among other interest groups besides the current users, contingent on the lowering of premiums. For the Solidarity Fund, acceptability was viewed as only moderate, due to strong concerns from some stakeholders, namely the insurance industry. The Rotterdam property insurance instrument was more ambiguous. Possible reforms will result in certain premiums increasing (and others reducing), thus limiting (or improving) the acceptability of the reform.

The case studies saw a number of different **conditions and barriers** to introduction of the EI, as in Rotterdam where the potential height of insurance premiums forms a strong barrier. Moreover, insurance reforms tend to be highly politically contentious between major stakeholders, which can limit stakeholder buy-in without considerable time and patience being expended. In regards to fire insurance, the absence of reliable information on risk, and limited incentives for coverage to small properties was seen as detrimental to encouraging insurance companies to provide coverage.

Environmental criterion

For most **environmental considerations**, for the majority of instruments there was not a good match with the indicators. Generally speaking, the Rotterdam case emphasised that while insurance was not directly tied to an environmental criterion, there may be some negative implications, as property insurance can facilitate economic activity that may lead to an increase in the magnitude of externalities. Conversely, incentivising DRM can also **encourage sustainable management**; agents are made aware of the risk and only locate economic activity in risky areas if it is worth the risk or cost of insurance. Greater interaction between insurers and planning agencies can provide guidance on the land use management strategies that would alter the overall risk in an area, highlighting the benefits of public-private partnerships.

The only instrument which consistently scored beneficial in this regard was Portuguese fire insurance, which is projected to increase quality of resources, due to adequate forest management resulting from those participating in the instrument being required to submit forest management plans. The instrument can also encourage the protection of biodiversity via improved protection against wildfires due to management plans and the application of the Plan for Forest Fire Defence, and has the potential to reduce human impacts due to wildfires via fire defence plans, as well as increasing most ecosystem services through the application of forest management plans.

Photo by cohdra/Morguefile.

Conclusions

This chapter presented the findings from several ENHANCE case studies with regards to the use economic instruments for disaster risk management in the EU. After an overview of the different instruments in operation we reflected briefly on the different analytical tools applied across the cases. We presented lessons and insights from each case and synthesised these via a common framework, using an MCA-based approach. We conclude by reflecting on the use of MCA, observations from the synthesis of case instruments, and general recommendations for further policy and research.

Use of MCA in assessing economic instruments

While MCA approaches have proven useful time and again in terms of assessing options and decision-support, full use of MCA was limited in scope within this work. Detailed MCA is time-consuming and requires common understanding by participants of all options being assessed, as well as the criteria and indicators being used to 'grade' such options. This is usually done via a set of participatory process of workshops and communication.

We found the initial use of an MCA tool to rank insurance options to be associated with a number of problems, of which two factors are particularly relevant: (1) the context-specific nature of each insurance instrument, which differs widely from case to case, as well as (2) differing understandings of what each indicator was supposed to mean, e.g. the participants' understanding of what is included when considering a cost or transaction cost ranking for an instrument. An MCA ranking of insurance options also led to imply that the options were similar enough to be compared, whereas experts felt they were all rather local and context-specific to be assessed in such a way as would imply their similarity or substitutability.

However, there was generally a belief that the MCA process was suitable for the assessment of water markets and pricing in the Santarem case, as two options to address a single problem in a single location were being assessed by the same group of experts and stakeholders. In this case, the use of MCA can be seen as more robust, and the results more meaningful, as the problems listed above for the insurance options were not that relevant for this case.

Even though we identified a number of challenges for the entire MCA process when evaluating the various insurance mechanisms, the study team considered the consistent framework of criteria and indicators as useful to lead to some common understanding and base for assessing each instrument. Instead of using a quantitative scoring system, **we took a more qualitative approach forward which allowed for greater understanding of each case instrument**. In addition, **it helped to synthesise the different instruments by providing a common framing and ability to compare** where certain instruments perform better than others, keeping in mind, however, the limits to comparability across cases.

Synthesis

Table 4.4 provides a compact synthesis of economic instruments assessed and summarises the observations for each indicator. For the most part, instruments appear **very context- and location-specific**; while all EI listed are insurance instruments, there exists a great variety as to how they perform against individual indicators, showing the complexity and importance of considering the economic, social, political, and environmental conditions and effects of the instrument.

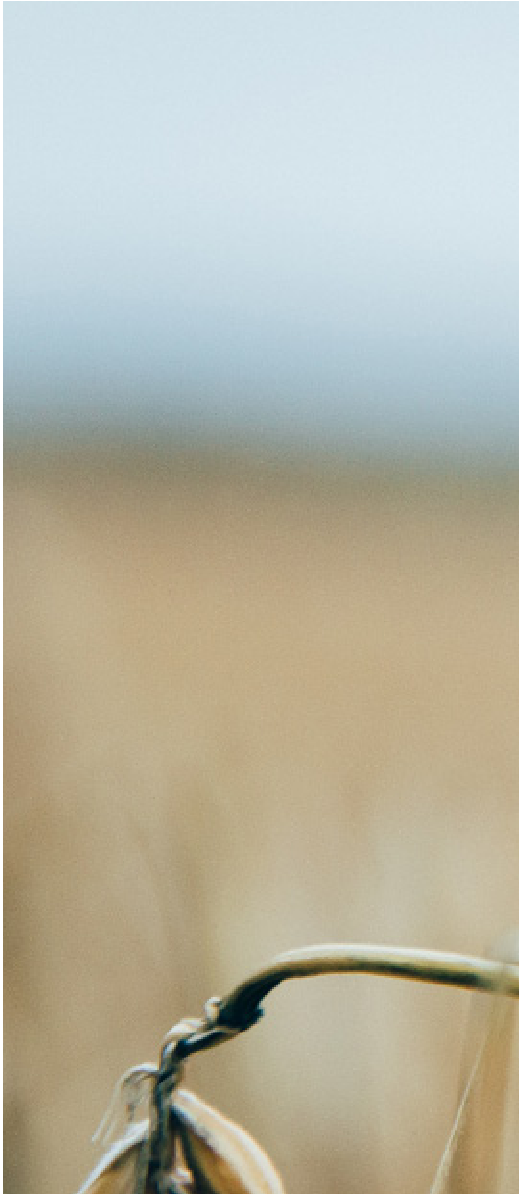
In terms of commonalities, far less can be said, other than two general similarities having to do with inequality and incentivising DRM. The effects of insurance instruments on inequality were seen to be mostly low, as it is not the role of insurance to directly reduce inequality. Some potential emerged for indirect effects, but generally, such instruments were seen to be a non-factor in this regard. Conversely, and as possibly expected, the analysis led to suggest that most instruments are beneficial in incentivising DRM, or at least, having good potential to do so, with premiums possibly being linked to DRM implementation and designing of options to be strongly linked to DRM measures.

Beyond this, instruments varied from indicator to indicator, with little similarity. Overall, we suggest the synthesis assessment can be useful in that it **provides a common set of criteria**, and when used with a variety of similar instruments such as in this case, **can highlight approaches which are successful at meeting said criteria**, and which are not, benefiting the design of future instruments by learning from the outcomes of others in a structured manner such as here. An example might be improving an option's performance in the environmental dimension; most instruments were seen as not applicable or having very low scores in this regard, with the exception of the fire insurance instrument, which mandated that in order to join the scheme, forest management and fire defence plans must be completed. If other instruments had similar requirements tailored to their individual hazard and context, it could improve their effectiveness in regards to this criterion in the future. At the very least, the synthesis allows us to **highlight areas of 'good' and 'incipient' practice, benefitting future research and policy design**.

Recommendations for policy and research

As mentioned, the synthesis of economic instruments allowed the study team to highlight the diversity in results from case to case and instrument to instrument, providing a set of examples. This can be interpreted as **a roadmap of practices**, and using a similar set of criteria to assess a number of instruments can lead to identifying examples which work in certain contexts, that can then be tailored to fit others (e.g. the use of forest management plans as an example of how to include an environmental dimension when considering similar plans in the future).

We suggest that the **MCA framework** is also useful in that it **provides a common, structured approach for looking at an instrument**, and that it **emphasises the need to focus on multiple factors**. Assessing multiple options in this manner enables more comparisons to be made, and more learning from others' experience, even if it is not directly relevant (e.g. deals with different hazards or spatial scales etc.) Such a framing could be used when designing



a new instrument, and could be used to catalogue those currently in existence, to provide an easy way to compare options and to find new innovations for improving current instruments or when designing new ones.

Working with an MCA approach has indeed highlighted the need for consistency and understanding when assessing options in terms of criteria and indicators used, and what each entails. What constitutes a cost, or a transaction cost? How does one score an option in regards to incentivising sustainable management? In order to compare options beyond a qualitative assessment, more structured interaction is needed between experts and stakeholders carrying out the analysis. This has important implications for the comparability across case studies – and therefore the results highlighted in Table 4.4 should be seen as an illustration of each case, but not necessarily a comparison across cases. With further work and interaction, the assessment, particularly on the insurance instruments, might be taken forward by moving from qualitative aspects to ranking options numerically as well as weighting their importance, but only after working towards a more thorough understanding of all options involved - an avenue for further research.

Photo by Dominik Martin/Unsplash.

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Annex: Table 4.4.

Synthesis assessment of insurance instruments for DRM.

Criteria	Indicator	OX + LSE: Flood insurance	PCC: Fire insurance and market commitments	IVM: Property insurance	IIASA: EU Solidarity Fund
Economic	Cost	Ambiguous - Government's impact assessment states that Flood Re is not value for money, but justifies it as it formalises the previous cross-subsidisation, so not creating a new degree of subsidies. The ABM does not provide a precise estimate of how costly Flood Re will be for the economy.	Low - Premium not affordable due to the absence of information to calculate premiums.	Ambiguous - expansion of insurance can promote growth of the insurance sector or facilitate development of economic activity, however insurance tends to require government support, which can be expensive.	High - Although annual budget is maximised at EUR 500M, can be still costly, considering increasing losses and potential political pressure for compensation.
	Transaction Cost	Ambiguous - Flood Re is the result of a 4-year negotiation between industry and government, the new scheme is a new not-for-profit body with its own administration and its own reinsurance purchasing arm. Qualitative investigation highlights the complexities of the negotiations (Surminski and Eldridge 2015).	Not relevant	Moderate - can be low due to large number of policyholders resulting in economies of scale, but high if stronger link to DRM is introduced due to greater monitoring and enforcement costs. Private insurers state transaction costs as reason for not strengthening link between premiums and DRM. Competitive markets can help to keep transaction costs as low as possible.	Moderate - Standardised procedure has been simplified by the recent reforms, but reporting requirements and monitoring are extensive.
	Incentivise DRM	Moderate - Flood Re itself not designed to incentivise DRM, but modelled results show insurers could create incentives for homeowners to implement DRM measures.	High - insurance application requires a Forest Management Plan and a Plan for Forest Fire Defense.	Ambiguous - can score very highly incentivising household level DRM if there is strong link between DRM and insurance premiums in areas of high risk. In areas where link with DRM is weaker or risk is not high, insurance is not able to incentivise DRM.	Moderate - Recent reforms better linked the Fund with DRM but only in the context of flood risk. Link could be further strengthened.

Social	Reduce Inequality	Moderate - Success of the scheme should be visible in terms of stability in local housing markets, which can be linked to inequality where residents in deprived or less affluent areas may be concentrated in areas at higher risk of flooding. Modeling shows scheme alleviates unaffordable insurance premiums - marginal effect on number of mortgage payments becoming unaffordable / house repossessions.	Low - It does not reduce inequalities at this stage since it only benefits owners of large properties. No subsidies are in place.	Low - It is not a role of insurance to directly reduce inequality. Insurance may have display a minor role in preventing the worsening of inequality after a disaster by providing compensation payments to help people get back on their feet, but role would only come into play after a disaster.	Low - Considering current rules, the Fund allocates more aid as a percentage of eligible costs to those countries most able to withstand the financial impact of disasters.
	Affordability	Moderate - Qualitative analysis suggests that this is the overarching aim of Flood Re. The ABM indicates that Flood Re will succeed, even under climate change scenarios, but the technical price and the subsidised price for insurance are expected to diverge more and more, raising questions about the temporary nature of Flood Re and its aim to lead to a free market system.	Low - Affordable only for large properties in good economic situation.	Moderate - Affordability can prove problematic for some (potential) policyholders if the link with risk if increased as proposed then high risk households (with risk adverse insurers) will face very high premiums. However, the increased use of risk based pricing means less cross subsidisation and lower insurance premiums for those at lower risk.	High - Easily affordable for most MS as they contribute based on economic performance.

Political and Institutional	Coverage	Moderate to high - Scope and coverage of Flood Re extended to cover a wider range of property types, but excludes new built (post 2009) as well as SMEs.	Low - Only applies for associates of forest organisations in the South of Chamusca (large properties).	Low to moderate - Insurance is targeted against specific perils to compensation if the peril occurs providing limited problem coverage. In the presence of a strong link between DRM and insurance premiums insurance may additionally increase the prominence of DRM activities in society.	Moderate to high - Covers a wide range of hazards, but not all events qualify for aid.
	Institutional feasibility	N/A	Moderate - Legal framework exists but not associated to support from EU or domestic institutions to decrease premium costs.	High - Several countries have developed the required institutions for a viable insurance market with risk based premiums. Feasibility of increasing the link with DRM will be dependent on the extent to which the market deviates from risk based premiums.	High - Full feasibility
	Consistency with other instruments	Moderate - Investment in SUDS or combination of SUDS and PLPMs can stabilize insurance premiums over time, a clear indicator that surface water risk management is essential to maintain viability of flood insurance.	Low - No consistency with other instruments.	Ambiguous - Dependent with the link of DRM. The stronger the overall link with DRM the more able insurance is reinforce the increased resilience against natural hazards.	High - Consistent
	Acceptability to other interest groups	High - ABM highlights that property developers and local gov could contribute to flood risk reduction; benefits seen as surface water flood risk is reduced in modelled area, and where these investments are considered by insurer, households benefit from lower premiums.	Moderate - Possibly well accepted by other interest groups besides current users if premiums would be lowered.	Ambiguous - The scoring is dependent on the interest group. The possible reforms will result in certain premiums will increase (reduce) limiting (improving) the acceptability of the reform.	Moderate - Strong concerns from some stakeholders – e.g. insurance industry.
	Conditions and barriers	Ambiguous - Investigated in the context of DRM incentives, ABM explores different conditions for the Flood Re scheme, found differing results depending on scenario.	High - Absence of information on risk; small properties not enticing to insurance companies; management areas not developed to large enough degree companies.	High - Potential hikes in premiums forms a strong barrier. Stakeholder buy in limited without considerable time and patience expended on discussion process	Low
Environment dimension	Decrease resource quality	N/A	High - Resource quality should increase due to adequate forest management.	Scores very low as property insurance is not tied to environmental resource quality.	N/A
	Decreases resource quantity	N/A	Moderate – improved resource quality may lead to increased extraction rates.	Scores very low as property insurance is not tied to environmental resource quantity.	N/A

	Incentivises more sustainable management	Mixed - Qualitative work indicates missing focus on broader flood risk context (Surminski and Eldridge 2015), including land-use management. Modeling highlights that most beneficial results in terms of reduced flood risk are realised when full range of development and government conditions are implemented together. Also highlights importance of coordinating developer and local government risk reduction strategies.	High - Forest Management Plans required	Moderate - in the sense of promoting DRM activities. Greater interaction between insurers and planning agencies can provide guidance on the land use management strategies that would alter the overall risk in an area.	NA
	Enhance biodiversity protection	N/A	High - Enhances protection against wildfires.	Very low – property insurance not directly tied to protecting biodiversity.	N/A
	Decrease negative externalities related to human health	N/A	High - decreases wildfire impacts through the application of the Plan for Forest Fire Defense.	Very low - May be negative implications, as property insurance can facilitate economic activity leading to an increase in the magnitude of externalities.	N/A
	Increase use of linked resources	N/A	High - increases most ecosystem services through the application of the Forest Management Plan.	Very low - May be negative implications, as property insurance can facilitate economic activity leading to increase in the magnitude of externalities.	N/A

(*) UPV also analysed the vulnerability during drought periods of agriculture to prices and water availability through an econometric approach

05

Insurance instruments and disaster resilience in Europe – insights from the ENHANCE project

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Introduction

Europe is vulnerable to most types of natural disasters. Recent events, such as the flooding in France, remind us that loss of lives, impacts on communities and disruption of economic activity continue to pose significant challenges to decision-makers at all levels.

Efforts to increase our current and future resilience are becoming more urgent: climate change, detrimental land-use practices and the increase of assets located in harm's way suggest that the social and economic impact of extreme events will continue to rise.

Responding to these challenges requires collaboration across different stakeholder groups and disciplines, as underlined by the Sendai Framework for Disaster Risk Reduction 2015-2030, which highlights that disaster risk reduction (DRR) needs the engagement of a variety of actors across sectors, partnerships between different stakeholders and across governance levels (UNISDR, 2015).

The ENHANCE project has developed new risk scenarios and hazard information and shared those with multi-sector stakeholders across different case studies, in order to support the development of innovative approaches to DRR. Amongst those, **insurance is one instrument that could benefit from increased collaboration across stakeholders**.

The economic losses of extreme natural disasters can have significant consequences for individual property-owners and businesses, especially when these effects exceed their financial capacity. Disaster insurance is one option to address the financial impacts of a disaster. It transfers the uncertainty of a loss to an insurer, who in return receives a premium payment from the policyholder. If and how insurance is used in a country is influenced by local traditions, cultural factors, experience with disasters, availability of data, as well as the engagement of public and private sector (Surminski et al., 2015a).

As the current situation in Europe shows, insurance can be provided publicly, privately, through a partnership, be subsidised or mandated – guided either by the principle of solidarity or considered as a risk-based market mechanism. In some countries only public compensation schemes exist, such as in the Netherlands, where the legislation on compensating natural disasters (WTS) can provide partial compensation for damage caused by natural disasters to property-owners and businesses under certain conditions. The system is provided as an ad-hoc compensation system by the government, and it is uncertain whether or not, and how much of the losses will be compensated. A declaration for compensation is based on a political decision. In other countries, such as France, we find public insurance systems. The French CATNAT is funded by insurance customers through a mandatory fee added to their property and casualty insurance. The private insurers are responsible for covering the flood risks, while the main role of the government is to provide reinsurance and establish natural disaster prevention and mitigation plans. The mandatory nature of the insurance results in a high market penetration, with clear rules on compensation (Poussin et al., 2014). In other schemes, such as in the United Kingdom or Germany, the private sector dominates, with the government playing a regulatory role, but not bearing any financial risks. In the United

Kingdom, this takes the form of a public-private partnership, where private insurers have agreed to provide flood cover in exchange for government investment in flood risk reduction. However, this partnership approach is currently being reformed, as highlighted in the ENHANCE analysis of surface water flooding and insurance in London (Surminski and Eldridge 2015; Jenkins et al., 2016).

Disaster losses are highly volatile, and the most common causes of financial problems in these schemes are a lack of risk assessments and insufficient funds, often due to inadequate premium levels (Botzen et al., 2015). This in turn clashes with the requirement of affordability of insurance cover, which often results in subsidisation to make insurance more economical for those at higher risk (Surminski and Eldridge 2015). Rising disaster losses are already putting pressure on all those involved in the provision of disaster insurance (e.g. Paudel et al., 2014), and in extreme cases could lead to private insurers withdrawing from certain regions or hazards, with systems facing insolvency or requiring a greater public sector involvement (Prudential Regulation Authority, 2015).

Effective disaster risk management can play a significant role for the future affordability and availability of loss compensation mechanisms (Kunreuther, 1996), but it is far from clear how existing and new schemes can foster risk reducing behaviour. Insurance may even increase risky behaviour through moral hazard, particularly if poorly designed and implemented (Ranger et al., 2011). To overcome some of the barriers associated with achieving adaptive responses and risk reduction, insurance partnerships with the public sector are advocated to harness skills and expertise in supporting insurance approaches (see for example KPMG, 2015). This link between insurance and risk behaviour is gaining attention in the discourse on climate change, where insurance is expected to play a vital part in supporting adaptation efforts and increasing climate resilience, as recently noted in the G7 announcement on climate insurance (see for example GIZ, 2015).

This chapter presents insights from the ENHANCE case studies on the use of disaster insurance in Europe, and presents lessons on how to use multi-sector partnerships (MSPs) to improve the risk reduction component of insurance. Across these case studies the research focused on two key aspects:

1) assessing existing insurance offerings;
2) designing new insurance schemes so that the strengthen and incentivise DRR

A range of different methodologies were applied, reflecting on data availability, stakeholder input and the characteristics of the particular cases. As outlined by Surminski and Hudson (2015), these methods included stress testing; investigation of flood insurance and moral hazard; estimation of effectiveness of household-level flood risk mitigation measures; assessment of risk based insurance pricing incentives for flood risk mitigation; analysis through a Risk Reduction Framework; and investigation of the design principles of insurance.

The application of these methods and the level of analysis varies across the cases – for a summary see Surminski and Hudson, 2015. Below we highlight three key findings from our analysis: (1) the role that risk assessment can play in supporting MSPs, (2) the use of insurance to incentivise risk reduction, and (3) insights on multi-sector collaboration.

[3] The G7 Climate Risk Insurance Initiative policy initiative, also known as InsuResilience was launched at the G7 summit in Germany in June, 2015, as part of the G7 Climate Change Commitments. It is a 5-year project funded by the G7 members to implement direct (such as microinsurance) and indirect extreme weather insurance (such as sovereign risk transfer) for an additional 400 million people in developing countries.

The ENHANCE insurance case studies

In the wake of recent natural disasters, we witness growing interest in the use of insurance as an economic disaster risk management tool from policy makers, practitioners and academics (Surminski, 2014). At a European level, The European Commission Green Paper on the Insurance of Natural and Man-made Disasters (EC, 2013) questioned the appropriateness and availability of current insurance options in the context of rising risk, and asked if and how the provision of insurance could be reformed. These questions have been further examined during the ENHANCE project, with a key focus on the prevention role of insurance, and how this could be enhanced and strengthened through MSPs. To investigate this, we chose **six regional case studies, which are deliberately diverse** (**Figure 5.1; Table 5.1**).

Table 5.1 shows the different insurance cases and a short description of current insurance schemes. In the United Kingdom case we have two very distinctive features: an evolving public-private relationship and a temporal consideration of affordability – with Flood Re proposed as a temporary measure to ease the transition to risk-based pricing. In Italy the intention is to show the role of insurance within a mix of policy instruments that jointly lead to a more efficient management of water resources and risk. In Portugal the novel aspect is the integration of public funds and private insurance, as well as the inclusion of Forest Intervention Zones to assist small landowners to gain access to insurance. The Netherlands case focuses on the quantification of flood risk in a participatory way, engaging the different stakeholders to better understand risks, which eventually might lead to new insurance solutions. The Romanian and EUSF cases consider the re-orientation of the EUSF from a post-disaster to a pre-disaster instrument, with a focus on how best to align this public form of compensation with existing and proposed insurance schemes.

Figure 5.1.
ENHANCE case studies with insurance focus.

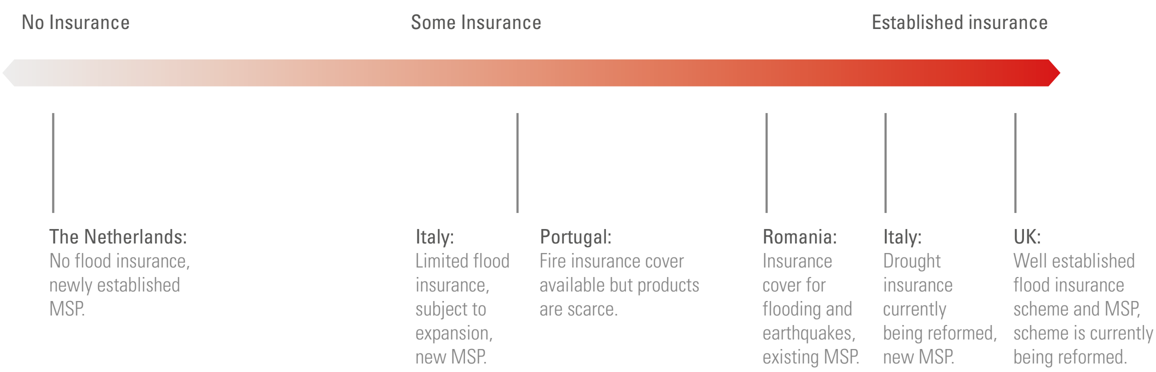


Table 5.1.

ENHANCE Insurance case studies (Source: Surminski et al., 2015a).

Multi-hazard risk assessment in Po River basin (Italy)	Flooding and drought pose two major concerns in the Po River Basin. Whereas state-subsidised agricultural yield insurance is in place, flood insurance uptake remains low and disaster losses are typically compensated by the state. The role of agricultural insurance in wide-reaching water management reform is analysed and the opportunities are shown for disaster risk reduction through cooperative agreements and partnerships.
Flood risk and climate change implications for Multi-Sector Partnerships (United Kingdom)	Insurance is provided by private insurers. To address concerns about affordability of insurance a new pooled approach (Flood Re) has been introduced, funded through a levy on all home insurance policies. The design and implementation of Flood Re highlights the challenges of addressing affordability in times of rising risks. Risk reduction and prevention elements are not integral to the new system.
Insurance and forest fire resilience in Chamusca (Portugal)	Forest insurance is mandatory yet insurance products are scarce in delivering insurance solutions. The case study explores the options for introducing a new forest fire insurance scheme, with a view on risk reduction elements.
Flood risk management for critical infrastructure (The Netherlands)	Provision of flood risk management in a high risk area presents several challenges for effective application and an innovative multi stakeholder approach aims to deliver a reduction in societal risk.
Reforming natural hazard insurance (Romania)	Mandatory natural hazard insurance is required under law for residential properties in Romania yet includes no risk reduction elements. The case study investigates the recent changes to the insurance system.
Reforming the European Union Solidarity Fund in support of insurance	Using a supranational fund such as the European Union Solidarity Fund could provide a link to potential ex-ante capitalisation of disaster funding for risk reduction action. The case study focuses on the options for aligning the EUSF with insurance solutions.

The importance of risk assessment and data gathering

In-depth assessments of natural disaster risks are a vital part of the ENHANCE project, as outlined in the recent ENHANCE policy brief on risk assessment (Botzen et al., 2015). Such assessments are important for guiding the development of risk transfer schemes. Particularly for the cases of flooding in Rotterdam and wildfire in Portugal the role of risk data and analysis is evident. In both examples risk data is used to trigger a debate about designing relevant insurance solutions. Another example of such a study is the EU-wide assessment of river flood risk which has been undertaken to estimate current and future risk levels (Jongman et al., 2014). The basic method is a probabilistic catastrophe model of about 1,000 large river basins in the EU. Model results show that current average annual flood risk is about €5 billion which may increase up to €24 billion by 2050 because of socio-economic development and climate change. These results have been used for a stress test of the EUSF and its ability to provide financial aid to the governments of EU countries hit by a natural disaster. An implication of the increased flood risk is that claims to the EUSF are expected to increase substantially in the future (See Box 2.1, Chapter 2). The model results show that by 2050 the fund's insolvency probability may be 80% higher than under its current structure, and that in addition the magnitude of uninsured flood losses may increase.

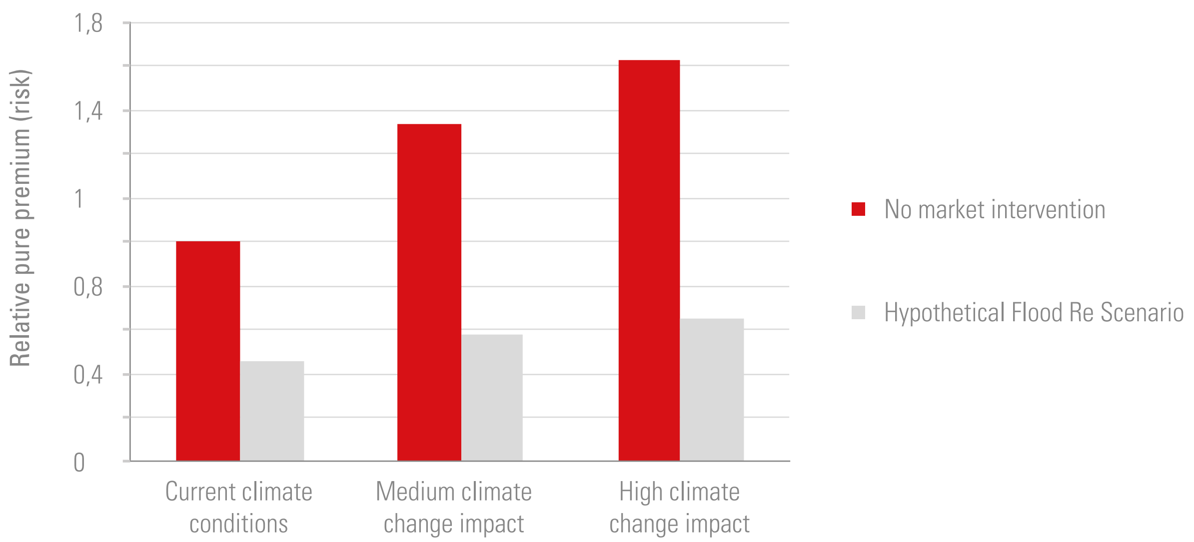
New risk data plays also a key role in the ENHANCE assessment of London's surface water risk and the implications for flood insurance. Through the application of qualitative analysis (Surminski and Eldrige, 2014) and a novel agent-based model (ABM), the investigation benefits from the incorporation of a surface water flood event dataset, for present and future climate scenarios, developed by combining probabilistic precipitation projections with broad scale surface water flood modelling and mapping (Jenkins et al., 2016; Jenkins et al., 2015b).

Figure 5.2.

The Pricing Implication of Climate Change (Source: Based on Jenkins et.al. (2016), cited in Prudential Regulation Authority and Bank of England. The impact of climate change on the United Kingdom insurance sector, 2015).

The case study analysis finds that more frequent and severe flooding as a result of climate change is a barrier to continued provision of affordable flood insurance. The results fro m Jenkins et al. (2016), highlighted by the Bank of England (2015), show that climate change and socio-economic risk drivers are expected to widen the gap between 'affordable' flood insurance premiums and premiums that reflect the technical price of flood insurance (see Figure 5.2 below).

The ENHANCE analysis underlines the importance of reducing flood risk through a range of flood risk management measures: Flood Re is designed as a temporary instrument to provide a buffer against high technical flood risk prices, before an anticipated move to a risk-based pricing system in 25 years. However, unless the underlying flood risk is reduced, the gap between the subsidised price of coverage and the technical risk price will grow over time, which would make a move to risk-based pricing unlikely.



The use of insurance to incentivise risk reduction

While stakeholders have only limited control over the occurrence of a natural disaster, their actions determine the extent of losses during and after the event. An ENHANCE study for Germany applied Propensity Score Matching techniques to estimate the flood damage savings of such DRR actions by households. The results show that DRR measures lowered damage during floods between €6,700 and €14,000 per flood event (Hudson et al., 2014). Another study also shows that flood damage mitigation measures implemented by households in France substantially saved damage during a variety of different flood events, and that these measures can be cost-effective (Poussin et al., 2015). However, households commonly do not invest in DRR measures, even when they are cost-effective. They insufficiently prepare for natural disasters, for example, because they underestimate low-probability natural disaster risk and the benefits of DRR.

Few studies have empirically examined the relationship between natural disaster insurance coverage and risk mitigation activities of individuals (Botzen, 2013). An ENHANCE study examined how the implementation of a variety of household flood risk mitigation measures differs between individuals with, and without, flood insurance coverage in Germany (Hudson et al., 2014). The results show that individuals with flood insurance coverage in Germany are significantly more likely to have employed mobile flood barriers that keep flood water out of their home, while other risk reducing measures were often implemented by insured and non-insured individuals equally. These findings suggest that the moral hazard effect of insurance coverage is absent since households with flood insurance prepare more for floods. Additional analysis indicates that the better flood preparedness of the insured is related with activities of seeking information about flood risk, which can signal that the individuals who purchase flood insurance are more careful.

Another ENHANCE study examined whether financial incentives offered by risk-based pricing of insurance in Germany and France can stimulate policyholder adaptation to flood risk (Hudson et al., 2016). This risk-based pricing implies that households receive a premium discount when they take measures that reduce flood risk. The effectiveness of such incentives is analysed using an integrated model of household level mitigation behaviour and public-private flood insurance. The results indicate that insurance based incentives are able to promote adaptation by correcting for individual misperceptions of flood risk and related benefits of DRR. The incentives could reduce residential flood risk by 12% in Germany and 24% in France by 2040. The higher level of flood risk in France results in a strong present incentive to reduce risk. Rapid growth of flood risks in Germany results in more effective incentives in later periods. An overall drawback of risk-based pricing is that flood insurance becomes potentially unaffordable for households who face a high risk. The study shows that such concerns for affordability can be overcome by providing insurance vouchers that help low-income households pay for flood insurance coverage. This voucher system that overcomes affordability concerns with risk-based flood insurance has a lower cost by 2040 than the benefits it brings of additional risk reduction. A main policy recommendation that follows from this study is that strengthening the link between insurance and DRR is worthwhile, but secondary policies may be needed to compensate additional costs for low-income households.

The effectiveness of risk-based flood insurance in stimulating risk reduction is also shown by an agent-based model (ABM) analysis for the ENHANCE case study Rotterdam (Haer et al., 2016). This ABM simulates the interaction between stakeholders like insurers and households, and allows for the modelling of complex decision-making when faced by real-world constraints, such as limited information availability (bounded rationality). The analyses of individual flood preparedness under a variety of behavioural theories simulated by the ABM show that the effectiveness of risk based premium in stimulating investments in DRR heavily depends on household behaviour. For example, incentivising DRR is most effective in situations when many households underestimate the flood risk that they face, because they have not been flooded for a long time and flood risk awareness of the community has faded (Haer et al., 2016).

Linking insurance to effective adaptation and flood risk management is also an issue in the discussion around Flood Re the United Kingdom. Effective adaptation is crucial to ensure the affordability and availability of flood insurance. However, these issues were not fully taken into account in the design of Flood Re. The ENHANCE analysis suggests that the efforts to reform the insurance arrangements have been predominantly focused on dealing with the current affordability of insurance, without considering the importance of managing and reducing the underlying risks. Flood Re does not have any direct levers to influence flood resilience, and it is unclear how it can impact the behaviour of those groups that will determine future risk levels: homeowners, national and local governments, developers and insurance companies. The failure to build incentives to increase resilience into the design of Flood Re is a missed opportunity (Surminski and Eldridge, 2015). It could even have a detrimental effect on overall flood risk management. The scheme's existence may reduce the urgency for Government to prevent and reduce risks and might also reduce incentives for home- and business-owners to invest in resilience measures i.e. it can create moral hazard (Surminski, 2014).

Flood in York, UK, 2006. Copyright: UNISDR.

The role of multi-sector collaboration for enhancing insurance partnerships for catastrophic natural disasters in Europe

Despite broad agreement for closer collaboration between public and private actors in response to rising risk levels, many challenges remain for translating this into innovative solutions. Public-Private Partnerships (PPP) in disaster insurance can serve as role models for a joint bearing of responsibilities and efficient risk-sharing, promote insurance coverage and penetration, and guarantee a strong financial backing in view of uncertain tail distributions of risk. Johansen (2006) summarised the principles and preconditions of successful PPPs as (1) being shaped through constructive dialogues (between public and private entities) and conscious of mutual principles and limitations, (2) safeguarding competitive environment; and (3) respecting, if not exploiting, risk-differentiated prices as incentive and reward for individual or collective risk prevention and protection. Ideally, private insurers (should) 'have the opportunity to carry on using their savoir-faire in an environment of mutual understanding' (ibid).

All ENHANCE case studies exemplify that public and private stakeholders have very different constellations and problem definitions. Therefore, stakeholder engagement is important in order to discover current barriers, perceived or otherwise, that are inhibiting innovative solutions or the development of new partnerships. For example, it may be that the level of risk itself is inhibiting the partnership or that the stakeholders do not have a suitable platform upon which to engage.

The ENHANCE assessment of flood insurance in particular highlights this need for more effective collaboration between stakeholders. The patchwork of flood insurance provision across Europe has fuelled the debate about the role that insurance can play and how other stakeholders such as homeowners or governments can respond to growing flood loses. This discourse over the future of insurance has mainly focused on insurance as a compensation mechanism, and less on the possibilities of increasing resilience and promoting risk reduction. Through the ENHANCE project, we show that this is an area that would require further action and increased multi-sector collaboration (Surminski et al., 2015). Acknowledging the significant challenges that insurers and risk managers face (e.g. Paudel et al., 2015), our analysis supports a move towards insurance and risk management partnerships that do not focus exclusively on compensating and transferring the financial losses but rather combine this with risks reduction.

To investigate this further the ENHANCE project convened a workshop with academics, (re)insurance industry, and policymakers, to discuss the role of such insurance partnerships. Focussing on the EU Green Paper and the role of public policy the workshop concluded that there is not a single partnership model that can be homogenously applied across Europe (Surminski et al., 2015). The discussion also underlined the importance of design and structure of any partnerships between insurers, governments, and policyholders. Spreading and exchanging knowledge were commonly referred to as key outcomes of improved collaboration. For instance, academics can contribute advanced risk models and forecasts, which would allow insurers to better price and prepare for risk, and which would pinpoint government to spot hotspots of unaffordability or areas that require investments in protection infrastructure. In turn, households could be made aware of the relative benefits of risk reduction measures to better manage the residual risks. Creating such virtuous cycles are possible, but require transparency, trust and engagement from all sides.

Our regional case study investigations provide further insights into if and how multi-sector collaboration can help utilising insurance for resilience. We note that across all our cases the provision of insurance is influenced by public policy: Directly through regulation such as mandating cover or instigating the development of new schemes. And indirectly by providing the enabling infrastructure and environment, for example through a broad risk reduction framework, including building codes and better flood risk data provisions. Overall, a stronger policy approach to disaster risk management (planning, defence, resilience measures, data etc.) would make the MSPs more viable (Surminski et al., 2015).

Another key aspect is how insurance targets and engages with those who can take action. The London ABM model investigates the roles and behaviour of different stakeholders and explore how they could support surface water flood risk reduction under future climate change (Jenkins et al., 2016). The model simulations show that the highest resilience results can be achieved by combining of resilience activities from insurers, government, and property developers. This is particularly relevant when future climate change is considered. This underlines the importance of including multiple actors in the MSP, and allowing a flexible framework that can be modified over time as different risk thresholds are passed (Jenkins et al., 2016).

Photo by Getty Images/iStock.

Outlook

The discourse about disaster insurance in Europe highlights the key challenges of managing current risks and preparing for future climate risks: at the core lies the issue of collective versus individual responsibility, and solidarity versus market-based approaches.

The ENHANCE analysis shows that flood insurance and DRR need to be closely linked and integrated in the face of rising losses. As our case studies show, there are significant barriers facing public and private stakeholders. This requires policy action—at EU and national, as well as regional level. The key question therefore is how to determine and define the roles of industry and policy-makers, recognising that this is likely to differ from country to country. This is an area where closer collaboration between academia, industry and government is needed to proceed (Surminski et al., 2015a). At European level the facilitation of DRR and adaptation, which will determine risk levels and viability of insurance going forward, can be supported by EU-led policies. However, the design and operation of insurance schemes can also play a role in this. Here national governments have a role to play.

The ENHANCE analysis on the EU Solidarity Fund (Jongman et al., 2014) shows that socio-economic development and climate change can substantially increase pressure on risk transfer or financing mechanisms, unless more risk reducing measures are applied, such as flood defences, stricter building codes and/or land use (zoning) policies. Improved risk assessment and data sharing amongst stakeholders are essential for developing those forward-looking solutions in an integrated way. National, local and household level DRR activities could be used as a mechanism for reducing the pressure placed on risk transfer schemes. In other words, risk reduction efforts are essential in maintaining the insurability of these risks, especially in the context of flooding and other extreme weather events. Effective adaptation may actually become a condition for granting insurance cover in the future (Surminski et al., 2015b). However, the ENHANCE analysis suggests that until today efforts to reform disaster compensation mechanisms in Europe have been predominantly focused on dealing with the financial losses, without considering the implications of these mechanisms for managing and reducing the underlying risks. Reflecting on evidence emerging from other European and international flood insurance schemes, we notice that this is not an exception, but rather the norm (Surminski et al., 2015b).

Our modelling approach and findings are highly relevant for wider discussions on the potential of insurance schemes to incentivise flood risk management and climate adaptation in the EU and beyond. There is a clear current momentum at international level to use insurance to incentivise risk prevention and adaptation, as highlighted by the increased efforts to design new insurance schemes in developing countries through the new G7 'insuResilience' initiative, and underpinned by the UNFCCC's Paris Agreement (see Surminski et al., 2016). As we have shown across the different ENHANCE case studies, the engagement of multi-sector partners and the clarification of their roles and responsibilities will determine if and how those new schemes can support climate resilience. This is an opportunity, and the lessons from across Europe provide important insights that can help to harness disaster insurance for risk reduction and climate adaptation.

Flood in Budapest, Hungary. Copyright: UNISDR.

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06

Development of multi-stakeholder partnerships

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Introduction

Partnerships have been endorsed and promoted as promising vehicles of ***polycentric*** and **inclusive** governance; complementary to traditional, hierarchical modes of governing and intergovernmentally agreed actions. Since 2000s, multi-stakeholder partnerships (MSPs) and initiatives (MSIs) have flourished in the context of the **UN-championed Global Partnership for Sustainable Development**, and have proliferated in the adjacent policy domains including natural hazard and risk management, biodiversity conservation, and climate change (Pattberg & Widerberg, 2015).

The ***multistakeholderism***, a term coined by Raymond & DeNardis (2015), does not have a well-defined institutional form and structure. It embraces multiple, to some extent experimental constellations of actors and authority relations between them; with different structural and organisational forms including coalitions, networks, community-based initiatives, value-based frameworks for action, and commitments (UN, 2009). The purposes for which partnerships have been forged are even more diverse. This inbuilt variety and conceptual vagueness has prompted some to censure partnerships as 'empty and merely politically expedient' (Brinkerhoff & Brinkerhoff, 2011), or become suspicious of the decision making power conferred to the private actors involved. **Dismissing partnership approach** to solving complex development or environmental challenges however, **would mean ignoring the past attainments and disregarding the reasons for which partnerships are so often invoked** (Raymond & DeNardis, 2015).

Since 2000, the UN General Assembly (GA) regularly has reviewed and deliberated on transitional partnerships for sustainable development that involved UN funds, programmes and agencies. In the run-up to the World Summit on Sustainable Development (WSSD), held in Johannesburg in 2002, the MSPs have been elevated to equal (or almost equal) terms as the commitments arising from intergovernmental negotiation. Termed **Type-II outcomes of the WSSD**, the partnerships were brought to the front **as a major method of achieving sustainable development** (Wilson, 2005).

The most recent UN resolutions (UN, 2015b) delineates partnership as

> ***'voluntary and collaborative relationships between various parties, both public and non-public, in which all participants agree to work together to achieve a common purpose or undertake a specific task and, as mutually agreed, to share risks and responsibilities, resources and benefits'***
>
> (UN, 2015b).

The MSPs are **among the means of implementing the 2030 Agenda for Sustainable Development** (UN, 2015c), and two (17.16 and 17.17) from among the 169 targets refer to MSPs as a way of (1) mobilising and sharing knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals (SDGs); and (2) encouraging and promoting effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships. Partnerships are also among the guiding principles of the Sendai Framework for Disaster Risk Reduction 2015-2030 (UN 2015a), along with all-of-society engagement and next to empowerment, participation and due care of people disproportionately affected by disasters.

In Europe, the MSPs have prospered especially since the 1990s, although arguably early forms of partnership have existed since much longer time. Italy was among the pioneers of the negotiated planning instruments[4] . In the EU, growing attention was devoted to fostering the participation of civil society in policy and decision making in the early 1990s, eventually leading to adopting the ***White Paper on European Governance*** (EC, 2001b). The White Paper emphasises the positive impact enhanced participation has on the quality, relevance and effectiveness of EU policies, as well as its capacity to promote improved confidence in the outcomes and in the institutions delivering the policies. To achieve such outcomes, online information on preparation of policy through all stages of decision-making, a stronger interaction with regional and local governments and civil society, as well as a more systematic dialogue with representatives of regional and local governments should be encouraged, among other relevant actions (EC, 2001a; Höreth, 2001).

The proposals for change mentioned in the White Paper highlight the need to

'renew the Community method by following a less top-down approach and complementing its policy tools more effectively with non-legislative instruments'

(EC, 2001b).

This entails the use of new governance forms, including framework directives, partnerships, greater participation by civil society in policy formation through 'civil dialogue', and a wider use of the Social Dialogue (Scott and Trubek, 2002). In the 2000s the EC reinforced the efforts dedicated to *the culture of consultation and dialogue*. Concomitant with the adoption of an action plan for a *simplified and improved* regulatory environment (EC, 2002b), the Commission espoused ***minimum standards of consultation*** (EC, 2002a) and consolidated regulatory *impact assessment* methods (EC, 2002c). The minimum standards of consultation set to increase the consistency and transparency of the consultation processes, and smoothing the participation of interested parties and civil society. The general principles comprise *participation, openness, accountability, effectiveness and coherence.*

The step change towards a smart regulation *('getting legislation right')* was then outlined in the 2010 Communication (EC, 2010a), building upon the principles of *whole policy cycle* analysis (including design, implementation, enforcement, evaluation and revision), *shared responsibility* (of EU and Member State (MS) institutions), and making policy efforts *accountable to those mostly affected*. These changes have not altered greatly the consultation practices but created some room for alternative ways of regulation, such as co-regulation and self-regulation (EC, 2009; 2005b). Inter-institutional agreement on *better law-making* (EC, 2003a) defined **co-regulation** as

'mechanism whereby a Community legislative act entrusts the attainment of the objectives defined by the legislative authority to parties which are recognised in the field (such as economic operators, the social partners, non-governmental organisations, or associations)' (EC, 2003a).

Likewise, **self-regulation** entails the possibility for the equivalent bodies to

'adopt amongst themselves and for themselves common guidelines at European level (particularly codes of practice or sectoral agreements'

(EC, 2003a).

[4] The law 662 of 23rd December 1996 Measures for improving public finances endorsed various instruments based on multi-stakeholder negotiated agreements, including framework programs, territorial pacts, program agreements, and thematic contracts.

The Principles for Better Self- and Co-Regulation[5], but in principle any multistakeholder process attempting to reach a specific societal goal, highlight both the **framing of the pursuit** (through choice of participants, open governance, clearly specified objectives, and compliance) as well as **its implementation** (flexibility and iterative improvements, monitoring and evaluation, dealing with dissent and financial arrangements).

The ***Seventh Environment Action Programme*** **(EAP)** (EC, 2013a) that outlined the EU environmental policy until 2020 and endorsed a vision up to 2050, stresses the importance of public participation and encourages a strengthened collaboration among different actors to reach environmental objectives. Article 3, for instance, calls public authorities at all levels to

'work with businesses and social partners, civil society and individual citizens in implementing the 7th EAP'.

Creating a common ownership of environmental goals and objective is one of the purposes of the Programme: consistently, the public is expected to play an active role and to be properly informed about environmental policy (art. 15). Moreover, *public dialogues* and *participatory processes* should be promoted, especially with regards to potentially conflicting issues like the development of environmental technologies.

The ***EU Cohesion Policy*** (CP) plays a role in strengthening the Union's *economic, social and territorial cohesion* and reducing regional disparities. In this context, the Regulation 1303/2013 pioneered a new multi-governance coordination and planning mechanism, articulated through ***Partnership Agreements*** (PAs). The PAs are developed by the MSs in collaboration with regional and local authorities, economic and social partners, and representative bodies of civil society. They infold tailor-made strategies, priorities and arrangements, making the European Structural and Investment (ESI) Fund investments work towards fulfilling the Union objectives. The PAs are reviewed and approved by the Commission. The EC has devised a *Code of conduct on partnership* (EC, 2014a) for this purpose. The Code of Conduct addresses selection of partners and their role in the formulation and monitoring of the PAs and the implementing programmes. The transparent and balanced choice of partners, one that pays due attention to the specific institutional and legal frameworks in each MS, is of paramount importance and the Code of Conduct lists categories of public and private bodies (hereafter partners) that ought to be effectively represented. Among the public authorities a vital role is assigned to (higher) educational institutions, training providers and research centres. Among the economic and social partners, a balanced representation of large, medium-sized, small and microenterprises ought to be guaranteed. The civil society is to be represented by environmental advocacy groups, non-governmental organisations, and bodies actively engaged in fostering social inclusion and equality. The partners are to be involved in main activities leading to PAs, including an 'analysis of disparities, development needs and growth potential', selection of the thematic objectives and indicative allocations of resources, and effective monitoring and evaluation of the programmes. The PAs are to include detailed information about the partners' composition, their role in the process and results of consultations, and the actions undertaken to ensure their active participation.

[5] http://ec.europa.eu/digital-agenda/en/news/principles-better-self-and-co-regulation-and-establishment-community-practice

Partnerships analysed in the ENHANCE project

In the ENHANCE project we have analysed empirically, through ten pilot studies spread across Europe, how partnerships for disaster risk reduction (DRR) perform under regular, but especially extreme hazard configuration, and what role they play (or can play) in the multi-governance regimes. The types of partnerships we have scrutinised include:

Risk and cost sharing arrangements between public and private actors designed to improve provisions of products or services. These partnership instances have been initiated to make **insurance** available for intensive risk, and to develop or better protect **critical infrastructure systems**. These essentially *public-private partnerships* (PPPs) typically entail contractual engagements (Beyerlin & Marauhn, 2011). An example of this type of partnership is the proposed ***Flood Reinsurance Pool*** (Flood Re) in the UK, laid out in the Water Act 2014 as a way to ensure affordability of flood insurance for high risk-prone properties, in transition to full risk pricing practice. Flood Re has been designed as a not-for-profit flood reinsurance fund, owned and managed by the insurance industry, but capitalised by a levy that under the EU state aid regulation constitutes state resources.

Assemblies of users of a resource, typically water, instituted to empowered community solutions to resource and/or development challenges. This type of partnership is studied in the context of the **Po and Júcar River Basin Districts** (RBDs) subjected to temporal water shortages and medium- to long-term declines of water availability as a result of climate change. In both cases, the negotiated cooperative agreements among the water users were instituted through the so-called *Drought Steering Committees* (DSCs), vested with power to take decisions concerning the (re-)allocation of strained water resources during the prolonged periods of drought.

Territorial, typically cross-border cooperation between communities united through sense and/or identity conferred to physical place, and committed to collaboration for the sake of economic development or environmental protection. These partnerships are similar to collaborative resource management pursuits but contemplate wider purpose such as regional development. In Europe these partnerships are epitomised by macro-regional strategies (MRS) that foster multi-level governance and help to better coordinate the EU Cohesion Policy with sectorial policies such as environmental protection, integrated maritime and transport. Several MRS have been propelled or initiated, including Baltic Sea Region (2009), Danube Region (2010), the Alpine Region, the Adriatic and Ionian Region, and the Atlantic strategy. Our research focussed on **the Wadden Sea (WS) region** that has been subject to trilateral (NL, DE, DK) cooperation since 1978, long before the EU territorial cooperation began.

Horizontal and vertical cooperation between public agencies and authorities for the sake of a better public service provision and more efficient allocation and use of public resources. For these, a term *public-public* partnerships (PuPs) was coined to distinguish them from *public-private partnership* (PPPs) (Calliari & Mysiak, 2015b). PuPs contemplate no direct profit-seeking pursuit as a driver for cooperation and thrive especially in public policy areas in which multiple, legitimate views are to be taken into account and ethical principles dominate in judging the policy fairness, such as health care. ***Health and wellbeing boards (HWB)*** have been introduced in the UK by the Health and Social Care Act 2012 as statutory bodies to be established by the upper-tier local authorities as a committee of that authority. The HWBs are a way to improve coordination of health, social, and other related public services. The HWB are requested to produce a joint strategic needs assessment (JSNA) and health and wellbeing strategy (HWS) for the respective local authority area. Although compelled by law, the HWBs epitomise a novel partnership fabric, for which no equivalent exists at the European level (Calliari & Mysiak, 2015a).

Photo by kconnors/Morguefile.

Public-private partnerships for affordable disaster insurance

Public-Private Partnerships (PPP) in disaster insurance is a **role model for a joint bearing of responsibilities and efficient risk-sharing**, intentional of increasing insurance coverage and penetration, and guaranteeing a strong financial backing in view of uncertain tail distributions of risk. Johansen (2006) capably summarised the principles and preconditions of successful PPPs as (1) being shaped through constructive dialogues (between public and private entities) and conscious of mutual principles and limitations, (2) safeguarding competitive environment; and (3) respecting, if not exploiting, risk-differentiated prices as incentive and reward for individual or collective risk prevention and protection.

While being in origin a private service, *equitable* and *accessible* insurance against low probability/high impact natural disasters may meet the scope of a ***Service of General Economic Interest (SGEI)***, that is a *public service* deemed by public authorities as being of particular importance to citizens and that would not be supplied, or only under different conditions, if not for a public intervention. Our analysis focussed among others on how the PPPs, that have been designed for sharing and transferring risk, operate within the regulatory constraints of the state aid.

Private flood risk insurance in UK has a long tradition and the cover of residential properties is among the highest in Europe (Maccaferri et al., 2012). The insurance market succeeded with no or little public policy intervention. The housing insurance typically covers a portfolio of risks in addition to floods and is compulsory for securing mortgage loans. The public-private cooperation in flood insurance sector started in the 1960s and gradually evolved into a partnership entailing tangible commitments on both, public and private sides. Penning-Rowsell et al. (2014) and others (Ball et al., 2013; Lamond et al., 2009; Penning-Rowsell & Priest, 2015) have examined in detail how the market developed over the past. Insurance scheme described hereafter has been built upon the groundwork laid down through progressively specified principles of public-private cooperation and partnership between the Association of British Insurers (ABI) and the UK Government.

In 2013, the UK Government selected the Flood Reinsurance Scheme as the preferred approach for ensuring that affordable flood insurance provision was maintained for properties exposed to high flood risk (DEFRA, 2013). The Scheme replaces the previous deal embodied in the *Statements of Principles* (SoP), the latest of a series of informal agreements between UK Government and ABI, that expired in 2013. The FR design is extensively discussed in Crick et al. (2013), Horn & McShane (2013) Surminski & Eldridge (2015) and Surminski et al. (2014). The core framework of Flood Re was laid down in the 2014 Water Act. The latter also introduced flood obligations by means of compulsory flood insurance coverage for the case that the Pool alone will not meet the expected availability and affordability of insurance. The initial impact assessment included also other policy options that were found less efficient and effective. The UK Government conducted public consultation on the Scheme's regulation between July and September 2014. Later the same year the UK Government notified European Commission (EC) on the state aid enclosed in the Scheme. The EC issued favourable opinion in January 2015 (EC, 2015).

From the beginning, Flood Re had been designed as a publicly accountable but privately owned and managed, not-for-profit service organisation. Public oversight is implemented via enabling legislation, monitored by the Department of Environment, Food and Rural Affairs (DEFRA); by supervision through financial regulators (PRA, FCA); and by National Audit Office's (NAO) review of economy, efficiency and effectiveness of resource use, as well as regularity and propriety in management. The Scheme Administrator is hold accountable to the UK Parliament for the operation of Flood Re. The ownership and management of the Scheme is entirely in the hands of the insurance industry, with limited membership role of the Government. This also includes a delegated power to call on a supplementary (top-up) levy or contributions, as explained later. Annual liability of Flood Re is limited to around 2.5 billion GBP, equivalent to 1:200-year loss scenario (Horn & McShane, 2013). Government holds no financial liability for the Scheme. In its response to the 2014 consultation the UK Government stated, along with the previous informal commitments, that

'should flooding occur on a scale greater than 1:200 event, Flood Re and the Government will decide how to best respond, as part of a wider response to what would be a national emergency'

(Bennett and Edmonds, 2014).

Flood Re is a reinsurance mechanism for flood components of housing policies. The commercial insurers are free to choose whether to reinsure the written risk on market, or cede the flood-risk component of housing policies to the pool at predetermined, capped prices. In the latter case, any and all damage claims will be paid by the Scheme and the primary insurers continue acting as a broker. The capped premiums are higher on average than those previously paid but lower than prices otherwise charged on free market (Diacon, 2013). The capped prices for 2016 are specified by regulation (FR Regulation, 2016), and for successive years updated by the Consumer Price Index (CPI) and revised every 5 years.

Flood Re is funded by annual statutory levee set to 180 million GBP for the period of first 5 years that is imposed on all home insurers operating in the UK (relevant insurers). The total amount of primary levee was decided as an equivalent level of current cross-subsidy which amounts to estimated 10.5 GBP per household. In addition, the Scheme Administrator can raise supplementary (top-up) levee or contributions in cases when it does not dispose with sufficient resources to meet its non-reinsured claims. A call on additional contributions exceeding 100 million GBP in any given year, except for the initial capitalisation, is linked to a duty to report to the Secretary of State. The primary and top-up levees are distributed among the relevant insurers in proportion to their market shares. The latter are obliged to provide information that makes it possible to determine the individual amounts due.

MSPs for resource management

In the **Po River Basin District – PRBD** (Mysiak et al., 2014) in Italy, and in the **Júcar River Basin District – JRBD** (Haro Monteagudo et al., 2014) in Spain, public authorities team up with civil society and private organisations in building decentralised, voluntary cooperative initiatives to empower community solutions to resource and/or development challenges.

The **PRBD *Drought Steering Committee (DSC)*** was established in 2003 as a coordinated response to one of the most intense droughts over the last 30 years. Promoted by the Po River Basin Authority (PRBA), it engages several regional administrations; Land Reclamation and Irrigation Boards (LRIB); public entities supervising the operation of the great regulated lakes, the Italian Grid Distribution Operator and major power producing companies located in the basin.

During the 2003 drought event, the DSC conducted negotiations that led to a reduction of water withdrawals aiming at moderating the adverse impact of the drought. The cooperative decision of the DSC was sanctioned by a *Memorandum of Interest* (MoI) detailing the roles and tasks of each partner so as to guarantee: (1) the minimum levels of water appropriation for irrigation, and (2) the required level of electricity generation (AdPo 2003). Given the positive experience in 2003, the *partnership* was broadened in 2005 to devise a coordinated way of monitoring and anticipating future water crisis. Consistently, the DSC was convened again during the 2006/2007 drought events, under the declared State of Emergency.

During the years, the DCS has played an important role in **fostering mutual understanding and trust among parties, enhancing information exchange and collaboration experiences** that are often hampered by the administrative and political fragmentation within the basin.

While the DSC is only activated in the case of extreme conditions, other collaborative tools are in place at the district level for the ordinary management of water resources. In particular, several **river contracts (RCs)** have been signed over the past years. The river contracts integrate the provisions of water management and protection plans with soil conservation, landscape and economic development considerations. A significant contribution towards their diffusion was provided by the *Blueprint on River Contracts* (Conference of Regions 2010).

Similarly to the PRBD experience, a ***Permanent Drought Commission* (PDC)** has been set in the Júcar basin since 2007 as a stakeholder forum for coordinated response to droughts and insuring water crises (Haro Monteagudo et al., 2013; Haro Monteagudo et al., 2014). The PDC is convened when an emergency is triggered and a *Royal Decree of Exceptional Situation* is released (Haro Monteagudo et al., 2014). The range of the stakeholders involved was extended over the past decades, including water users, NGOs, economic and social partners, and representatives of civil society organisations. The PDC is assisted by the *Drought Technical Bureau* and is empowered to adopt decisions on water restriction and allocation. Usually, decisions are taken by consensus of the involved partners but the *modus operandi* of the partnership provides also for situations in which a consensus is unlikely. Although not yet experienced in the JRBD, a compromise solution can be reached by casting votes, however, not all partners have a *right* to vote (Haro Monteagudo et al., 2013).

MSPs for territorial and cross-border cooperation

The ***macroregional strategy* (MRS)** is a pioneering instrument of European policy that fosters territorial cohesion through (1) **better collaboration and multi-level governance arrangement**; and (2) **better coordination of the Cohesion policy with other sectoral policies** such as environmental protection, integrated maritime and transport policy. The macro regions are delineated rather broadly as 'countries or regions associated with one or more common features or challenges' (Katsarova, 2012). The idea behind is that macro-regions with distinct identity and functionally connected features defy the administrative boundaries, around which the Cohesion policy evolved. The macro regions and sea basins strategies are pursued through improved cooperation and coordination, without recourse to new legislation, institutions and funding. Rather, they rely on a better use of the resources already available, coordinating and optimising them to tackle macro-regional challenges. The strategies are being explored as *new modes of territorial governance* and should serve as platforms for EU and national actors to coordinate actions across policy areas of common interest, including environmental and disaster risk reduction concerns.

The **Wadden Sea (WS)**, focus of another ENHANCE case study (Gerkensmeier et al., 2014; 2013), is a unique intertidal ecosystem in the south-eastern part of the North Sea, declared a World Heritage site[6,7]. Considered as the world's largest unbroken system of tidal sand and mud flats, it is shaped by natural dynamic processes in nearly unimpaired natural state (IUCN, 2014). Extending from the Varda Estuary and Skallingen in Denmark up to the island of Texel and the mainland port of Den Helder in the Netherlands, totalling to around 450 km of coastline.

Subject to an **international (trilateral) cooperation since 1978**, long before the Union territorial cooperation began, the first international agreement *(Joint Declaration on the Protection of the Wadden Sea)* was signed by the governments of Denmark, Germany and the Netherlands in 1982 and renewed in 2010. The Declaration is a formal but not legally binding commitment for cooperation at the governmental level to preserve the ecological integrity of the WS in its entirety, along with the connected cultural landscape, without an ('unreasonable') impairment of the local population's interest. The cooperation entails common (coordinated) policies and management, joint monitoring and assessment, public engagement through awareness-raising and environmental education, and sustainable development with due attention to its natural and cultural values. In 2002, a **WS Forum** was established as a vehicle of stakeholders' participation, transnational cooperation, and collective problem solving. The WS Forum is a partner to the ENHANCE project. The scope of the case study driven research is to **strengthen the coastal risk management topic under the WS Forum and the WS Plan** (Gerkensmeier et al., 2014). The Trilateral WS Convention is an example of a territorial cooperation, which dates back to period where such cooperation had not yet been contemplated in the Union. The cooperation established *partnership* practices that meet the scope of a macroregional strategy.

[6] The Dutch-German Wadden Sea was inscribed on the World Heritage List in 2009 while the Danish part became a part of the World Heritage list in June 2014.

[7] The Vision of the Trilateral cooperation is summarised as follows: 'The Wadden Sea is a unique, natural and dynamic ecosystem with characteristic biodiversity, vast open landscapes and rich cultural heritage, enjoyed by all, and delivering benefits in a sustainable way to present and future generations' (Joint Declaration, 2010).

MSPs for vertical and horizontal cooperation in disaster risk management

The notion of ***Public–Public* Partnerships (PuPs)** emerged in the early 2000s as a counterpart of PPPs (Corral 2007) and arguably building upon *community-based* natural resource management (CBNRM), disaster risk reduction (CBDRR) and other cooperative initiatives promoted by public alliances. PuPs materialised first for provision of public services in the water and health sectors, where multiple views and competence need to be taken into account and ethical principles dominate.

In ENHANCE we have analysed a classical prototype of PuP provided by the British experience of the ***Health and Wellbeing Boards (HWB)*** and explored the role they play in addressing climate change-related health impacts.

HWB were established by the Health and Social Care Act 2012 as statutory committees of all upper-tier local authorities, with the aim of bringing together different actors in planning how best to meet local care and health demands. They are not explicitly requested to factor climate change-related hazards in their planning activities. Yet, the 2014 *Heatwave plan for England (HP)* (PHE 2014) assigned HWB a key role in facilitating coordinated long term multi-agency planning and coordinated response to heatwaves. In doing so, HWB are to work closely with the Local Health Resilience Partnerships (LHRP) and Local Resilience Forums (LRF). LHRP bring together public health sector representatives with the aim to mainstream resilience considerations in the health and social care system and supervise health service's plans for emergency preparedness. Local resilience forums (LRFs) are instead wider multi-agency partnerships, including representatives from local public and emergency services, local authorities, the NHS, the Environment Agency, among others. Their role is to identify potential risks and produce emergency plans to be adopted by their local communities (Cabinet Office, 2013). **The HWB epitomise a novel partnership fabric, for which no equivalent exists at the European level**.

Another example of PuP analysed, broader in terms of spatial and thematic coverage, is the **UK *National Hazard Partnership* (NHP)**. It was established in 2011 as a consortium of public bodies (government departments and agencies, and public sector research centers) aiming at providing applied research and analysis to adequately prepare and respond to natural hazards at the country level. The partnership acts as a forum for exchanging data, knowledge and expertise, and for the formulation of coordinated and coherent scientific advice to the government and the emergency responders. It provides a major contribution within the *National Risk Assessment* (NRA) process, through advice and recommendations on existing and future risks. The NHP has also developed specific tools for risk assessment and communication. Among them is the *Natural Hazard Impact model*, which is to identify vulnerable areas and assets and consistently prioritise responses by policy makers. On the communication side, daily *Early Warning bulletins* are circulated to inform relevant government bodies on on-going issues and on the general outlook for the next 30 days. The NHP represents a model of cross-government cooperation, which could be applied for handling other complex issues, not necessarily related to natural hazards. Among the main benefits that can be detected, despite its recent establishment, is its capacity to effectively pool together competences and avoid duplication of efforts (UNISDR, EC, and OECD, 2013).

Interesting examples of PuPs for DRR can be also found in completely different policy domains. It is the case of the ***European Aviation Crisis Coordination Cell* (EACCC)**, a partnership established in 2010 to promote an integrated and coordinated approach in identifying and mitigating aviation safety risks. Prompted by the **Eyjafjallajökull volcano eruption in April 2010**, which paralysed the EU airspace for more than a week, the Cell includes one representative from each of the following institutions: the Presidency of the Council of the EU, the European Commission, the European Aviation Safety Agency (EASA), the European Organisation for the Safety of Air Navigation, the military sector, the air navigation service providers, airports, and airspace users (EC, 2011a). The EACCC was later crystallised in the European Union legislative framework through the Commission Regulation No 677/2011 (EC, 2011a).

In the event of a crisis, the EACCC chairperson convenes the cell in order to discuss and agree on a common crisis mitigation policy, which is coordinated at national level – when appropriate – by the relevant State Focal Points. Following the crisis resolution (and thus the deactivation of the Cell), a debriefing session is held to highlight lessons learnt and decide on residual actions to be taken.

The creation of the cell marked a shift away from a prescriptive way, through which safety was to be pursued (as resulting from the conformity to regulations and standards) to a goal-based one to be defined through a coordinated approach. Besides the 2010 event, EACCC was activated in 2011 in response to the eruption of **Grímsvötn volcano**, and in 2014, when the **Malaysia Airlines Flight MH17** was shot down by a surface-to-air missile in the Ukrainian airspace. In the case of the **Ebola outbreak** (2014-2015), EACCC monitored the potential impact of the epidemic on European aviation, with the aim of supporting the actions undertaken by the World Health Organisation (WHO), the European Commission and the Member State national health authorities (EC, 2016).

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07

Synthesis and policy recommendations

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Introduction

Climate change adaptation (CCA) and disaster risk reduction (DRR) are among the paramount goals of the UN sustainable development agenda, galvanised through major UN conferences and summits held over 2015. The ENHANCE project has contributed to achieving the goals of several new policy frameworks, such as: the UN *Sendai Framework for Disaster Risk Reduction 2015-2030, the Addis Ababa Action Agenda on risk financing, and the Paris Agreement on Climate Change on climate adaptation.*

First, the Sendai Framework for Disaster Risk Reduction 2015-2030 adopted during the Third UN World Conference on Disaster Risk Reduction laid down priority actions and policy targets to substantially reduce disaster risk and losses in lives, livelihoods and health, and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries (UN, 2015, p.5). Understanding the hazard and risk, and measuring the progress towards accomplishing the DRR targets will only be possible if substantial efforts are put in improving risk assessments and disaster impacts' records. The Sendai Framework advocated for multi-hazard, inclusive, science-based and risk-informed decision-making for which it is necessary to collect and share (non-sensitive) disaggregated risk information, including detailed records of the past events' impacts. The Sendai Framework singled out climate change and variability as drivers of disaster risk, in conjunction with poverty and inequalities, uncontrolled urbanisation, and poor land management. Consequently, the Sendai Framework pleaded for improved coherence between policy instruments fostered for the sake of addressing climate change, biodiversity, sustainable development, poverty eradication, environment, agriculture, health, food and nutrition. The ENHANCE research endorsed an inclusive approach **for risk analysis and assessment, putting emphasis on economic and social ripple and spill-over effects; and truly contributing to enhancing resilience of communities and societies**.

The *Addis Ababa Action Agenda (AAAA)*, adopted at the Third International Conference on Financing for Development, erected a financial framework for sustainable development, fostering inclusive economic prosperity and lining up financing resources and flows with the priorities of the *2030 Agenda for Sustainable Development*. The AAAA does not only focus on official development aid (ODA), even though developed countries recommitted to meet the 0.7 per cent of ODA/GNI target of global solidarity and justice. The Framework addressed trade, investments, cooperation, science and technology, capacity building, illicit financial flows, tax reform (including harmful tax practices and subsidies), role of private sector, and other areas, essentially redesigning the global economic governance. **The ENHANCE research contributed to exploring a range of policy instruments for risk financing, including insurance and partnerships**.

The *Paris Agreement on Climate Change* agreed upon at the United Nations Framework Convention on Climate Change's twenty-first Conference of Parties (UNFCCC COP21) embraced bold actions set to curb the global temperature rise *well below* 2 degrees Celsius, and possibly below 1.5 degrees, compared to the pre-industrial levels. The Paris Agreement explicitly includes climate adaptation, a part of which are the efforts to strengthen societies' ability

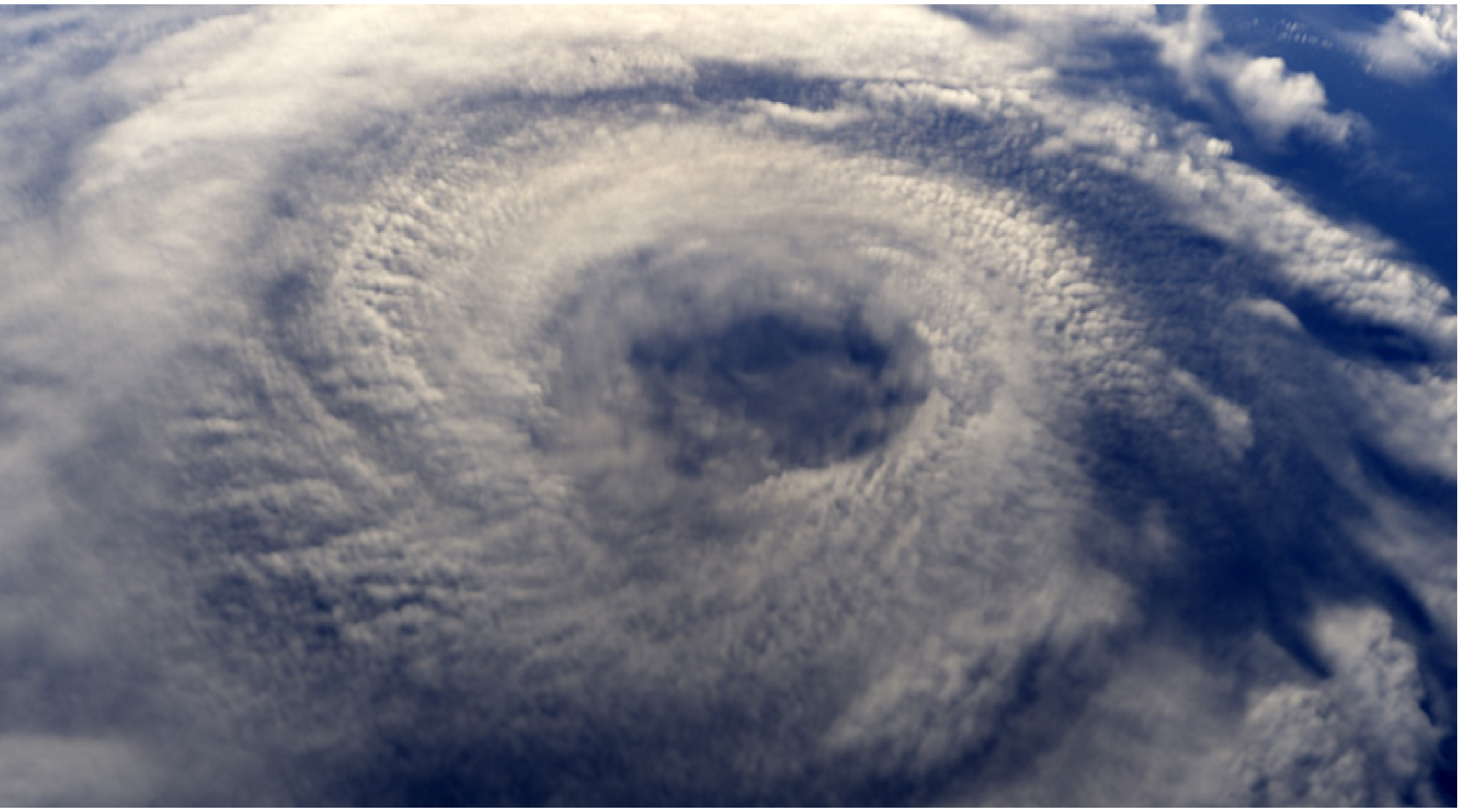

Photo by Guido Amrein/Shutterstock.

to deal with the impacts of climate change as well as financial commitments to foster adaptation and climate resilience. The Agreement reiterated that the *Loss and Damage* mechanism should be a part of the global contract.

The UN Secretary General's *Agenda for Humanity* was prepared for the World Humanitarian Summit. It includes five Core Responsibilities (CR) of which at least three are related to natural hazard and climate risk: (i) CR3 *Leave no one behind* addresses displacement and movements of refugees; (ii) CR4 *Change people's lives* entails emphasis on risk analysis and data investments; and (iii) CR5 *Invest in humanity recalls* the Sendai Framework's and the Paris Agreement's pledges for investment in risk (reduction) and adaptation. Moreover, the Summit served as a backstage for launching a *Global Partnership for Preparedness* (GPP) to help most vulnerable countries to get ready for disasters.

The *New Urban Agenda* that will be endorsed at the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) entails three *transformative* commitments: leaving no one behind and fighting against poverty; urban prosperity and opportunities for all; and ecological and resilient cities and human settlements. The latter places emphasis on a rapid and efficient recovery from natural hazard strikes. Resilient city is one that cares about safety of *individuals and cohesion of communities, while actively transforming their habitat and taking advantage of reduced risk exposure to improve its essential functions* (UN, 2016, p.79). This is important because globally some 66% of population (in Europe 80%) are expected to live in cities by 2050 and therefore success of the 2030 Agenda for Sustainable Development will depend to a large extent on the achievements made in the urban centres.

The European Union (EU) has played an important role in devising the above multilateral frameworks and lined up the European policies to the same or more ambitious targets (EC, 2014b, 2014c, 2014d). The *EU Action Plan on the Sendai Framework for Disaster Risk Reduction 2015-2030* (EC, 2016a) praised the Sendai Framework as an opportunity not only to advance disaster risk management agenda in Europe and to reinforce resilience to shocks and stresses, but also to boost up innovation, growth and job creation.

The ENHANCE project has contributed to many of the above objectives and goals, in particular (i) ***better understanding of risk*** and evidence-based and risk-informed public policies; (ii) ***managing risk by means of partnering*** and horizontal and vertical cooperation between private and public entities; through (iii) high policy level targeted dissemination and outreach. As a recommendation for further research, we believe it is critically important to analyse the contribution of the declining ecosystem services to increasing disaster risk in future, and to devise the role of insurance and risk financing in protecting ecosystem integrity.

Better understanding of factors and policies driving risk

Measured in economic damage and losses, natural hazard risk in Europe is high and tends to increase. Growing population and economic wealth are driving the upward trend in disaster losses, which is indicative of unsound disaster prevention and protection. Observed changes in extreme weather and climate events and possibly deteriorated status of natural ecosystems may have also played a role. The stochastic nature of disaster risk with uncertain tail distributions, along with rather partial observations of disaster damage and impacts, make it difficult to estimate the extent to which observed climate change has already contributed to growing disaster losses. Although detecting climate signal in disaster loss records has attracted large attention in the recent past, this is arguably neither the sole nor the most notable purpose for which the disaster impacts should be analysed. Within the project we have focussed on the following factors and policies relevant for understanding the wider consequences of natural hazards, and responding to the associated risk.

Macro-economic losses: A better understanding of natural hazard risk and ensuing economic losses is important for preventing excessive macroeconomic imbalances, and for coordinating responses to shocks and crises within the European Economic and Monetary Union. This is particularly important in countries that suffered most and did not yet fully recover from the recent economic, financial and sovereign debt crises. For example, Italy's high sovereign debt makes the national and regional economies susceptible to shocks caused by natural hazards. The debt sustainability analysis (DSA) showed that even a marginal change in GDP growth and subsequent interest rates can sizably influence the country's ability to reach the commitments made under the Stability and Growth Pact (SGP, see also chapter 14). The stochastic debt projection that considered the size and correlation of past shocks yielded a relatively high probability (11%) that the Italian debt ratio will be greater in 2020 than in 2015 (EC, 2016b). Furthermore, Standard & Poor's simulated the impact of low-intensity/high-impact disasters on credit trustworthiness rating (S&P, 2015), demonstrating that in some countries the disasters may downgrade the rating by more than 0.25 notches.

Post-disaster recovery and insurance: A better understanding of disaster risk is also important for post-disaster recovery, and within the context of the internal market regulation on state-aid conferred to business enterprises. State aid on selective basis that distorts (or threatens to distort) free-market competition is incompatible with the EU internal (single) market, except for cases in which the aid is to make good the damage caused by natural disasters. The Flood Reinsurance Pool (Flood Re) successfully passed the compatibility check with the internal market regulation. The Commission recognised the goal of ensuring affordable insurance against flood risk as a legitimate scope of public policy, and accepted the motivation for setting up the scheme as well as the underlying assessment of the baseline with no action taken by the UK Government. The EC concluded that Flood Re was both appropriate and necessary. The scheme was designed to promote free flood insurance market, and rectify market failures that could compel insurers to stop providing insurance cover in some areas or to increase insurance premiums beyond affordable levels to many households. Most importantly, the Scheme was designed so as to minimise the (competitive) advantage granted to the insurers.

EU Solidarity Fund: Exposure to natural hazards exemplifies natural handicaps, which threatens economic, social and territorial cohesion. As an expression of solidarity that is pinned down in the EU Treaty, the EU Solidarity Fund (EUSF; EC, 2014d; ECo, 2002) was set up as a way to respond with financial assistance in an efficient and flexible manner in the event of a major natural disaster in a Member State or in a country negotiating membership. Since 2002 and until March 2015, the solidarity aid was mobilised in 63 cases for a total amount of €4.037 billion (2014 Euro value). The EUSF was reformed over 2013-2014. By choosing to reinstall the absolute damage threshold criterion of €3 billion in 2011 instead of 2002 prices, the legislator made it easier for the largest (six) EU economies to access the post-disaster solidarity aid. Because the relative threshold of 0.6 per cent of the gross national income (GNI) remained unchanged, the access hurdle for the smaller economies are in 2015 considerably higher than in 2002, even if in part the real economic growth was lost to the post-2008 economic and financial crisis. Our analysis in Hochrainer-Stigler et al. (2015) showed that the risk of depletion of the EUSF could be reduced by increasing member state contributions and/or engaging in risk transfer. In the current form, the EUSF does not entail 'needs-based solidarity'. Lower-income member states received disproportionately lower compensation although they received larger disaster aid than their own contributions to the Fund. Solidarity could be enhanced by changing the rules for disbursing aid.

Need for complete and accessible loss data: Notwithstanding the importance of the quality-assured, systematically collected and thorough datasets on impacts of natural hazards, the loss data systems (LDS) in Europe are fragmented and inconsistent. Because open and accessible records on disaster impacts and losses are prejudiced by data gaps, European policy makers have little choice but to resort to proprietary data collection. The Sendai Framework for Disaster Risk Reduction 2015-2030 attempts to break up with the evidence-negligent practice. To demonstrate progress in reducing disaster risks, the Framework calls on the national and regional governments to better appreciate the (knowledge of) risk. Empirical and evidence-based risk analysis and assessment are a vital part of the disaster risk reduction efforts. The Open-Ended Intergovernmental Expert Working Group (OEIWG) was instituted to develop a set of indicators for measuring global progress. The Sendai Framework is not alone in this quest. The OECD invited the member countries to better prepare for and collect data on catastrophic and critical risks (OECD, 2010, 2014). Unlike the Sendai Framework indicators that focus on exclusively on direct damage and structural/physical losses, OECD recommended considering the whole distributional and implied ripple or spill-over effects of natural hazards.

Risk assessment: A sound understanding of risk does not only imply accounting for the past damage and losses. We also need to assess current and future risks, to assess whether our risk management policies are robust to future developments such as climate change. This needs new modelling approaches, using multiple stochastic methods and addressing the low probability character of extreme disasters. On temporal scale, the probability distributions of such models span over years, decades and centuries. In some cases, the probabilities of once-in-millennia or even rarer events are still relevant for today's decision-making. These stochastic processes are often not stationary but respond to environmental changes, including climate change. Hazard manifestations of the same intensity and magnitude may also lead to diverse, sometimes significantly so, damage and losses, depending on the circumstantial factors. Vulnerability of people and societies in risk assessments is still poorly understood, and more data is needed to better understand how our societies respond to natural hazard risk, and transform in demography, wealth, cohesion and use of technology (e.g. Mysiak et al., 2015). The European Union Civil Protection Mechanism (EC, 2013) acknowledges the importance of such modelling approaches and compels the EU member states to conduct risk assessments, where possible also in economic terms, at national or appropriate sub-national level. Member states had to make a summary of the relevant elements thereof available to the Commission by December 2015 and will have to do one every three years thereafter. For both purposes, the Joint Research Centre (JRC) is developing loss indicators that should be part of operational disaster loss databases (De Groeve et al., 2013, 2014; JRC, 2015).

The ENHANCE research led or contributed to a number of seminal publications on novel risk assessment and management methods. Jongman et al. (2015) showed that vulnerability is an important driver of disaster damage and annual hazard variability alone only explains a minor part of the observed variation in the recorded damage. Ward et al. (2014) contributed to determining the influence of El Niño Southern Oscillation on flood risk around the world. Mechler et al. (2014) explored the risk management and financing choices within the UNFCCC

Warsaw International Mechanism for Loss and Damage. Carrera et al. (under review) analysed flood risk in Italy in terms of economic losses (as opposite to damage and financial loss) using an innovative assessment methodology. Koks et al. (2015) compared disaster impacts using different model types in a systematic way and for the same geographical area, using similar input data. Koks et al. (2015a) analysed social vulnerability within flood hazard zones and showed that flood hazard zones are home to disproportionately large share of socially vulnerable households. Poussin et al. (2015) estimated potential damage savings and the cost effectiveness of specific flood damage mitigation measures that were implemented by households during major flood events in France. Kellermann et al. (2015) and Amadio et al. (2016) developed empirically driven flood damage assessment models. Veldkamp et al. (2015) assessed water scarcity by taking into account temporal changes in socio-economic conditions and hydro-climatic variability, and Perez-Blanco et al. (2015) explored the use of incremental water charging for reducing the environmental costs that arise during drought events. Surminski (2014) shed light on the ability of flood insurance to contribute to direct risk reduction.

Flood in Budapest, Hungary. Copyright: UNISDR.

Managing risk through partnerships

International and multi-stakeholder partnerships (MSPs) are an important component of the transformative change and vehicles of development, environmental, and disaster risk reduction agendas. The MSPs represent a step change away from solely government-centred to multilevel modes of risk governance (Calliari and Mysiak, 2013). The ENHANCE project has analysed various MSPs in different contexts and situations (see chapter 6). We have found that despite broad agreement for closer collaboration between public and private actors in response to rising risk levels many challenges remain for translating this into innovative solutions. Public-Private Partnerships (PPP) in disaster insurance can serve as role models for a joint bearing of responsibilities and efficient risk-sharing. The principles and preconditions of successful PPPs as (i) being shaped through constructive dialogues (between public and private entities) and conscious of mutual principles and limitations, (ii) safeguarding competitive environment; and (iii) respecting, if not exploiting, risk-differentiated prices as incentive and reward for individual or collective risk prevention and protection (Johansen 2006).

Our findings exemplify that public and private stakeholders have very different constellations and problem definitions. Therefore, stakeholder engagement is important to discover current barriers, perceived or otherwise, which may be inhibiting innovative solutions or the development of new partnerships. For example, it may be that the level of risk itself is seen as already too high for the private sector to engage, or the stakeholders may not have a suitable platform upon which to engage. We have further explored this in the context of disaster insurance: The current discourse about disaster insurance highlights the key challenges of managing current risks and preparing for future climate risks: at the core lies the issue of collective versus individual responsibility, and solidarity versus market-based approaches. This is where the biggest potential for global policy lies - in the facilitation of DRR and adaptation, which will determine risk levels and viability of insurance going forward. However, the design and operation of insurance can also play a role in this. As the ENHANCE examples show, there are significant barriers facing public and private stakeholders. This requires policy action—at global and national, even regional level. The key question therefore is how to determine and define the roles of industry and policy-makers, recognising that this is likely to differ from country to country. This is an area where closer collaboration between academia, industry and government is needed to proceed (Surminski et al., 2015).

The received responses to the EC-initiated consultation cautioned against harmonising the regulation on natural hazard insurance across the EU (EC, 2014f). Both, the uneven-distribution of hazard risk and the diversity of economic standing and requirements of the customers have been brought up by the UK Government, and echoed by others, as reasons against an EU intervention (HM Treasury, 2013). Consequently, harmonised regulations could harm innovation and competition in insurance products. The Dutch government underlined that a concerted EU action in this policy area was neither warranted nor in line with the subsidiarity principle of the EU governance (NL, 2013). Mandatory product bundling, suggested as a way of dealing with insurability of certain natural hazard risks, was seen with skepticism by insurers and public authorities alike, for similar reasons. The European

Parliament (EP) expressed analogous opinion (EP, 2014) while underlining that flexible markets should operate in non-mandatory framework and that no one-size- fits-all solution would serve the magnitude of different risk and economic conditions in Europe. On the opposite side, the risk-based insurance pricing received high support across all categories of consulted stakeholders, and so did a better collaboration between public and private entities on improved risk analysis and assessment. Almost unanimous agreement was voiced for making disaster loss data publicly accessible in detailed and disaggregated form.

In a 2014 speech, Kristalina Georgieva (at that time the EU Commissioner for international cooperation, Humanitarian Aid and Crisis Response) said that the European Commission would seek to address low uptake of disaster insurance, while encouraging transition to a higher degree of risk-based pricing and improving the accuracy and comparability of risk data and risk modelling. So far, the EC has not disclosed whether it intends to take any follow-up actions based on the results of the Green Paper, and what those actions may be. Disaster insurance however is unlikely to be off the table entirely. In summer 2015, the Five President's report[8] (5PR, Juncker et al., 2015) anticipated further steps to deepen the Economic and Monetary Union. The report, released amidst deteriorating Greek sovereign debt crisis, laid out an ambitious agenda for integration of economic, financial, fiscal and political policies across the EU. It included, among others, a proposal to institute a European Deposit Insurance Scheme (EDIS) acting as a re-insurance system at the European level for the national deposit guarantee schemes. Disaster risk has already been addressed under the Greening the European Semester initiative (Fenn et al., 2014). The 5PR sets to bring the EU on top form for overcoming shocks and crises of whichever cause, including large disasters with lasting repercussions.

Partnerships are promoted either indirectly, through stimulating a culture of consultation and dialogue, or directly through cooperation and shared responsibilities. The regulation 240/2014 (EC, 2014a) for example makes compulsory partnerships between public authorities, economic and social partners and bodies representing civil society when it comes to deployment of resources from the European structural and investment (ESI) funds. The lack of an unambiguous specification of partnerships, here especially those designed for DRR, does not necessarily mean that there is no normative guidance so as how to build or judge them. The guiding principles can be inferred from the copious rules, standards and practices that characterise European governance on matters related to internal market, competition, cross-border and trans-national cooperation, environment, and risk management, to name but a few (Calliari and Mysiak, 2015; Mysiak and Perez-Blanco, 2015). The ENHANCE research has shown that the MSPs ought to be seen and evaluated from either *instrumental* or procedural point of view, or both. Instrumental when the MSPs are conceded by discretion of public authorities as equivalent to other public policy choices. An example is co- or self-regulation when the attainment of the public policy objectives is entrusted to parties recognised in the field (EC, 2003). When MSPs supplant or complement the choices of competent authorities, the same normative standards apply as in the case of public decision-making, i.e. openness, transparency, accountability, flexibility, and effectiveness. *Procedural* when the MSPs are conceived by quests of making public policy choices more accountable and inclusive. In the former sense the MSPs are legitimised when they yield outcomes at least as effective and/or efficient as alternative policy courses, and better on other accounts.

[8] Report written by the President of the European Commission, in close cooperation with the President of the Euro Summit, the President of the Eurogroup, the President of the European Central Bank, and the President of the European Parliament.

Public-Private Partnerships (PPPs)	Public-Public Partnerships (PuPs)
Mutually beneficial cost and/or risk sharing arrangements	Collective benefits with no direct individual financial or competitive gains contemplated
Scope: partnership targeted at market failures or where public investments or performance are likely less effective or successful	Openness: sincere efforts to engage all relevant or representative parties, both public and private, in a genuinely concerted and collaborative pursuit; allowing other parties to join in
Additionality: where substitute or sustain actions would not materialise anyway	Flexibility: enable redefinition as the scope of collaboration evolves
Consistency: partnerships not to harm the incentive for risk reduction	Transparency: partners sponsor the partnership with their knowledge and skills, competences and standpoints in good faith, and share the outcomes in plain way
Efficiency: sound use of public resources and limiting to the extent possible the distortion of competition	Accountability: objectives and principles of the partnership are well specified and respected
Transparency, equal treatment, effective analysis and monitoring	Constructive dialog: partners preserve the sense of common purpose, while accommodating the dissents and fertile divergences
Sustainability of the partnership based on clear rules of viability and legitimacy	

High policy level targeted dissemination and outreach

During the course of the project, the ENHANCE team participated in, and organised or co-organised numerous workshops and side events in major scientific and science-policy conferences to further develop the ideas on MSPs and DRR. These meetings include *the Third UN World Conference on Disaster Risk Reduction* (WCDRR, Sendai/Japan, March 14-18, 2015); *the European Climate Change Adaptation Conference* (Copenhagen, May 2015); the *Understanding Risk Forum* 2016 (UR2016, Venice/Italy, May 16-20 2016[9]); the Global Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) conference *Adaptation Futures* (Delft, May 10-13 2016); the OECD High level conference on flood risk (Paris, May 12-13 2016); and the UNISDR *High Level Forum on implementing the Sendai Framework for Disaster Risk Reduction at Local Level* (Florence, June 16-17, 2016).

The ENHANCE research was presented at the high policy level workshop on possible reform of the European Solidary Fund (Brussels, October 2015), the European Forum for Disaster Risk Reduction (EFDRR, October 7-9, 2015); the 7th EU-Japan Climate Change Research (Tokyo, April 26-27, 2016); and at the meetings of the EU *Loss Data Systems*[10] initiative under auspices of the DRMKC, to mention but a few international policy workshops. ENHANCE was referred to in the EEA's review of the disaster losses in Europe[11]. Furthermore, we have contributed to the consultation initiated by the UN Open-Ended Intergovernmental Expert Working Group on Indicators and Terminology (Mysiak et al., 2015), and developed recommendations of how to integrate and reform various European and international policies on sharing and storing disaster loss data. Furthermore, we held summer schools, capacity building workshops, stakeholder meetings and webinars.

Our research contributed to, otherwise informed, or has been acknowledged in a number of high policy level reports and/or outcome documents, such as the Global Water Partnership & OECD report *Securing water, sustaining growth* (Sadoff et al., 2015), the Outcome document of the *European Forum for Disaster Risk Reduction* 2015[12], the 2016 Report of the European Environment Agency's (EEA) *Flood risks and environmental vulnerability - Exploring the synergies between floodplain restoration, water policies and thematic policies* (EEA, 2015); the Bank of England's 2015 report *The impact of climate change on the UK insurance sector* (PRA, 2015); the upcoming 2017 EEA Report on *Disaster Risk Management and Climate Adaptation policies;* the River Basin District Management Plan (RBD-MP) of the Po river in Italy; and the first edition of the *State of Science*

[9] During the UR2016, ENHANCE liaised with another EC funded project Placard to organise a workshop/side event (Learning across communities of practice: risk assessment for disaster risk reduction and climate risk management) and a technical session of the conference (Climate extremes and economic derail).

[10] http://drr.jrc.ec.europa.eu/Loss-Data

[11] Clim039 indicator Economic losses from climate-related extremes, www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-2/assessment

[12] 2015 EFDRR was held in Paris, October 7-9. The outcome document can be found here: www.unisdr.org/files/43847_efdrr2015franceoutcomesfinal.pdf

[13] drmkc.jrc.ec.europa.eu

[14] Strengthening and redesigning European flood risk practices: towards appropriate and resilient flood risk governance arrangements, FP7, www.starflood.eu/

[15] The economics of climate change adaptation, FP7, econadapt.eu/

[16] Platform for climate adaptation and risk reduction, Horizon 2020, www.placard-network.eu/

Report on Disaster Risk Reduction of the EC Disaster Risk Management Knowledge Centre (DRMKC[13]). ENHANCE research is also poised to inform and contribute to the Italian National Climate Adaptation Plan (PNACC) and the National Flood Risk Management Plan.

Our research has inspired, set off, or otherwise informed new research and innovation actions, including the Climate-KIC funded pathfinder *Cost Adapt* (FEEM), the *Copernicus Climate Change Services* (IVM), the H2020 proposal *NATURANCE* (Nature for insurance, and insurance for nature) and others. Motivated by our results, the Port of Rotterdam Authority - a private company - has invested more than €200 000 in research to further investigate the risk from flood and climate change. The Wadden Sea Forum, established to advise the Trilateral Wadden Sea Convention, extended its focus to include disaster risk, as a result of the ENHANCE research. These are major acknowledgements of the impacts our research has had on public and private choices, and a proof of broad knowledge-transfer.

ENHANCE has regularly produced policy briefs and a booklet summarising the results and methods of the project for the broad public and policy makers. We have liaised with other European research projects such as STARFLOOD[14] and ECONADAPT[15], with whom we have organised a joint session during the ECCA 2015 conference, and other projects such as PLACARD[16]. We have used extensively the social media (twitter) to engage high level policy officials from the European Union in the project's activities.

Photo by Andrey Yurlov/Shutterstock.

Future research

The ENHANCE project set the stage for further innovative research on DRR and partnerships. As one of the important topics, we have focussed on the role of insurance and the ecosystems and nature-based solutions for DRR. Ecosystems can provide means to mitigate natural hazard risks, by mediation of flows and nuisances; or through maintenance of physical, chemical, biological conditions in the face of pressures. Ecosystem services for disaster risk reduction are most frequently associated with mass stabilisation, water flow regulation especially flood control, wind dissipation, and (micro- and regional) temperature regulation. Other, equally important hazard mitigating services include control of pest, disease and alien species; water filtration; dilution and detoxification of hazardous substances. Compared to engineered or built solutions, ecosystem-based approaches may be cost-effective, have certain co-benefits, and may become increasingly valuable in the face of more frequent and/or severe extreme events. They have an economic value in the context of natural disaster risk reduction and insurance, even if no price actually is paid for their provision and/or maintenance.

Ecosystem services are often 'taken for granted' in risk assessments. But many changes to ecosystems, for example to increase agricultural production or to provide land for infrastructure development (buildings, railways, roads…) may have the unintended consequence of reducing these regulating functions, potentially leading to growing societal vulnerability and susceptibility to harm that is expensive and/or difficult to reverse. The combination of increasing intensity and frequency of natural hazards, continuing conversion, homogenisation and simplification of (semi-)natural ecosystems, and the increasing footprint of built infrastructure may be contributing to the observed rapid increase in the costs and damage from natural hazards. It appears sensible to harness insurance and other financial instruments to protect or restore risk-mitigating ecosystem services. In theory, the recognition of ecosystem services could motivate insurers and other stakeholders to protect or restore the ecosystems. However, the combination of financial risk transfer mechanisms and ecosystem restoration is not straightforward because of the widely variable funding habits and traditions that cut across public and private sectors. Many conceptual, legal and financial barriers exist. Where insurance is primarily offered to individuals, such as farmers and homeowners, there is limited scope for using insurance (for example through risk pricing) to incentivise behaviour change. The example of flood insurance, and efforts to motivate property level protection and resilience-building, amply illustrate the challenges (Surminski and Eldridge, 2015). Marginal ecosystem improvements may not be enough to substantially reduce hazard risk. Purposeful ecosystem service provision often requires management intervention at the landscape scale, rather than the individual property. The return on investment may take decades to be profitable. And because ecosystem services are public goods, the cumulative effects generated through insurance-based incentives will also benefit uninsured proprietors. Collective insurance schemes appear better equipped to deliver sizeable improvements of ecosystem services and to get around concerns about free-riding. But collective insurance implies a dominant position or a (quasi-) monopoly of a local insurance market that undermines competition and demands close public control. An example of collective insurance reward under state-subsidised insurance scheme is the Community Rating System (CRS) under the US National Flood Insurance Program (NFIP), where households receive a premium discount if their community takes specified flood mitigation measures. These can include nature-based solutions. Financial incentives through risk pricing are not the only way of harnessing the latent potential of disaster insurance. Other means, even less explored, include taxation, public procurements and concessions, large-scale investment programs and public-private partnerships (PPPs). Individually or together the ENHANCE team members are committed to analyse the potential for cost-effective investments in protecting, enhancing or restoring ecosystems by developing and applying methodologies for estimating the 'insurance value of ecosystems', exploring ways in which insurance and public policy instruments can incentivise cost-effective investments in ecosystem maintenance and restoration, and assessing the legal, economic, social and institutional feasibility of insurance and other financial and economic instruments for promoting cost-effective investments in protecting, enhancing or restoring ecosystems.

There is also further research needed on full economic impacts of disaster risks, including distributional and spill-over effects of natural hazards. This need has been echoed by the scientific community (Jonkman, 2013; Mechler et al., 2014; Ward et al., 2015). While many existing disaster risk models focus on direct (material) damage on tangible assets such as residential properties and infrastructure, few models address the so-called 'indirect economic consequences', including production losses in areas affected through supply chain networks, or the cost of economic recovery after a flood. Research within the ENHANCE project shows that conventional risk modelling may severely underestimate disaster risk (Koks, 2016). One of the most important reasons for this underestimation is the degree of dependency of economic systems on critical infrastructure. One of the current focus points for policy makers is the vulnerability of this critical infrastructure to natural disasters. Infrastructure is the backbone of economic growth and social cohesion. The disruption of (critical) infrastructure, as a result of natural hazards, may be estimated through productivity losses and increased cost of production, which are set in motion by the substitution of more efficient and competitive supplies with lesser efficient supplies. For impact assessments, it is essential to outline the spatial extent of regions physically unaffected by the extreme event(s) that are disrupted as a result of damaged infrastructure.

Besides the impacts of large-scale disaster events, such as floods and earthquakes, there is an increased interest in the economic effects of extreme weather events, such as extreme rainfall, wind and hail. In north-western Europe, for instance, wind and hail storms are the most costly events for the insurance sector and have a much larger probability of occurrence in comparison to large-scale river or coastal flooding. Moreover, in relation to the failure of critical infrastructures, the modelling frameworks presented in the ENHANCE project serve as a good starting point to develop methods to assess the economic consequences of extreme weather events.

Finally, the ENHANCE project has pointed to the need for a greater research focus on options to address the residual impacts associated with both extreme and slow onset hazards. The topic has gained increasing visibility within recent climate change talks, eventually resulting in the creation at COP 19 of a specific 'Loss and Damage Mechanism' to deal with unavoidable climate-related effects (UNFCCC, 2014). In 2014, the UNFCCC set up an Executive Committee and devised a work programme to inform the deliberations. The mechanism was eventually endorsed as a stand-alone article of the Paris agreement (2015): Parties are called to work 'on a cooperative and facilitative basis' to 'enhance understanding, action and support' in areas including early warning systems, comprehensive risk assessment and management, risk insurance facilities, climate risk pooling, and non-economic losses. Yet, the mechanism features a mere explorative mandate and options for making it operational are currently subject to a vibrant debate.

There is need and scope for more broad-based discussions taking a research focus while aiming to inform policy. A number of promising avenues exist and have been preliminarily identified for taking the debate further, such as focussing on climate risk management and current international efforts for promoting disaster risk management. There have been a few studies reporting on empirical assessments. Yet, overall a comprehensive assessment exercise to identify the grounds for Loss and Damage (e.g., compared to adaptation), key principles to build on, as well as evidence regarding risk 'beyond adaptation' is currently missing. Further research is needed to support the science-policy dialogue on the Loss and Damage mechanism, and to identify practical and evidence-based policy and implementation options for its operationalisation.

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08

Forest fires and insurances in Portugal

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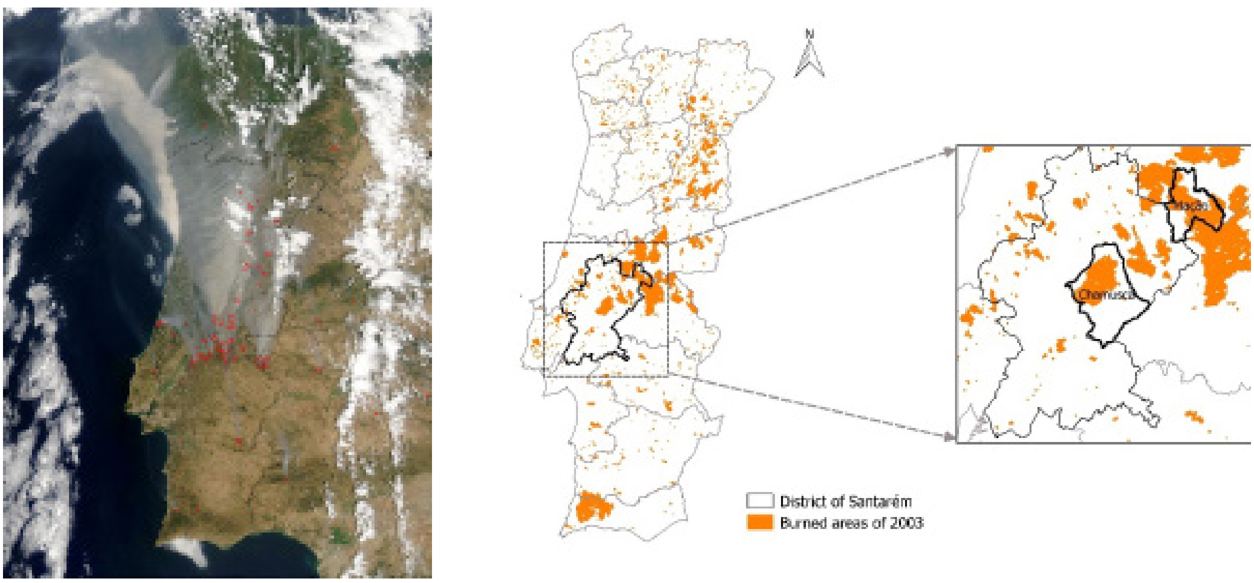
Introduction

Every year, forest fires have a major impact on urban areas and the environment in Portugal. In 2003, the district of Santarém, Central Portugal, was severely affected by wildfires, with almost 64 thousand hectares burned (INE, 2003). With respectively 26% and 48% of municipality area burned, Chamusca and Mação were most severely hit, facing multiple fatalities and several houses destroyed (ICNF, 2012a). Figure 8.1 shows the smoke plume from the 2003 wildfires in the satellite image (left) and the final shapes of fires showing the district of Santarém in Central Portugal (right). Considering the extent of area burned, and extensive damage sustained, the Santarém district offered a suitable case study for the ENHANCE project.

The goal of the Portuguese case study was **to analyse the Multi-Sector Partnership (MSP) and the economic instruments (e.g. insurance) which could promote the society's resilience to forest fires**. The case study area is one of the few areas in Portugal with two forest insurance products in place, one more directed to the pulp and paper industry and the other more directed to the diverse forest owners.

Figure 8.1.

Images of the 2003 wildfires. Left: 3rd of August 2003 satellite image, showing the smoke plumes from the active fires, which are shown in red. Right: the final extent of the burned area, for the whole of Portugal, the district of Santarém in Central Portugal, and the municipalities of Chamusca and Mação (Source: NASA Earth Observatory).



Several analyses were performed during the project to assess the viability of the MSP, the current risk levels, and the possible solutions to further manage risk:

- assessment of the MSP healthiness and preparedness using the 'capital approach' (see Ch. 1);
- forest fire risk assessment for the district, using probability loss curves;
- assessment of the meteorological component of the forest fire risk;
- assessment of the MSP perception of future scenarios;
- evaluation of the possible use of different economic instruments, including insurance and risk policy management.

Both quantitative and qualitative methodologies were applied.
The results were discussed with the members of the MSP studied, and their ideas and thoughts are included in this chapter.

Photo by Vladimir Melnikov/Shutterstock.

“Although partnerships are no ‘one-size fits all’ concept, learnings from Santarém can be transposed and adapted in other European Union regions.”

Multi-sector partnership

The multi-sector partnership consists of the Intermunicipal Commission for Forest Fire Defence (CIMDFCI – Chamusca) from the municipalities Chamusca, Alpiarça, and Almeirim, and the Municipal Commission for Forest Fire Defence in Mação (CMDFCI – Mação). The establishment of the Forest Fire Defence Commissions was mandated by law in 2004, (Decree-Law nº14/2004, of 8th May) with the objective *‘to articulate all means of action that intervene in the forest fire prevention in what concerns actions of fire prevention, education, surveillance, detection, supervision, first intervention, firefighting, mop-up actions and post-forest fire surveillance’*. The CMDFCI of Mação was formally created in 2004, whereas the CIMDFCI of Chamusca was created later in 2008.

The **Forest Fire Defence Commissions**, 220 in total, covering the entire country, were established as a response to the wildfire season in 2003, which was the worst ever recorded in Portugal. These commissions, or MSPs, were included as one of the strategic tools in the Portuguese National Plan for Forest Fire Defence (RCM nº65/2006). The MSPs develop their actions at a local level, in cooperation with the population, the forest owners, and the active forces from the municipality. They have the responsibility to coordinate the actions between the different stakeholders involved in forest protection, as well as to further develop **the Municipal Plan for Forest Fire Defence – PMDFCI** and **the Municipal Operational Plan – POM** (Decreto-Lei nº 17/2009 de 14 de Janeiro).

The MSP consists of both public and private institutions (**Table 8.1**), where each institution has very specific competences within the National System for Forest Fire Defence. Although the public sector has a major role in the functioning and coordination of the MSP, the inclusion of the private sector is of major importance, since close to 90% of the Portuguese forests are privately owned. This means that the MSP would, for instance, strongly benefit from the inclusion of the forest owners’ associations or the pulp industries with their firefighting teams (AFOCELCA).

As a member of the MSP, the **Technical Forestry Office (GTF)** has the yearly responsibility to coordinate and elaborate both the four-year plan (PMDFCI) and the yearly Operational Municipal or Intermunicipal Plan (POM). The POM comprises of all the information concerning the forest fire defence system of each municipality. This includes the available means and resources, such as the institutions and/or key persons in the system, and their contacts and responsibilities in the fire season. The POM is the operational tool that provides guidelines and duties to every partner, in particular those guidelines and duties related to surveillance, detection, inspection, first intervention, fire-fighting, mop-up and surveillance post-fire (GTF, 2013). The document also contains the risk assessment from the PMDFCI, which includes the maps that support the commander decision (ICNF, 2012b).

While most of the work developed by the MSP reflects the strategic planning for both the structural (PMDFCI) and operational actions (POM), their coordination is the responsibility of the Mayor, and the municipality is responsible for management and implementation (Lei nº20/2009, 12 de Maio).

Table 8.1.
ENHANCE Insurance case studies (Source: Surminski et al., 2015a).

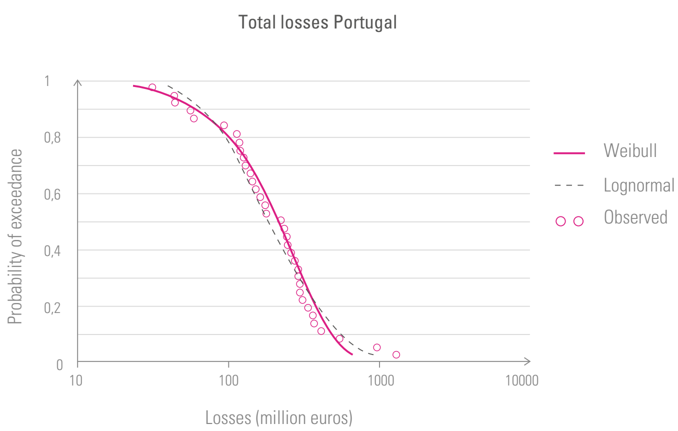
Entities	Role	Sector
Municipalities		Public
Mayor	The mayor is the President of the CMDFCI. He/she is responsible for putting together all the decisions taken at assembly and implement them.	
Technical Forestry Office (GTF)	Elaborate and develop the actions written in the Municipal Plan for forest fire defence.	
Municipal civil protection	Responsible to conduct actions that lead to prompt first intervention to extinguish a forest fire. He/she should support the operations in case of forest fire.	
Parishes		Public
President	Responsible to provide information about the territory to support the Municipal Operational Commander. He/she should also provide means to help firefighting, like tractors, track machines, or other equipment if needed. Also, it is his/her responsibility to communicate fire risk to the population, to signal forest infra-structures and make the local population aware of forest fires and forest prevention.	
Nature Conservation and Forest Institute (ICNF)	Responsible to coordinate public awareness actions; to provide specialised technical support to the Municipal Operational Commander (elaborate cartography, field maps, first intervention map and fire maps); to provide information to support the GNR in what concerns prevention, surveillance and detection decisions; to elaborate forest fire reports, burned areas by district comparing the information with previous years.	Public
National Republican Guard (GNR)	Responsible for the actions of prevention, surveillance, detection and control of access and circulation of people in critical areas. He/she is responsible to investigate the causes of forest fires and to identify possible authors.	Public
Public Security Police (PSP)	Responsible for the actions of control of the use of fire in the critical period and access and circulation of people in critical areas.	Public
Forest landowners organisations	They have an active intervention in the Forest Defence to Wildfires especially in the components of stands structure, preventive forestry, surveillance, first intervention and firefighting support.	Private
AFOCELCA	Give support in the firefighting operations in their pulp and paper company lands.	Private

Forest fire risk assessment expressed in monetary losses

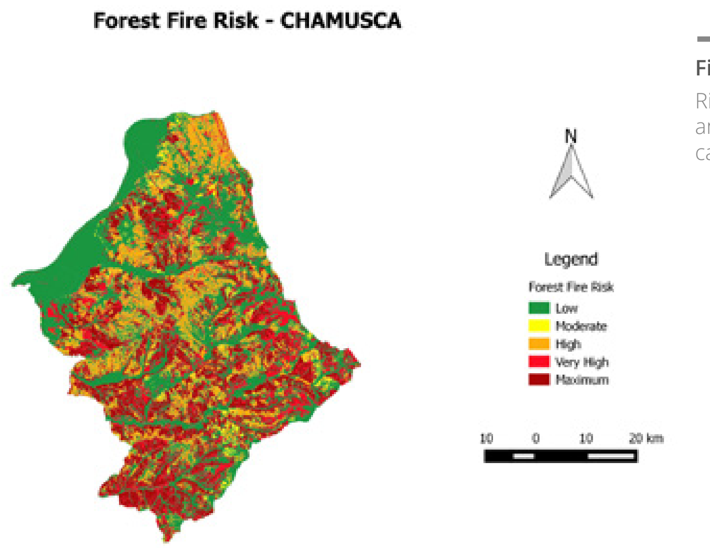
Using the unit values for losses included in the National Forest Strategy of 2006 (DGRF, 2006) for the two categories of vegetation types (Shrublands: 0,6 K€/ha; Forest stands: 4,1K€/ha), **a probability-loss curve** was established (**Figure 8.2**; see also Chapter 2). The probability-loss curve shows values of estimated losses above €100 million for the Santarém district, for the three most extreme years (1991, 2003 and 2005). Probability-loss curves were also developed for the whole of Portugal, to allow for a comparison (**Figure 8.3**). The probability-loss curves show that in extreme years (2003 and 2005) losses can attain very high values, above €1000 million. For both the the district of Santarém, and for mainland Portugal, the best probability distributions were Lognormal and Weibull, which were evaluated using data spanning a 35-year period (1980-2014).

Figure 8.2.
probability-loss curve for wildfires in the district of Santarém.

Figure 8.3.
Probability-loss curve for wildfires in Portugal.



The wildfire risk is analysed in-depth for both their spatial and temporal component. The **spatial analysis** is developed by the GTF of each municipality, often in a partnership with the Forest Owners' Organisation. The analysis is included in the PMDFCI, combining the susceptibility assessment with the probability of an area to burn (also referred to as 'return period'). The model of wildfire hazard integrates the following variables: land cover (CORINE Land Cover data, the exposed assets), slope (Digital Elevation Module 80m) and past burned areas (historical data of burned areas). The resulting hazard map is then overlaid with the vulnerability and economic value of the elements at risk, to specify the impact for different types of forests ('assets') which have different exposure and economic values (ICNF, 2015). The final spatial risk maps are shown below in **Figure 8.4**.



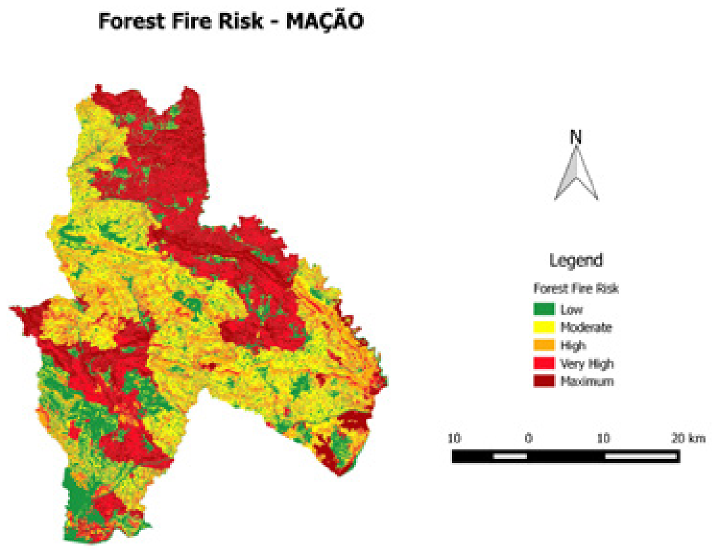


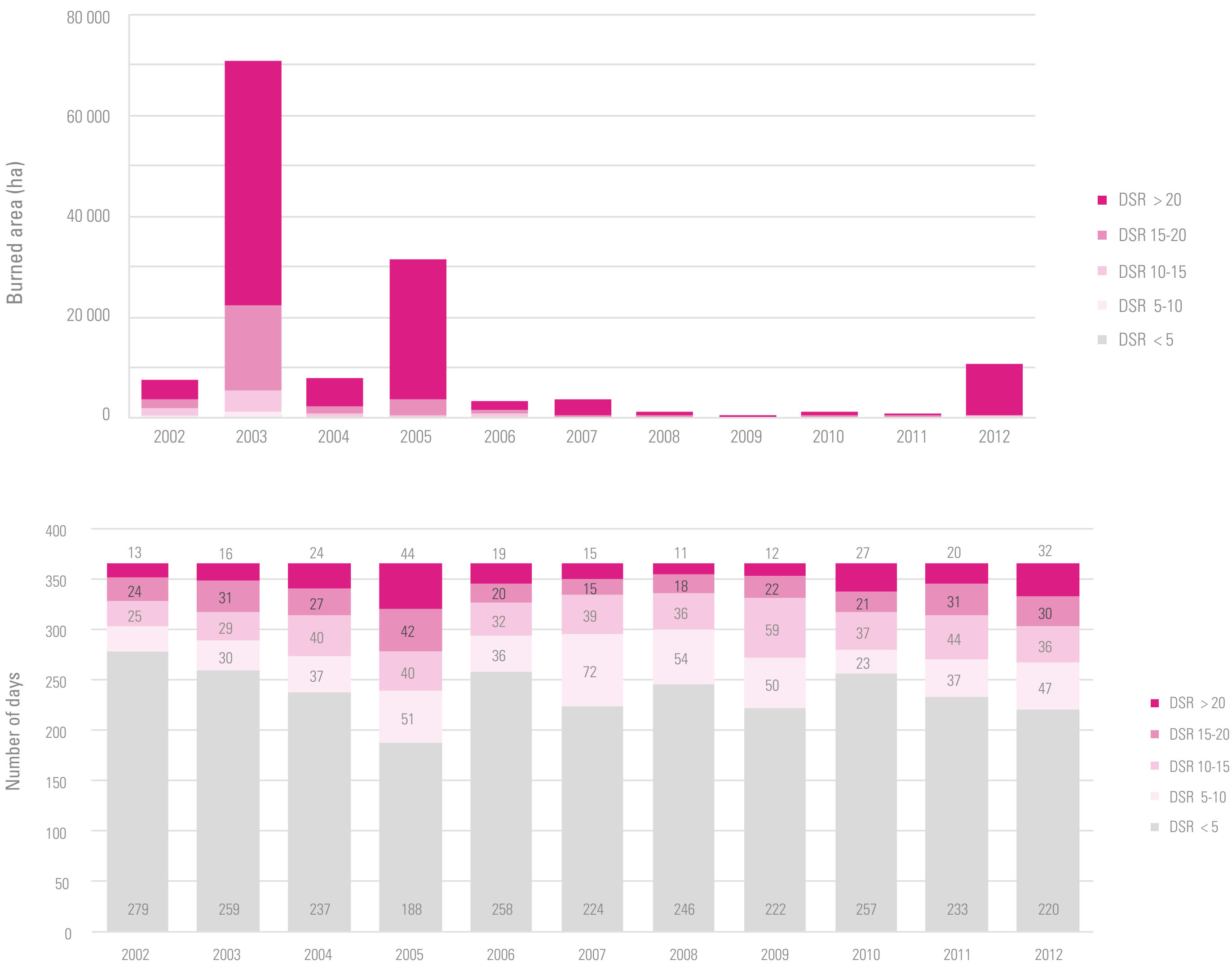
Figure 8.4.

Risk Maps produced for the municipalities of Chamusca (top) and Mação (bottom) for the established partnerships in our case study (Source: GTF Mação and GTF Chamusca).

The spatial risk maps were complemented by a dynamic **temporal analysis** using meteorological information (temperature, precipitation, wind, etc.). This information is generally combined in a Fire Weather Index (Van Wagner, 1987). In Portugal, an adaptation of the Canadian Fire Weather Index (FWI) is used, which is a numeric rating of fire intensity (IPMA, 2015). Furthermore, a Daily Severity Rating (DSR) is used, derived from the Canadian Fire Weather System (DSR = 0,0272 FWI1,77), to provide a numeric rating of the difficulty of controlling fires. Analysis of the DSR for the period 2002-2012 shows that large burned areas only occur as a result of wildfire in the few days that the weather is extreme DSR>20 (**Figure 8.5**). In the period 2002-2012, the number of days per year in which the DSR is extreme (> 20) fluctuated from a minimum of 11 days in 2008 to a maximum of 44 days in 2005 (Figure 8.5).

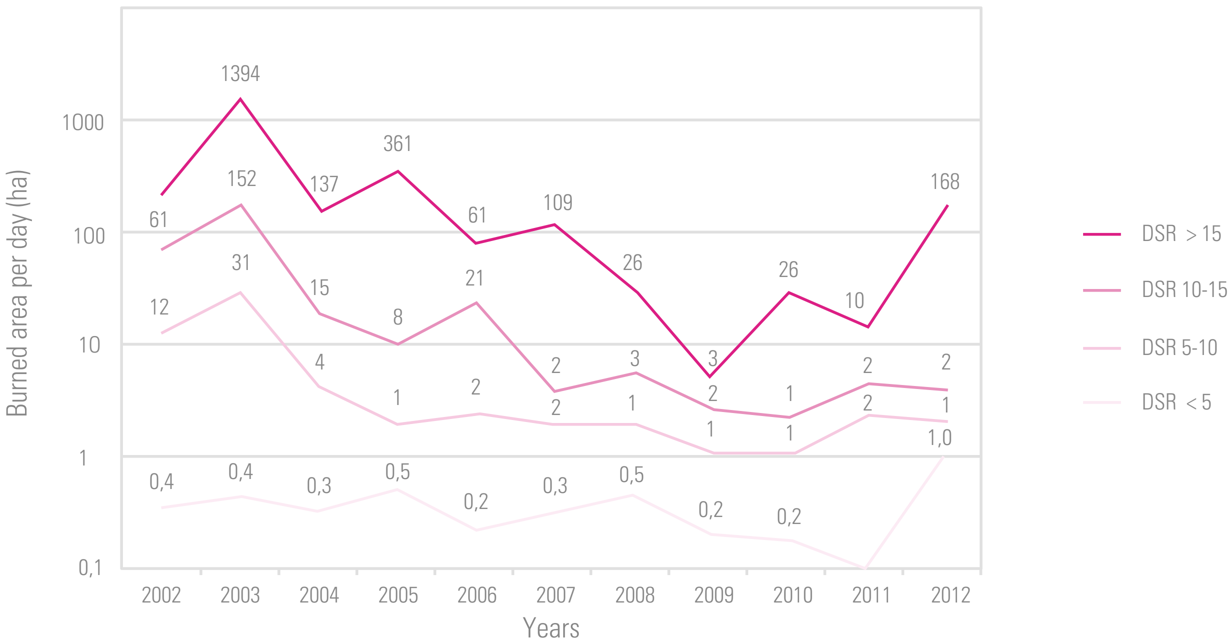
Figure 8.5.

Burned areas per DSR (Daily Severity Rating) class (left graph) and number of days per DSR class (right graph) from the district of Santarém, related to the period of 2002 to 2012.



Analysing the extent of burned area per day and per class of DSR, **Figure 8.6** shows that in extreme years, like in 2003, **it is possible that over one thousand hectares burn in Santarém on days with a very high DSR (> 15)**. Figure 8.6 (NB: the y-axis is in logarithmic scale) shows the **strong dependence of the areas burned on the different weather conditions (DSR)**. This is especially important as extreme weather conditions are expected to occur more frequently in the future according to the current weather scenarios.

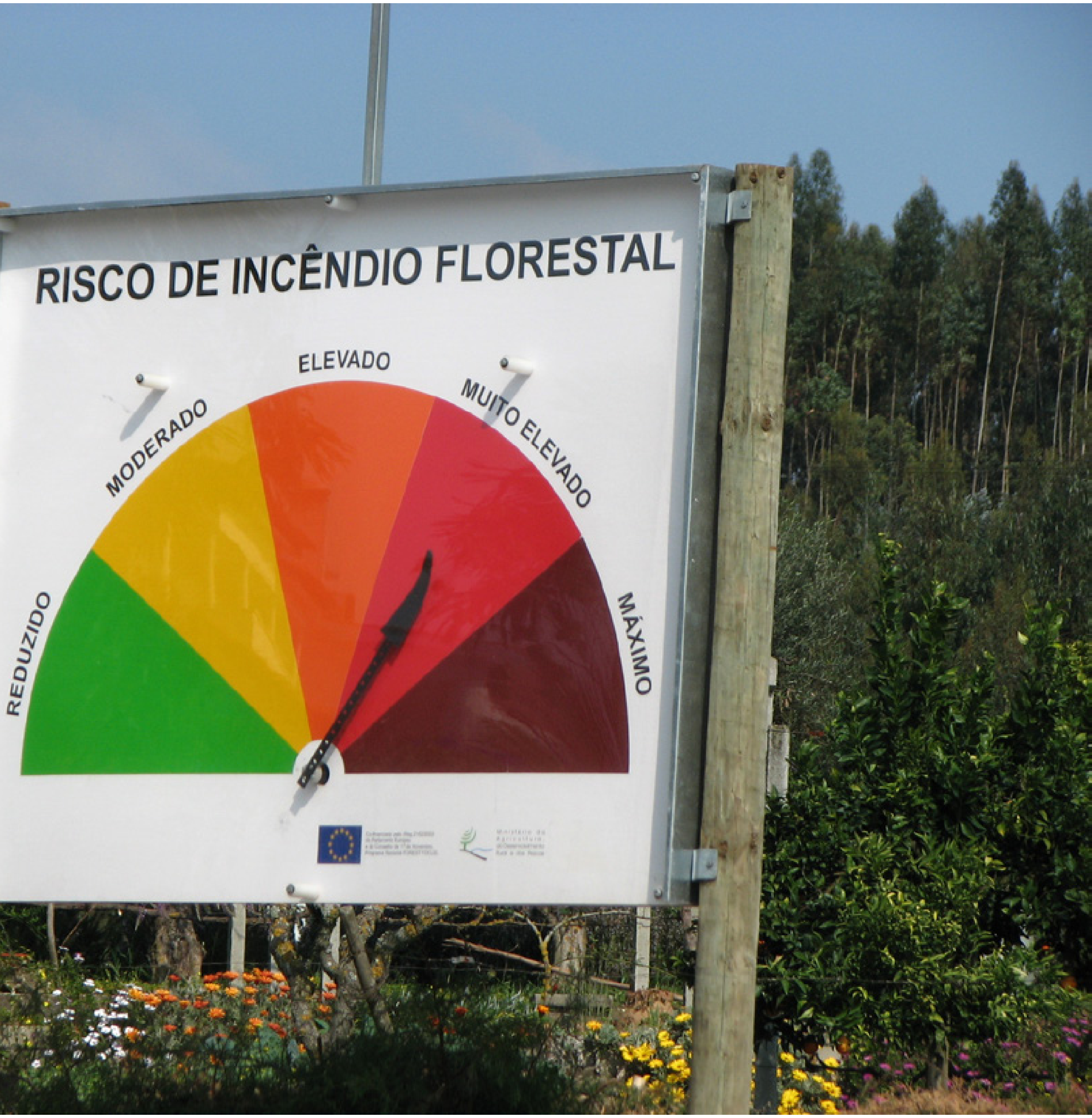
Figure 8.6.
Burned area per day and per DSR class on the period of 2002-2012 in the district of Santarém.



The DSR is considered a suitable indicator for both the length of the fire season, and the difficulty of controlling fires. Pereira et al., (2002) analysed the Daily Severity Rating (DSR) projected for 2080 for Portugal, under climate change conditions. The results show that there will be a significant increase in the number of days with high DSR, which will start much earlier in the year (late spring) and finish later (beginning of autumn).

On days with higher DSR, it is advised to carefully monitor the occurrence of ignitions. When the number of ignitions is very high, which possibly results in large areas burning simultaneously, the country's fire extinction capacity can be overpassed. This potentially results in a collapse of the forest fire defence system, similar to what happened in 2003. Hence, **since DSR numbers will probably increase in the future, fire-fighting capability in these extreme conditions should be clearly enhanced**.

Photo by M. Conceição Colaço.


RISCO DE INCÊNDIO FLORESTAL
REDUZIDO
MODERADO
ELEVADO
MUITO ELEVADO
MÁXIMO

Current and future MSP healthiness and preparedness

To analyse the capacity and potentialities of the MSP for managing forest fires, a **governance assessment** was performed following the five capitals approach (see Chapter 1). For the Portuguese case, the assessment focused on the local scale (municipal level, according to the MSP analysis). The applied methodology focused on semi-directive interviews with key persons, complemented by one focus group for each Commission. Complementing statistics were obtained from the National Institute of Statistics.

The results show that the two Commissions have reasonable capacity to develop Disaster Risk Reduction (DRR) measures to manage forest fire risk. However, both Commissions are limited in terms of financial and environmental capital. In discussion with members of both Commissions, it was concluded that for a regular fire season with a medium risk layer, the MSPs are able to respond to the different events in their territory.

However, the capacity of the MSPs may be limited considering future climate change impacts. This was further evaluated during a few stakeholder workshops and interviews, using climate scenarios taken from the 'Adaptation Strategy to Climate Change for Agriculture and Forestry Sectors'. (MAMAOT, 2013) (Table 8.2).

Furthermore, socio-economic scenarios were used for highlighting possible trends in demographic projections of the National Statistical Institute (INE, 2013) and trends in the valuation and demand of forest products. Socio-economic scenarios were categorised into quadrants, where A and B mean that there is a demand for forest products and therefore they have a high value, D and C represented the opposite situation. Scenarios A and B assume the existence of adequate forest and fuel management, reduced land abandonment and the creation of a more resilient forest. In the quadrants A and D there is a population decrease and aging, and on the contrary in quadrants B and C the population slightly increases and the aging is less severe. Although the great majority of the participants consider scenario B as the most desirable, scenario A is the more likely scenario to occur.

Concerning the future of the MSP, the participants considered that the current MSP, or a different partnership with the same focus, will continue to exist, but with more political involvement. The participants considered, furthermore, that with less population, the MSPs will have a more important role in the forest and environmental management of the rural areas.

The MSP and the Forest Owners' Organisations will continue to be mediators between the forest owners and the local and central entities. The search for different solutions to increase the forest and society resilience will continue to be one of the main focuses of the MSP.

The participants furthermore indicated that the role of the collective organisations of forest owners for the management of Forest Intervention Zones (ZIF) is likely to be important, and should be enhanced in the future. This is of particular importance in areas where the forest properties are very small. It was also mentioned that, as a result of inheriting land, a new type of forest owner could emerge, such as charities.

Table 8.2.
Climate scenario for 2050 (Source: MAMAOT, 2013).

Scenario for 2050	Impact on Forests
• 0,5ºC temperature increase by decade • More rain in Fall and less in Spring • Increase of frequency and severity of droughts • Heat waves occur more frequent and longer • Longer season (more months) with high meteorological wildfire risk (from Spring to Fall)	• Wildfire severity increase • Changes on the potential geographic distribution of forest species • Decrease of pine and eucalyptus productivity • Increase of the favourable conditions for pests and diseases on pine, eucalyptus and cork oak

Photo by M. Conceição Colaço.

Potential for new insurance and risk policies

Throughout the project, one of the main conclusions reached by the MSPs was that they operate well in their current form, but only up to a certain level. When dealing with very large wildfire situations that surpass the medium risk layer (Mechler et al, 2014), local MSPs can no longer offer sufficient support in risk management. In such a case, the extreme losses become greater than the capacity of the local MSP to offer financial support in post-fire recovery, limiting risk reduction. This emphasises the need to expand to a regional, national or even international level.

In addition to scaling up, it is important to promote resilience by **reducing the risk directly** (e.g. more efficient fire-fighting in extreme conditions), and by **providing ex-post compensation**. To facilitate increased resilience, a review of possible economic instruments was made for the Santarém MSP (**Table 8.3**). In the schemes shown in Table 8.3, the partnership would be part of the risk-sharing agreement, where costs and burden are shared between state/district authorities and private owners.

An economic instrument that is already used by the MSP, is the *Permanent Forest Fund* (Portaria nº 77/2015 de 16 de Março), which supports the Forestry Technical Offices and the forest sappers' teams. The PDR2020 (Portaria nº 134/2015, de 18 de Maio), has several policies, which could be interesting for the MSP. However, participants of the workshops mentioned that several applications of these funds were not considered by the evaluators, as they were not in line with the requisites of the National Plan for Forest Fire Defence. Regarding the *European Solidarity Fund* (EC, 2016), the perception is that there are many resources available after a major disaster, but without the objective of preventing future disasters.

The effectiveness of the funding of the *EEA Grants* (2015) was also discussed for stimulating DRR action in some areas. However, it was indicated that this funding is not applied in the district. Furthermore, The *Portuguese Carbon Fund* (APA, 2015) was not considered to be currently relevant to the Portuguese forest sector.

Insurance schemes covering risks related to wildfire also exist, and were presented. However, they have a very low market penetration and were not considered to be a short-term solution by the workshop participants. Nationwide, only two insurance schemes are in use, but they both have a very small coverage.

Table 8.3.
Potential economic instruments for the Santarém Case Study.

Economic Instrument / Manager	Objective
Rural Development Program PDR2020 / IFAP	• Improving resilience and environmental value of forests • Forest prevention against abiotic agents • Forest recovery due to biotic and abiotic agents or by catastrophic events
EEA Grants / National Management Unit	• Climate Change and Renewable Energy • Reduced human and ecosystem vulnerability to climate change
PORTUGUESE CARBON FUND – FPC / Portuguese Environment Agency	• To contribute to the goals defined by the Portuguese Government in order to achieve the political commitments related to climate change
FOREST PERMANENT FUND – FFP / National Forest Authority	• To promote and ensure the continuing investment in the forest management and planning, promoting the ecological, social and cultural functions of forests • To support actions which prevent forest fires • To ensure additional support tools that contribute to the protection and sustainability of Portuguese forests
The European Union Solidarity Fund – EUSF	• Set up to respond to major natural disasters and express European solidarity to disaster-stricken regions within Europe
Forest Insurance / Insurance companies	• Risk sharing

Recommendations

The MSPs assessed for the Portugal wildfire case study have a good level of response to the different events. However, when dealing with extreme conditions and very large wildfire situations, **risk management is not adequate. In such cases, risk management should be coordinated at regional, national or even international levels**. This premise also applies to the different economic instruments.

Key to enhance resilience with respect to forest fire risk is **risk reduction**. Risk reduction can be stimulated through prevention measures and pre-disaster management incentives, or directly with more efficient fire-fighting in extreme conditions or with more post-disaster financing.

On a local level, the municipalities can apply for the available national or international financial programs. However, it seems that the MSP members are not always fully aware of these funding opportunities. On a local level, the degree of freedom of the municipality to apply for different economic instruments is very low. The Municipal and Intermunicipal Commissions have to follow the national guidelines and documents. Moreover, the final approval of their local plans has to be done at the national level by the National Forest Authority.

For increasing the resilience to wildfires in a local level, we consider it of importance to **involve the national and European institutions**. Together, the MSPs and the national and European institutions can evaluate the effect from different economic instruments to support disaster risk reduction (DRR) efforts by the MSP.

Among the various economical instruments presented, we identified **forest insurance schemes** as an instrument with great potential to establish the linkage between extreme meteorological conditions (as those measured by the Daily Severity Rating - DSR), and the losses caused by wildfires under these extreme conditions. This setup is similar to what is done in the agricultural sector.

As mentioned by some of the stakeholders, the support given by the Government to recover from the direct losses, plus a contribution from the Forest Permanent Fund and from the Portuguese Carbon Fund could contribute to diminish the insurance premiums. Furthermore, they could encourage adequate forest and fuel management and therefore maximise risk reduction.

Finally, together with several stakeholders, we advocate that **a new level of wildfire risk alert (critical level) should be created**. This wildfire risk alert needs to be disseminated to the members of the National Forest Fire Defence System. In response to this wildfire risk alert, the surveillance and dissuasion teams can strive to minimise the number of fires on those critical days. The operational planning for this critical alert level could be expressed in documents written and approved by the Municipal and Intermunicipal Commissions.

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Photo by Pedro Palheiro.

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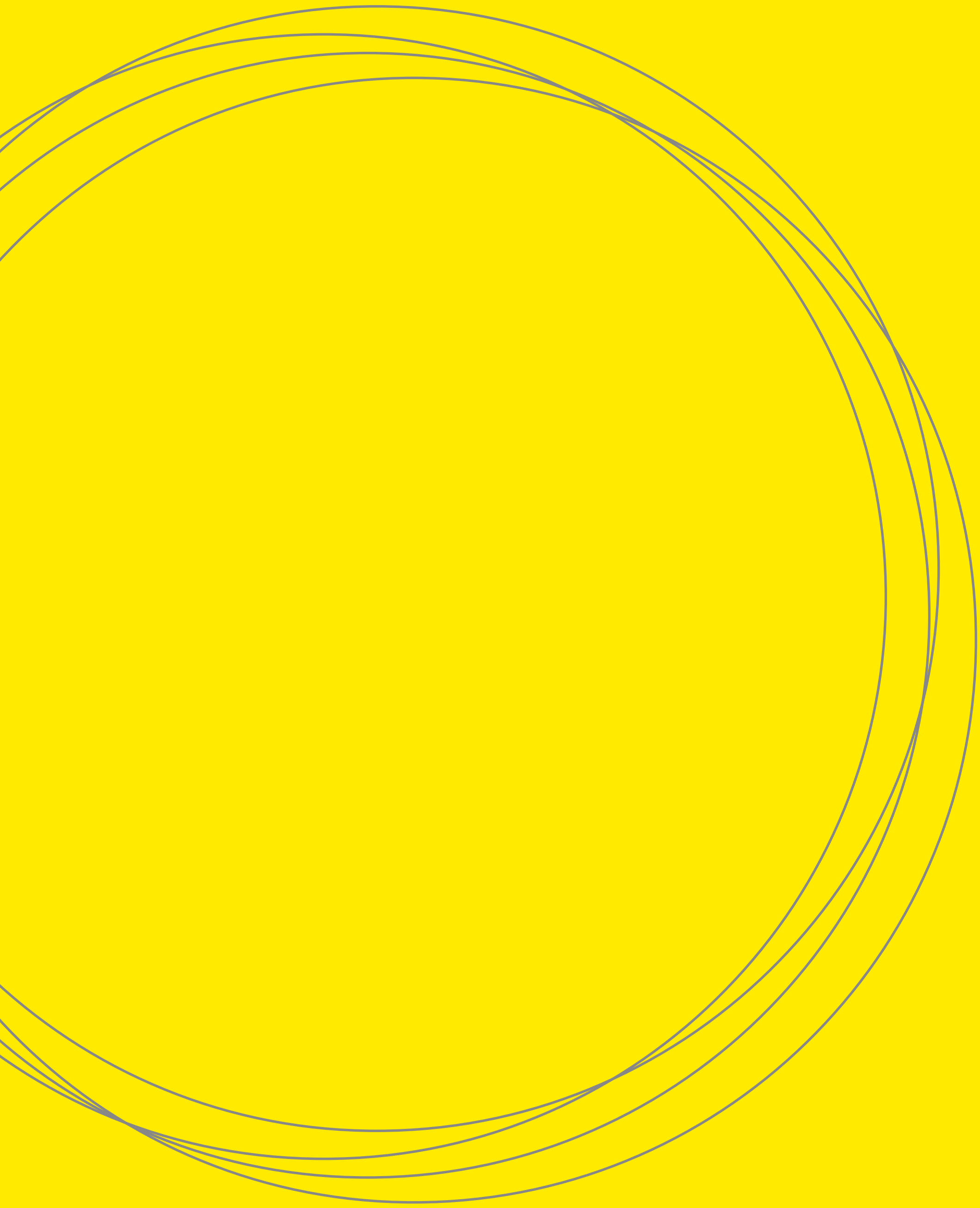

09

Air industry response to volcanic eruptions

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Introduction

With increasing interconnectedness, a disturbance of air traffic in one part of the world can have long-ranging financial and social effects on other parts. The eruption of the Eyjafjallajökull volcano in April 2010 illustrated this memorably. The eruption prevented millions of passengers, as well as goods, from reaching their destination, as air traffic was halted in Europe for several days (Ulfarsson and Unger, 2011). It led to what is known to be the greatest disruption of air traffic since World War II and caused an estimated worldwide loss of US$5 billion with more than 100.000 flights cancelled (Oxford Economics, 2010).

Historic records (see Gudmundsson, 1987; Haraldsson, 2012; Höskuldsson et al., 2013) suggest a volcanic eruption in Iceland approximately once every five years. **Since such an event cannot be prevented from happening, cooperation and preparation are key in mitigating its impact**. With the certainty of a new volcanic ash eruption at some point in the future, the question is, however, whether the aviation industry is prepared for the next eruption?

As part of the EU project ENHANCE on stakeholder partnerships, this case study has sought to obtain insights into how the European aviation sector has advanced its risk management with regard to volcanic ash since the eruption in 2010. The case study focused on the cooperation and information exchange of the stakeholders involved in the post-disaster process of reducing impact from ash outburst to the air industry. The study has conducted expert interviews and used the method of scenario narratives and visualisation in an alternation participatory stakeholder workshop to facilitate the discussion and jointly develop improvement measures. This chapter draws on the reports developed in the course of the project (Ulfarsson et al., 2013; Ulfarsson et al., 2014; Reichardt et al., 2015a; Reichardt et al., 2015b).

Ash plume of the Eyjafjallajökull volcano eruption on April 22, 2010. Photo by G. F. Ulfarsson.

“Eyjafjallajokull led to the greatest disruption in air traffic since World war II.”

The multi-sector-partnership

The management of volcanic ash risk to aviation is complex and requires the efforts of a number of stakeholders from different sectors. According to their position in the process, the stakeholders can be grouped into information providers, crisis coordination and network management, air navigation service providers, global/international and national regulators and aircraft operators.

An overview of the sectors, roles, and associated institutions involved in the Multi-Sector Partnership (MSP) of this case study can be found in Table 9.1. The MSP's main aim is to prepare an aligned strategic response to volcanic eruptions, which (1) should guarantee flight safety and prevent harm to humans or machines, and (2) should minimise interruption of air traffic and thereby economic losses.

In the MSP, roles and responsibilities are roughly divided as follows: global and national regulators provide the legal framework for aircraft operations. In case of a volcanic eruption, the information providers collect information on the eruption and create 'ash forecast maps' on predicted ash concentration. These maps facilitate the decision-making-process of the aircraft operators on whether to proceed, divert or cancel flights. Air navigation service providers coordinate the air traffic. To ensure a smooth transition of flight plans the network manager facilitates on a European level and acts as crisis coordinator if needed.

This study used the Eyjafjallajökull volcanic eruption in 2010 as a reference for the analysis of the MSP, the MSP's responses to the volcanic eruption, and the effects of the volcanic ash on air traffic.

Table 9.1.
The MSP - Overview of sectors, roles, and institutions.

Sector	Role	Institutions
Global air regulator	Development of global standards and recommended practices	ICAO (International Civil Aviation Organisation)
International regulator	Limit setting for shared air transport zones	EU Directorate General for Mobility and Transport
National regulator	Responsible for state's Volcanic Ash Contingency Plan, approval of Self Risk Assessment procedures, airspace closure	ICETRA (Icelandic Transport Authority)
Crisis coordination and network management	Coordination and planning of air traffic control in Europe	EUROCONTROL (European Organisation for the Safety of Air Navigation)
Information provider	Issue weather observations and forecasting. Monitoring of volcanic eruption, detection of seismic activity, ash measurements, issue warnings	IMO (Icelandic Meteorological Office)
Information provider	Tracks volcanic activity and issues ash distribution forecasts	London VAAC (Volcanic Ash Advisory Centre)
Air navigation service provider	Management of airport operations and air traffic in control area	ISAVIA (Icelandic Air Traffic Management)
Aircraft operators	Air transport and service providers to passengers and cargo	Icelandair (Icelandic Aircraft operator)

Photo by Valeriy Poltorak/Shutterstock.

Risk assessment and extreme-case scenarios

To evaluate the functioning of the MSP, two extreme volcanic ash scenarios were developed using expert judgement and historic data:

1) One scenario describes a volcanic eruption of medium ash concentration over a long period of time ('Eyjafjallajökull times Four scenario') to test MSP decision-making when facing a long period of continuous risk assessment and maintenance (Figure 9.1).

2) In order to assess the reactions of the stakeholders to an extreme large-scale severe interruption of air traffic, a second scenario contains a volcanic eruption with a large ash emission but in a rather short period of time (´Öræfajökull scenario´, Figure 9.2).

Although the uncertainties are considered too large to perform a detailed economic risk assessment, the financial consequences in both scenarios are expected to be in the order of billions of euros. The **NAME model**, the ash dispersion model used by the London Volcanic Ash Advisory Centre (VAAC), is used to simulate the ash cloud from the scenarios. Both scenarios are modelled under the meteorological conditions that were prevalent during the Eyjafjallajökull eruption from the 15-19th of April 2010 (Petersen, 2010).

The reason the ash cloud is shown as a discrete area, separate from Iceland, is due to the modelling input. The duration of the modelled eruption was set to 24 h as this is assumed to be the timeframe for the main ash emission during an eruption phase, but repeated bouts of ash eruption phases are possible. Once the pressure of the eruption declines, the plume height changes and the model needs to be adjusted (discussion with the IMO, 2015). The maps display different concentrations of ash, low (blue), medium (grey) and high (red) over a period of up to 5 days into the eruption.

The risk of volcanic eruptions is a natural phenomenon (Gudmundsson, 2008; Thordarson and Hökuldsson, 2008) and research indicates that it may be increasing due to climate change (Compton et al., 2015) with an event like the Eyjafjallajökull eruption even possible up to every 7 years (Schmidt et al., 2013). It is however not possible to derive meaningful probabilities about the likelihood of the proposed scenarios of volcanic eruptions because of the complex characteristics of the hazard and limited data available.

Figure 9.1.

Eyjafjallajökull scenario. Example of modelled ash distribution for one of the eruptions in the scenario, at day 5 after the eruption. While high ash concentrations slowly decrease, a broad band of air with low ash concentration between 200 – 2000 µg/m³ is forecasted 5 days into the eruption up to flight level 200 (denotes 20,000 feet).

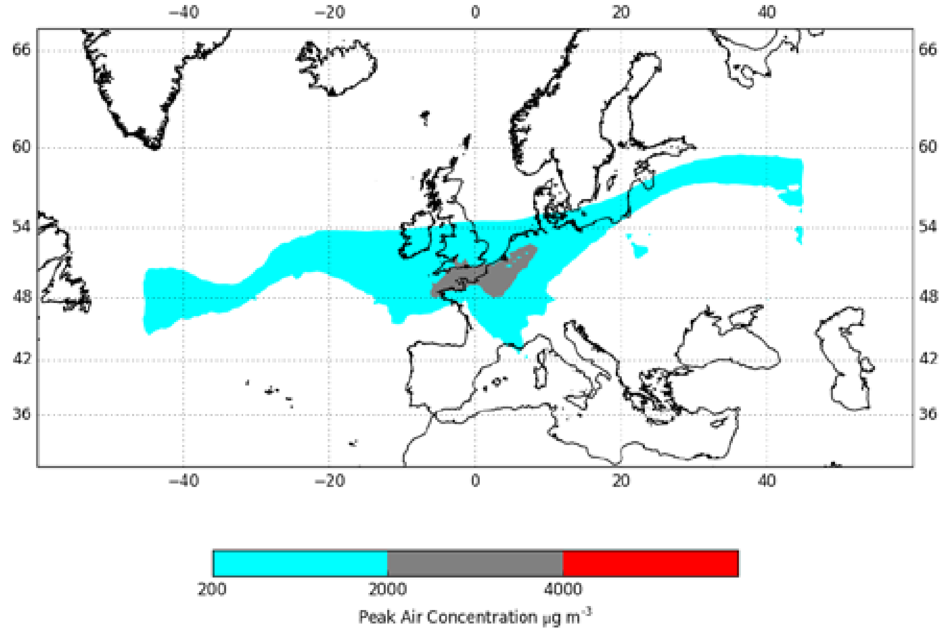
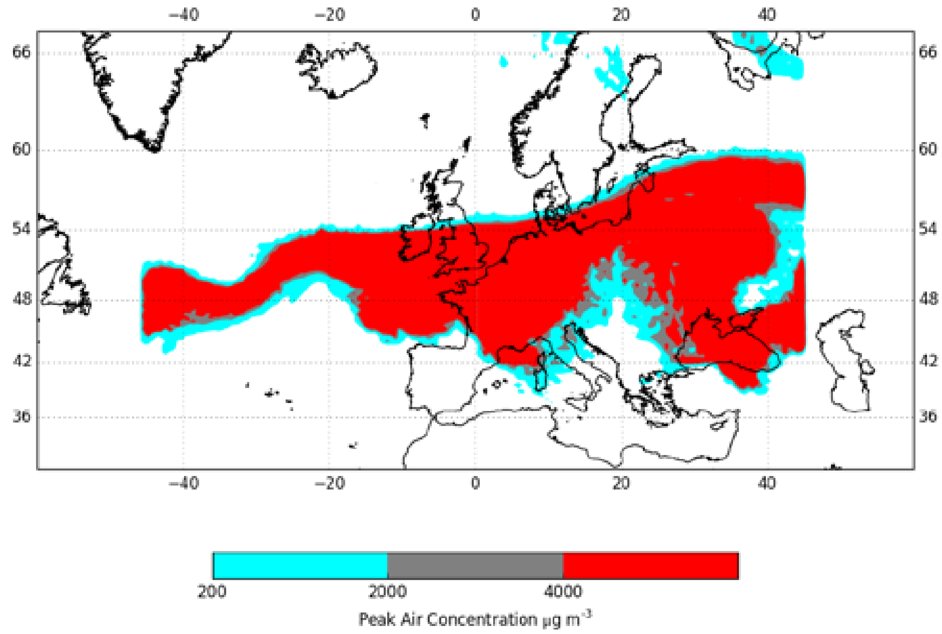


Figure 9.2.

Öræfajökull scenario. Example of modelled ash distribution, at day 5 after the eruption. High ash concentrations of more than 4000 µg/m³ are predominant throughout the whole forecast period up to flight level 200 (denotes 20,000 feet).



MSP performance

To gain insight into the stakeholder partnership's reaction to the scenarios, the stakeholders were invited to participate in a workshop to meet face-to-face and work through the scenarios. The workshop day was set up as an alternation between short presentations from research team mediators and the stakeholders, plenum discussions, scenario group discussions and opportunities for the participants to discuss in smaller groups. The scenarios were presented as a narrative in fictitious newspaper articles to support the group in imagining the real-life event and to discuss real-life implications.

The MSP performance under normal conditions

The Disaster Risk Management (DRM) of the MSP takes place on two levels: the stakeholders' individual management; and the overall joint stakeholder partnership. The individual stakeholders' responses and their interplay present the basis for the partnership's response as a whole with major improvements done since 2010. The **VOLCEX exercise** rehearses the initial mutual response to a volcanic eruption, often in Iceland, and is conducted roughly on an annual basis. In a preparatory meeting the stakeholders agree on a scenario to be tested. The VAAC runs the NAME model for the eruption scenario using agreed weather conditions (Interview with representatives from UK Met Office, October 2014). These exercises are under the supervision of the International Civil Aviation Organisation (ICAO). VOLCEX involves air navigation service providers, air traffic control centres, civil aviation administrations, meteorological offices, London and Toulouse VAAC, EUROCONTROL, and aircraft operators.

MSP performance assuming extreme scenarios

The stakeholder workshop helped to analyse the performance of the MSP under extreme case scenarios and the new regulation that gives decision-making for take-off to aircraft operators who provide an approved Self Risk Assessment (ICAO 2012a, 2013). The Eyjafjallajökull scenario would mostly impact air traffic at low altitudes, affecting take-offs and landings. A representative of Rolls-Royce estimated that ´even under the new regulations, by day two flights would be limited, approximately up to 50%´, a significant reduction in air traffic.

An extreme scenario like Öræfajökull is likely to impact air traffic at all flight altitudes. A representative from EUROCONTROL stated that even though the airspace would most likely not be closed by national authorities, there would be no flying within one or two days of the eruption onset.

The stakeholders emphasised that large uncertainties exist, related to understanding the risk that ash posesto engines, modelling uncertainties, regulations and staff capacity. The MSP is focused on the management at the onset of an eruption. The MSP's performance with regard to extreme case scenarios of long or high impact is mixed and exercises to practice extreme conditions are not yet in place.

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Policy recommendations

The improvement of the MSP and its preparation is crucial as the mishandling of an eruption threatens entire economies (Sammonds et al., 2010), can send companies to bankruptcy (Alexander, 2013) and seriously affect lives, for example in case of medical emergencies such as air transport of organs. The estimated future probability of the occurrence of an event similar to the eruption in April 2010 is every 7 years given climate change (Schmidt et al., 2013) which puts additional economic value on the profound importance of the development of crisis management infrastructure and the successful work of the MSP. To create a noteworthy mitigation of the financial and social impacts of a more intense volcanic eruption, enhanced communication and cooperation is key.

Established communication processes are fundamental to the successful cooperation of a partnership. Despite many improved communication streams within and between institutions, like e.g. between the information providers, a lot is still to be desired in that field, with ample opportunity for improvement. **The following improvements are recommended**:

Single point of information

While information is important in times of crisis, the amount of information and scattered sources of information can cause confusion and hinder efficient management. The MSP would benefit from a designated single point of information. Managing the network, EUROCONTROL suggested the establishment of a website platform as an acknowledged single point of information. The use and content can be discussed, tested and evaluated during VOLCEX planning exercises, and improved in connection to the EVITA tool. It is to be discussed whether this single point of information should also serve for public information. The call for more awareness of the public as a stakeholder was strongly voiced during the stakeholder workshop, e.g. aircraft operators giving more detailed and expansive information to passengers. The use of social media should be planned. The channel and depth of information need, however, to be chosen carefully as overly extensive warnings can be an economic blunder as shown by previous examples of mass cancellations of flights following a warning. In 2014, a warning issued about an eruption of the Bárðarbunga volcano caused flight cancellations and led to a decrease of new holiday bookings in Iceland (Juskis, 2014).

Communication on aligning products with end-user needs

In the present study, Icelandair served as an interview partner and stakeholder representative for the aircraft operator sector. As an aircraft operator with longstanding experience in volcanic threats, Icelandair has in-house experts for modelling volcanic ash forecasts. The involvement and recognition of experts in reacting to the transboundary threat of an Icelandic volcanic eruption, appears to be a crucial point in smooth cooperation (Reichardt, 2011). The missing direct communication with the VAAC may be reflected in the aircraft operators' scepticism to the accuracy of forecasts provided by the VAAC as well as the stated divergence between needs and supply. Presently, communication between airline operators and the VAAC foremost takes place with the International Air Transport Association (IATA) as a mediator. A similar problem is reflected in the flight level categorisation of the ash distribution forecasts which air traffic controllers would like to see adapted to their needs (Interview with ISAVIA, 21th October 2015). While it may be helpful to interact with one single point of contact in general, a platform where the information provider and the end-user can interact directly helps to create trust and a common effort to align the product to the needs.

Input to the aircraft operators' Self Risk Assessment (SRA)

The process of the Self Risk Assessment (SRA) appears to be mostly disconnected from the institutions that provide the information on which the SRAs are based. While the significance of the ash concentration charts has been debated amongst the information providers and other stakeholders, they cannot be easily replaced as they form the basis for the airlines' SRA. Again, direct and transparent communication as well as the inclusion of the information providers is advised to combine effort in improving the process.

Communication of uncertainties

A further communication issue evolves around delivering the message of uncertainties that accompany, e.g., the susceptibility of the jet engines to volcanic ash, the input parameters for the ash modelling, and forecasts. It was discussed whether or not to include a level of confidence. Though a confidence rating can be problematic to put into practical use, especially if it indicates large uncertainty, airlines would benefit from a transparent communication of detailed information on the uncertainty of data – to then trust the pilots to make the right decisions.

Additional Research

Various research projects have been initiated to determine input parameters and the set-up of models to improve forecasts for volcanic ash dispersion (see Bonadonna et al, 2014). This research and multi-disciplinary collaborations need to be pursued to approximate the models closer to real-life conditions (FutureVolc, 2015) and meet the needs of the aircraft operators and other users. The research for on-board detection equipment is to be extended.

The stakeholder workshop and expert interviews stressed the need for a more detailed understanding of the impact of different ash concentrations on jet engines as a basis to better manage a volcanic ash incident in the European airspace. This is in line with the recommendations of the International Volcanic Ash Task Force (IVATF) that was set in place in 2010 to develop recommendations after the Eyjafjallajökull eruption (ICAO, 2012b). Given the variety of ash compositions, engine types, operating temperatures, speed and altitude, the call for more than one project to conduct tests on this issue appears to be clear. This is all the more important as discussions showed that ongoing improvements of the modelling environment and research on the volcanological input parameters seem of limited effect as long as the baseline understanding of effects to the engines remains poor. Testing the engines' reaction to ash would therefore also strengthen the impact of efforts in other contributing fields.

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Improving the MSP's leverage

Improved exercises

The MSP recognises the importance of emergency training to test the processes. The VOLCEX are established exercises that invite stakeholders throughout Europe to test their procedures. The programme is commonly planned months in advance to agree on the scenario that will be tested and integrate it in the participants' day-to-day schedule. A comment by one of the stakeholders portrays the pitfalls of the set-up: 'People prepare for the disaster that already happened. The exercises take a lot of assumptions that aren't real life situations and give a false feeling of safety'. The false feeling of safety is possibly manifested in the decreased interest airlines have in participating in the exercise. After the eruption in 2010, 70 airlines participated in the VOLCEX exercise in 2011. Around 50 airlines were involved in the last exercise. For the MSP to be successful, as many stakeholders as possible should participate in the exercise and use the platform simultaneously to exchange experience, knowledge, views and opinions. To increase interest among potential participants and create additional learning value, the exercises should be novel and challenging and drive the stakeholders out of their comfort zone. Flaws in the process that can be improved are more likely to be identified if the pressure of real time situations is recreated in the exercise.

Staff funding

Most stakeholders at the workshop agreed that lack of staff would prevent the partnership from working successfully. The information providers raised particular concern on work overload that affects their services. For the IMO, the workload of staff during the Holuhraun eruption in 2014/15 revealed the need for a back-up plan for alternating working schedules. Solutions to this problem would involve staff training to prepare them for accelerated demands and restructured tasks during a crisis, which indeed is recommended for the whole MSP. Another option might be staff exchange. Specialised workers could be prepared to share shifts. The conditions could be set up beforehand and participation of the 'exchange staff' in exercises would ensure that they are up-to-date. In the case of the IMO, this could potentially be established with the Earth Science Institute of the University of Iceland. Beside core duties, media coverage also increases in crisis times. Staff is required to cover communication with journalists and other media, including social media.

Another aspect of staff funding concerns the connection between general operations and research on a daily basis. The staff at the UK Met Office that runs the volcanic ash forecasting during exercises and eruptions works on day-to-day operations within the meteorological team under normal conditions. To better accommodate user needs, it would be beneficial if some VAAC staff could work fulltime on volcanic ash related research. This would also facilitate the cooperation between scientific institutions and the VAAC to put more background science and research into its operations.

Regulatory alignment

The varying legislation regarding SRA provisions in the different countries caused concern by stakeholders, especially voiced by the air traffic managers. These variations may lead to confusion in a new crisis, on top of the new regulation regarding the decision making. A platform with authorities from all the states seems necessary to create a better understanding of how the regulations can be coordinated. A further step would be a comprehensive alignment of SRA regulation throughout the European states involved.

Long-term contingency plan

The current contingency/crisis response plans for the MSP generally do not account for more than the initial onset of a disaster, practised in the VOLCEX and VOLCICE exercise. It is planned up to a few days into the incident. However, the entire dynamics of the situation might change during a longer scenario. These exercises do not take longer durations into account, partly because eventually each scenario would take on its own characteristics, calling for a tailor made response to each case. However, as the creation of the European Aviation Crisis Coordination Cell shows, time for reorganising is costly. It is important to plan alternative transport solutions should aircrafts be grounded for an extended period of time. Fragmentation of the European sky (Alemanno, 2010) makes a pan-European approach difficult but important. Stakeholders from all walks of transportation must cooperate internationally to form a contingency plan for rerouting passengers and goods through alternative modes of transport.

Hence, the most important measure to strengthen the MSP's positive impact on society's resilience is the **creation of a comprehensive long-term contingency plan that includes an alternative if aircrafts are grounded**. Alternative transport modes—road, rail or ship— play an important role in reducing economic loss and inconvenience due to delayed or cancelled flights. A smooth transfer between transport modes requires good preparation and coordination. This means timely information flow to other transport agencies and partners in order to enable them to plan and respond to the crisis in a coordinated fashion. Broadening the MSP in such a way will enhance resilience and simultaneously strengthen trust towards the MSP and its decisions.

Further research, beyond the scope of the ENHANCE project, needs to be conducted on how coordination of trans port service providers could be improved by inviting stakeholders representing alternative transportation modes for passengers and goods to join the present MSP. Improvement measures identified by such an extended MSP will serve to further increase societies' resilience to disruptive volcanic events in the future.

Conclusion

The aim of this study has been to facilitate improving resilience to the impact of volcanic ash on society, caused by the disruption of air traffic. The study analysed the dynamics of the multi-sector partnership engaged in the risk management of the impact of volcanic ash on the European aviation industry. This analysis has been done in order to propose improvement measures that can increase resilience.

Based on the Eyjafjallajökull eruption in 2010 and its impact on European aviation and neighbouring sectors, the study identified the current and future risk profiles at a European scale and analysed the current responsibilities of stakeholders of the multi-stakeholder partnership. In workshops, representatives from the information and service providers, air traffic managers, and regulators were invited to assess their disaster resilience schemes assuming extreme ash cloud scenarios.

The analysis shows that the MSP has grown and strengthened since the eruption in 2010 and created a valuable network. However, this network requires further enhancement to prepare for the next ash incident to successfully mitigate its economic and societal impact even further. The MSP would benefit from a designated single point of information. It is to be discussed whether this single point of information should also serve for public information. The call for more awareness of the public as a stakeholder was strongly voiced during the stakeholder workshop. New response exercises must avoid training for the previous 2010 event. The exercises should be novel and challenging and drive the stakeholders out of their comfort zone.

The study identified improvement measures along the lines of communication, research and development, staff preparation and contingency planning. Regarding staffing, to better accommodate user needs, it would be beneficial if some Volcanic Ash Advisory Centre staff could work fulltime on Volcanic Ash related research. The most important measure to strengthen the MSP's positive impact on society's resilience is the creation of a comprehensive long-term contingency plan that includes an alternative if aircrafts are grounded.

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10

Flood risk management Port of Rotterdam

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Introduction

The **Port of Rotterdam** is located in the mouth of the Rhine-Meuse Delta in the Netherlands (see **Figure 10.1**). The port's annual throughput amounts to some 450 million tonnes, which makes the Port of Rotterdam the largest port in Europe. Moreover, the port is one of the largest industrial and electricity hubs of Europe. Cargo finds its way to roughly 500 million consumers in Europe over water and over land. It is transported by trucks, trains, pipelines, inland vessels or sea-going vessels. Yearly, approximately 30,000 sea-going vessels and 110,000 inland vessels arrive in the Port of Rotterdam. The industrial cluster contains, amongst others, five oil refineries. The power plants in the port power a quarter of the industry and homes in the Netherlands. The total added value (direct and indirect) of the port is €22 billion, which is about 4% of the Dutch Gross National Income. Moreover, the strategic value of the port, as a logistic hub to the international business competitiveness of the Netherlands, is even 30% higher (Van den Bosch, 2011).

According to the Dutch national climate scenarios (KNMI, 2015; Klein Tank et al., 2009), it is expected that both the intensity and severity of natural hazards such as floods will increase. Severe economic damage can occur from long-term closures of the port and its industry (such events are considered low-probability, high-impact events). Moreover, economic developments and changes in the nature and size of businesses and industrial activities also affect the port's exposure to floods. This raises the question how the port remains safe with respect to flooding in the future.

The case study 'Port of Rotterdam' focuses on the strategic preparation to prevent or minimise economic losses and societal disruption resulting from floods. The ultimate goal is to reduce and/or mitigate flood risk by **strengthening or enhancing the current flood risk partnership** (Multi-Sector Partnership, MSP) involving the Municipality of Rotterdam and the Province of South-Holland.

The initial evaluation of the MSP shows that private sector companies are not fully aware of the flood risk in the Port of Rotterdam. In order to increase the flood awareness, the flood risk has been mapped in a quantitative manner, and has been communicated in workshops with stakeholders.

The following research steps have been taken in this joint fact-finding process:

- describe current MSP and responsibilities of partners;
- develop a modelling approach for assessing (direct and indirect) losses in the Port of Rotterdam;
- discuss risk assessment results with all relevant stakeholders;
- define acceptable risk levels for the pilot area;
- specify the next steps for a climate adaptation strategy for the pilot area;
- formulate policy and research recommendations.

This chapter summarises the results of this joint fact-finding process.

“Overall, floods caused more than €52 billion in insured economic losses, making floods the most costly hazard faced by Europe.”

Figure 10.1.
The Port of Rotterdam case study area.

Flood risk governance in the Port of Rotterdam

Most of the industrial areas within the Port of Rotterdam are **unembanked** (see **Figure 10.1**) and, due to its location near the North Sea, the port is potentially prone to storm surges and coastal flooding. To date, however, flood events have not caused any significant damage to the port. Most industrial areas are located on relatively high grounds and the port is considered safe against coastal floods. For most industrial areas, the flood probability is thought to be smaller than 1/1,000 per year, which is lower than the probability of flooding in most other large ports in the world.

The unembanked port areas are not incorporated in the national flood protection policy. Land owners and businesses located in these areas are responsible for their own flood protection. This underpins the importance of a good understanding of the flood risk they face.

The national government has delegated the 'flood risk governance' of unembanked areas to regional authorities. The Province of South-Holland and the Municipality of Rotterdam form the current Multi-Sector Partnership or Multi-Stakeholder Partnership. This MSP primarily aims to reduce the flood risk of new development projects on unembanked industrial areas in the Port of Rotterdam. Since 2011, a new policy framework for building in unembanked areas is enforced by the Province. The City of Rotterdam applies a Risk Assessment Tool in order to evaluate and assess different design alternatives within new land-use and zoning plans. Note that this Risk Assessment Tool has not been developed to assess the flood risk of existing developments. In other words, the policy does not apply to most port areas as the development in these areas date from before 2011. Moreover, the Risk Assessment Tool only takes into account two indicators (casualties and societal disruption), while the direct and indirect economic losses due to a storm surge flood can have a sizeable impact on the Gross National Product. Hence, the question is to what extent the current partnership reduces (economic) flood risk.

Although other parties, such as the ministry of infrastructure, the water boards and the private sector (businesses and industry), were involved in the development of the provincial policy and the risk assessment tool, none of these other stakeholders have any formal liability or responsibility concerning flood protection. Furthermore, they are not involved in the decision-making process.

Health of the current MSP

The **'capital approach'** (Chapter 1) is applied to evaluate the health of the current MSP. Although the municipality and province have to approve outer dike developments, they are not responsible or liable for possible consequences as a result of possible floods. The Port Authority, and especially the users (the private sector businesses), are not directly involved in the MSP.

Our assessment shows that **there is a lack of awareness, information and communication between stakeholders in the port region with regard to flood risk of unembanked areas**. Therefore, improving the available flood risk information, and improving insights in the consequences of a flood can, together with a sound communication strategy, make businesses more aware of flood risks in the Port of Rotterdam. This communication strategy should not only provide a clear overview of flood risk in the Port of Rotterdam, it should also pay attention to the business objective of the Port and the Port Authority. This requires a balance between providing information and evoking fear. Increased knowledge on the consequences of a flood in outer dike areas can be a tool to break the vicious circle between lack of awareness and insufficient communication. When risks are mapped, the information can be shared with stakeholders in the Port of Rotterdam to create a broader MSP.

One possible way to explore new partnerships and possible protection strategies is to organise workshops. Such workshops are primarily aimed to open the dialogue, improve communication, and build trust between the stakeholders. Once this is established, the MSP can focus on the preferred strategy for outer dike flood protection.

Enhancing the current MSP with private stakeholders leads to a more balanced decision-making process, and contributes to consensus and increased transparency. Furthermore, exchange of views can lead to a coherent and holistic flood protection strategy for outer dike areas in which involved parties know their responsibilities and are aware of the consequences of a flood.

Photo by Katarzyna Wojtasik/Shutterstock.

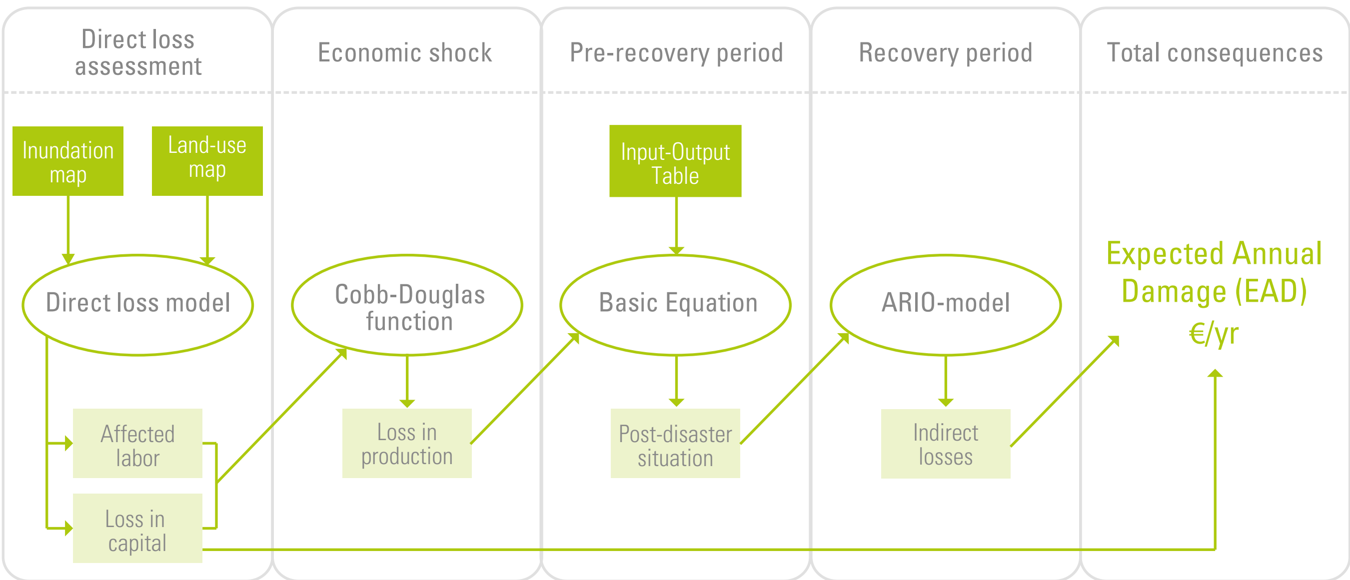
A quantitative approach for flood risk assessment

To decrease the information deficit, the port's flood risk related to storm surges has been assessed in terms of direct and indirect economic losses, failure of infrastructure and societal disruption. The quantitative assessment is done for both low-probability and high-probability flood scenarios, now and in the future. A modelling framework has been set up that incorporates the flood vulnerability of businesses and industry in the exposed (unembanked) area. The following three indicators have been quantified:

1. direct economic losses (material damage)
2. indirect economic losses (losses due to business interruption)
3. societal disruption.

Figure 10.2.

Overview of the different components of the framework. The dark green boxes are the inputs, the ellipses are the different models and the light green boxes are the model outputs.



Direct losses

The first two indicators are expressed in terms of monetary values. Direct economic losses are also referred to as material damage, stock input losses or asset losses. Direct economic losses have been computed by a **depth-damage function approach** (See Chapter 2). Such depth-damage functions are used in conjunction with **inundation and exposure maps** (e.g. land-use or population maps) to assess the damage at any given point on the exposure maps, based on the depth in the inundation map (see **Figure 10.2**). Every class of land-use has a different maximum amount of potential damage per m^2, which represents the total value of the assets at stake. The different vulnerability curves relate the possible inundation depth on the x-axis to the corresponding damage factor (from 0 to 1) on the y-axis (see e.g. Koks et al., 2014).

Indirect economic losses

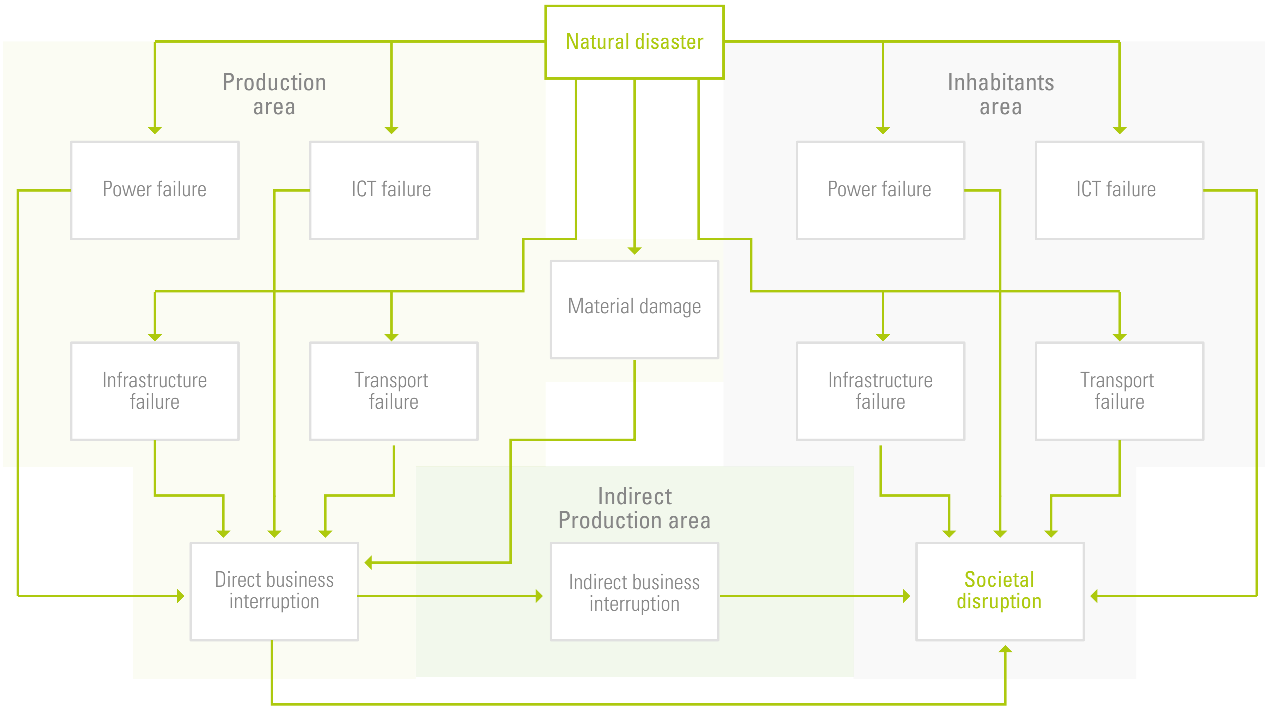
Indirect economic losses are the result of (temporary) business interruptions or a decrease in production capacity. These losses are the lost added value of firms inside and outside the flooded area. Numerous studies have developed approaches to model and estimate the consequences of flooding. A few studies have proposed a more integrative approach for the calculation of both direct and indirect flood damage. For instance, Jonkman et al. (2008) proposed an integrated framework for the combination of direct and indirect losses, and FEMA (2009) developed two modules within the HAZUS-FLOOD model to assess direct- and indirect losses in the United States. However, in our opinion, an integrative model with the capacity to dynamically incorporate various elements of flood damage assessment, such as the flood hazard, the direct damages and the total economic effects, is still lacking. In particular, existing models often fall short of systematic estimation of direct and indirect losses and the coupling between the two. In the ENHANCE project, we have attempted to close this gap. For the development of methodologies, the Port of Rotterdam is used as case-study area.

For the port of Rotterdam, two indirect modelling frameworks have been developed and applied: a single-regional and a multiregional model. The **single-regional model** is a dynamically integrated direct and indirect flood risk model. The framework consists of multiple steps and includes elements salient to integrative loss estimation. For the **multiregional modelling framework**, a new model is introduced that takes available production technologies into account, that includes both demand and supply-side effects, and that includes multiregional trade-offs via trade links between the regions. This model, further referred to as the MRIA (MultiRegional Impact Assessment) Model, is a dynamic recursive multiregional supply-use model in the tradition of input-output IO modelling combined with linear programming techniques (Koks & Thissen, 2014).

Societal disruption

Societal disruption has been defined as 'the extent to which people experience physical, social and emotional hindrance by failure of a function due to a flood'. To quantify this indicator **a novel integrated framework** has been developed (**Figure 10.3**). The framework takes into account societal disruption as a result of business interruption and failure of infrastructure functions (e.g. accessibility, electricity, etc.).

Figure 10.3.
Framework for societal disruption.

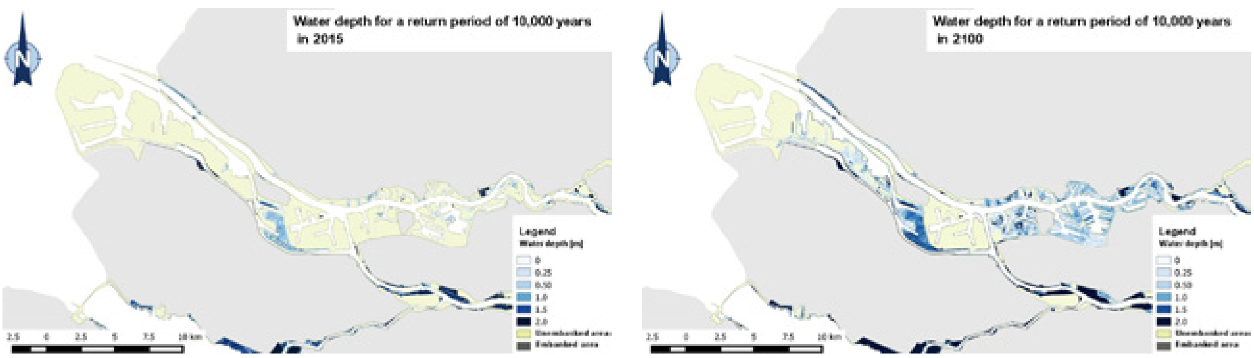


Flood risk assessment Port of Rotterdam

Using the modelling framework described in section 10.3, flood risk has been assessed for three climate scenarios (2015, 2050 and 2100) and six return periods (from 10 to 10,000 years). The **inundation maps** resulting from the flood scenarios are the main input of the quantitative assessment.

The maps in **Figure 10.4** show that the low-probability (1/10,000 per year) floods can lead to severe inundations in several areas covering the Europoort terminal (water depths up to 0.5 m), the docks in the city centre and the Waalhaven (water depths up to 1.0 m) and Botlek-West (water depths up to 1.5 m). In the climate scenarios 2050 and 2100 the probability of such flood depths increases to 1/3,000 and 1/1,000 per year, respectively. High-probability floods are usually limited to parks and river bank inundations in urban and industrial areas.

Figure 10.4.
Water depth of inundated areas Port of Rotterdam for a return period of 10,000 years in 2015 (top) and 2100 (bottom) (Source: Huizinga, 2010).



Direct flood losses significantly increase due to expected climate change (Table 10.1). A 1/10,000 per year flood yields a flood damage between €0.7 billion (now) and €6.8 billion (in 2100, assuming climate change). The flood risk in 2050 and 2100 is comparable to the flood risk in certain, highly protected, embanked areas in the Netherlands. The spatial pattern of the direct losses closely resembles the inundation patterns in Figure 10.4.

Table 10.1.
Direct flood damage (flood risk is expected annual damage).

Return Period [years]	*Direct flood losses (Billion Euros)*		
	2015	*2050*	*2100*
10	0.03	0.21	0.42
100	0.07	0.33	0.69
1,000	0.17	0.59	2.40
2,000	0.20	0.79	3.45
4,000	0.25	1.75	4.75
10,000	0.70	2.79	6.84
Flood risk (M€/year)	**5.84**	**29.5**	**66.6**

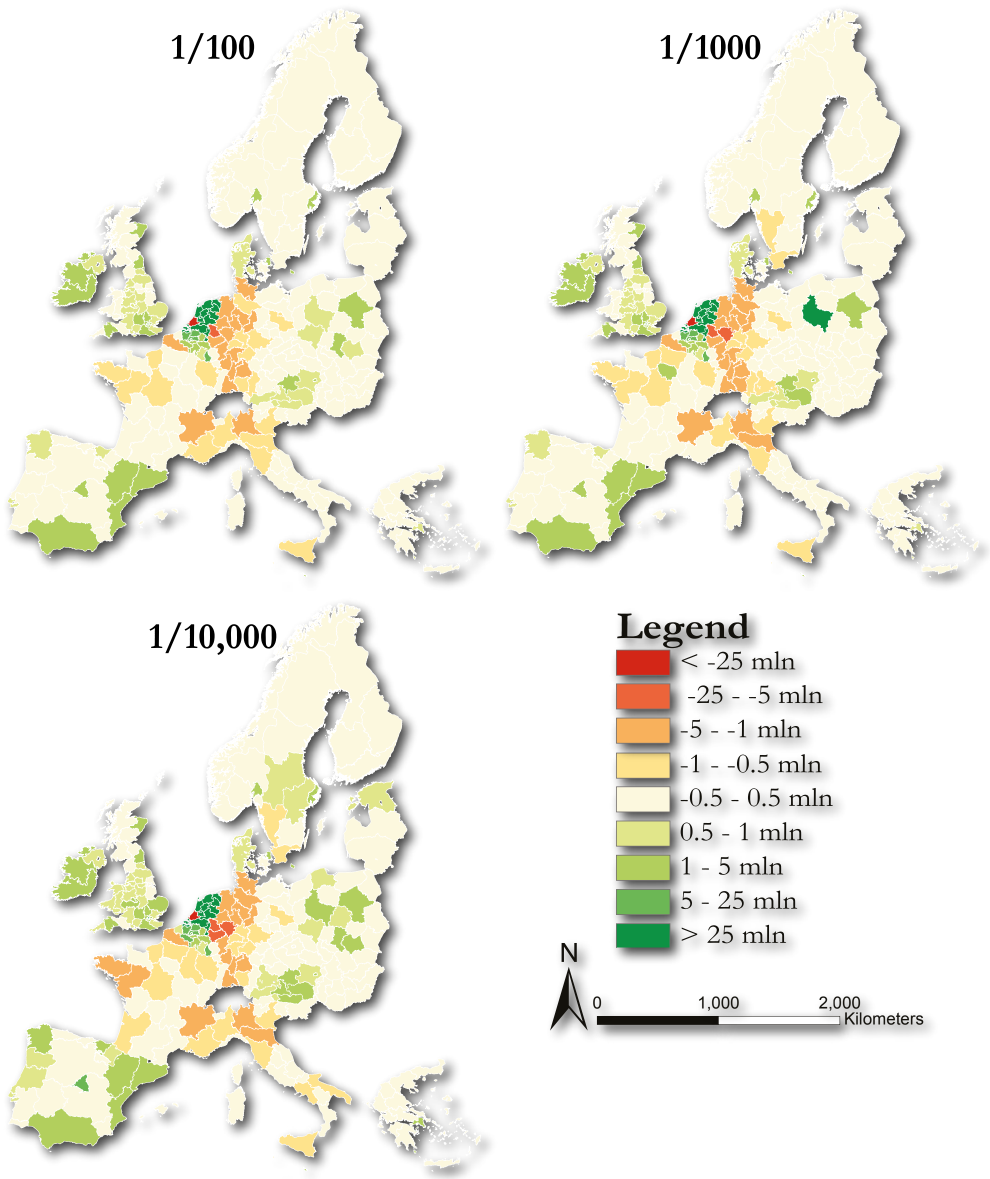
According to the single-regional model, the indirect losses can be substantial and have the same order of magnitude as the direct economic losses. Even though the flood duration is only a few days, the economic recovery to the pre-disaster situation may be several months or up to two years for low-probability floods. Uncertainty and sensitivity analyses show that the losses for a 1/10,000-year flood event range between about €1.1 and €7.3 billion. The model outcome appears sensitive to the large variety in parameter values. Yet, in the context of flood risk decision-making this factor of 7 is not alarming.

The indirect losses are rather robust to different assumptions, although some parameters appear to be of particular importance in this context. An interesting result is that the assumption on available stocks is critical for low-probability floods. A reduction of the available stock by 50% doubles the losses in 1/10,000 year floods. A reduction by more than 50% yields up to 10 times higher losses in such floods. On the other hand, a 100% increase of post-disaster inventories results in a relatively small (8%) decrease of the losses for a 1/10,000-year flood. These results suggest that there might be an optimum value of stock available. Maintaining an inventory to allow a certain degree of flexibility in the production chain is an important focus point for disaster management. It is important that businesses can maintain and quickly restore their inventories to speed up the recovery process.

Indirect losses on the European scale

The multiregional modelling approach shows that the cascading effects of a flood in Rotterdam may lead to substantial indirect losses and strong distributional effects between regions in the EU. The Rotterdam case in Figure 10.5 clearly shows that many regions outside the affected area are indirectly affected by the natural disaster. Some of the neighbouring regions benefit from the flood by increased reconstruction demand or by overtaking some of the production from the affected region. Results show that most of the neighbouring regions gain from the flood, due to increased demand for reconstruction and production capacity constraints in the affected region. Regions located further away or neighbouring regions that do not have a direct export link to the affected region mostly suffer small losses.

Figure 10.5.
Indirect effects per region in the European Union for floods in the region of Rotterdam.



Societal disruption

Application of the framework for societal disruption to the case study area shows that many people inside and outside the Port are affected by a flood. The impact of infrastructure failure (being transport over roads, rail and waterways) is especially high for high-probability flood events. The disruption due to business interruption lasts longer and is more prominent for low-probability floods. The societal disruption indicator appears to be rather robust for assumptions on the critical modelling assumptions and parameters: critical inundation factor, population size and water-borne transport failure.

Photo by strelka/Shutterstock.

Implications for flood risk management

The quantitative flood risk assessment (QRA) highlights the economic losses and societal disruption both inside and outside the port under various flooding scenarios. The expected annual direct losses amounted to about €5.8 million per year in 2015 and amount to up to €67 million per year in 2100. The expected annual losses due to business interruption are of the same order of magnitude. Moreover, the recovery period ranges from 3 months (return period 100 year) to two years (return period 10,000 years). The indicator 'societal disruption' also stresses that the port's downtime affects many people outside the flooded area.

What are the conclusions and implications of the QRA for the current MSP?

- Climate change adversely affects the port's flood risk. The consequences of potential floods are large in terms of economic losses and societal disruption. The Rotterdam port area is vital for the Dutch economy and society, and further discussion is needed to determine who should regulate the port's flood protection: the national or regional government, the industry, the Port Authority or all together?
- The speed of recovery of the economy is an important issue as well. How should the (national) government and the industry deal with the knowledge that the recovery may take months?
- Without adequate risk information, businesses in the Port cannot take adequate risk reduction measures.
- The case study application shows added value of an enhanced risk assessment, which also covers superregional effects in the case of critical infrastructure systems and highly interconnected industrial networks.

Extending the current MSP

The port's future flood risk is comparable to the flood risk in certain, highly protected, embanked areas in the Netherlands. The current risk governance solution, i.e. the provincial policy framework, is not an appropriate response to extreme floods in the future. Especially not for the existing developments. Although the notion of acceptable risk should be elaborated further for the Port of Rotterdam, it is clear that especially the indirect consequences of possible floods (business interruption, societal disruption, etc.) are large and undesired. Hence, the current MSP is not sufficient.

An enhanced partnership should recognise the role the Port of Rotterdam plays at the national level. Also, it should trigger cost re-allocation between the various levels of risk governance. .

The enhanced MSP should at least include:

- the national government as the Port is of strategic importance to the country;
- the Port Authority as main 'landlord' of the Port area;
- the Municipality of Rotterdam;
- business and industry in the Port area as driving force of the Dutch economy;
- the Province of South-Holland;
- other stakeholders with knowledge required to reduce or mitigate flood risk or responsibilities with regards to a safe environment: e.g. environmental agency DCMR, safety region, water boards, and utility companies.

Photo by polderfoto/Morguefile.

Pilot study: Botlek area

On the basis of the recommendations of the national Delta program on flood risk in unembanked areas, the national government started a 'pilot study Botlek' has been started in 2015. This pilot study aims to **develop a climate adaptation strategy for the Botlek area**.

The pilot study project group consists of the following main stakeholders: Port Authority Rotterdam, (executive body of) the Ministry of Infrastructure and the Environment, and the municipality of Rotterdam. The project consists of two phases. The goal of the first phase is to develop **a framework for mapping and assessing risk levels**, which is the basis for discussions with all stakeholders. The ENHANCE project team has fed this framework with quantitative risk information. The second phase, to be started later in 2016, deals with developing the **adaptation strategy**. Here we summarise the main findings of the first phase.

The Botlek area (see Figure 10.1) is an ideal study area for several reasons. The area is located a few kilometres to the west of the city of Rotterdam, and the oldest parts of the area are built approximately sixty years ago. Two major oil refineries and many chemical plants are situated in the Botlek area. Liquid bulk (chemical products and oil) is stored in many smaller and larger storage tanks. The highway A15 and a major cargo railway cross the area. The water system is somewhat complex. The west part of the Botlek area is connected directly with the North Sea. A small dike, which is not part of the primary water defences with specified safety standards, offers some protection to storm surges at sea. The east part of the Botlek area is located behind the Maeslant storm surge barrier and is located lower.

The pilot study started with a broad scope, the initial QRA, and converges to an adaptation strategy including the question of risk governance and responsibility (see Figure 10.6).

Figure 10.6.
Process to involve stakeholders in the Port of Rotterdam to develop a flood risk adaptation strategy.

Enhancing the MSP and societal resilience

The pilot study Botlek area provided the ENHANCE project team a great opportunity to apply and refine the risk methods with detailed information. The stakeholders are still discussing the Botlek-specific assessment. We therefore mention only the most important process steps and their impact on the stakeholder process.

Data on land-use, elevation, location of critical infrastructure objects, economic value and flood vulnerability of buildings, products and installations at (industrial) sites, economic value and vulnerability of infrastructure, and (inter)dependencies between companies have been collected. With these data, new Botlek-specific flood maps have been created and an **initial quantitative flood risk assessment (QRA)** for the Botlek area has been done.

The results have been discussed with the stakeholders in **four workshops**. Several local stakeholders indicated that they were not aware of the potential flood risk in the area. Over the course of the workshops, they gave feedback on several modelling assumptions, which resulted in substantial improvements of the modelling frameworks. For example, they argued that comparatively low water depths can lead to production stops and lengthy business interruption (up to 9 months for some industries). This led to an adjustment of some stage-damage functions and the duration parameters in the indirect loss modelling framework. Also, they estimated direct and indirect economic losses within their business site for several flood scenarios. The model output appeared to be of the same order of magnitude as the business estimates. The process converged to a refined QRA for the Botlek area in terms of four indicators: direct economic losses, indirect economic losses, societal disruption and casualty risk (loss of life).

At the same time, a **conceptual framework for assessing risk levels** has been developed. The ENHANCE project team has mapped quantitative risk information into this framework. The results were discussed with the stakeholders. Discussions on what the stakeholders think is acceptable for them (with respect to each indicator) are on-going. Different stakeholders have different responsibilities and preferences. For example, some businesses say their safety policy asks for preventive measures if a flood with probability of occurrence 1/1000 per year causes damage to installations on their site. Also, since the port areas are heavily industrialised, most stakeholders are much more focused on the indirect effects than on the direct effects of floods.

The joint fact-finding process in the pilot study has stimulated the communication between the stakeholders as well as the flood awareness. Until 2015, it was quite difficult to involve the stakeholders in the discussion on flood risk in the port area. The national authorities had delegated the 'flood risk governance' of unembanked areas to regional authorities, which had just developed a provincial policy framework for building development. The Port Authority, the land-lord of the port area, hesitated to communicate about flood risk with the businesses and industries, who were not really aware about this issue. Finally, in 2015 the research by the Dutch Delta program has initiated the pilot study. The timing could not have been better. From June 1, 2015, the EU enforced the SEVESO-III directive (2012/18/EU). Many businesses and industries in the port area have to show that they take into account flood risks in their safety plans to ensure that major accidents are adequately controlled. As most of the private stakeholders were not really aware of the flood risks in the port area, they were quite eager to join the workshops. In the beginning of the process they asked for information, later they also provided information to improve the QRA. This confirms that flood risk is a joint issue, which can only be tackled through cooperation and open communication.

The workshops in the pilot study Botlek have contributed to a higher flood awareness amongst the stakeholders and a better understanding of (future) flood risk in the area. The expected increase in flood risk and the vital importance of the Port of Rotterdam to The Netherlands ask for a joint response of the stakeholders: a climate adaptation strategy. This strategy will be the basis for further discussions on risk governance, responsibilities and risk financing.

Recommendations

The research shows that flood risk management of the unembanked industrial areas in the Port of Rotterdam is a joint issue of national importance. Increased knowledge on consequences of a flood in these areas, the joint effort of the authorities, and the participation of businesses in the pilot study helped to break the vicious circle between the lack of awareness and insufficient communication. Also, by sharing the risk information with stakeholders in the Port of Rotterdam a broader MSP can be created. Hence, it is really promising to see that public and private stakeholders (national and regional authorities, industry, utilities, and so on) work on a climate adaptation strategy for a pilot area. Joint fact-finding and open discussions on risk governance, financing and partnerships will be the key factors to realise such a strategy.

We recommend answering at least the following questions when developing the adaptation strategy:

- Is it necessary to reduce flood risk in all regions?
- Are disaster risk reduction solutions that are cost-effective for industry also cost-effective for society?
- Are the solutions flexible enough with respect to uncertainties and climate change?
- How large is the influence of uncertainties in the risk indicators on the cost-effectiveness of particular measures and the adaptation strategy?
- What is the impact of disaster risk reduction solutions on the current activities and responsibilities of the stakeholders?

The stakeholders should answer these questions together, after which they can decide on the structure of the enhanced MSP.

A recommendation to the EU is to identify other critical infrastructure 'hubs' in Europe and map their resilience to natural (and man-made) disasters, taking into account climate change.

Tanker and oil storage tanks in Rotterdam, the Netherlands.
Photo by VanderWolf Images/Shutterstock.

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Trilateral (flood) risk management in the Wadden Sea Region

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Introduction

Widening the perspective in risk management towards broader and more people-centered approaches has been, and is still, a general endeavour in risk management (e.g. United Nations ISDR, 2015). The complex and dynamic nature of environmental problems and risks resulting from natural hazards requires flexible and transparent decision-making that embraces a diversity of knowledge and values (Renn, 2008a) in order to successfully deal with the effects and impacts of these problems and risks on the society. This requires enhanced risk management processes, which emphasise integrating different rationalities and concerns of various institutions, sectors and the public. In order to facilitate such processes, enhanced stakeholder involvement is required, hereafter referred to as multi-stakeholder involvement, as much as the understanding that participation and societal support have to be understood as crucial for successful risk management processes.

The case study area of the **trilateral Wadden Sea Region (WSR)** is facing the challenge of a complex and dynamic nature of environmental problems and risks. The WSR, which includes the seaward Wadden Sea areas of the bordering North Sea as well as the landside[17] (see **Figure 11.1**), is a **multi-risk area**, resulting from different risk components such as: natural hazards like storm surges and sea level rise, socio-economic risk from demographic change, and conflicting spatial uses due to environmental changes. Storm surges are a constant hazard along the WSR and projected climate change conditions may lead to increasing risk (Woth et al., 2006, Weisse et al., 2014) through, for example, increased sea levels in the coming decades (Church et al., 2001; Katsman et al., 2008; IPCC, 2013; Katsman et al., 2011). The challenge in the WSR is not only its flood risk resulting from multiple drivers, but the fact that risks and uncertainties appear on a **transnational scale**, affecting the entire WSR – in the three Wadden Sea Region countries of the Netherlands, Germany and Denmark. Partly resultant from similar ecological characteristics as well as similar social and economic structures, the multitude of risks in the region represents a highly interlinked risk system of threats, causes and consequences that goes beyond administrative borders.

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[17] The definition of the vulnerable landside in the WSR case study follows the definition of the Wadden Sea Forum, encompassing the administrative units of municipalities/counties/provinces in Denmark, Germany and the Netherlands along the Wadden Sea coast.

"Storm surges protection is considered to be in good hands, therefore risk management of storm surge events is not perceived as a burning issue. Rather, it is important to consider risk management as a process to ensure that we identify and understand the risks; and, that we manage the risks according to the identified needs and concerns not only of the people involved in the process but as well of the society at large."

Figure 11.1.
The Wadden Sea Region, as defined by the Wadden Sea Forum (Source: Common Wadden Sea Secretariat, CWSS).

The specific spatial dimension in coastal risk management in the WSR strengthens the call for collaborative actions in risk management on a trilateral level. However, most of the risk management processes are currently performed within the national and administrative borders. For example, storm surge risk management processes have taken place exclusively within national and in Germany within the Bundesländer boundaries. No management processes are in place across the national borders, even though risks appear on a trilateral scale and affect all three countries in a comparable way.

Based on this situation, the need for enhanced coastal risk management processes in the WSR becomes apparent. In this spirit, it is appropriate to question whether the current understanding and structures of risk management allow the implementation of risk management processes in the form of broader cross-national and more inclusive approaches.

This case study addressed the claim for enhanced coastal risk management processes by asking the question if and how multi-stakeholder processes, in the form of a Multi-Sector Partnership (MSP) on a trilateral level, can improve risk management in the WSR? What is the role of such an MSP? What are their contributions towards enhanced trilateral risk management processes? And how can trilateral, multi-stakeholder involvement be performed successfully? The challenge for this case study lies in the reframing of risk management, detecting mental lock-ins against alternative approaches and tackling potentials for trilateral cooperation in a multi-risk area.

Wadden Sea Coast in Northern Frisisa.
Photo by Birgit Gerkensmeier.

Why an MSP in trilateral risk management?

Successful risk management processes in the trilateral WSR should be guided by perspectives and concerns of stakeholders and the society to encourage that the multiple risks are managed according to the identified needs and concerns of the people involved in the process. Risk management, therefore, becomes **a societal endeavour**, which has to consider people's awareness and perception of risks. To underpin this rethinking of (coastal) risk management processes, an integrative risk management approach is needed which includes stakeholder interests and respects urging issues of the population.

The MSP 'Wadden Sea Forum'

The focus of our case study is the **Wadden Sea Forum (WSF)**, an already established transnational MSP. The WSF is an independent platform of stakeholders from Denmark, Germany and the Netherlands, once established to contribute to an advanced environmental protection scheme and promote sustainable development of the WSR. In particular, this means integrating specific cross-sectoral and transboundary strategies, actions and techniques which are environmentally sound, economically viable and socially acceptable (Wadden Sea Forum, 2013). The participating stakeholders represent the sectors Agriculture, Energy, Fisheries, Industry, Harbour, Nature Protection, and Tourism, as well as local and regional governments from the three Wadden Sea countries. In addition, the national governments are represented as observers (Wadden Sea Forum, 2005; 2010). The WSF is equipped with an advisory function in the Wadden Sea Board, the governing body of the Trilateral Wadden Sea Cooperation on the protection of the Wadden Sea.

In the context of ENHANCE, the case study analysed benefits, disadvantages and limits of the WSF, as a MSP, in the risk management processes. **What is new here is the idea to organise risk management processes on a cross-national level with the help of a MSP, without creating a new organisational body**. Although the WSF has a legal status as a non-profit organisation, it has no normative power in decision-making outside the forum. Consequently, this MSP will not have any direct influence on developing or instructing technical and economic measures in the three Wadden Sea countries. Nevertheless, the experience over the years has shown that a trilateral MSP, also anchored in decision-making as an advisory board, will not be ignored and has proved its communicative and advisory power. Furthermore, the MSP can use its already existing trilateral grass-root structure to foster trilateral collaboration.

For the target to enhance risk management as people-centred and as requiring acceptance and understanding within society with its stakeholders and interest groups, the WSF is an appropriate MSP to cooperate with.

The topic of risk management has been put on the agenda for the WSF following the 12th Trilateral Governmental Conference on the Protection of the Wadden Sea in Tønder (Common Wadden Sea Secretariat, 2014) so that the ENHANCE case study was able to take advantage of the situation and support the WSF in developing its newly declared objective and investigate the potentials to integrate risk management in the WSF's future activities.

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Integrated Risk Management Approach – the conceptual background

Trilateral risk management processes involve more than the development and monitoring of technical measures to reduce the impact of risk and the harm to society caused by their consequences. Risk management is a societal process, which addresses uncertainties in relation to society's concerns. This understanding is rooted in a sociological perspective on risk[18], which understands risks as constructs that are mentally and socially conceived. These constructions result from people's perceptions and interpretations of the environment and responses depending on social, political, economic and cultural contexts and judgments (Luhmann, 1993; Ratter, 2012; 2013) as much as on responses of actors on the individual level and the societal system's level due to expected exposure to hazard events and their potential consequences (Luhmann, 1991; IRGC, 2005. Ratter, 2012). Possibilities for future events are not confined to the calculation of probabilities, but encompass group-specific knowledge and vision (Renn, 2008b) as a result of negotiation and evaluation processes within the society.

In consequence, risk management is not only a technical issue, but also takes place within a societal frame as much as in historical and cultural settings with constantly changing and uncertain boundary conditions. Therefore, dealing with risks requires more than the classic elements of risk management, commonly understood as risk analysis, risk assessment, development of strategies and measures to handle the risks and processes to monitor these elements.

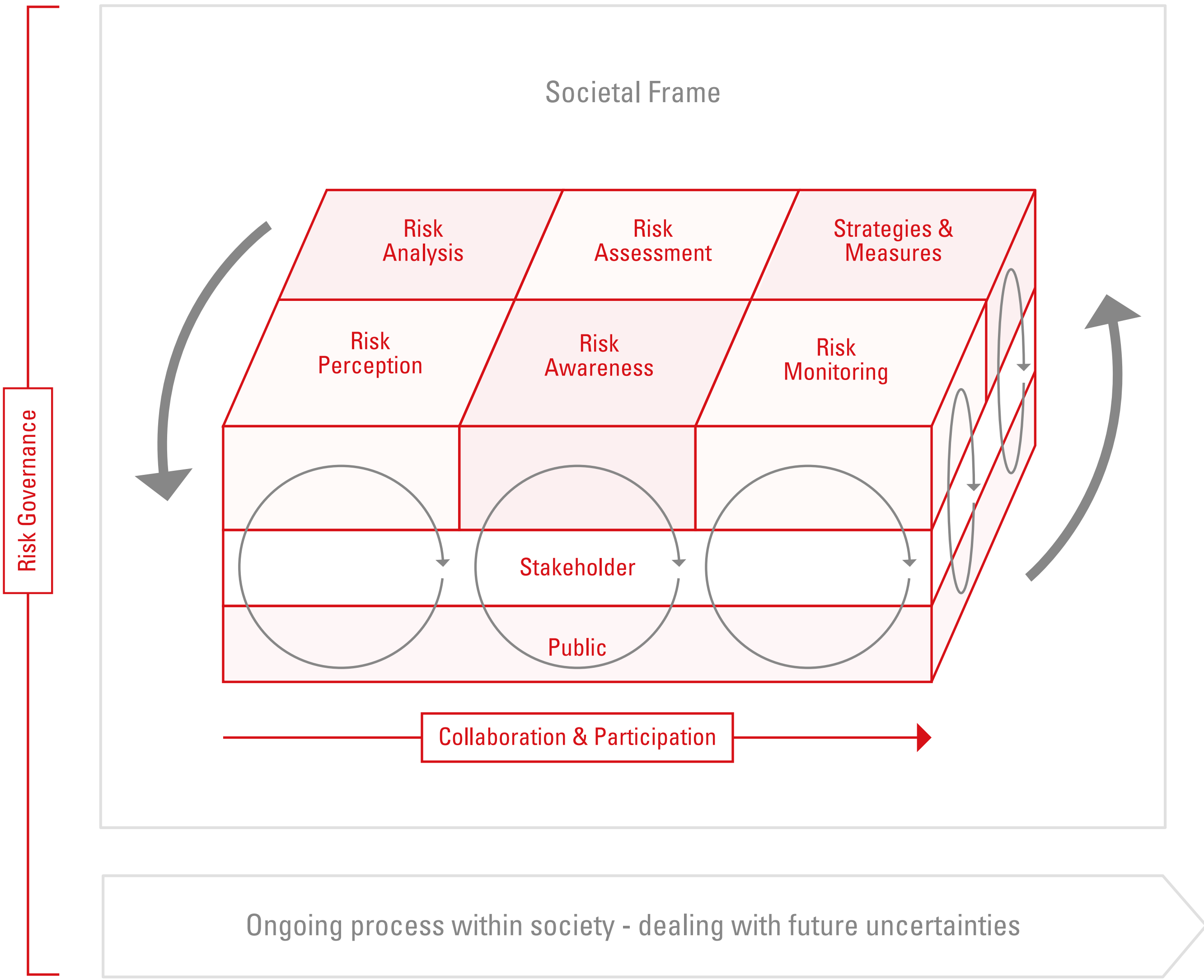
An **Integrative Risk Management Approach (IRMA)**, as we present it, includes and fosters the integration of different sectoral interests and concerns and the influences and restrictions imposed by societal frames. The starting point for an integrative risk management is the identification and integration of the regional society's understanding of risks, as it determines the concerns and needs of the people involved in and impacted by the risk management process – in our approach represented by the element of risk perception and risk awareness (see **Figure 11.2**). In consequence, a thorough risk analysis is needed, which helps to identify risks from the perspective of vulnerabilities and in the light of existing or future drivers operating in the management area. Risk assessment, in this context, aims to acquire an understanding of the potential consequences and impacts in relation to the perceived risks. These basic steps are followed by the development of an adequate risk strategy or measures to adapt to the causes of risks and reduce the consequences of risks. And finally, the risk management process has also to include an on-going evaluation and monitoring process in order to deal with changes and upcoming uncertainties (Ratter, 2013). Figure 11.2 illustrates the essential elements and processes of IRMA..

[18] In contrast to natural science and technical perspectives on risks, where risk is mainly understood as an algorithmic calculation to estimate expected physical harm from hazard events in the form of likelihoods.

Figure 11.2.

Integrative risk management approach (IRMA). IRMA includes the classic elements of risk management (risk analysis, risk assessment, development of strategies and measures to handle the risks, processes to monitor these elements) as much as it considers risk perception and risk awareness as equally important elements – all of them are interlocked as pieces of a jigsaw. Risk management takes place within a specific societal frame with constantly changing and uncertain conditions influencing the management processes. These aspects require collaboration and participation of the public and governmental/administrative institutions. Therefore, risk management has to be understood as a negotiation-based process of governance which addresses needs, objectives and goals, mediates between different interests and, if necessary, (re-)arranges responsibilities.

The above-mentioned elements should not be seen as independent from each other, but rather being complementarily connected like interlocking pieces of a jigsaw. In view of these aspects, IRMA is comprehensive not only in the sense that all management steps are included in an on-going, iterative process, but also in terms of acknowledging the shared responsibility between the agents of the social system. Integrative risk management in this sense becomes **a collaborative process involving the public sector, the private sector and the public at large**. Top-down approaches imposed by governments are less successful; rather, risk management has to be understood as a negotiation-based process of governance which addresses needs, objectives and goals, mediates between different interests and, if necessary, (re-) arranges responsibilities. Therefore, it is essential to have continuous and close connections to stakeholders and the public during the process. Collaborative and participatory processes represent a central element in IRMA in order to ensure a continuous exchange and feedback to current management processes. Communication and discussion are essential in order to continuously adjust risk management processes to the societal frame.



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Investigating the multi-risk situation in the Wadden Sea Region

Addressing risk management issues in the Wadden Sea Region (WSR) started with the identification and investigation of the hazard situation, followed by differentiating between the causes and consequences of the perceived risks. On this basis, we assessed consequences based on competing interests in different sectors, and identified the scales at which risks will be addressed and where respective responsibilities lie.

Practical implementation of IRMA's discursive processes was based on **a series of three moderated, participatory workshops** with the stakeholders of the MSP, supported by different methodical approaches and supplemented by additional analyses. The latter were performed mainly as further in-depth analyses on the risk of storm surges (one risk out of many in this multi-risk area) to generate and provide additional knowledge supporting the collaborative stakeholder process.

The first workshop was dedicated to the disclosure of different risk perceptions and stakeholders' awareness on existing risks and risk management processes in the WSR. In the second workshop we supported a structured and guided dialogue using the bow-tie analysis to facilitate enhanced understanding of risk pathways, including the overview of causes and consequences of risks, and to disclose the feasible points of action for a risk management strategy. The third workshop continued the discussion and detected the potential role of the WSF in risk management processes on the trilateral level. This combination of different methodical steps provides a practical example of how to implement the integrative risk management perspective, as described in IRMA, in collaboration with stakeholders.

Disclosing the different risk perceptions of the stakeholders in the kick-off workshop underlined the fact that the WSR is faced with a multitude of risks resulting from different natural hazards and socio-economic developments. Natural hazards in the area, particularly storm surges, represent major risks. The importance of stakeholders' risk perceptions and risk awareness were underpinned by a personalised stakeholder online survey on storm surge management, conducted with stakeholders beyond the MSP who were directly and indirectly related to storm surge management (for detailed information see González-Riancho et al. 2015). However, stakeholders in the WSF do not consider storm surge risks as the highest priority for improved trilateral risk management actions – but perceive an urgent need for improvement with regard to other risks. These include risks related to demographic change, the imbalance of interests in nature conservation, and social and economic development in the WSR.

Building on the insights on risk perception and awareness, assessing impacts of disastrous events like storm surges is the next crucial step, in order to provide a descriptive basis to evaluate DRR solutions with regard to their suitability, feasibility and effectiveness. From our understanding, risk assessment not only involves the assessment of hazards or risks from a scientific point of view, but it has to include societal experiences with hazardous events and their impacts on their life worlds, too

We performed an in-depth risk assessment on the specific risk of storm surges as well as a risk assessment together with the stakeholders focussing on the multi-risk characteristic of the WSR. For the latter, results from the storm surge risk assessment provided additional background information, supporting a broad understanding of the issue. The in-depth assessment of storm surge risks should be seen as an example; ideally these steps could be conducted for the other risks as well.

Risk assessment and information

The in-depth risk assessment on storm surge risk in the WSR highlighted that in the WSR, risks can be more successfully assessed by a combination of quantitative and qualitative risk assessment approaches in order to arrive at a comprehensive integrated risk assessment.

We gained this insight by combining three different perspectives to assess the impacts of storm surge risks to society:
(1) climate scenarios and flood maps;
(2) a comprehensive state-of-the-art desktop study on storm surge damage modeling;
(3) a perception study carried out through the stakeholder online-survey mentioned before (see González-Riancho et al., 2015).

The results of these steps on storm surge assessment highlight that management of the causes of storm surge risks is restricted by climatic and topographic boundaries. Existing coastal protection measures designed to deal with the causes work adequately and largely satisfactorily. The consequences of storm surges will pose a greater challenge in the future due to climate change. Impacts will occur in different sectors and at different levels and will affect the economic, social and environmental spheres. Stakeholders along the Wadden Sea coast of Schleswig-Holstein (results of the online-survey) are mainly concerned about impairments of living conditions, including financial penalties as a consequence of storm surge events. It follows that enhanced (storm surge) risk management in the WSR has to focus on the consequences of storm surges if the society's capability of mitigating and successfully lowering these risks is to be improved.

The state-of-the-art desktop study on storm surge damage modelling showed that damage modelling could facilitate the decision-making process by showing what economic consequences could be expected in the case of storm surge events. However, modelling results differ widely based on different projections, specific boundary conditions, data sets and levels of detail defined in each project. In general, little research has been carried out at the national or transnational level, and damage estimates are of very limited significance and validity. The majority of research focuses on the meso- and micro-scale levels. A major challenge is an adequate process of damage estimation; often damages are estimated in different damage categories, each of which is related to certain estimations of values. Key aspects are the level of detail and the range of damages considered in the assessment of values, as these are essential for the level of detail of the estimated final risk – and in most cases call for a huge amount of data for each approach (see in detail Gerkensmeier et al., 2015 presenting a comprehensive desktop study on storm surge damage modeling). Under these circumstances, general transnational damage assessment remains rather vague[19]. These results can merely support the essential negotiation process surrounding the risks to be taken by society.

Bow-tie analysis: causes and consequences of perceived risks

For the multi-risk area of the WSR causes and consequences of perceived risks need to be assessed keeping in mind that risk management in the WSR has to consider and negotiate different perspectives from different sectors and across the different countries.

In order to enhance understanding of this complexity, we introduced the bow-tie analysis as a structural tool to the stakeholder forum in the second participatory workshop. The bow-tie analysis is a commonly used risk assessment technique of the International Organisation for Standardisation IEC/ISO 31010. It is used to analyse cause and effect pathways of risk and enables the users to develop a common, sound understanding about the differentiation of risks, their causes and consequences (IEC/ISO 2009). Moreover, the bow-tie analysis facilitates the identification and analysis of the system of management controls which is necessary to adapt to the causes and to mitigate the consequences.

We chose the bow-tie analysis to derive an improved understanding of what elements constitute risk management, to differentiate between the system elements and increased awareness towards interlinkages between different risks. Therefore, we adapted the bow-tie analysis

[19] An exemplary study by Schwerzmann & Mehlhorn (2009) highlights an increase of expected annual losses between 100% and 900% compared to today for all North Sea countries.

for the framework of the WSR, which is usually applied to analyse the management control system in place for a well-known risk, to our specific needs and to facilitate participatory stakeholder involvement in risk management processes (for a more detailed description of the bow-tie analysis in the WSR see Gerkensmeier et al., 2015). The bow-tie analysis showed that hazard impacts and damages affect social, physical and economic structures in comparable ways. Three major risk complexes were addressed: a) demographic change, b) environmental change and c) imbalanced development. Discussions and analysis along the bow-tie also emphasised the interconnectedness of the different risks and risks complexes alike. Feedback as well as cascading effects between the complexes can influence the performance of the others.

Structured risk analyses and comprehensive risk assessment, as presented above, are the basis for the subsequent development of risk management strategies and measures. These strategies and measures for enhanced trilateral risk management processes on the WSR should meet the requirements of the stakeholders elaborated in the previous steps: Improved activities on awareness raising, information and knowledge exchange as well as communication are essential actions for an improved trilateral risk management. Such actions will address the negligence of societal risk perception for the development of DRR solutions as well as they will facilitate society and practitioners to overcome the existing lock-in situation resulting from trust and success of the recent technical measures in which continuous, successful investment in construction measures hinders a perspective on non-technical or mixed adaptation measures and strategies.

Based on these requirements, it became clear that the MSP itself has to be seen as an important, structural DRR tool that has the potential to improve trilateral risk management processes in the WSR. The MSP in the WSR will be able to make a significant contribution to an increased communication and enhanced integration of stakeholders' and society's risk perception in transnational risk management in the WSR. These improvements could pave the way for additional DRR solutions. From this it becomes clear that the MSP itself has to be understood as one of the most important DRR solutions that are needed in the WSR for the moment and in the near future.

Using future scenarios to test the MSP

In order to further define the scope, ability and limits of the MSP as a structural DRR tool, the MSP's ability to operate was tested under critical conditions. We used a qualitative future scenario approach (based on the Future Search Method) as a participatory scenario approach. Qualitative scenarios provide a (negotiated) future vision about a certain area or sector. Qualitative scenarios are visionary narratives of future development based on experiences, regional cultural frames and a visionary dialogue process, as defined by Possekel (1999).

In the third stakeholder workshop three different extreme risk scenarios related to the risk prioritisation given by the stakeholders were developed and discussed within small stakeholder groups:
(1) a very low-pressure system heading towards the WSR;
(2) the closure of grocery shops in peripheries cause special problems of provision especially for the rural WSR;
(3) an oil tanker crashes in an offshore wind farm and leaks.

In practice this meant that each working group, consisting of members from different countries and sectors, received a small set of information that was used to set the scene. Based on this information the working groups were asked to look ahead to the year 2030 and describe the anticipated threat and the impacts of the crisis for the society and the region. Based on these extended future vision scenarios, discussions were focused on how to handle gaps in management and strengthen the already existing management strategies and measures, and how to define roles and responsibilities for these actions, and on defining the role of the MSP in this context.

Key findings of the MSP performance assessment - role of the MSP

The ENHANCE cases study of the WSR highlights the need for enhanced communication beyond the limits of technical measures of storm surge management as much as for enhanced understanding of the risk management processes in a multi-risk area by the stakeholders.

Following this claim, the MSP's major role is seen as a communicator, multiplier and institution to raise awareness about risks and potential improvement of management processes. In this context the MSP provides an exchange platform of knowledge and experience (cross-sectoral and cross-national), offering space for discussion of new issues and reflection on on-going processes. Thereby, the MSP can initiate a snowballing effect and inspire other stakeholders to open up their minds towards a more comprehensive thinking about risks and uncertainties and stimulate a process of awareness of natural hazards.

In this sense the MSP might contribute to enhanced risk management strategies in two ways: (1) the MSP fosters new discussions on different political levels, especially on the trilateral one, and (2) the MSP might use its networks to communicate new developments in the region and support the implementation of already existing strategies. Thereby the WSF can function as a bridging body using the stakeholders' networks and contacts to foster acceptance of necessary decisions in risk management. Outcomes, such as elaboration of advice for political levels, might be a practical contribution fostering transnational collaboration in the trilateral WSR beyond national legal requirements.

In relation to these findings about the role of the WSF as a MSP in trilateral risk management processes, the conducted MSP performance assessment under ordinary and critical conditions offers suggestions on how to further improve and strengthen this role. The current composition of the WSF, including stakeholders from all three countries as well as from the public and private sectors on local, regional and national levels, provides a comprehensive basis for an enhanced level activity. There is actually no urgent or essential need for increased personal capacities. However, there is a continuous need to maintain personal commitment of the participating stakeholders. As a voluntary, advice-giving stakeholder forum, the WSF is highly dependent on the personal engagement and commitment of each participant. Continuous and strong stakeholder engagement and commitment is an essential attribute for successful performance of an advice-giving, independent MSP in order to sustain a broad commitment and to achieve a win-win situation for the voluntary stakeholder organisation and the normative political level.

Nevertheless, the analysis of the current level of activity and responsibility makes clear that all parties involved in the work of the WSF do not make the maximum use of this win-win situation for the time being. The WSF, currently, does not use the potential and its possible political weight in current debates. Continuous activities to encourage and strengthen stakeholder engagement and commitment are of major importance. There is a need to make the WSF more visible and heard at the political level in the WSR, therefore, striving actively for a larger role in decision-making. However, for an on-going and lasting role in decision-making, appropriate structural and financial support is crucial. At this point, improvement is needed with regard to the WSF. Secured long-term structural and financial support is an urgent issue in terms of further improvements of the MSP; otherwise the success of the WSF's work is at risk.

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Policy recommendations for advice-giving, independent MSPs

Generally speaking, the ENHANCE work in the WSR underpinned the hypothesis that an advice-giving MSP, once established to support environmental management across national and regional boundaries, can take on a decisive role in transnational risk management. An independent, advice-giving MSP can act as a communicator, ambassador and multiplier in risk management, which is of major importance in integrated risk management processes in a multi-risk area on trilateral level. Even without decision-making power, an advice-giving MSP can constructively and decisively contribute to an inclusive and integrated perspective on transnational risk management since risk management has to be understood as an iterative, on-going process that has to be continuously fed back with society. These requirements on risk management process claim for an MSP as a long-lasting supportive institution.

Using its networks to communicate new developments as well as to support the implementation of already existing strategies, collaborative stakeholders' actions in the MSP can be very beneficial for the political level and their decision-makers. Thereby it has to be an overall aim to strive for a win-win situation for the voluntary stakeholder organisation and the normative political level. If the members use the potential of their networks in the WSR in different sectors and countries, collaborative activities can enable stakeholders to formulate policy advice outside the traditional scientific and traditional cadre. Major requirements for successful performance of an advice-giving, independent MSP include continuous and strong stakeholder engagement and commitment. Strong commitment of the MSP's stakeholders and the involvement of visionaries who are willing to take ownership are the fundamental basis of an independent stakeholder forum in risk management processes.

If these activities are underpinned by the essential elements of financial security and organisational stability for the long-term coordination and advice-giving, independent MSP can exploit its full range of competence as a long-lasting supportive institution in transnational risk management processes. With this in mind, establishing an MSP is just half of the process. Keep an MSP successfully running over a longer period requires a quite some effort and support from each stakeholders and their regional roots

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12

Heat and health risk in European cities

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Heatwaves

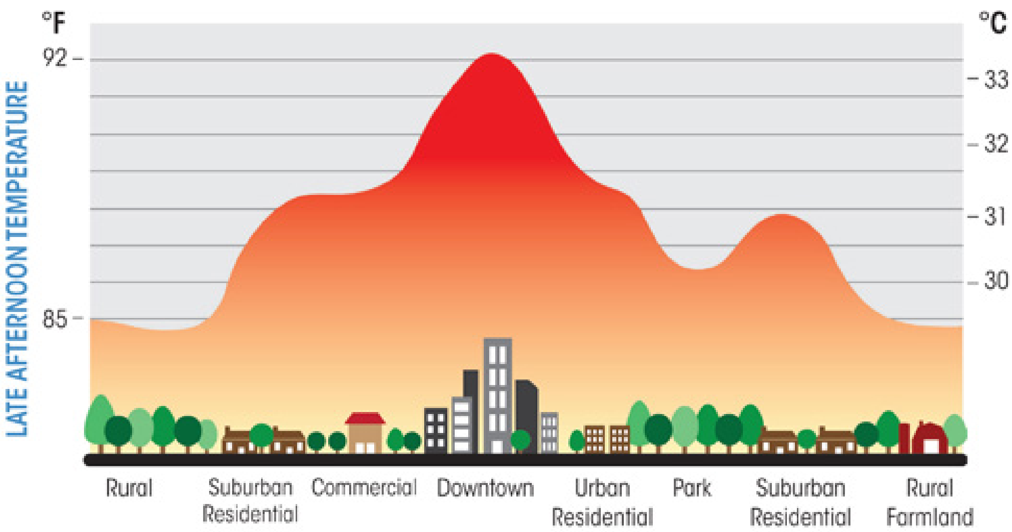
Although warm conditions affect human health, significant impacts are created by strong and prolonged events. These events, which are codified as 'heatwaves', are generally described as a period of abnormally high and quite often humid weather, usually lasting for a minimum of one day. But heatwaves that cause high or catastrophic impacts generally last considerably longer, sometimes even weeks at a time. The most hazardous conditions to human health are multi-day heatwaves where extreme daytime temperature is combined with high nocturnal temperatures, high-relative humidity and light wind conditions for a period of several consecutive days.

The UK Meteorological Office, among others, defines a heatwave by using criteria based on varying thresholds, dependent upon the region's average temperature conditions. For example, in London, heatwave conditions are declared when temperatures exceed the 32˚C upper threshold, including night-time temperatures of 18˚C or more, for a period of 5 consecutive days. In the Netherlands, a heatwave is defined as a period of five or more consecutive days with temperature above 25˚C, of which at least three days reach temperature above 30˚C ('tropical days'). Belgium uses the same definition. The average temperature conditions, and degree of heat to which people may be exposed is shaped by the geographical features of the urban landscape. An example of this consists of the large urban areas (especially built-up centres) where temperatures are disproportionally higher than in the surrounding areas because of the **urban heat island effect** (**Figure 12.1**).

Heat is particularly a problem for large urban areas containing dense populations, and because of the amplifying effects of the urban heat island as well as atmospheric pollutants. The urban heat island effect is the thermal contrast between urban space and its surroundings, primarily occurring due to non-evaporating surface materials such as asphalt and concrete disturbing the atmosphere surface energy balance (Figure 12.1). It represents the clearest expression of anthropogenic impact of climate at the local level, and may well exacerbate already high temperatures in cities, which can lead to stressful levels during periods of extreme temperature. During the 2003 event, anomalous heat produced nocturnal temperatures in London that reached 6-8 degrees higher than those found in rural environments.

Photo by pedrosala/Shutterstock.

Figure 12.1.
Temperature differences between areas with different levels of built environment.



Heat mortality and morbidity

The impacts of heatwaves on urban populations represent **an emerging environmental health concern**. Recent heat events, in particular the 2003 event, which accounted for up to 80,000 deaths (Robine, 2008) provides a stark example of this health burden across the European continent. From the period 1990-2013 at least 132,523 fatalities have been recorded in Europe due to heat-related health complications (CRED, 2013). Thus far, figures that illustrate heat-related mortality have been deeply alarming. Moreover, such figures are likely to be underestimated because of lack of surveys and misreporting, especially with regards to non-high impact events that generate a reduced societal response.

Even when a heatwave is not technically in progress, warm temperature conditions are still linked to mortality (Kovats & Kritie, 2006). Every year, a significant number of people die and/or require hospitalisation because of the physiological stress imposed by elevated levels of ambient heat. A 'j-shaped' (see **Figure 12.2**) graph often represents the connection between mortality and both cold and warm temperatures. The optimum or 'healthy' temperature is dependent on average temperatures experienced in geographical region (linked to latitude) as well as the implementation and effectiveness of adaptive measures designed to acclimatise populations to warmer or colder temperature conditions.

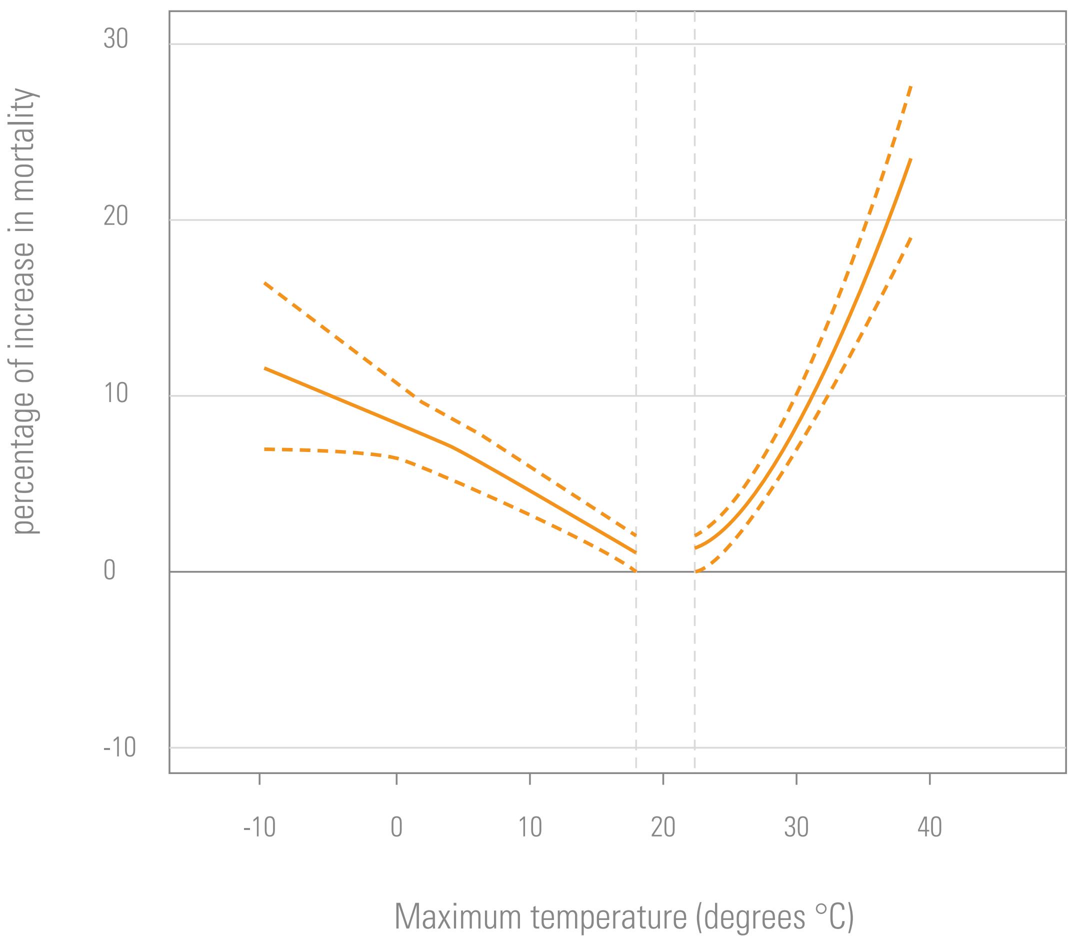
While there is a predominance of research focused on heat-associated mortality in Europe, a significantly smaller number of papers have been preoccupied with **heat-related morbidity**, even though the relationship between elevated temperature and heat-related morbidity is recognised as a serious public health issue (Ye et al., 2012). Studies have shown that the elderly (≥ 65 years of age) are more at risk for detrimental effects of heat and heat waves, including an increase in the number of hospital admissions (Gronlund et al., 2014), such as admissions for respiratory diseases (Michelozzi et al., 2009; Mstrangelo et al.; 2007; Kovats et al., 2004) and for heart diseases (Schwarz et al., 2004). Adverse health conditions that occur also more frequently during a heatwave are dehydration, hyperthermia, malaise, hyponatremia, renal colic and renal failure (Josseran et al., 2009).

Future projections of heat in Europe

Heatwaves are among small clusters of hazards firmly associated with the influences of climate change. The IPCC report 'Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation' (SREX, 2012) highlights that warming trends will probably result in more frequent, intense and persistent heat periods in years to come with the onset of anthropogenic-induced change. Climate change experts and meteorologists agree that the extreme summer of 2003, which was very unusual by historical standards, will become normal by 2050 (SREX, 2012). In terms of daily extremes, climate models suggest that a 1-in-20 hottest day will become a 1-2 year event by the end of the 21st century in most regions.

Figure 12.2.

The exposure-response relationship for temperature-associated mortality. (Source: Li et al., 2013).



Heat as a public health priority

In the United States, extreme heat is known to account for more deaths per annum than the combination of hurricanes, electrical storms, earthquakes and floods (Luber & McGeehn, 2008). In Europe, however, heat as a major hazard was underestimated until the 2003 high temperature event. The 2003 European event was thought-provoking in the sense that it appeared to be a region neither particularly exposed nor vulnerable due to the capabilities of organisations and institutions, technology and infrastructure, as well as financial strength to manage negative impacts (Lass et al., 2011). Yet, the heat experienced in the summer of 2003 serves to underscore that Europe is not invulnerable to suffering extremely high death tolls, the severity of which justifiably drew comparisons to impacts observed in low-income developing nations.

The impact of heatwaves on population health in the context of past impacts and predicted changes in prevalence and intensity is of great concern for health practitioners, policymakers and the hazard management community. Public health concerns regarding heat-mortality and morbidity are likely to increase with the synergistic effects of demographic change, urbanisation, and the climate change induced warming of the atmosphere. However, **notwithstanding the devastating historical impacts and predicted rises in heat-mortality under various scenarios, the adverse effects of extreme heat are largely preventable**. Disaster response strategies are at their most effective when populations, the health sector, emergency planners and responders, care and social services, and public infrastructure are prepared. This gives the best chance in both current and future risk to significantly reduce health-related mortality and morbidity.

One of these strategies consists of the implementation of a so-called **Heat Health Warning System (HHWS)**, which is an approach to protect humans, in particular vulnerable populations, from the detrimental consequences of heatwaves. A HHWS usually describes at least the following items:

- criteria for implementation of the plan
- role of the different stakeholders (including
- collaborations with other stakeholders)
- target groups
- awareness messages.

Following the 2003 heatwave, at least 12 countries in Europe have introduced a HHWS (Lowe et al., 2011). Since a functioning HHWS requires an intensive collaboration between a number of stakeholders, this multi-stakeholder partnership (MSP) requires coordination from one organisation, usually the Ministry of Health or the National Institute of Health. Although the main purpose is to establish the role of professionals (e.g. in elderly care facilities, or general practitioners) during a heatwave, national heat plans also contribute in increasing awareness of heat risks in vulnerable groups and their care providers. The messages are channelled through community professionals and indirectly through the media.

We assessed the MSP within the HHWSs for selected case study locations by performing a desk review and interviewing key informant stakeholders. The two selected locations were Amsterdam (The Netherlands) and Brussels (Belgium).

Multi-sector partnership on heat and health in Amsterdam

The Dutch National Heat Plan (RIVM, 2007) is aimed at managers of a variety of organisations. It offers an overview of the responsibilities and measures in health care during a period of extreme heat. The aim of the heat plan is to improve wellbeing and quality of life of citizens and reduce illness and disease due to extreme heat. One important aspect of the heat plan is to increase knowledge and raise awareness on the adverse health effects of heat, in risk groups as well as in their direct environment. This environment consists of institutes, health providers and volunteers with whom the risk groups are in contact with. Awareness and knowledge are prerequisites for an adequate response during a period of ongoing heat. The plan describes the actions that are taken in the short term to increase the sense of urgency and the willingness to undertake action, and it is described in the form of a communication plan.

Different levels of alertness within the HHWS

To distinguish between periods with different heat intensities, different levels of alertness are described in the HHWS:

(1) Watchfulness phase – This phase lasts the whole summer period (1st of June to 1st of September. It means that all involved stakeholders should prepare for the summer period and check whether all plans are still up to date. In addition, organisations should raise awareness among employees.

(2) Pre-warning phase – The second phase starts when the odds of a period with at least five days with temperatures above 27˚C are above 20%. A limited number of organisations are informed by RIVM in this stage, including stakeholders such as VWS, GGD-NL, NRK and regional health inspection departments, GGDs. The reason for this is that these organisations should be in a higher state of alertness from that point onwards, in case there will actually be a hot period. The general public is not yet informed in this stage.

(3) Warning phase – The third phase starts when the odds of a period with at least five days with temperatures above 27˚C are above 90%. Again, a message is sent out to all partner organisations of RIVM, but this time with another message. A press release is issued by RIVM and KNMI (Netherlands Meteorological Service), to inform the general public on the increased risk. Stakeholders will take pre-determined measures, e.g. an elderly care institute will launch its own heat plan. GGDs will take on their roles as regional information points. There is no explicit signal to end this phase, but this depends on stakeholders' own observation.

Multi-sector partnership

The aim of the plan is to reach a stage where involved stakeholders will take responsibility, cooperate in carrying out measures and organise their organisation in such a way that they can optimally deal with periods of ongoing heat. Below is a description of the organisations that have a role in the heat plan:

- Ministry of Health, Welfare and Sport (VWS) organises the collaboration that is aimed at making and evaluating the heat plan in a yearly cycle.
- Royal Netherlands Meteorological Institute (KNMI) monitors the weather predictions and calculates the odds of a period of ongoing heat.
- Branch of Municipal Health Services in the Netherlands (GGD-NL) is responsible for the national agreements with representatives of organisations of professionals and branch organisations that are involved in care of risk groups for heat.
- The Dutch Red Cross (NRK) maintains contact with organisations of volunteer care. They emphasise the heat plan and their contribution therein. These tasks are also fulfilled towards NRK's direct followers.
- Health care institutes – This category consists of hospitals as well as elderly care institutes.

The flow of communication goes from KNMI (responsible for monitoring weather predictions) to RIVM. RIVM informs regional contact points (GGDs) in all regions of the Netherlands, 25 in total. These contact points are mainly responsible for: providing information to the public on behalf of RIVM; serve as an information point for professionals; agree on collaborations with various care institutes. Other stakeholders that GGDs are informing in their region include volunteer organisations, home care, child care centres, municipalities, general practitioners, hospitals, and elderly care centres.

Multi-sector partnership on heat and health in Brussels

In Belgium, there are different heat plans for the different regions (Flanders, Wallonia, and Brussels). The plans for the different regions are almost identical, but the organisations and their responsibilities differ quite a lot. Since our case study primarily assesses cities, we focussed on Brussels.

Brussels has a **combined plan for heatwaves and ozone**. It starts with a description of some terminology, e.g. a heatwave and an ozone peak. After, it describes symptoms and health effects related to exposure to heat or ozone. The main risk groups are described, namely children, the elderly, socially isolated individuals and individuals who perform a lot of physical effort. In addition, it describes which factors can induce health effects due to heat (e.g. taking certain types of medication). The next section describes how to prevent or treat health effects in each of the risk groups.

Different levels of alertness within the HHWS

There are three levels of alertness described in the plan, each associated with different actions and activities:

(1) Watchfulness phase – In this phase, the general public is sensitised about the risks of heat and ozone, and they are encouraged to help family members, neighbours and other potential sensitive individuals. General information is brought forward by the health care sector and social partners. The leaflet 'Heatwaves and ozone peaks' is spread to a large number of awareness raising organisations.

(2) Warning phase – The second phase starts when a heatwave is predicted during a period of two days. Activities that are started during this phase are informing the Minister of Health and other actors in the health sector. A media campaign will start with clear preventive and curative messages for risk groups and individuals who take care of them.

(3) Alert phase – This phase is activated when the threshold is reached and when the measures that have already been taken need to be intensified. This can include further media campaigns, announcing an alert and possibly organising a risk-control cell. This cell would be able to take concrete measures, e.g. cancelling certain events.

Multi-sector partnership

Several stakeholders are specifically listed in the plan, although most of their roles are not described in detail:

- FOD is the organisation for Public Health, Food Safety and Environment, and is in charge of the heat plan and upscaling the plan to a different level.
- KMI is responsible for temperature measurements, and provides FOD with temperature predictions.
- IRCELINE is the KMI equivalent for ozone measurements.
- Minister of Health is the first one to be informed in case of an expected heat event, and the activation of the warning phase.
- Health sector consists of general practitioners, emergency rooms and other departments of hospitals, who are being informed during the warning phase.
- Social sector provides elderly care and home care through partner organisations, which are also informed during the warning phase.

In contrast to the heat plan in the Netherlands, the plan in Brussels does not provide a schematic overview of how the communication between the different stakeholders is organised. Instead, the plan seems rather top-down, where the FOD Public Health, Food Safety and Environment are solely responsible for informing all stakeholders on the activation of the alert phase.

Key informant interviews

Interviews were held in Amsterdam and Brussels. The interview outline was created in such a way that it provides an optimal perspective on the stakeholders' views on heat and health, mainly on existing collaborations with other stakeholders. We specifically asked for the opinions of the interviewees on some topics (e.g. the importance of heat as a public health priority), even though they might not always reflect the exact views of their stakeholder organisations. Since we are evaluating whether national heat plans work in daily practice, we also asked interviewees to name what they considered to be strengths and weaknesses of the plan.

Amsterdam

This section describes a compilation of the key informant interviews that were held in the Netherlands. Most of the stakeholders were aware of the National Heat Plan, although this was not the case for the elderly care organisation and the hospital. Some key informants have also provided input for the new plan that was launched in 2015. When the warning phase is indicated, many intermediaries of risk groups, such as general practitioners, pharmacies and volunteer organisations, receive a message. This does not include health care and elderly care institutes, since they should be contacted by the branch organisation for the health care sector. However, in practice this is not the case.

Most key informants feel that heat in general is an important public health priority, especially in cities. This is due to the fact that there is a relatively large impact, especially on vulnerable populations (elderly and lonely individuals), and there are easy measures to cope with this impact. Heat during big events (e.g. concerts) is also a particular area of interest, since it affects large segments of the community. The organisations that deal directly with risk groups (elderly care and hospitals) saw heat as a lower priority, especially compared to other health problems (such as infections).

It is unclear how the messages from the heat plan are perceived by the majority of the professionals who provide services, let alone by the risk groups themselves. To be able to evaluate this would require a survey among these professionals, which would lead to important insights. The message that is sent is quite non-committal, and that applies also to the roles and tasks of the different stakeholders. However, the advice that is given, e.g. on stickers that are used to inform the public, is perceived by the key informants to be quite clear. The communication link between the general population and authorities is considered to be quite passive and effort should therefore be made to intensify this contact, e.g. in the form of press releases.

With respect to partnerships with other organisations, most interviewees feel that the roles of the stakeholders could be fully clarified and more enforced. Currently it is not difficult for stakeholders to avoid responsibility and some collaborations are non-existent or still need major development. None of the stakeholders are really considering yet how partnerships should evolve in the future, due to the impact of climate change and the accompanying increase in extreme heat events.

Brussels

The Belgian heat plan was initially implemented on a federal level, within the National Environmental Health Action Plan (NEHAP), but now it works on a regional level. There is generally more interest from social organisations (e.g. elderly care) than from medical organisations, partly because the system is also more oriented at social activities. Within the plan, key informants are responsible for providing information to the general population, preparing the watchfulness phase and providing information to professionals through an email list of a large group of stakeholders. However, our interview highlighted the fact that not all organisations are aware of the Belgian heat plan.

Targeting at-risk individuals work indirectly through a cascade. Most key informants feel that the messages within the heat plan are clear for at-risk individuals, although it is important to continue improving. In addition, they are often repeated, since they are broadcasted e.g. during the weather forecasts on television. An important point of the key informants was that people who are institutionalised, according to them, are more likely to follow the recommendations than people living alone or homeless individuals.

Different organisations are in contact with each other, and several stakeholders meet once a year, when the watchfulness phase of the heat plan starts. Most key informants felt that the responsibilities of different stakeholders are not clearly described: when there is an extreme event, stakeholders do not know which tasks belong to whom. Partly this is inherent to the Belgian political system, which is divided in three regions (Flanders, Wallonia and Brussels). Communication in general is good, but less so between the social sector and the health sector. On a national level, the number of stakeholders is sufficient, but on a regional level this needs to expand further. This is particularly true for Brussels, for which the regional implementation of the heat plan started only in 2015. Some key informants feel that it might be necessary to meet more often, when there is an expected increase in extreme heat events due to climate change, although most stakeholders are most likely not willing to invest more time.

In conclusion, the existence of a heat plan is an undoubted strength, and it provides a platform for stakeholders from the health and environment sectors to meet. Weak points include a low engagement at the regional level and lack of clarity in responsibilities.

Photo by Rafal Buch/Unsplash.

Recommendations for the partnerships and suggestions for future research

First, **there is a significant difference in the perception of different stakeholders, on the importance of heat as a public health priority**. Stakeholders who have heat as one of their major objectives in their work perceive heat as a bigger priority than stakeholders who deal with heat only as a minor issue (e.g. representatives from elderly care, home care and the hospital). However, as they are the health care institutes who generally have the closest contact with populations at risk, this creates a dilemma. Based on these outcomes, **awareness of the impact of heat health among stakeholders working in these types of institutes should be urgently addressed**.

Second, there is a discrepancy between the intended stakeholders involved in the heat plans and the actual stakeholders. Even though elderly care institutes, hospitals and home care organisations are listed in the heat plans of both countries, representatives from elderly care, home care and the hospital were not aware of the existence of the heat plan, and are not informed during a hot period. This can either be due to the fact that they do not see heat as a public health priority (as discussed in the item above) or due to the fact that the current system is not able to include a good representation of the intended stakeholders. **We recommend that more research is needed to assess to what extent e.g. general practitioners undertake actions after receiving a heat warning**. The fact that we never received a reply from the circle of general practitioners in Amsterdam also indicates that they do not see this topic as a priority.

Third, there is some overlapping in the strengths and weaknesses that are perceived by the different stakeholders. Most stakeholders agree on the fact that it is useful that there is a heat plan, in which roles and responsibilities of the different stakeholders are described. However, weaknesses are that not everyone is familiar with the existence of the heat plan, and that the roles and responsibilities are not clearly described: stakeholders can decide not to undertake any actions, since none of the intended actions are obligatory and everything is voluntary. It is a conscious decision to organise the heat plan in this way, but there is no consensus between the stakeholders that this is the best approach. **We recommend that for a next version of both heat plans, a meeting is organised for which representatives from all involved stakeholder organisations are invited, so that they can discuss their views and challenges before the next version of the heat plan is finalised**. The fact that such an event was lacking was also mentioned as a weakness by one of the stakeholders in the Netherlands.

Fourth, **communication with the general public is considered rather passive, and this should be changed**. A more active approach (e.g. radio, television, press releases) could help in enticing the population in undertaking appropriate actions. In addition, more attention should be given to reaching out lonely individuals (especially elderly), since they are a group particularly at risk for negative effects due to heat.

Finally, **governments can undertake specific actions that help in reducing the risks due to heat**. They could provide shelter and water in certain places in the city during extreme heat, so that vulnerable individuals have an escape when their homes would become unbearable. Similarly, 'cold spots' could be organised during events, such as concerts.

"Stakeholder partnerships, and roles they can offer as a tool to increase health resilience, are a neglected area of both disaster studies and public health research. "

Suggestions for future research

We identified also areas for future research to address these gaps, based on the key informant interviews.

First, **there is no clarity in how messages from the heat plan are perceived by professionals and service providers**. This is important information, since it could mean that the current messages are not successful in obtaining the desired actions (e.g. whether general practitioners undertake actions for patients in their practice). To be able to evaluate this, a detailed quantifiable survey of a large sample of persons providing care to risk groups, such as general practitioners, elderly care workers and hospital personnel, would be required. This would provide a concrete and detailed overview on what the main challenges are for service provision. In addition, a check should be done to find out how complete the mailing list of recipients is.

Second, the key informant interviews show that **most stakeholders are not fully aware of the expected increase in frequency and intensity of heatwaves due to climate change**. Furthermore, climate change and its impact are not on the agenda of any of the stakeholders when it comes to heat preparation. Within the ENHANCE project, we have undertaken a study to assess the impact of heat on general practitioner consultations and emergency room admissions in Belgium and the Netherlands, respectively. When these results are combined with temperature predictions due to climate change, this could be new and valuable information for all stakeholders in question.

Photo by C. Jimenez/dreamstime.

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13

Flood risk: the EUSF and Romania

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"Re-orienting the EUSF from a post-disaster response and aid instrument to a pre-disaster, risk-based solidarity instrument."

Introduction

Between 2002 and 2014 natural disasters caused over €100 billion of economic losses in the European Union (EU). Floods are among the most significant natural hazards, with 17 of 18 EU member states reporting flood risk in their national risk assessments (European Commission, 2014). Over the last 15 years Central European member states, including Austria, Czech Republic, Germany, and Hungary, were hit twice (in 2002 and 2013) by one-hundred-year floods (Zurich, 2014). As well as causing damages totaling more than €30 billion, these two events once again demonstrated the high regional interdependency of flood risk in Europe. Taking into account these interdependencies across regions, together with climate and socioeconomic projections, we estimate (based on the A1B scenario) that **average annual flood losses in Europe could increase from the current level of €4.9 billion to €23.5 billion in 2050**. A comparison of these results with previous assessments also suggests that neglecting the spatial correlations between river basins could lead to an underestimation of continental flood risk, which has major implications for European disaster risk financing strategies (Jongman et al., 2014).

The 2002 Central European floods triggered an unprecedented political will to institutionalise financial compensation for disaster-stricken EU member countries; this led to the establishment of the **European Union Solidarity Fund (EUSF)**, an ex-post loss-financing vehicle for EU member states and candidate countries for use in cases where a disaster exceeds the government's resources to cope. Until 2014 the fund operated with an annual budget of €1 billion. However, the latest Multiannual Financial Framework (MFF 2014–2020) has halved its budget to €500 million (2011 prices) and added a temporal risk-spreading dimension (OJ, 2013). The primary aim of the EUSF is to finance emergency operations undertaken by public authorities to alleviate non-insurable damages. Hence, it covers only a fraction of the total damages: compensation has averaged about 3% of total direct losses since 2002. In addition, it should be noted that the EUSF is a 'virtual' fund – in the event of disaster, the money is raised above and beyond the normal EU budgeting procedure.

The EUSF compensates only non-insurable public damages; but public sector responsibility often exceeds those losses. Based on a cross-country sample of European natural disasters, Mechler et al. (2010) highlighted that governments, as insurers of last resort, often absorb half the direct damages because of their explicit and implicit liabilities. The post-disaster financing ability of governments varies. Based on very restrictive assumptions, Austria, for instance, is able to finance losses of up to around €3.9 billion, while Hungary and Romania could find it difficult to finance damages above €1.6 billion (Hochrainer et al., 2010). This difference in coping capacities is reflected in part in the differentiated intervention threshold of the EUSF, which, in most cases, is calculated on the basis of gross national income.

There have been on-going discussions within the EU concerning disaster risk financing in general and disaster insurance in particular (European Commission, 2013, 2015a). Experts argue that there are cases where the European NatCat insurance markets do not seem able to fully cope with existing risks (Maccaferri et al., 2012).

Some of the policy discussions are thus seeking to ascertain how great the need is for action to enhance disaster insurance penetration at the EU level. In general, the discussions aim to contribute to a more disaster-resilient European Union; most importantly, they include disaster risk reduction (DRR) as an overarching aim in the field of disaster risk management (DRM). Over the years, **although disaster risk management considerations have been reflected in a number of key policies, the EUSF is still the only dedicated EU-wide disaster risk financing instrument**.

This chapter investigates the Fund and assesses its performance as well as aims to identify alternative policy options to further enhance the financial resilience of the EU with respect to natural disasters. As the EUSF was essentially created to assist governments, we will also take a closer look at one highly flood-prone country, **Romania**, in order to gain a better insight into how the advanced operating systems already in place could be enhanced. The investigation focuses on the key stakeholders and their perceptions regarding the limitations of current operating systems and how these could be addressed by, inter alia, the EUSF. Romania is a natural choice, as floods are a devastating phenomenon there. The country has suffered from frequent flood-related disasters as well as major associated economic losses. Over one million hectares (ha) of land are exposed to flooding; nearly one million Romanians live in high flood risk areas; and over 900 communities in the country are situated in high flood risk areas (Romanian Waters National Administration 2013). Table 13.1 indicates the total losses, damage, and EUSF funding for major events in 2005, 2008, 2010, and 2014.

Table 13.1.

Major flood losses and EUSF interventions since 2002 for Romania (Source: European Commission, 2015b).

Occurrence	Nature of disaster	Category	Damage (million €)	Aid granted (million €)	Total aid granted (million €)
April 2005	spring floods	major	489	18.8	
July 2005	summer floods	major	1.050	52.4	
July 2008	floods	regional	471	11.8	
June 2010	floods	major	876	25.0	
April 2014	spring floods	neighboring country	168	4.2	
July 2014	summer floods	regional	172	4.3	**116.5**

Disaster risk financing in Romania relies strongly on ex-post financing instruments, such as the government's Intervention Fund, budget reallocation, donor assistance, and domestic and/or external credit and aid granted by the EUSF. It also has ex-ante instruments in operation. Among the most important are mandatory and optional property insurance schemes. The financial protection against damage from natural catastrophes is thus achieved **by a mix of compulsory and optional insurance and state intervention**.

In line with the main objectives of the ENHANCE project (see chapter 1), **this chapter focuses on two multi-sector partnerships (MSPs)**:

(1) At the EU level, where the only dedicated disaster risk financing instrument is the EUSF, we assess the options and benefits of formulating **an EU-wide MSP** to enhance pan-European disaster resilience.
(2) In the context of Romania we focus our attention on **an existing partnership between the public and private sectors**.

The assessment is based on various methods, including state-of-the-art quantitative risk analysis, multi-criteria assessment, stakeholder workshops, and a large-scale survey. With respect to specific risk management and adaptation strategies to increase the resilience of different stakeholders or risk bearers, we distinguish between different scales and include possible dependencies among them via the EUSF mechanism.

Photo by Baloncici/Shutterstock.

A risk-based assessment of current policies

For a risk-based assessment of the EUSF and multi-sector partnerships, the first priority is **a comprehensive, continental flood risk analysis**, including the comparison of different adaptation options (**Table 13.2**; see chapter 2 for the methods used here). As the EUSF operates on the pan-European level, one major outcome of our assessment is the importance of taking **river basin dependencies** across countries explicitly into account in order to avoid the severe underestimation of continental flood risk, especially for extreme events (Jongman et al., 2014). At the same time, the analysis demonstrates that the increasing risk could be manageable using a **combination of various disaster risk management options**, such as risk reduction and insurance instruments (Jongman et al., 2014). For example, raising the flood protection standards in all basins to a minimum of 1 per 100 years could decrease the total expected annual flood losses by around €7 billion (close to 30%) by 2050. Increasing insurance penetration, on the other hand, does not itself reduce risk but rather reallocates the financial burden across public and private stakeholders (Table 13.2).

Table 13.2.
Continental flood risk assessment considering various risk management options (Source: Based on Jongman et al., 2014; Supplementary Section).

Options	Year	Uninsured loss (billion €)	Insurance claims (billion €)	EUSF claims (billion €)	Additional investment in DRR (billion €)
BAU	2013	4.48	1.89	0.35	0.0
	2050	17.55	4.64	1.29	0.0
50% insurance penetration	2013	2.86	3.51	0.35	0.0
	2050	10.45	11.74	1.29	0.0
100% insurance penetration	2013	0.00	6.45	0.00	0.0
	2050	0.00	22.28	0.00	0.0
Min 1/100 protection standards	2013	3.17	1.34	0.25	0.49
	2050	12.42	3.28	0.92	1.72
Min 1/300 protection standards	2013	1.00	0.42	0.08	1.24
	2050	3.92	1.04	0.29	4.56

As already indicated, under the business-as-usual (BAU) scenario, increasing losses will put high pressure on the fund. Table 13.2 shows that the average annual payments from the Fund can increase from the current level of €350 million to €1.29 billion. Compared to the old EUSF budget, this equates to 9% of annual probability of depletion (on average, once in every 11 years) by 2050. Because of its additional temporal risk-spreading dimension, the new budget structure increases the Fund's robustness, but only marginally so (Hochrainer-Stigler et al., 2015).

Based on a detailed assessment of the EUSF applications, a third important finding is that despite its name, **the Solidarity Fund does not necessarily show solidarity among member states**. Hochrainer-Stigler et al. (2015) demonstrated that the Fund allocates significantly more aid as a percentage of eligible costs to those countries that are most able to withstand the financial impact of disasters. Thus, if solidarity is defined as a needs-based concept, the Fund's performance is questionable. On the other hand, an investigation of 25 EUSF interventions in the five-year period from 2008 to 2013 suggests that, in most cases, less wealthy new member states have been net gainers from the Fund. This means that countries less able to cope with the economic consequences of disasters have generally contributed less to the pool in relation to their expected losses than those with higher coping capacity. This can be seen as a form of contribution-based solidarity, similar to an insurance pool with cross-subsidised premiums. However, it should still be noted that contribution-based solidarity stands in stark contrast to needs-based solidarity, where aid is awarded to countries based on their ability to cope and irrespective of their contribution.

As well as the funding issues and possible MSPs for reducing current and future risk at the pan-European level, another important dimension includes **perceptions at the national level**. The EUSF as an ex-post fund may encourage EU governments to take fewer prevention measures, as they do not bear the full cost of this behavior (often referred to as moral hazard). The recent reforms of the Fund address this issue, actively encouraging member states to implement disaster prevention and risk management strategies via a requirement to report before and after applications. The European Commission can even reduce or refuse a grant if a member state repeatedly breaches its obligation to implement EU law regarding preventive measures (OJ, 2014). In practical terms, the latter mainly concerns flood risk and, at least in theory, makes EUSF aid conditional on the implementation of the Floods Directive. The results in the Table 2 above were used in a key stakeholder workshop in Brussels which discussed the feasibility of possible schemes to be implemented in the future. At the workshop, relevant Romanian ministries also shared their experience. This is discussed next.

Generally speaking, in Romania the insurance industry has developed considerably since the fall of Communism in 1989. At first, insurance density was very low (Petrescu, 2009). Today, however, the supply of insurance is diversified and the insurance sector is fully integrated into the world wide insurance industry. There are currently 36 insurance companies operating in Romania, with all the largest companies represented. The potential of the insurance market in Romania is recognised as high, not least due to the large size of the country and the large number of people and properties at risk. However, real demand is quite low, and the financial crises have depressed demand still further. Moreover, insurance demand is not spatially uniform but concentrated in geographical areas of high economic potential and above-average incomes. Thus, the largest insurance premiums were underwritten in 2014 in the Bucharest area, that is, around 49.88% of the national total (ASF, 2015).

Insurance in Romania has some unique characteristics. It **takes the form of an already established multi-sector partnership. Law 260/2008** regarding **mandatory home insurance** created a public-private partnership – linking home owners, insurance companies, and local and central authorities. Its role was to manage financial risk associated with floods, landslides, and earthquakes through insurance (Parliament of Romania, 2008). In November 2009, twelve insurance companies came together to form the Insurance Pool against Natural Disasters (PAID). According to Law 260/2008, homeowners must insure their buildings against three natural risks: flood, earthquake, and landslides. Homeowners without mandatory home insurance are subject to a fine which is collected by the local public authorities. As discovered during workshops in Bucharest, the local public authorities play an important role not only in the prevention of risks but also when disasters occur (evacuation, shelter etc.).

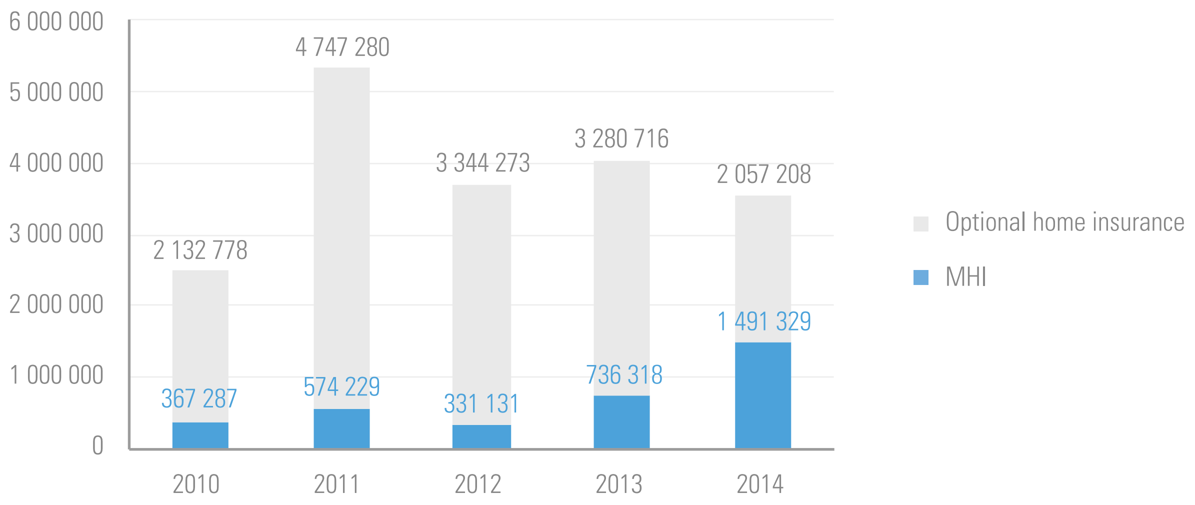
As indicated, the law was intended to be a mechanism for collaboration between the public authority, the private insurance industry, and homeowners, and thereby to incentivise risk reduction for households, given that the government was no longer legally bound to provide financial compensation to homeowners to rebuild their properties after flood-, earthquake-, and landslide-related disasters. The greatest added value of this mechanism is seen as the prevention of financial risk related to natural catastrophes.

However, the insurance mechanism has been debated heavily over time, and several changes have been made to the legislation on mandatory home insurance. **Law 243/2013** was promulgated to modify and complete Law 260/2008. Under it, other insurance companies were authorised to supply **optional insurance** for catastrophic risks and signed cooperation protocols with PAID to close mandatory home insurance contracts (Parliament of Romania, 2013). The first mandatory policy on home insurance was issued in July 2010. At the end of 2010, there were 2,132,778 optional home insurance contracts, and 367,287 mandatory contracts related to 8.3 million privately owned homes in Romania (4.5 million in urban and 3.8 million in rural areas) (ASF, 2015). In 2011, the highest number of optional home insurance contracts 4,747,280 (and 574,229 mandatory) was written, amounting to a 63% insurance coverage of homes in Romania. In 2014, the number of optional home insurance contracts decreased to 2,057,208 and the number of mandatory home insurance contracts increased to 1,491,329 (see **Figure 13.1**).

The analytical methods and tools applied to study the risk and performance of the MSP were both qualitative and quantitative; they included semi-directed interviews, workshops, and large-scale surveys. Workshops and semi-directed interviews were conducted in 2014 among insurance companies, public authorities, including the ministry of finance, flood and water management officials from the ministry of the environment, and specialists in the environment and insurance. Additionally, in May 2015 **a large-scale survey of homeowners and insurance companies was conducted**. Because of space restrictions, we focus here not on details but on key results. The survey aimed to focus on the perception of i) **natural disaster risks** and ii) **the main instruments for recovery and risk protection in specific households**. We studied the general perception of mandatory home insurance and the main factors influencing it. We were also interested in the perception of the insurance premium, the sum insured, and the quality of the relationship between the stakeholders – the population, the public authority, and the insurance companies– and, last but not least, the perception of the usefulness and mechanism of the EUSF. In total, 461 households were interviewed, as well as 117 respondents from insurance companies and brokers.

Figure 13.1.

Evolution of the number of optional and mandatory home insurance contracts 2010-2014 (Source: ASF 2015 data).



ENHANCE Workshop in Bucharest, Romania, October 2014.

Summarising the findings from the survey, in the opinion of both home owners and insurers, earthquakes and floods were perceived as the most dangerous events. The local authorities have the main role in fighting natural catastrophes; however, the central authority, the insurance companies, the population, and the EUSF were also perceived as important in the prevention of natural catastrophes and recovery following them. As far as preparedness to deal with natural disasters is concerned, homeowners consider EU institutions to be better prepared, while insurance companies and brokers consider insurers to have higher preparedness. Conversely, respondents considered the population and the local/central authorities to have low preparedness.

The perception of the natural disaster-related activity of insurance companies in Romania is favorable; the mandatory home insurance is perceived as necessary, but not sufficient, for protection against natural disasters. Insurers have a more positive view regarding mandatory home insurance and the relationships between the stakeholders. Mandatory home insurance has limited coverage (and was seen as insufficient for covering risk). This has generated the need for optional insurance to include additional risk. In the case of mandatory home insurance, the insurance premiums in the sample are perceived as being moderate, but in the opinion of homeowners they are still rather expensive. The main reason for homeowners not having mandatory home insurance was 'not having enough money' (53.15% of total). Other reasons for not buying mandatory home insurance included i) a lack of understanding of the necessity of mandatory home insurance and ii) lack of information about mandatory home insurance.

The EUSF is considered by 87.9% of homeowners and 90.6% of respondents from insurance companies and brokers as an efficient tool in recovery after natural catastrophes. It is also perceived as vital for post-disaster recovery for the member countries of the EU by 75.7% of the population and 72.6% of insurance specialists – a very positive view of the EUSF. We also asked for best ways forward. In that regard, the majority of respondents thought that **the EUSF should be reoriented to incentivise prevention**. The respondents emphasised that the EUSF should allocate funds for consolidation of buildings, dam infrastructure, riverbeds, and reforestation (87.2% of homeowners, 81.2% of insurers and brokers). Additionally, 61.8% of homeowners and 58.1% of insurance-sector respondents indicated that the EUSF should be oriented toward prevention through the allocation of funds for insurance/reinsurance purposes. Given the nearly same perspectives on some aspects of the EUSF at both the pan-European level and the local level (at least for Romania), a workshop in Brussels was coordinated to discuss and evaluate promising new steps forward to enhance resilience through new multi-sector partnerships.

Policy recommendations

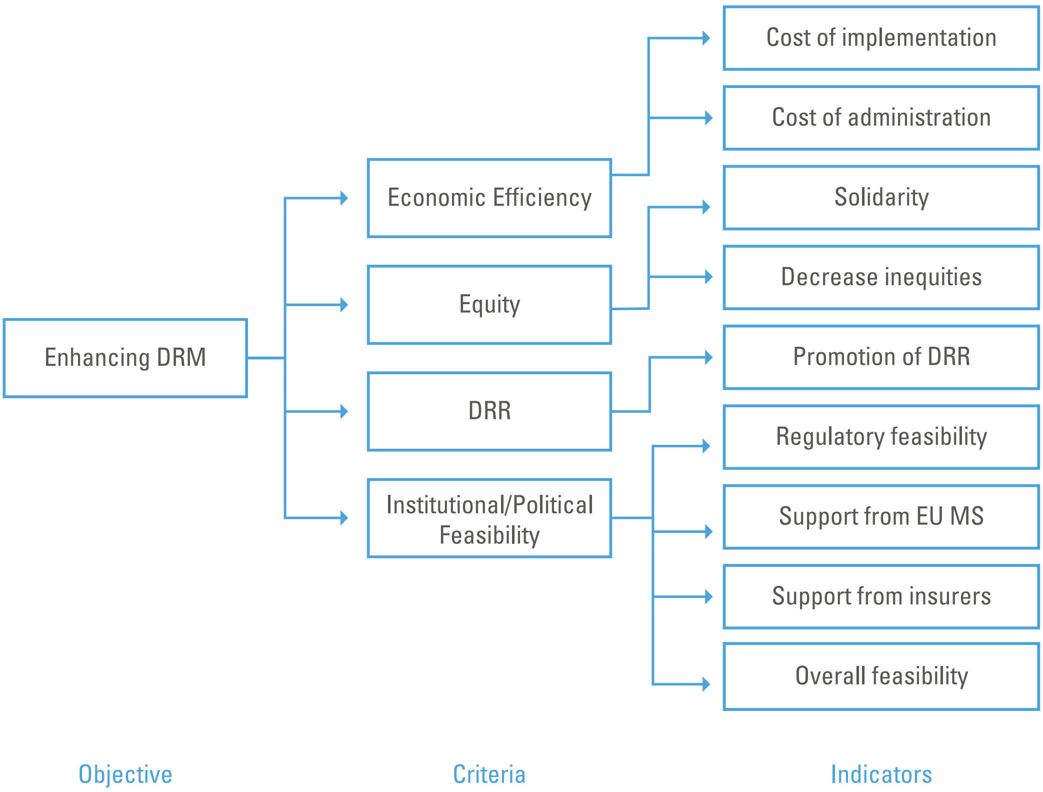
The quantitative assessments outlined above suggest a combination of various risk management instruments at the European and national levels, including the EUSF, risk reduction, and insurance, that can eventually create significant benefits (Table 13.2). However, a quantitative assessment like this falls short in that it does not take into account important qualitative aspects, such as political and institutional feasibility considerations. We thus combined the quantitative analysis with a more nuanced approach that takes explicitly into account the views and preferences of key stakeholder groups. In so doing, we applied **a state-of-the-art multi-criteria approach** within a workshop setting involving stakeholders from the public and private sector, and from the non-governmental and research communities. We now discuss the outcomes. Again, due to space limitations only an overview can be provided. We refer to chapters 2, 3, and 5 for more information (see also Hochrainer-Stigler and Lorant, in progress).

The framework of our multi-criteria analysis builds on the work described in Chapter 5 and a previous study by Bräuninger et al. (2011) which assessed risk financing options for Europe based on a set of criteria and indicators; this was adapted for our assessment (**Figure 13.2**). Economic efficiency covers the cost implications of operationalising and running the instrument. Equity relates to how strongly the instrument promotes solidarity and creates inequities (winners and losers). Feasibility relates to the the instrument's consistency with other policy instruments and the regulatory environment, and its acceptability to the key interest groups. Unlike Bräuninger et al. (2011), we introduced the promotion of disaster risk reduction as a separate criterion. Based on these criteria and the related indicators, a set of questions was developed and pre-tested in a number of test runs in order to determine further questions and to test the clarity and adequacy of the proposed questions .

Based on the results of the quantitative assessment discussed in section 2 above, **a risk layer approach** (see Mechler et al. 2014) was adopted during the workshop to identify three different options for multi-stakeholder partnerships:

- **Option 1**: eliminate the upper limit of the Fund, which is currently €500 million annually (with optional borrowing from previous/subsequent years) with the aim of responding to all qualifying disasters.
- **Option 2:** further strengthen the link between the EUSF and disaster risk reduction contributions to the Fund not only to take into account the economic performance of member states but also the risk reduction measures implemented by the country.
- **Option 3:** completely or partially transform the EUSF into a pre-disaster instrument that supports (reinsures) a national (public/private) insurance system with more affordable premiums and higher disaster insurance penetration in the EU (less dependence on post-disaster government assistance).

Figure 13.2.
Criteria and indicators for assessment of options.



A new state-of-the-art multi-criteria tool (the **Preference Decision Wizard based on the CAR method**) (Danielson & Ekenberg, 2015) was used for the evaluation. It enables information and evaluations to be handled in an automated way. Details of the analysis can be found in the ENHANCE Deliverable 7.4 and Hochrainer-Stigler and Lorant (in progress); here we give only a brief overview of the results.

From a policy-making point of view, choosing the option with the highest overall satisfaction rate across the groups does not necessarily lead to the most appropriate outcome, as one should also consider how satisfaction is distributed among different stakeholders. In general, a more evenly distributed satisfaction level can increase acceptability across the board. Our analysis revealed that stakeholders as a whole considered the link between disaster risk reduction and the EUSF (Option 2) as most satisfying in terms of the four criteria described above (see Figure 13.2). Nevertheless, it should be noted that the most radical option (Option 3) – the complete transformation of the EUSF – also showed similar satisfaction levels and had the additional benefit of more evenly distributed satisfaction levels across different stakeholders. Option 1 performed worst compared to the other two options. Next we present some policy recommendations.

As indicated, we have chosen three risk instruments as the focal point for our assessment of MSPs, namely, the EUSF, insurance, and risk reduction. As the quantitative analysis shows, the combination of these instruments can create significant additional benefits, including increased robustness and decrease in overall risk, as well as various co-benefits. However, the workshops in Brussels and in Romania have revealed that various boundaries of an institutional, political, or efficiency-related nature need to be overcome. **We thus stress some necessary conditions for possible MSPs on the pan-European level and how they could be linked with the country and household level**: First, any strategy for upcoming successful MSPs has to recognise that there is no 'one-size-fits-all' approach from the European to the individual member state level. In other words, **a flexible European framework is required** that allows member states to develop and implement tailor-made strategies. Secondly, there is **a need to precisely define responsi-**

bilities in terms of disaster risk reduction and risk financing of stakeholders at different policy levels (from local to regional to national). Thirdly, **prevention measures to reduce risk need to be supported in the long run** and not switched away (as in the past) due to non-disaster risk related circumstances. Fourthly, **communication about risk financing measures and their costs and benefits** is essential for understanding, valuing, and accepting MSPs.

We further found that the **explicit incorporation of risk due to natural disasters within the government budget** (and planning process) is very likely a key aspect for any successful MSP to enhance the resilience of its society to catastrophic natural hazard impacts. It has already been noted in other publications (see IPCC 2012; and more recently Mechler & Hochrainer-Stigler, 2014) that a substantial risk of unaccounted-for disasters (also called a hidden disaster deficit) coupled with weak fiscal conditions can lead to major additional stress on the fiscal position and eventually to reduced fiscal space for public finances to fund other public investment projects. It was therefore suggested that to reduce fiscal vulnerability, ex-ante risk management and financing measures can be taken, such as implementing risk prevention, offering state-sponsored insurance to households, or engaging in sovereign risk financing measures. It is important to note that, conceptually, this array of measures transforms the contingent disaster liability into a direct liability which could be paid for with, for example, certain annual premiums, fund outlays, and debt service payments. Such options can help to move some disaster risk liabilities to regular budget practice and could lead to, on the one hand, improved accountability and, on the other hand, clear incentives for risk reduction (being specifically accounted for in the budget balance sheet promotes the implementation of such measures). However, as indicated, to transform a contingent state of disaster risk into a certain one, a probabilistic approach using an estimate of risk is necessary. The following simplistic visualisation of a government balance sheet can serve as a basis for planning and for inclusion of contingent risk (**Table 13.3**; see Mechler & Hochrainer-Stigler, 2014 for further discussion).

Table 13.3.
Government liabilities and disaster risk (Source: Based on Mechler and Hochrainer-Stigler, 2014).

Liabilities	Direct Obligation in any event	Contingent Obligation if a particular event occurs
Explicit Government liability recognised by law or Contract	Foreign and domestic sovereign borrowing, expenditures by budget law and budget expenditures	State guarantees for non-sovereign borrowing and public and private sector entities, **reconstruction of public infrastructure**
Implicit A 'moral' obligation of the government	Future recurrent costs of public investment projects, pension and health care expenditure	Default of subnational government or public or private entities, **disaster relief**

Photo by Petrescu Ștefan (2008), Romania. O perspectivă aeriană (Romania. A Bird's eye View), Uranus: Bucharest.

In principle, this approach could be also implemented at the pan-European scale. The Committee on Regional Development of the European Parliament indicated that the rationale for financing the EUSF outside of the EU budget is that it is impossible to know in advance how much will be drawn from the Fund in the course of the year (European Parliament, 2012). However, this is not the case, given that estimates of risk are now available, and explicit incorporation of risk should be possible at the pan-European and the country level. Incorporating these disasters into the budget planning process also provides an opportunity to estimate the benefits of risk reduction in monetary terms, for example, through reduction in annual average losses, etc. As we have seen via the quantitative modeling approach applied at the pan-European level, risk reduction could also have many benefits in terms or reduction of the individual risk of MSPs, for example, an increase in robustness of the EUSF and a decrease in the capital needs of insurers.

Based on the expert judgments presented during the workshops, we can conclude that increasing the size of the EUSF (Option 1) is the least feasible option at the moment. On the other hand, creating a stronger link between the Fund and risk reduction, or the complete transformation of the Fund to an MSP (namely, a more radical option) are both considered good options and regarded as satisfactory for many stakeholder groups. If, as suggested, risk is explicitly budgeted for, then risk reduction investments could, at least partially, be financed via the insurance sector. Moreover, part of this decrease in risk can also easily be transferred to decrease premiums. As seen in the case of Romania, money from the EUSF fund can only be used to repair damaged infrastructure up to the level before the disaster occurred, that is, it cannot be used directly for risk reduction. If the government includes in a part of its budget a contingent for disaster appearing, it could use this money to build back better and the EUSF to restore assets to the original state (a major point within the Sendai Framework for Disaster Risk Reduction 2015-2030). Hence, a direct link between the EUSF, government risk, risk reduction, and insurance can be made if the risk is explicitly accounted for in the government budget.

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14

Controlled flooding as a last resort of flood control

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Flood risk in Italy and in Emilia Romagna

Italy is notoriously prone to natural hazards and disaster risk. Among the 28 EU Member States (MSs), Italy has experienced the largest economic damage from natural hazards over the period 1980-2013, according to a recent analysis of the European Environmental Agency (EEA). The damage to tangible physical assets topped €112 billion (in 2013 Euro value), on average ~ €3.3 billion per year. This is about a quarter of the damage registered over the rest of the EU. With about 30% of the recorded damage, floods are second only to earthquakes in terms of damage (Mysiak, 2015).

These estimates capture the physical asset damage over a medium-long period. Low-probability/high-impact events are not fully represented. The simulated expected annual damage (EAD) from floods in Italy has been estimated to around €800 million (Feyen et al., 2012; Rojas et al., 2012a, 2013), or higher if the spatial correlation between the flood risk across the major river basins is taken into account (Jongman et al., 2014). A more recent Pan-European study has positioned the EAD higher (Alfieri et al., 2015). The insurance industry commissioned study estimated annual average fluvial flood loss to residential properties in Italy to €230 million a year (ANIA, 2011). The flood hazard and risk mapping conducted in the context of the Floods Directive (FD) (EC, 2007) revealed that respectively around 4.0%, 8.1% and 10.4% of Italian territory (12.000; 24.000 and 31.500 sq.km) is prone to high (return period/RP 1:20-50 years), medium (RP 1:100-200 years) and low (RP 1:300-500 years) risk (ISPRA, 2015). As a result of climate and socio-economic changes, the EAD from floods is projected to increase by factor 2-5 by the end of the century (Alfieri et al., 2015; Ciscar et al., 2011, 2014; Feyen et al., 2012; Jongman et al., 2014; Rojas et al., 2012a, 2012b, 2013).

Emilia Romagna (RER) is the second most flood-exposed among the 20 Italian administrative regions, after Lombardy. According to our analysis of geo-localised floods, the total registered damage in RER amounted to €7 billion over the past 34 years. The extent of area exposed to high, medium and low hazard amounts to 2.500 sq.km (11%), 10.250 sq.km (46%) and 7.980 sq.km (36%) respectively (ISPRA, 2015). In terms of population living in the exposed areas, RER is second only to Tuscany for the low-probability hazard exposure, while maintaining the infamous primacy for the medium and high flood hazard scenarios. Notably, more than 60% (2,760 million) of the RER residents live in areas prone to medium-level hazard and more than 40% in the areas prone to very low-frequency type of hazards. For comparison, around half of the Italian population that lives in areas exposed to medium-level hazard resides in RER.

Our research examined how impairments to infrastructure designed to drain low-altitude areas in the downstream part of the Po River Basin increases the flood risk and amplifies the ensuing economic damage. The analysis informed the multi-sector partnership (MSP), rooted in an inter-regional civil protection agreement, and negotiated among a multitude of public and private institutions including the river basin authority, the regional and provincial administrations, land reclamation and irrigation boards, civil protection agencies, and the land holders.

We have contributed to (1) better delineating the areas exposed to higher flood risk as a result of inoperable DS; (2) outlining flood-prone areas under different precipitation and DS disruption scenarios; and (3) determining the economic losses caused by the controlled and uncontrolled floods, in terms of capital stock damage and foregone production losses.

Photo by Amidala/Shutterstock.

Multi-sectoral partnership

The MSP was formed as a response to the temporary disruption of drainage system (DS) in the low-altitude floodplains at the foot of the Tuscan-Emilian Apennines between the rivers Po, Secchia and Enzo. The DS disruption was caused by earthquakes in May 2012, with epicentres of the two major quakes (5.8 and 5.9 RS respectively) less than 30 km away from the study area. The DS consists of river embankment, drainage channels and pumping stations developed over centuries. The sophisticated system of the gravitational water drainage is complemented by water uplifting plants enabling to discharge the water to Secchia when the high river levels do not permit natural emission. The earthquake damaged the critical nodes of the DS, especially the pumping plants Mondine and San Siro, compromising the flood risk protection. As a consequence, almost 100 sq.km of residential, 85 sq.km of industrial and 840 sq.km of agricultural land turned into flood-prone area in the case study area and elsewhere. The affected area holds several middle-sized urban centres (20–60 thousands residents), pieces of central infrastructure systems (high speed train Milano-Bologna-Rome; highway A1 and A27), and major industrial areas.

Conceived as a provisional arrangement until after the full capacity of the DS has been restored, the MSP consents controlled floods on agricultural and/or scarcely developed rural land, to protect settlements and industrial facilities in areas prone to the exacerbated flood risk. The designated areas are neither equipped for holding flood water nor secured from damage.

The major partners in the MSP include on the emergency response side the Civil Protection Agency/Mechanism (CPA), and on the risk prevention side the Land Reclamation and Irrigation Boards (LRIB), in our case the LRIB Emilia Centrale (LRIB-EC), the LRIB Burana and the LRIB Terre dei Gonzaga in destra Po (LRIB-TG). The LRIBs are public bodies established as consortia of real estate property owners within a delimited hydrological district. They embody water institutions with long history, the predecessors of the LRIB-EC had been established back in the 1870s. The landholders in the areas designated for controlled floods are active partners to the MSP-F. The partnership, promoted and overseen by the Po River Basin Authority (PRBA), was sanctioned as an **inter-regional emergency management plan** (PIE, 2012) signed by the presidents of the regions Lombardy and Emilia Romagna. The regions, the first-level administrative divisions of the state, exercise ample control over the water resource management and vest vital responsibility for disaster risk management. The presidents of the respective regional councils were designated Commissioners Delegate in the sense of the law 225/1992[20]. The emergency plan clarifies the role and tasks of organisations concerned, designates areas for controlled flooding, and establishes an inter-regional crisis intervention unit. The plan determines the roles and tasks of other organisations who are not partners to the MSP-F per se but whose participation is essential during the emergency response. The provisions of the plan are to be transposed to district-level and municipal emergency response plans.

[20] Law of 24 February 1992, n. 225 'Establishing the National Civil Protection service'.

“Although the Po River Basic District is believed to be exposed to relatively low seismic risk, the 2012 earthquake has demonstrated that low does not mean non-existent. ”

Photo by Rafael Ben-ari/dreamstime.

Risk-based assessment

Improving and enhancing the risk assessment

Our research comprises hazard and risk model development; simulation and assessment of risk, and wide-ranging policy analysis. By use of the empirically recorded structural damage caused by a recent flood event in the case study area (the Secchia levee break in January 2014), we have revised and extended the model for assessing the damage on residential properties and agricultural land (Amadio et al., 2016).

After our adjustments, the maximum damage values for residential buildings were decreased 4 to 4.5 times and the simulated damage assessment tallied the empirical records. Similarly, the added agricultural damage module that reckons temporal variability in production patterns and crop value resulted in halving the maximum crop-yield loss per hectare compared with one of the benchmark models. Besides tangible physical assets, we have analysed the production (output or flow) losses arising from the floods. By gross value added (GVA) information available for detailed spatial units, we have compared the damage inflicted on tangible physical assets with economic losses that arise as a result of foregone production. The latter may either be a consequence of productive capital impairment, and hence a counterpart of physical damage, or a result of business interruption. In either case the output losses are better estimates of fiscal repercussions than the structural damage alone.

In Koks et al. (2015) we have analysed the effects of various modelling tools, notably the **Input-Output (IO)** and **Computable General Equilibrium (CGE)** models, on the estimated output losses as well as their spill-over effects on other regions in Italy. To this end we have replicated the 1951 Polesine flood disaster in Veneto under present-day socio-economic circumstances. In addition to the reconstructed event, we have simulated the levee break on the opposite side and subsequent flood in the Ferrara province in the Emilia Romagna region. Both flooding scenarios yield comparable structural asset damage (around €2 billion each), but the share of industrial damage is much higher in RER (35%) than in Veneto (15%). This has important implication for the ensuing output losses at national level that are under all model experiments almost double as high for the RER flood scenario compared to the flood scenario in Veneto.

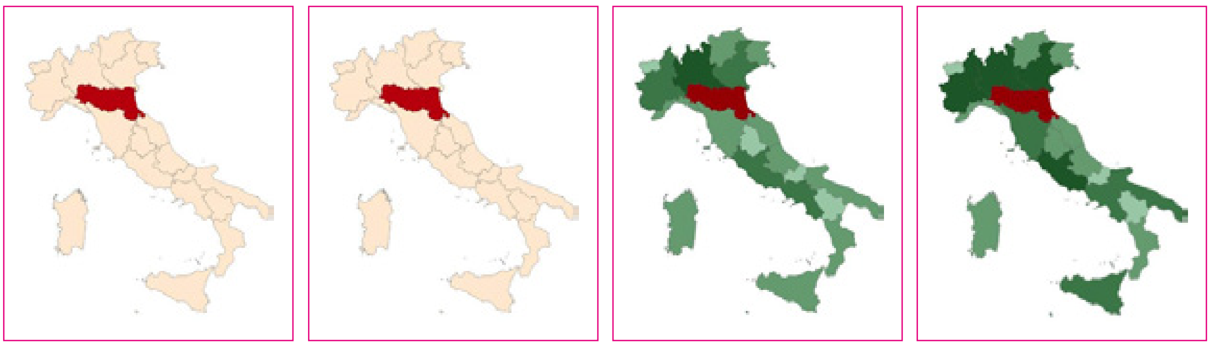
The replicated and simulated flood events were analysed subsequently using **two models built upon the IO approach** and the **regionalised CGE model**. The model comparison for the same events are valuable both from methodological and practical point of view. Firstly, the comparison is useful for identifying model features that determine the entity of loss, its distributions across regions, and the total impact at national level. Secondly, the model results produce a range of possible impacts on the primary affected regions as well as on the other regions that are not affected by the flood scenario itself but by the economic and trade relations. In line with our expectations, the CGE model yielded lower output losses compared to the two hybrid IO models. At regional level, the models yielded less diverging results. Notably, the two IO models yielded different distributions of losses across regions that are at least to some extent reproduced by the different set-up of the CGE model.

In Carrera et al. (2015) we have analysed the **output losses caused by floods across all Italian regions**, including the RER region. This analysis is based on the flood inundation data obtained from the Joint Research Centre (JRC, Rojas et al., 2013). The flood-prone areas are based on LISFLOOD (Van Der Knijff et al. 2010) model simulations forced by 12 different regional climate simulations (Van der Linden and Mitchell, 2009) for the SRES A1B scenario. Production losses are modelled using a vulnerability function that associates the simulated flood depth to the length of the disrupted production. The impacts calculated for each climate simulation have been used as input to the regional general equilibrium model (R-CGE). The R-CGE model estimates the output losses (or gains) separately for each region, flood probability and future time period. The results show that the expected annual output loss (EAOL) under the current climate totals to €191 million for Italy and around €14 million for Emilia Romagna (ranking 7th most affected). The distribution of EAOL losses is highly uneven, with the most economically developed regions in the North suffering from the largest production shortfalls. Interestingly, because of the low flood protection standards, Sicily tops all other regions, followed by Lombardy and Veneto. By the end of the century, the EAOL is expected to increase threefold to €620 million for Italy and €36 million for RER.

Furthermore, we have analysed the **fluvial and coastal flood risk in RER** (**Figure 14.1**) under current and future climates in a similar way as in the previous paper (Carrera et al., 2015) but under different configuration (Mysiak et al., under preparation). We used both the older and the newest flood simulation from JRC and the R-CGE model to assess the economic output losses. A better distribution of wealth and production activities (see also further down) was instrumental to a better appreciation of economic risk from floods. The estimated EAL under the current climate in this work is double as high (€26 million) for RER as in our previous work. This difference is attributable to improved distribution of gross added value (GVA) on the basis of detailed economic accounting (below the NUTS3 level) and on dasymetric mapping of socio-economic variables. The most recent flood hazard simulations lead to higher EAL (€80 million for RER). The economic losses due to climate risk range between 50% and above 100% of the economic damage, depending on the model set-up. By the 2040s, the human induced climate change may amplify the damage and losses caused by extreme weather and climate events with 20-40%. Climate variability and change has sizeable spill-over and distributional effects. Flexible economy may double the costs to the directly affected region. These costs arise from temporary transfers of capital and labour to other, non-affected regions. The gains of the latter regions equate the amplified losses of the directly affected region.

Figure 14.1.

Fluvial and coastal flood risk in Emilia Romagna Region (RER) under current and future climates, using different economic modelling setups (inflexible/ flexible).



(A) Inflexible R-CGE set-up according to 1980s climate

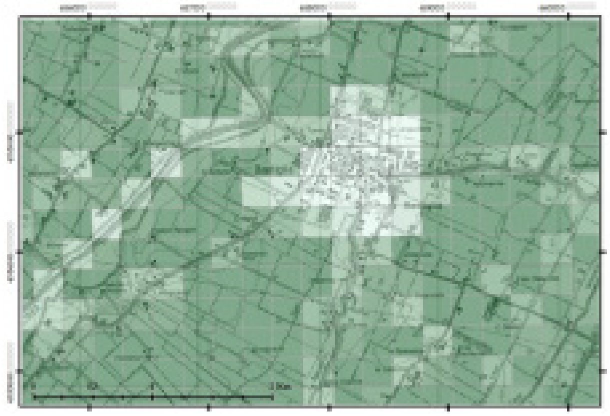
(B) inflexible R-CGE set-up according to 2040s climate

(C) Flexible R-CGE set-up according to 1980s climate

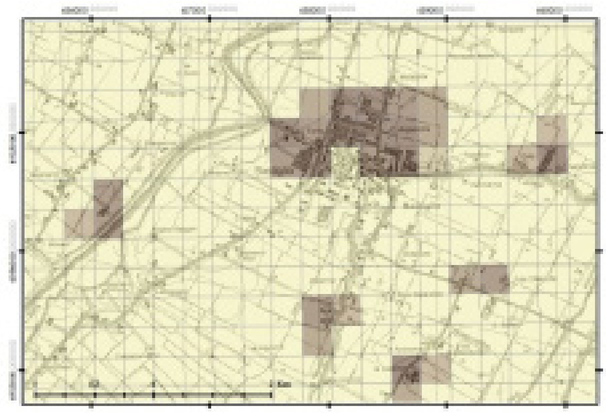
(D) Flexible R-CGE set-up according to 2040s climate

We have also analysed the coastal flood risk in RER (Figure 14.1). Around 20% (€360 million or 0.25% of GRP) of the GVA generated in the 1km wide coastal zones of RER and exposed to medium (p=0,01) risk is below 1m altitude. Some 45% (840 million or 0.65% GRP) of GVA are below 1.5m altitude. Three quarters of the exposed value is generated by services. In the absence of detailed coastal flood simulation, the GVA loss is a good proxy of the GRP losses under inflexible model set-up. Around 30% (€660 million) and almost 60% (€1,3 billion) of the coastal zone-generated GVA located in the areas prone to coastal flood risk with probability of exceedance 0.4% are below 1m and 1.5m altitude. We estimate EAL of the 1km wide coastal zone to at least €10-15 million under current climate. Climate change will lead to permanent loss of land and critical assets.

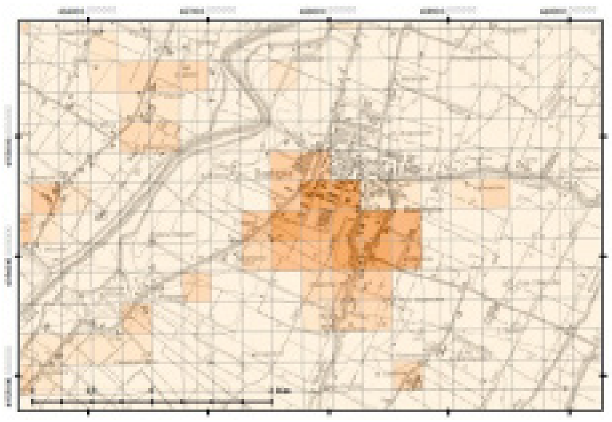
The risk and vulnerability analyses conducted for the scope of the above research benefit hugely from spatially distributed economic and social variables. In Amadio and Mysiak (under preparation) we have used **dasymetric mapping** for deriving a rectangular (grid) representation of population and gross added value (GVA) over the entire RER with high resolution (250m×250m) (see Figure 14.2). Population grids are recently widely available, but most of them do not have the requisites to be reliably employed in small-scale assessments (Figure 14.3). For the purpose of country-wide or global studies, grid datasets with small-scale resolution (from 1 to 5 km) are available: GeoStat (EFGS, 2011), LandScan (Bhaduri et al., 2002) or GWP (Balk and Yetman, 2004). These are adequate at a larger scale, but less suitable to represent local and sub-regional scales. A more accurate depiction can be obtained using a dasymetric mapping approach, starting from census records and disaggregating them to a finer units using ancillary data, such as land use and buildings. The precision of population grids influences the derived datasets that employ population density as a proxy. Dasymetric mapping seeks to improve the assumptions made for areal weighting, by establishing a relationship between the underlying statistical surface and the different classes contained within the area-class map (Mennis and Hultgren, 2006). In recent years this approach has gained interest to estimate populations for small areas (Eicher and Brewer, 2001). In fact, dasymetric mapping can provide more accurate small-area population estimates than many areal interpolation techniques (Mrozinski and Cromley, 1999; Wu et al., 2005).



(A) Agricultural GVA



(B) Industrial GVA



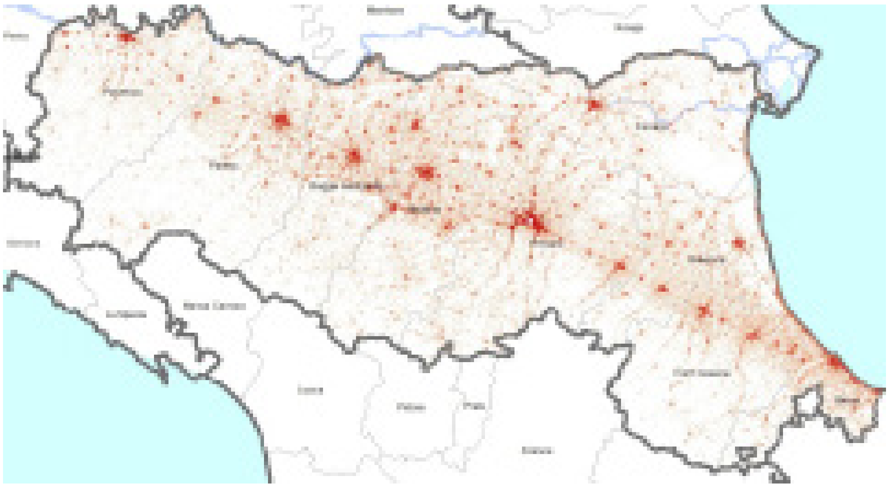
(C) Services related GVA

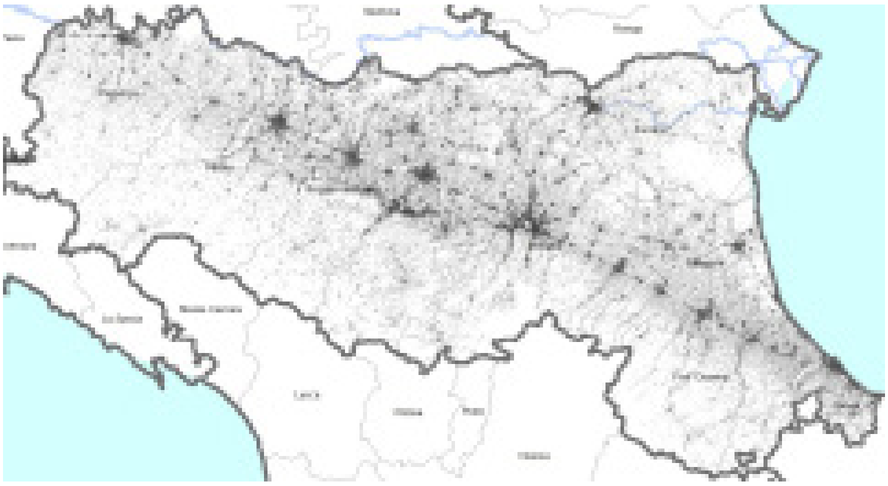
Figure 14.2.

A gridded sectorial gross added value (GVA) (250m×250m) for a small area within the case study (around the town Bomporto) in Emilia Romagna.

Figure 14.3.

Gridded population (left) and total GVA (right) of the Emilia Romagna region. Our analysis shows high (r= 0.88) correlation between GVA-S (services) and GVA-T (total) and relativelly high correlation between GVA-I (industrial) and GVA-T (r= 0.6). There is a low (but statistically significant) negative correlation btewene GVA-T and GVA-A (agricultur) (-.12). Similar correlations are observed for gridded population which is highly correlated with GVA-T and GVA-S (.86 and .97), but low with GVA-I (.15) and low and negative with GVA-A (-.10).





Policy recommendations

Risk assessment

Italy in general, and RER in particular, would be well-advised to substantially step-up its efforts and capacity in natural hazard and economic risk assessment. The outcomes will be conducive to a better framed and informed risk management and governance.

The high sovereign debt makes Italy's economy susceptible to adverse shocks to growth and debt's interest rates. The most recent debt sustainability analysis (DSA) of the European Commission (EC) showed that marginal changes in nominal GDP growth (-0.5%) and interest rates (+1%) would lead to much higher (+7%) debt-to-GDP ratio in 2026 than the one projected as a baseline (EC, 2016). The stochastic debt projection that considered the size and correlation of past shocks yielded a relatively high probability (11%) that the Italian debt ratio will be greater in 2020 than in 2015 (ibid). In the absence of disasters' financial protection tools, the low-frequency/high-impact events are capable of straining the growth beyond the levels considered in the EC study. For comparison, in RER alone a fluvial flood event associated with chance of being exceeded in any given year equal to 0.4% (i.e. a 250-year flood) is likely to cause structural damage equal to or greater than €9 billion (~ 6.3% of gross regional product GRP), or between €5 and 10 billion (3.5-7.2% of GRP) production losses, depending on the flexibility of the regional economy (Mysiak et al., in preparation).

The hazard and risk assessment should build upon a systematically collected, re-assessed, and possibly openly shared data on past disaster events embedded in the FloodCat database that is managed by the Department for Civil Protection (DPC) in collaboration with the regional civil protection (CP) offices. The records of past flood compensation should be re-assessed and used for producing regionally validated economic assessment models for structural damage, in a similar way as we have done in Amadio et al. (2016) for the 2014 Secchia event. Proper attention paid to a systematic analysis of economic and production losses could be driven by extending the Great Risk Committee[21] – a high level expert body advising the DCP – to cover areas related to disaster impacts on economic growth, social cohesion, and disaster financing. This is consistent with the draft OECD Recommendations on disaster risk financing strategies (OECD, 2016) and other OECD and EC recommended practices (De Groeve et al., 2014; OECD, 2014a, 2014b).

The hazard assessment in low-altitude floodplains in RER and elsewhere in Italy deserve particular attention. The flood hazard maps produced in the context of the Floods Directive in RER are not available for the low-probability scenario (Trigila et al., 2015). This means that the extent of areas prone to medium hazard level is greater than that of areas prone to low hazard level (respectively 46% and 36% of the total RER territory). The hazard simulations completed by the ENHANCE team complement the flood hazard and risk assessments in RER with more differentiated hazard scenarios, including the scenarios of disrupted DS, for the lowland areas of the LRB-EC. In our simulations, the initial conditions of the DS in terms of water volume stored immediately prior to the precipitation events are a critical factor influencing the assessment results.

Italy's participation in the United Nations Economic Commission for Europe (UNECE) Task force on climate change related statistics (UNECE, 2011) and the Task force on measuring extreme events and disasters (UNECE, 2015) presents an opportunity to closer engage the national and regional statistical offices in flood vulnerability and risk assessment under current and future climate change. In addition, UNISDR also provided opportunities for Italy to align its existing disaster loss database with the standards set by UNISDR and the European Commission (DESINVENTAR). Our analysis was based on leading-edge regional climate projections (at 8km resolution) and advanced hydrological and hydraulic simulations. We have shown the effects of climate change and soil sealing on ensuing flood hazard risk in the study area and over the entire RER. For the flood damage and risk assessment we have used detailed regional, high-resolution data on land cover/use and population. Availability of the micro-data on household disposable incomes and the structural building characteristics – both of which are collected through the population and housing census – would greatly improve the potential economic damage. We recommend that this potential is explored by means of targeted pilot studies with due attention paid to ensuring compliance with privacy and data security policies.

Compensation of inflicted damage

The *controlled flooding* strategy that forms a central element of the MSP serves as an emergency measure until after the DS has been fully restored. The strategy allows inflicting flood damage on low-value lands that would otherwise not be affected or only to a lesser extent, in order to protect exposed high-value urban areas further downstream. The MSP has detailed the role of the various parties to the agreement, but has not elaborated on how the damage would or should be compensated. In absence of an explicit cost-recovery mechanism contemplated for this purpose, it is likely that the economic damage would have to be compensated, according to the prevalent practice, from the *National Civil Protection Fund* and/or through additional regional excise taxes on motor fuel. We have explored various alternative financial instruments, including land drainage charge, land and property taxes, mutual insurance, and compensations for land easement.

The flood risk management on secondary and minor water courses in Italy is delegated to the *Land Reclamation Boards* (LRBs); semi-public entities introduced in the 1930s that are operated with certain degree of autonomy by landowners and which are authorised to levy and collect charges to recover costs of flood protection and surveillance measures. The LRBs are similar in structure and function to *internal drainage boards* (IDB) in the UK, and water boards in the Netherlands. The drainage levee contributes to recovering operational and maintenance (O&M) costs of LRBs, whereas the capital investments for extending or improving flood protection operated by LRBs are born by public funds. The LRBs use a rather complex scheme to split up their O&M costs connected to rainwater collection, flood protection and surveillance across the served land and properties. The principles of the cost allocation is specified by regional legislation (RER, 2012, 2014) and further developed in the so-called drainage *district classification* scheme by LRBs themselves (CdB-EC, 2015). The LRB-EC applies an index-based scheme to estimate benefits, which the properties situated within the reclamation district derive from the Board's operations. To serve as damage compensation instrument the scheme would need to recognise the damage inflicted by controlled flooding and the damage should be compensated by LRBs as an eligible cost item. This would require amendment of the regional legislation. In our case study area the matter is further complicated by the fact that the controlled flooding incurs cost in the LRB-EC if the landowners benefiting from it are situated in the LRB-*Terre dei Gonzaga in Destra Po* (LRB-TG) in the Lombardy Region. Hence, the compensation would entail financial transfer across LRBs and across administrative regions. Our flood risk analysis estimates shows the ensuing costs in much more detail than the district classification scheme, and across more the entire probability distribution. As such, our results lend themselves better for this scope.

Alternatively, the costs can be recovered through council taxes. The IMU (*Imposta Municipale Propria*) is an immovable city property tax that replaced earlier city council taxes (ICI, *imposta comunale sugli immobili)* in 2012. The tax base is determined by the land registry income of the property. The rates are differentiated according to the registered type and use of property. For the first time the tax is levied on agricultural land, except for municipalities situated in mountainous areas. The tax is not levied on residential properties serving as the main residence, apart from upper-class housing. The TASI (*tributo per i servizi indivisibili*) is a tax meant to cover the costs of indivisible services, which are services that cannot be charged separately to individual *taxpayers*.

[21] The National Committee for Predicting and Preventing Major Risks was set up in 1992 to advise the DPC on technical-scientific matters and future directions on coping with various risks.

The tax base is the same as of IMU but the rates are different and the tax is not levied on agricultural land.

Property insurance coverage in Italy is low, except for explosions and fires, not necessary of natural origins, which is a mandatory requirement for obtaining mortgage loans. The system of state compensations of disaster losses, which does not constitute a duty-to-compensate, but connotes a long-established customary practice, is seen by many as the main obstacle for private insurance markets. Over the past decades there have been numerous, so far fruitless attempts to give a boost to a private insurance market and relieve the notoriously ailing public finances (Mysiak, 2016). Most of these proposals embraced some type of coercive public-private partnership (PPP) and risk sharing. Typically, the schemes that were put forward have imposed duty on homeowners to underwrite disaster insurance or to extend existing policy to natural hazard risks. Our review has shown that actuarial risk pricing has never been envisaged neither in short- nor in long-term. The proposed schemes take for granted that actuarial risk pricing is either not socially equitable or not viable. Up to date there has been no or limited public debate and consultation about what solidarity principles should the insurance-based PPP be based on. This is important insofar the current hazard exposure is at least to some extent a result of decades-long unsustainable land management and spatial planning practices. As a result, one may argue that in the current situation the collective accountability holds sway over individual responsibility and risk-careless choices. The currently established compensation practise relies on general tax revenues in which the income taxes have the largest share. The compensation regime exemplifies a solidarity that entails transfer of wealth from high- to low-income households regardless of the hazard exposure or risk reduction undertaken to limit the damage.

Independently of the cost recovery scheme, the MSP should set agreed rules for calculation of the flood damage inflicted by controlled flooding. The compensation may not only reflect the crops damaged or destroyed, but possibly also the loss of land value. Designating a land property for recurrent controlled flooding is equal to imposing a restriction (easement) of the land tenure rights. Elsewhere in Italy, notably in the Veneto region, the land easement was adopted as alternative for land expropriation in cases of dry polder construction. The easement imposes an obligation to accept occasional flooding of the land, in exchange of a fee or compensation. The compensation of lost land value in Veneto was set to 40% of the value that would have been paid if the land was expropriated. The crop damage is estimated as the present value of perpetuity due (infinite annuity with payments at the beginning of each period), whereas the perpetuity is calculated as annual expected damage (AED) to the crop cultivated in the area on which the easement was imposed. In the case of LRB-EC the damage compensation can take form of a one-off payment as in Veneto, or annual agreed payments, or periodic damage reimbursements.

Improving the partnership

Italy has a long-standing tradition of MSPs dating back to the 1990s. The law 662[22] endorsed various instruments based on multi-stakeholder negotiated agreements, including framework programs, territorial pacts, program agreements, and thematic contracts. These instruments were transposed into regional legislations. In Lombardy for example, the regional law 2/2003[23] introduced among others *framework agreements for territorial development*, an example of which are river contracts (RCs). The Piedmont's *Water Protection Plan* and the *Po River Basin District Management Plan* encourage application of RCs for achieving the objectives laid out therein. The reason behind this is that RCs are becoming more common and proving to be an effective tool able to detect actions and strategies for the preservation of collective goods and contributing to riverine local development. As for now, around 60 RCs were signed in Italy or are in advanced negotiation phases. Recent reform of the Environmental Code (law 152/2006) recognised RCs as alternative planning instruments, complementary to traditional hierarchical instruments. LRBs play an important role in the RCs.

We have recommended extending the MSP so as to become **a cross-regional negotiated agreement similar to RCs**. The partnership should engage LRB-EC and LRB-TG, along with landowners and municipal councils, under auspices of the Po River Basin District Authority (PRBDA) and the regional civil protection agencies.

The partnership should aim at:

- improving the assessment of risk associated with controlled flooding, while paying due attention to risk amplification driven by climate change and soil sealing;
- designing a fair financial compensation of inflicted damage along with an equitable cost recovery scheme;
- further developing the flood protection from minor and secondary river courses and artificial drainage networks.

[22] Law 662 of December 23rd, 1996 Measures for improving public finances, Official Journal 303 of December 28th, 1996.
[23] Regional law 2 of March 14th, 2003 Negotiated regional planning, Regional Official Journal n. 12 of March 18th, 2003.

Photo by Rafal Buch/Unsplash.

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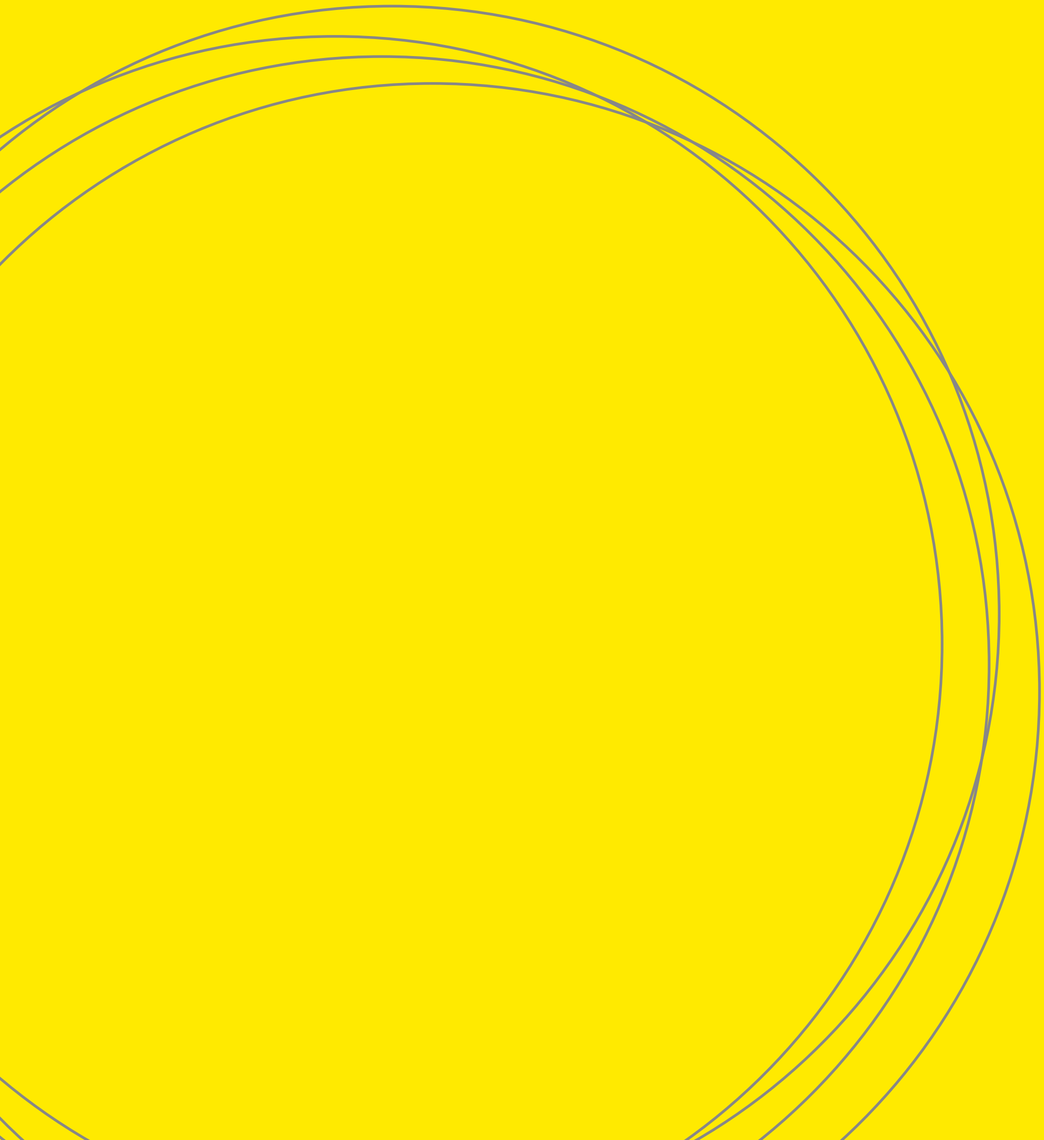

15

The Júcar River Basin, Spain

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"Droughts do not always occur under the same conditions, neither socio-economic nor hydrologic."

Introduction

The Júcar River Basin District (JRBD), in South Eastern Spain, has an irregular hydrology, which is very characteristic of Mediterranean basins. The JRBD is one of the most vulnerable areas to drought in the Western Mediterranean region due to semi-aridity, high water consumption, hydrological variability, and environmental and water quality problems when droughts appear.

Recent major drought events occurred in 1983-1986, 1992-1995, 1998-2000, and 2005-2008. The most severe impacts concentrated on the agriculture and hydropower sectors: in case of a drought, these two sectors have lower priority for water supply, compared to urban water supply and supply to environmentally sensitive areas. The reoccurrence of drought episodes has triggered an increased use of non-conventional resources, such as reuse of wastewater or desalination of seawater, conjunctive use of surface-ground waters, purchase of water rights, and the improvement of purification treatments to deal with higher pollutants concentrations.

It is likely that the succession and impacts of dry-humid periods will increase in the future, due to increasing human pressures and climate change. Moreover, the Water Framework Directive (WFD) (EC, 2000) requirements imply that more water will be assigned to environmentally vulnerable areas.

Based on this context, the main goal of the ENHANCE project was **to develop strategies to minimise the risk of drought episodes in the JRBD, and to improve resilience**. This is done by enhancing existing Multi-Sectorial Partnerships (MSPs), and by assessing current and new disaster risk reduction (DRR) measures and whether they can be adopted by the MSPs.

Photo by Aleksandr Petrunovskyi/Shutterstock.

Júcar-Turia Canal at Alzira. Photo by Jaime Gaona.

Tous reservoir in the middle course of Júcar River.
Photo by Jaime Gaona.

The JRBD partnership (CHJ)

Stakeholder participation and development of partnerships have been of great importance for the management of droughts within the JRBD. Historically, drought management has been mainly carried through infrastructure development, and existing MSPs have been developed around water supply measures. Initially, single-sectorial partnerships were predominant, but in 1936 the **JRBD Partnership (CHJ)** was created, which included all major sectors of water users, as well as national, regional and local governments' representatives. The role of this MSP has evolved over time, and nowadays the CHJ is in charge of the different aspects of water planning and management including infrastructure development, floods and droughts mitigation, protection of public water domain, and environmental objectives.

Strategies and measures for planning horizons are defined in River Basin Management Plans (RBMPs) as required by the WFD. However, the diversification of interests within the CHJ revealed the need for the division of the decision-making process into several internal bodies, which still include most stakeholders. Therefore, a cluster of satellite MSPs has been created along the years to deal with the different problems existing within the Júcar RBD. This is the case of the **Permanent Drought Commission (CPS)**, which is activated by means of a Royal Decree when an emergency drought stage is declared, until recovery of normality. The CPS is in charge of applying the DRR measures against drought defined in the Drought Special Plan (DSP), and defining additional measures if necessary. With the support of the Drought Technical Office, the CPS assesses risks and discusses and sets the necessary measures to increase resilience and to mitigate the effects that drought might have on the water supply system. All the stakeholders within the CPS act under an equality basis, and decisions are usually made by consensus. All the participants have access to all the existing data and analysis regarding the risk and the effects of the different measures studied.

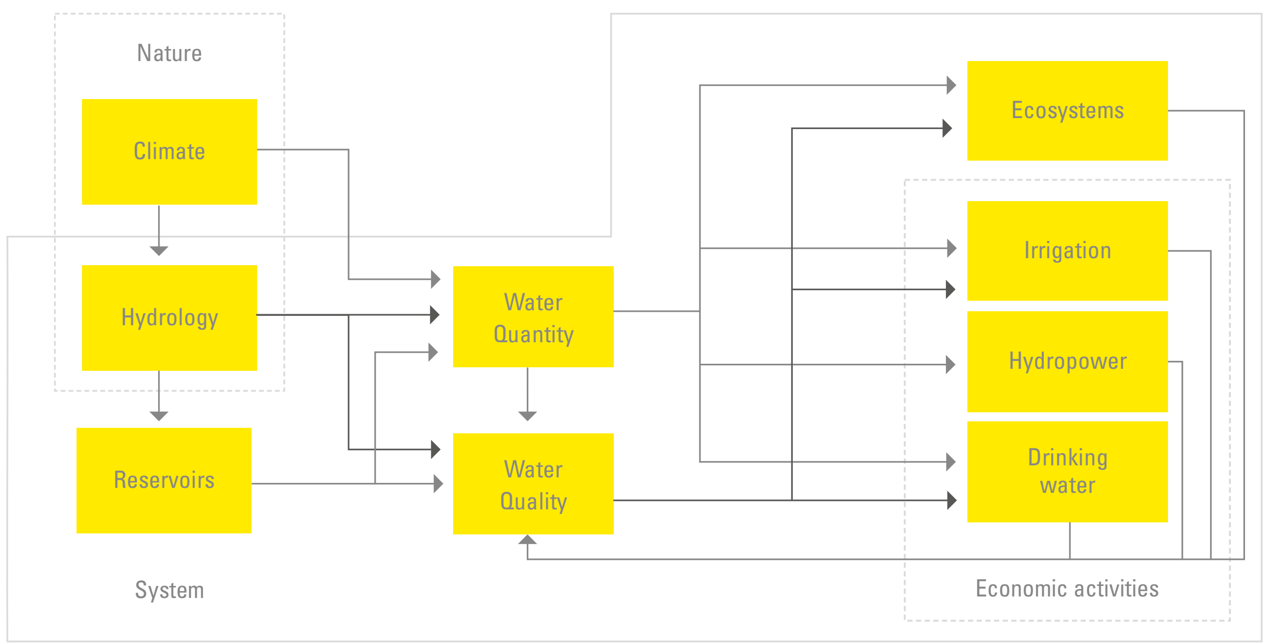
Photo by orxy/Shutterstock.

Risk assessment

Tools and results

Different risk assessment tools[24] are available for the JRBD Partnership, and some of these are used for participative decision-making, and to analyse the efficiency of the possible measures against drought. This involves the implementation of a series of models and methodologies to assess current and future risk, and are schematically displayed in Figure 15.1.

Figure 15.1.
Elements considered in the risk analysis.



For the planning horizon, the deterministic water allocation model SIMGES was run using the river discharges resulting from the hydrological model EVALHID, assuming different scenarios. Table 15.1 shows the volumetric reliability (average annual supply/annual demand) for the demands in the Júcar River Basin for 6 scenarios. The scenarios are:

- Baseline scenario 0: Historical streamflow time series from 1940 to 2008-09, current water demands and infrastructures.
- Scenario 1: Near-future situation: streamflow series from 1980-81 to 2008-09.
- Scenario 2: Medium-long future situation: streamflow and renewable groundwater reduction from CEDEX-DGA (2011).
- Scenario 3: Long future situation (2040-2070): streamflow series from HadCM2 model.
- Scenario 4: Very long future situation (2070-2100): using the same model as scenario 3.
- Scenario 5: Very long future situation (2070-2100): streamflow series from the regional model PROMES (Gallardo et al., 2001) nested in the HadCM3 model (Pope et al., 2000) in the emissions scenario SRES-B2.
- Scenario 6: Like scenario 5 but changing the emissions scenario to SRES-A2.

Results indicate that for the short- and mid-term, the supply to all demands would remain high, but on the long-term, all demands would suffer water scarcity. Especially agricultural demands and the urban demand of Albacete face water scarcity.

The main conclusion based on the results is that drought impacts are very likely to increase in the future and, thus, **it will be necessary to pay special attention to system management and optimisation**. The improvement of indicators systems and the need of advanced prevention and mitigation measures should become a priority. In the same way, it will be necessary to define new adaptation and/or DRR strategies to cope with negative effects.

[24]Available models comprise hydrological- deterministic approaches: hydrological model EVALHID (Pedro-Monzonís et al., 2013), stochastic models: ARMA model MASHWIN (Sánchez-Quispe, 1999) –, water allocation simulation: SIMGES (Andreu et al. 1996), and probabilistic models: SIMRISK (Andreu and Solera, 2006); water allocation optimisation models: OPTIGES (Haro, 2014); probabilistic models: OPTIRISK (Haro 2014; Haro et al., 2014) –, water quality analysis – at river basin scale: GESCAL (Paredes et al., 2010), and at drinking water treatment plant (DWTP) scale: Microbiological Risk Assessment Tool (Macián-Cervera, 2015) –, hydro-economic analysis – SIMGAMS (with simulation of water management based on priorities and economic post-processor) and OPTIGAMS (with optimization of water management based on maximization of economic efficiency) respectively (Lopez-Nicolas, 2014).

Table 15.1.

Vulnerability results for the Júcar River Basin demands under 6 different scenarios.

	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Urban Demand	100.00%	100.00%	99.80%	91.41%	86.97%	82.95%	75.91%
Albacete	100.00%	100.00%	100.00%	51.94%	43.53%	43.51%	40.34%
Valencia	100.00%	100.00%	99.75%	98.76%	94.94%	90.08%	82.06%
Sagunto	100.00%	100.00%	99.75%	99.19%	96.75%	93.01%	87.92%
Irrigation Demand	99.56%	98.42%	95.79%	86.60%	79.51%	63.39%	54.56%
Mancha Oriental	99.70%	98.94%	97.20%	95.18%	92.45%	88.40%	86.81%
Júcar-Turia Canal	99.67%	98.50%	95.46%	89.50%	82.54%	54.76%	44.50%
Ribera Alta	99.66%	97.87%	94.09%	74.95%	60.94%	35.48%	20.85%
Ribera Baja	99.75%	98.58%	95.49%	85.00%	76.53%	59.13%	47.91%

In real time management and early warning, it is necessary to monitor the evolution of drought in order to decide when to activate each DRR measure. In the case of the Júcar and Turia River Basins, the 'state drought indicator' (Haro et al. 2014) as defined in the DSP (Drought Special Plan) shows the state of drought in the Júcar basin. However, this indicator can be improved if it is combined with the results provided by the OPTIRISK model used as an early warning system. It requires stochastic flow series from MASHWIN, which are based on historical streamflow patterns. The evolution of the index as calculated with OPTIRISK shows a similar behaviour with regard to the drought events occurred in the Júcar River Basin, but it is a little more alarming (Figure15.2).

When the officially measured drought indicator enters for two consecutive months in the 'emergency state' (Figure 15.2), the DSP (Drought Special Plan) is set into action, and is being coordinated by the Drought Technical Office. If the drought indicator remains for two consecutive months in the emergency state, a drought episode is officially declared. Then, the CPS is in charge of assessing and implementing the measures envisaged in the DSP. For this particular drought stage, results of SIMGES and SIMRISK models are combined to show the effects of the situation with- and without measures (Figure 15.3).

Figure 15.2.

Evolution of the 'state drought index' in the Turia River system calculated from the SIMGES results (blue), from OPTIRISK results (dashed black), and official CHJ values (black), compared to the drought scenario thresholds.

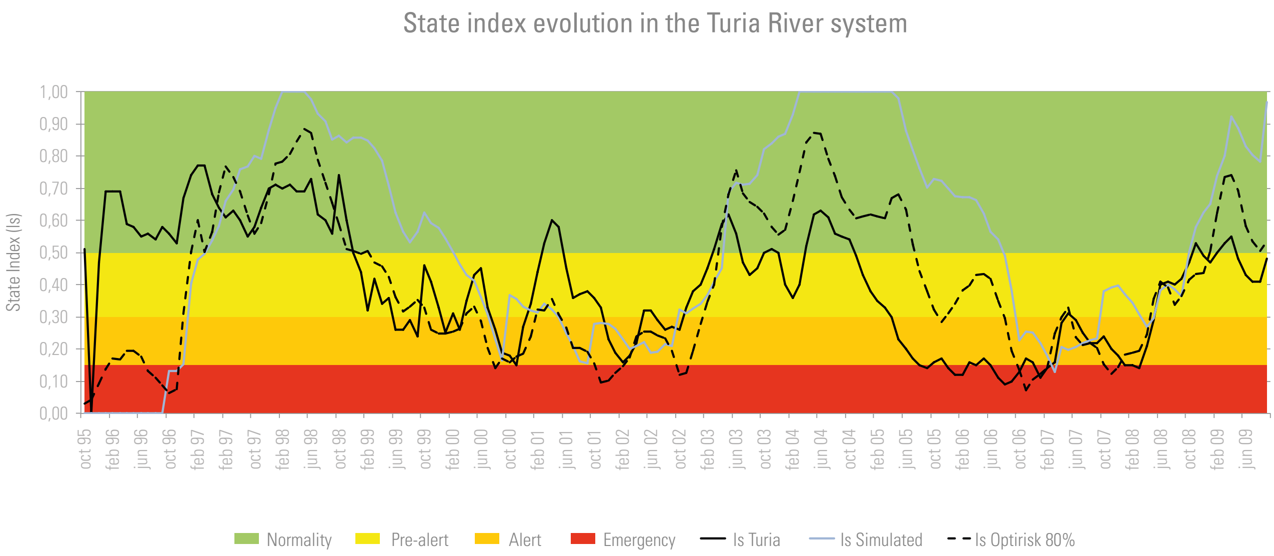
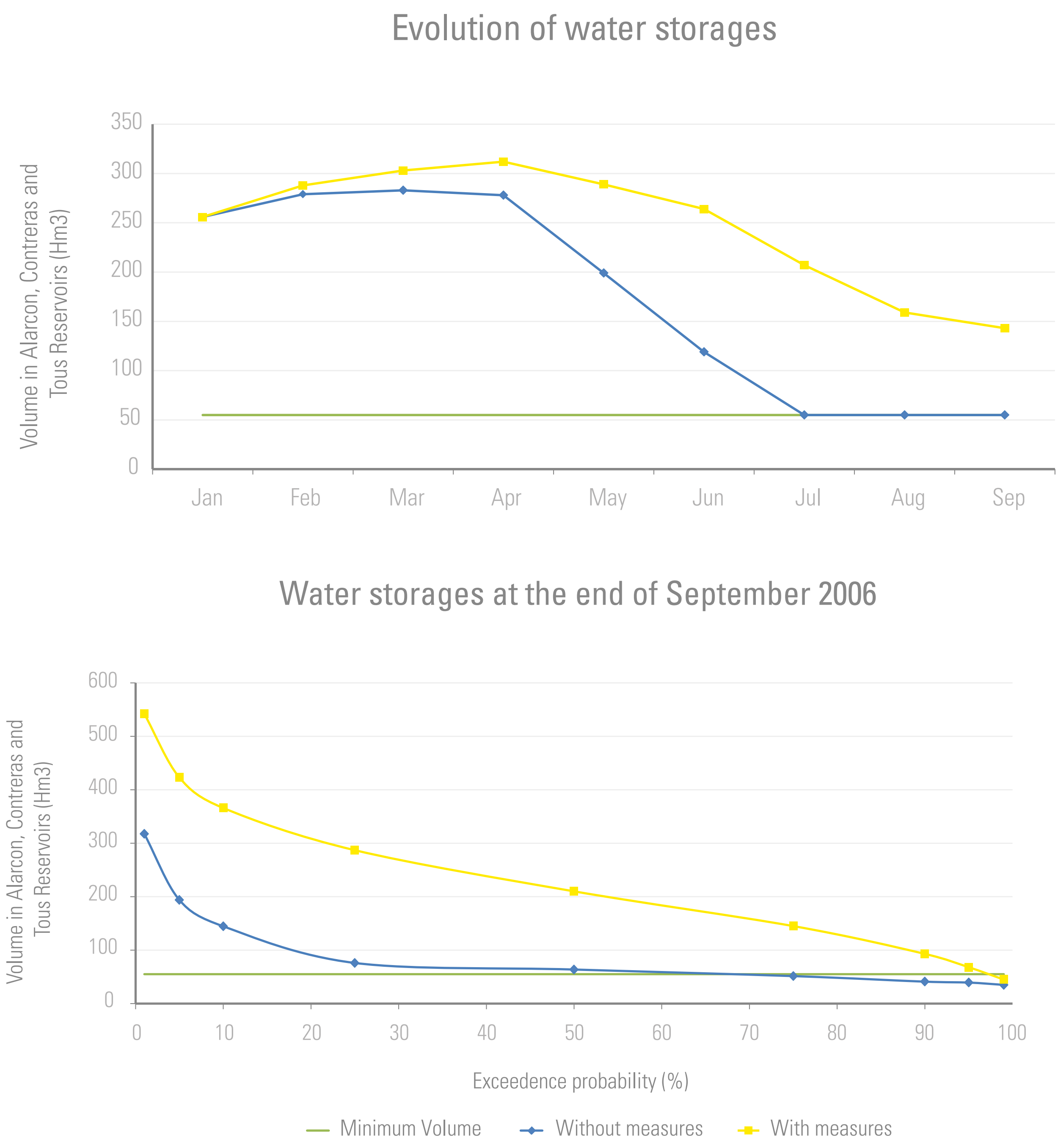


Figure 15.3.

Effects of an emergency drought with (yellow) and without (blue) drought reduction measures using two models: Deterministic (left) and probabilistic (right) forecasts for the Júcar reservoirs storage evolution in 2006 campaign.



Water pricing and risk

The potential of economic instruments to manage drought risk has been analysed through *hydro-economic models*, (HEMs) (Pulido-Velazquez et al., 2008). The use of HEMs allows calculating *water scarcity costs* as the economic losses due to water deliveries below the target demands, which can be used as a vulnerability descriptor of drought risk (Lopez-Nicolas et al., 2015).

Figure 15.4 shows the scarcity-based water pricing policy of the Alarcón reservoir, the main surface reservoir of the Júcar system with a capacity of 1112 Mm3. It was obtained with the SIMGAMS model, based on the marginal resource opportunity cost at a specific location and time, which can be defined as the system-wide benefit of having available one additional unit of resource at that location and time (Pulido-Velazquez et al., 2013). This step water pricing policy allows sending a signal to the MSPs, since the price is higher when the storage is lower (ranging from 0.31 €/m^3 to 0 €/m^3).

Figure 15.5 shows that the total water scarcity cost (foregone benefits during droughts) would be lower in the Júcar River Basin when water pricing policies are applied, as compared to the business as usual scenario. The consequence of pricing policies would be the reduction of total economic losses during drought periods, with more water available for high-value crops at the expense of low-value crops. Furthermore, simulations to optimise water allocation show that water markets would significantly reduce the total water scarcity cost, with voluntary water transfers from low-value crops to higher value crops during drought periods.

Water quality

Regarding water quality, the World Health Organisation (WMO) identified *cryptosporidium* as the most dangerous emergent pathogen for urban water supply. We analysed the health risk caused by this microbe for the supply to the city of Valencia during low flow conditions at two different scales. On the one hand, water quality model GESCAL was used to determine the effect of drought on cryptosporidium concentrations at a river basin scale (Figure 15.6). Since the number of pathogens in water is very difficult to measure directly, we used the total and fecal coliforms as indicators (Carmena et al., 2007).

On the other hand, we applied a methodology to quantify risk of cryptosporidium presence in the most known, classical and extended drinking water treatment, the conventional treatment. The risk model is based on facilites' simple on-line operational parameters and the results are the health risk estimation for the served population. We used the relationship between risk and microbiological concentration (Macián-Cervera, 2015).

Figure 15.4.
Scarcity-based water pricing policy for Alarcón reservoir.

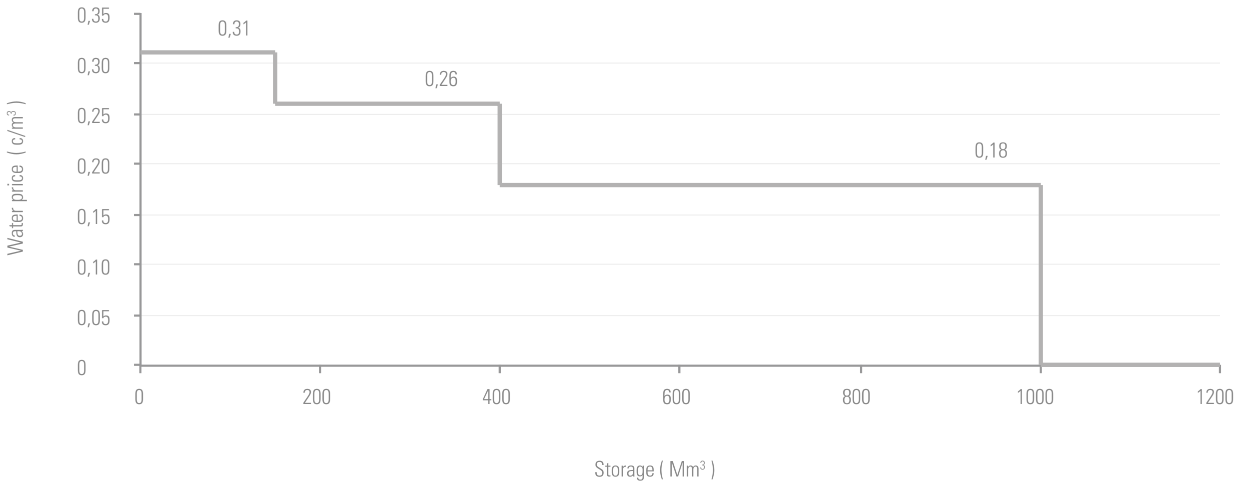


Figure 15.5.

Water scarcity cost comparison between business-as-usual scenario and the water pricing policies scenario.

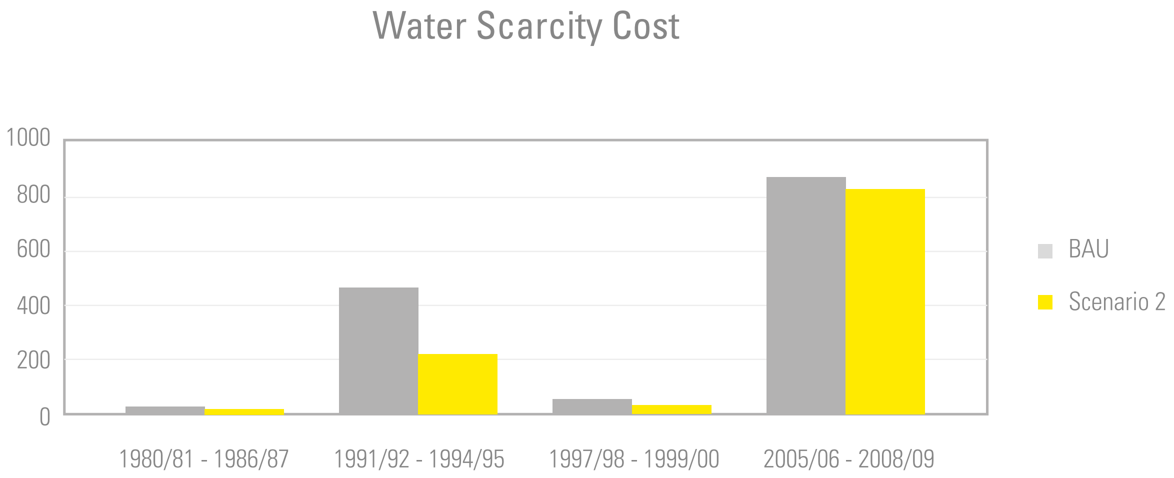
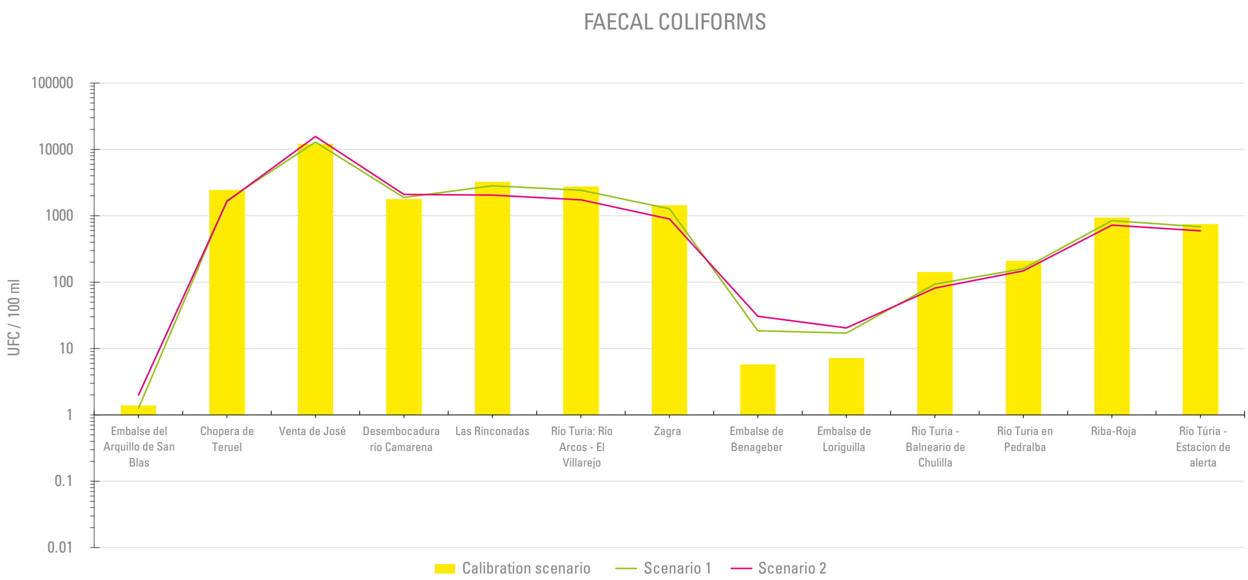


Figure 15.6.

Comparison between average concentrations of fecal coliforms simulated in calibration scenario, scenario 1 (reduction of 15% of streamflows) and scenario 2 (reduction of 30% of streamflows).



Healthiness of the Júcar River Basin MSP

The MSPs under consideration in the JRBD, CHJ and CPS, are considered successful regarding their governance capacity and their effective role for drought management in the JRBD. However, in order to ensure their effectiveness in future uncertain situations, it is important to further analyse their capacity to implement DRR measures under future scenarios.

Using the **'capital approach'** (Chapter 1; Mañez et al., 2014), recommendations for improving the MSPs' performance were derived. These include changes to strengthen existing control mechanisms, to improve the executive capacity of the MSPs (regulatory frameworks, institutional protocols, and financing options), and to increase the MSPs' autonomy, among others.

Improved risk assessment results

Some of the methodologies and tools included in the risk analysis are currently used by the MSPs in order to cope with droughts. For example, the deterministic and probabilistic simulation models of water allocation are already applied to test the validity of certain measures at the planning scale. The efficacy of these methodologies has been tested under average and extreme scenarios, and they seem to work properly. However, the optimisation of water allocation using **stochastic approaches** provides valuable information which is not currently used by the MSPs. The results show that the drought indicator calculated with OPTIRISK results in additional severe drought scenarios. Additionally, the OPTIRISK drought indicator reaches the emergency scenario more assiduously than the others, which makes this enhanced indicator a much more extreme estimate.

Hydro-economic models can provide useful insights on optimal strategies for coping with droughts, as they simultaneously analyse engineering, hydrology and economic aspects of water resources management, while taking into account all users, at river basin scale. They allow testing the possible impact of **economic instruments**. The results show the potential of applying economic instruments to deal with drought risk management. Water pricing policies and water markets would have a positive impact on drought risk management, reducing the total scarcity cost. Both instruments would contribute to the reallocation of water resources to high-value uses during water scarcity periods.

The final recommendation regarding the risk analysis involves **Drinking Water Treatment Plants (DWTP)**. On the one hand, it is necessary to assess the risk of DWTP, which apply conventional treatments while operating. If the risk estimation gets to non-tolerable levels, investments must be done in the treatment and plant operation. On the other hand, given the relationship between the E.coli and cryptosporidium concentrations in the river, the effect of a DRR measure can be modelled with the water quality model at river basin scale GESCAL, consid-

Xirivella irrigation canal. Photo by M. Carmona.

ering coliforms, to identify potential risks for the DWTP.

Institutional improvements

The recommendations to improve MSPs in the JRBD, and specifically the CPS, are mostly inferred from the insights provided by the Capital Assessment and from the conclusions obtained from several seminars related to drought in the JRBD.

Regarding the composition and functioning of the CPS, one could ensure **a minimum technical education of members**. Then, it would be reasonable to extend the voting right to all members, which currently is not the case. In addition, for an effective transmission of information about the state of the water system and the agreements and measures developed by the CPS, feedback mechanisms between CPS members and their represented groups must be strengthened.

Public information as promoted by the EU Water Framework Directive for River Basin Management plans approval is not so vehemently applied to information about the evolution of drought and the measures adopted to reduce its effects. This information should be made available in a clear and easily accessible way by different means, such as the CHJ webpage and media. This would make people more aware of the situation and would enhance the adoption of DRR 'water saving' measures by society. Moreover, it would be easier to mobilise volunteer networks, which could help implementing information/awareness campaigns and environmental actions (control of illegal uses, accidental spills, river cleaning, etc.).

Several existing plans and protocols should be improved or updated for an efficient drought management. In relation to plans, the most relevant is the inclusion of **more drought management mechanisms** in the JRB management plan, and a **better anticipation capacity** against droughts without the need of activating the DSP. Also, significant importance should be given to the development and updating of **emergency plans for urban areas**: for example, microbiological risks in DWTPs, heat waves, fires and nuclear plant failures. In order to ensure a quick activation of the emergency protocols as well as to maintain the social and institutional awareness and to avoid the relaxation of cooperation between institutions in drought situations, some kind of drought emergency simulation should be periodically performed.

From an economic perspective, scarcity-based **water pricing policies** send a strong signal to water users (when the storage decreases, water price increases), and so work as an incentive towards a more efficient water use. In turn, **water exchange in water markets** is voluntary and, therefore, represents a win-win situation for both buyers and sellers. Water markets are more easily acceptable for farmers, since they would increase their revenues, while scarcity-based water pricing would reduce them. However, the additional revenues generated by applying these economic instruments could be potentially used to compensate losses and increase water security. Other useful instruments for economic resilience would be **drought insurances** for irrigated agricultural uses; the creation of **strategic funds for drought episodes** to ensure that the necessary measures can be applied independent of the global economic situation of the country; and the creation of **a basic network of drought infrastructures** of which maintenance costs are shared between all the water users in order to distribute the costs along time and among the beneficiaries and to avoid disproportionate costs in drought episodes.

Regarding institutional hierarchy, CHJ and CPS are in charge of managing drought, proposing the emergency drought stage declaration, and updating the DSP. The Spanish Ministry of Agriculture, Food and the Environment is responsible for the legal declaration of an emergency drought stage and the legal approval of the updates of DSP. While this declaration and approval depend on the socio-political situation, delays can be expected. Hence, **it would be highly recommendable to ensure an immediate response**, for the sake of a quick and effective activation of DRR measures.

Finally, more technical recommendations, even though they have policy implications, include **the revision, and if necessary, reform of water allocation regimes**. This issue is addressed by the OECD (2015) which proposes a 'health check' to identify areas for potential improvement in water resources allocation. The results for the CHJ and CPS in this check are presented in Table 15.2.

Table 15.2.

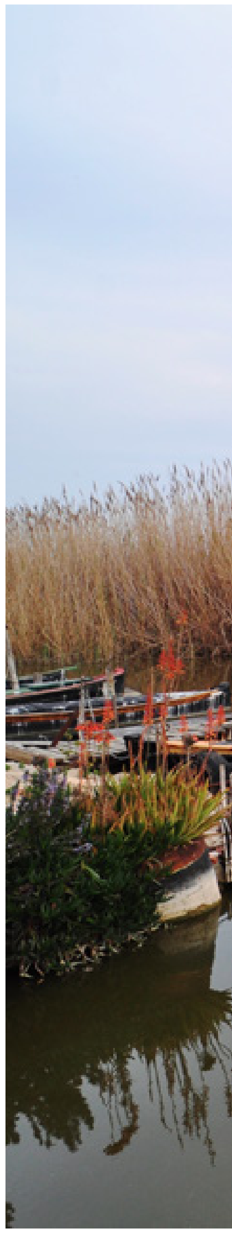
OECD Health check for the water allocation regime in the JRBD.

Check 1. Are there accountability mechanisms in place for the management of water allocation that are effective at a catchment or basin scale? Yes, there are. CHJ publishes annual Water Exploitation Reports providing relevant information on water availability and use at river basin scale (Andreu et al. 2012).
Check 2. Is there a clear legal status for all water resources (surface and ground water and alternative sources of supply)? Yes, there is. At least for most of them, since there are always illegal uses which are not controlled.
Check 3. Is the availability of water resources (surface water, groundwater and alternative sources of supply) and possible scarcity well-understood? Yes, it is. RBMPs include a full section about the assessment of available water resources.
Check 4. Is there an abstraction limit ('cap') that reflects in situ requirements and sustainable use? Yes, there is. Water rights have a limit of water abstracted and water allocations are in line with it.
Check 5. Is there an effective approach to enable efficient and fair management of the risk of shortage that ensures water for essential uses? Yes, there is. The Spanish Water Law together with the RBMPs define the different priority uses.
Check 6. Are adequate arrangements in place for dealing with exceptional circumstances (such as drought or severe pollution events)? Yes, there are. The CPS and the Drought Special Plan establish and apply these arrangements, although they implemented some improvements.
Check 7. Is there a process for dealing with new entrants and for increasing or varying existing entitlements? Yes, there is. In all cases, people must apply for a (new or modified) concession which is informed by the CHJ planning office to ensure that the concession is in line with the RBMP.
Check 8. Are there effective mechanisms for monitoring and enforcement, with clear and legally robust sanctions? Yes, there are. There are water meters which gauge the surface water delivered and the main groundwater abstractions are also directly measured or inferred from satellite images; however, there is room for improvement. If abstraction limits are surpassed, sanctions are applied.
Check 9. Are water infrastructures in place to store, treat and deliver water in order for the allocation regime to function effectively? Yes there are, although some improvements could be made to increase storage.
Check 10. Is there policy coherence across sectors that affect water resources allocation? Not always. For example, subsidies from the Common Agricultural Policy are promoting water abstractions. Regional Statutes claim for the use of more water than the established in the RBMPs. Land use planning developments in the JRBD territory require a report from CHJ regarding the capacity to supply water, however it is not binding.
Check 11. Is there a clear legal definition of water entitlements? Yes, there is.
Check 12. Are appropriate abstraction charges in place for all users that reflect the impact of the abstraction on resource availability for other users and the environment? No, they are not. They should be in accordance to the recovery cost principle of the Water Framework Directive, which they are not.
Check 13. Are obligations related to return flows and discharges properly specified and enforced? Not for all uses. They are for urban uses in terms of water quantity and quality, but not for irrigation uses.
Check 14. Does the system allow water users to reallocate water among themselves to improve the allocative efficiency of the regime? Yes, it does. There are different ways in which this can be done: Inside irrigation districts, farmers are free to re-distribute the resources allocated to the district; water markets are considered by Spanish Water Law as the Centres for Water Rights Exchange, but they are not frequently applied; the Alarcón treaty for conjunctive use allows traditional irrigated areas of the lower basin to start to use the drought wells in order to 'release' surface water which is used by the junior rights users and by urban water users, who assume the maintenance and energy consumption costs of drought wells.

Policy recommendations

From previous considerations, and from the experience gained with the JRBD case study, some general policy recommendations can be given for a successful and effective drought management in other cases:

- The creation of River Basin Partnerships with governance capability is very important for an adequate integrated basin management and drought resilience building.
- River Basin Partnerships should define proactive measures against drought in the RBMPs, and apply them.
- An operative MSP, which applies reactive measures, is needed, since drought is a long-lasting hazard, compared to floods and fires. These reactive measures should be defined in a DSP.
- Effective and quick mechanisms should exist for a legal emergency drought stage declaration and DSPs legal update.
- MSPs should include representatives of all stakeholders related to water and drought, with a minimum technical profile, which ensures an effective participation. The representation must be real in the sense that there has to be feedback between the MSPs and the different stakeholder groups through the representatives.
- A system of drought indicators should be defined for the early identification of drought risk and for drought monitoring. The DSP should include these definitions.
- Definition and update of action protocols for hazards potentially triggered by drought (microbiological DWTP risk, fire, heat waves, etc.) should be included in the DSP.
- The use of economic instruments (e.g. water pricing policies, water markets, and insurances) to derive a more efficient use of water, and to lower vulnerability, should be considered. Nevertheless, their compatibility with environmental and socio-political issues should also be assured.



Pier and canal in the Albufera wetland. Photo by David Haro.

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16

Evaluation of multi-sectoral partnerships (MSPs): flood risk management and climate change in London

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"Adaptation by societies and economies alone is not considered to be sufficient to address the complexity, range and magnitude of risks and opportunities associated with climate change (EEA, 2014)."

Introduction

Flooding is the costliest natural disaster worldwide, and the effective management of long-term flood risk is an increasingly critical issue for many governments across the world, especially in light of climate change. In England flooding is recognised as one of the most common and costliest natural disasters and is listed as a major risk on the National Risk Register. The consequences of surface water flooding were brought to the forefront by the summer floods of 2007, which caused the country's largest peacetime emergency since World War II. The total economic cost of the floods was estimated to be £3.2 billion (2007 prices), with £2.5 billion borne by households at a cost of £1.8 billion to insurers (Environment Agency, 2010).

The Pitt Review (Pitt, 2008), conducted to provide lessons and recommendations in the aftermath of the 2007 summer floods, highlighted major gaps in the understanding and management of risks from surface water flooding. Similar concerns have also been raised across Europe with some member states in the past giving a much lower priority to this type of flood risk meaning that vulnerability has crept upwards (European Water Association, 2009). The Pitt Review emphasised the need for urgent and fundamental changes in the way the UK is adapting to the likelihood of more frequent and intense periods of heavy rainfall projected under future climate change (IPCC 2013). Changing precipitation patterns are expected to result in an increase in surface water flood events in the UK (Ramsbottom et al., 2012). Combined with an increasing pattern of urbanisation it has been estimated that damages from surface water flooding could increase by 60-220% over the next 50 years (Adaptation Sub-Committee, 2012).

The combination of biophysical and human factors influencing surface water flood risk means that it is extremely challenging to predict the occurrence and extent of events, limiting the ability to warn and plan for future risks (Houston et al., 2011). This and the large number of stakeholders involved (e.g. in the case of the UK and London see Jenkins et al., (2016)) make managing surface water flooding a very complex issue that requires multi-sectoral collaboration. One area where this is particularly apparent is flood insurance.

A unique aspect of cross-sectoral involvement in flood management in the UK is the public-private partnership on flood insurance between the government and insurance industry known as the **Statement of Principles (SoP)**. Flood insurance in England (and across the United Kingdom) is unique amongst most other national schemes as it is purely underwritten by the private market, while the government commits to flood risk management activities. The SoP was established in 2000 in the wake of growing flood losses and sets commitments from both the insurance industry and government to establish flood insurance provision. The main obligations can be summarised as follows: flood insurance is provided by private insurers under the SoP to both households and small businesses, generally up to a risk level of 1:75 return period (RP) (1.3%) as part of their building and/or contents cover. Properties at higher risk are granted cover if insurers are informed by the Environment Agency (EA) about plans for flood defence improvements for the particular area within the next five years. Government commits to investment in flood defences and improved flood risk data provision as well as a strengthened planning system. Under this agreement, the emphasis on flood risk reduction is primarily placed on the government (national and local) as insurers provide the financial underwriting. While insurers traditionally insure against all types of flooding in the UK, over the last decade the concerns about surface water flooding have contributed to a review of existing insurance practices.

In 2008, the SoP was extended for a final five-year period until 2013 and committed the government and insurance industry to a transition to a free market for flood insurance. However, sparked by concern about rising risk costs, the frequency of high loss events and the belief by the insurance industry that a free market might leave around 200,000 high risk homes struggling to afford cover (Committee on Climate Change, 2015) a modified version of the partnership was agreed in 2013 with the creation of Flood Re, which started operations in 2016. Designed to secure affordable cover for properties at high risk of flooding, Flood Re complements the current insurance market, where private insurers are offering cover against flood damage as part of standard home insurance policies. Households under low to normal flood risk will still be provided with insurance as standard, whilst the flood element of the home insurance policy for the 1-2% of highest risk properties can be passed to Flood Re by insurers (Figure 16.1). The premiums offered for high risk households are fixed dependent on council tax banding. Flood Re will be funded by these premiums and an annual levy taken from all policyholders and imposed on insurers according to their market share (Surminski & Eldridge, 2015). The proposed Flood Re scheme is designed by Government and industry as a transitional solution, with an anticipated run time of 20-25 years. It aims to help smooth the transition to more risk-based pricing in a competitive insurance market in the future, while securing future affordability and availability of flood insurance (Defra, 2013).

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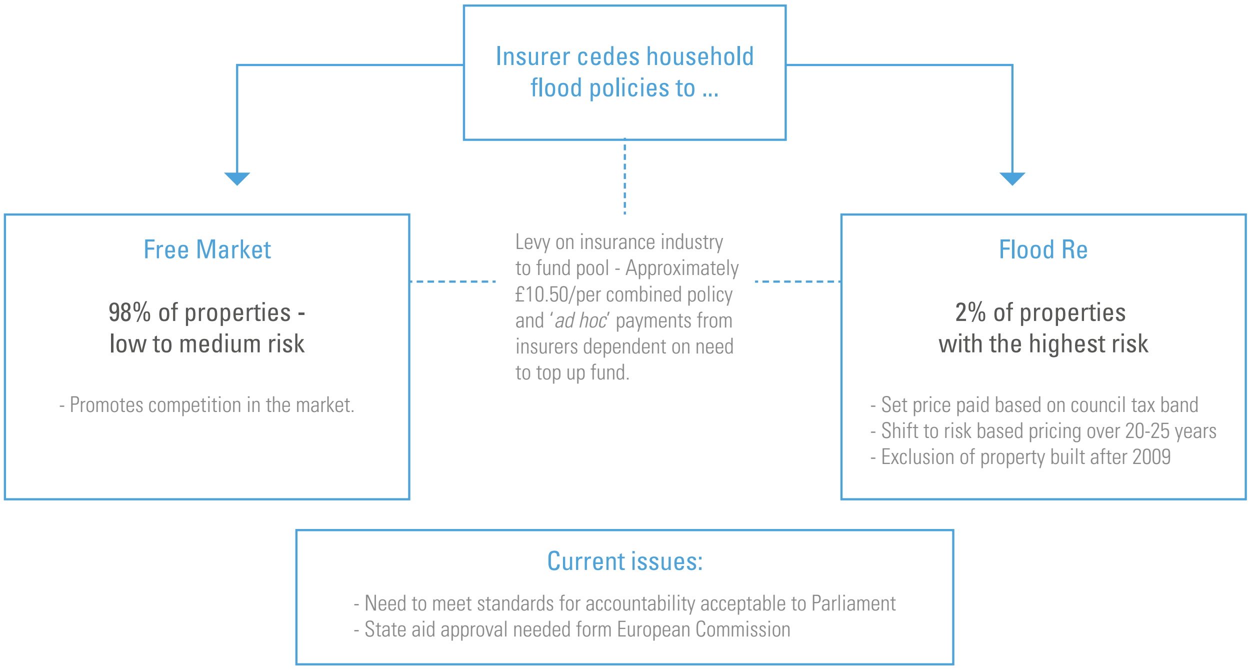

Figure 16.1.

The proposed Flood Re system. Details taken from the Environment, Flood and Rural Affairs Committee on 26th February 2013 for the Flood Re insurance proposal and Flood Re MoU (Source: Defra and ABI, 2013).

While the change in the flood insurance scheme has been triggered by concerns of insurers about rising flood losses and concerns of at risk homeowners over future affordability, it remains unclear if and how Flood Re will be able to cope with future risks and fulfil its tasks (Surminski & Eldridge, 2015). Rising losses and increased volatility can affect the fine balance between affordability and profitability for insurers. In extreme cases this could lead to insurers withdrawing from certain markets and regions, as highlighted by the UK's insurance regulator PRA (Prudential Regulation Authority, 2015). While the recent flood loss trends in the UK are largely due to socio-economic factors, such as more development in exposed areas, climate change is expected to exacerbate these impacts (IPCC, 2013). One important aspect therefore is **if and how the insurance partnership can be integrated into overall risk management and climate change adaptation efforts, and how insurers can collaborate with other stakeholders to achieve greater resilience and ensure future insurability**.

In this analysis we investigate this through a local lens: we focus on a case study of Greater London for evaluating existing and potential new partnerships for surface water flood risk management. Floods are a major issue for London, as it is vulnerable to tidal, fluvial, surface water, sewer and groundwater flooding. Surface water flooding is considered to be the most likely cause of flood events in London, and one of the greatest short-term climate risks (Greater London Authority, 2009, 2011). Around 680,000 properties are estimated to be at risk with 140,000 Londoners at high risk, and another 230,000 at medium risk (Greater London Authority, 2014).

We investigated the existing public-private flood insurance partnership and the proposed new insurance scheme Flood Re, and explored how this could influence London's resilience to surface water flood risks today and in the future. The case study combined qualitative analysis in the form of relationships, governance and risk levels, and the development and application of a quantitative oriented agent-based model (ABM) to capture and model the dynamics of surface water flooding, changing surface water flood risk, and how adaptation and insurance decisions could affect future surface water flood risk in that dynamic.

York, UK - December 27, 2015: Flood water near Clifford’s Tower, York. Photo by Phil MacD Photography/istock.

Investigating the aims of Flood Re - the 'design principle' approach

An investigation of the underlying design principles of insurance considers the aims and objectives stated by different stakeholders during the development and design of an insurance scheme, and asks if and how those have been met by the eventual solution that was implemented.

Different stakeholders have different constellations and problem definitions. There are a range of political motivations at play when considering introduction or reform of flood insurance schemes, showing that the pendulum of political support can swing in many directions. On the one hand there is the aim of reducing current public expenditure for flood losses, while at the same time there are political considerations such as the need to maintain a visible 'helping hand' function after a disaster.

The investigation of design principles allows insights into potential trade-offs between certain aims, such as affordability, availability, and vulnerability reduction, particularly when considering the political realities that drive the reform or development of new insurance schemes.

At the start of the negotiations for the new flood insurance mechanism a set of principles were published by the UK government outlining the vision for flood insurance (Figure 16.2). This had a clear emphasis towards affordability and availability of insurance provision. Yet adhering to all these principles has proved extremely difficult.

The proposed scheme, Flood Re, takes principles 1, 3 and 8 at its core and aims to 'ensure the availability and affordability of flood insurance, without placing unsustainable costs on wider policyholders and the taxpayer' (Defra 2013a). However, the 'value for money' aspect of this is highly debatable as the scheme does not meet the minimum government standard for cost-benefits (Defra 2013a p.30; Defra 2013b). The lack of risk reduction was clear in the official proposal other than in the Memorandum of Understanding, setting out the government's commitment to flood risk management and joint efforts to improve flood risk data (Surminski & Eldridge, 2015).

Furthermore, the qualitative analysis also highlighted a lack of reflection on climate change. The findings from the qualitative analysis challenged the government's assumption that flood risk management will keep up with climate change and that therefore risk levels would remain stable, and was incorporated in subsequent policy impact assessments.

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Figure 16.2.
Principles for flood insurance (Source: Defra, 2011a, p.5).

Principles

1. Insurance cover for flooding should be widely available.
2. Flood insurance premiums and excesses should reflect the risk of flood damage to the property insured, taking into account any resistance or resilience measures.
3. The provision of flood insurance should be equitable.
4. The model should not distort competition between insurance films.
5. Any new model should be practical and deliverable.
6. Any new model should encourage the take up of flood insurance, especially by low-income households.
7. Where economically viable, afforadable and technically possible, investment in flood risk management activity, including resilience and other measures to reduce flood risk, should be encouraged. This includes, but is not limited to, direct Government investment.
8. Any new model should be sustainable in the long run, affordable to the public purse and offer value for money to the taxpayer.

Assessing surface water flood risk and management strategies under future climate change - an agent-based model approach

Analysing the outcomes of such an insurance reform as Flood Re, and its potential integration with flood risk management and climate change, required a model that could simulate the dynamics of flooding, changing levels of risk, and the choices made by different stakeholders. ABMs provide a bottom-up approach for understanding the dynamic interactions between different agents in complex systems. They are particularly advantageous for visualising the effects of changing behaviours and emergent properties of complex adaptive systems. They have a number of advantages as a support tool for policy-making such as their accessibility and flexibility for testing different conditions and behavioural rules (van Dam et al., 2012).

An ABM was developed for Greater London and applied to a case study of the London Borough of Camden, an area at high risk of surface water flooding (although the modelling approach could also be extended to other areas in the UK or specific situations in other countries). The ABM includes six different agents: people, houses, an insurer, a bank, a developer and a local government, each with their own behaviour (see Dubbelboer et al. (2016) and Jenkins et al. (2016) for further model details). The model was used to assess the interplay between different adaptation options; how risk reduction could be achieved or incentivised by different agents; and the role of flood insurance and Flood Re, all in the context of climate change.

The ABM highlighted how socio-economic development could exacerbate current levels of surface water flood risk in Camden. Surface water flood risk increased over time, reflecting the continued development of properties in areas of flood risk in the model, and under the high emission climate change scenarios for the 2030s and 2050s modelled. An analysis of the role of Flood Re and structural adaptation options, in the form of Property-level Protection Measures (PLPMs) and Sustainable Drainage Systems (SUDS), for managing surface water flood risk highlighted that the most beneficial result for risk reduction was a combination of investment in both PLPMs and SUDS (Figure 16.3). However, even with SUDS and PLPMs in place the average surface water flood risk continued to increase over time under all experiments. Given the implications of climate change on surface water flood risk this illustrates the danger of further trade-offs between future development plans and flood risk management.

For insurance the model showed that Flood Re would achieve its aim of securing affordable flood insurance premiums (Figure 16.4). However, findings also highlighted that the new pool would be placed under increased strain if challenged with increasing risk as highlighted by the future climate change projections. The results also showed that the implementation of Flood Re had no additional benefits in terms of overall risk reduction. This supports the concerns that the scheme is missing an opportunity to contribute to risk reduction.

Figure 16.3.

The average surface water flood risk calculated for each of the experiments under the baseline, 2030 high and 2050 high climate scenarios.

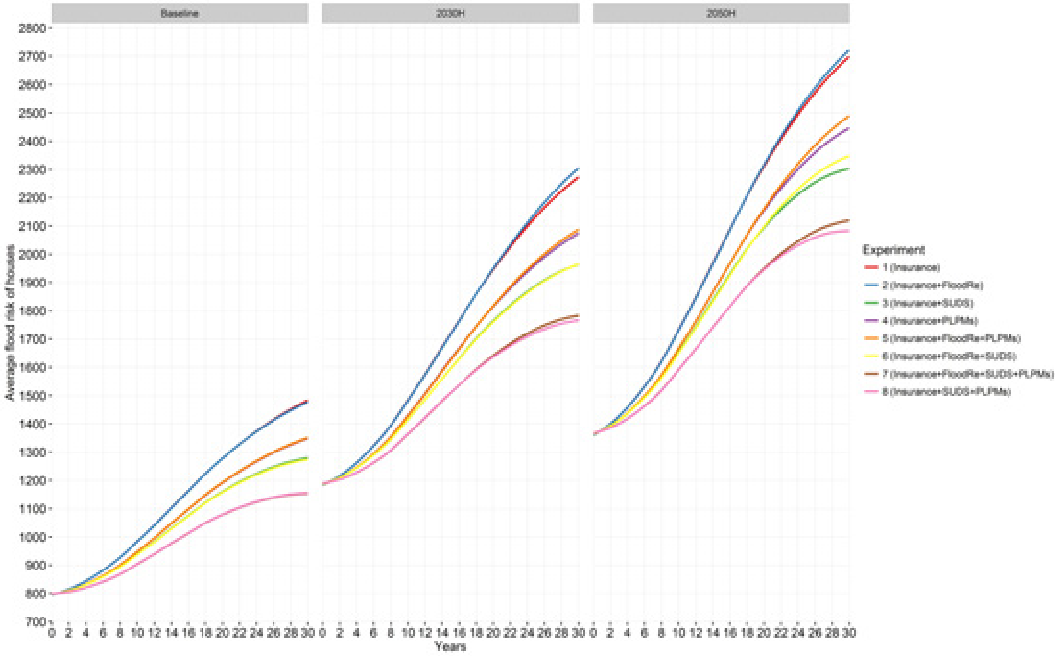
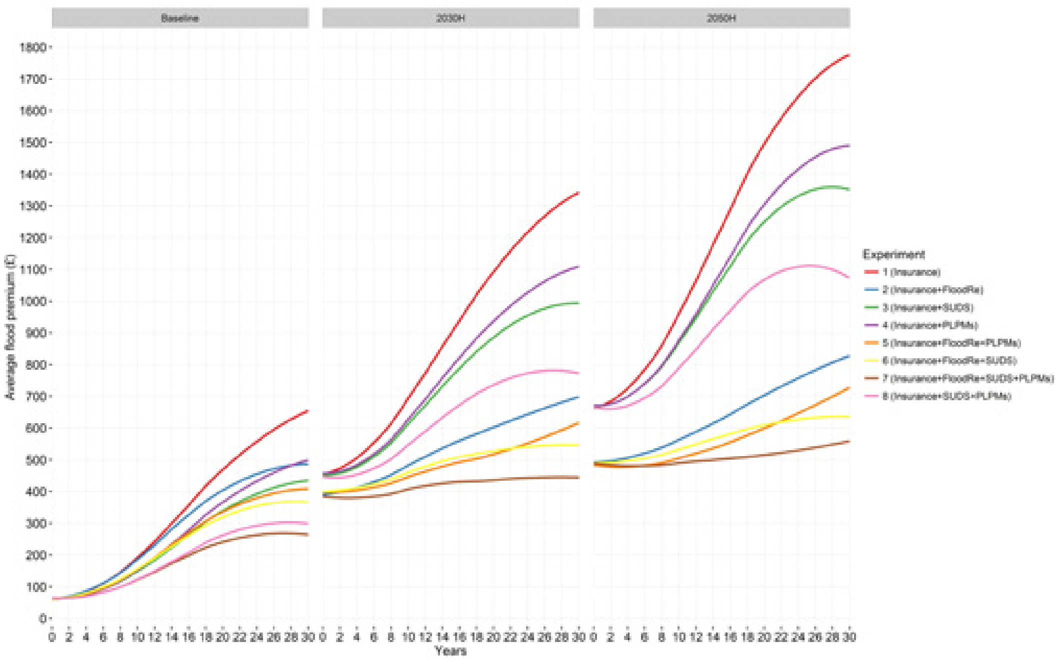


Figure 16.4.

Average flood premiums of houses in risk for each of the experiments under different climate scenarios.



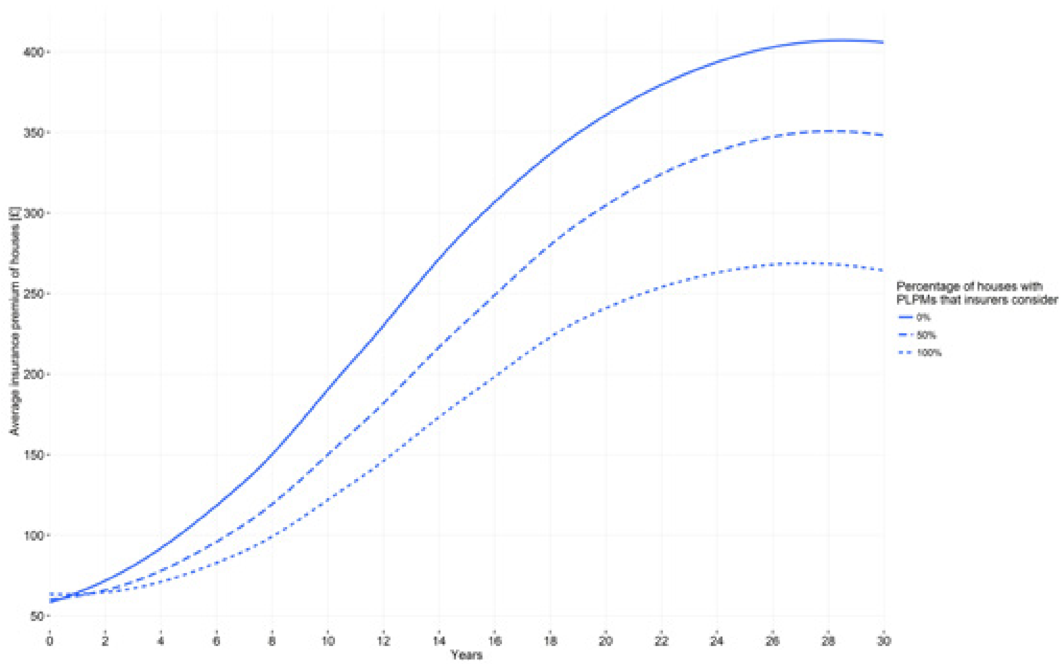
The analysis also focused on the role of different actors in the MSP. Despite calls for greater private sector involvement in flood and disaster risk management there is still a lack of clarity around the roles these different actors can play and, in particular, around the interactions and trade-offs in their actions. The ABM allowed us to test the current partnership by examining the role that the local government and insurers can play in reducing surface water flood risk and/or incentivising risk reduction behaviour by households. For example, by investigating the effect if the insurer accounted for investment in PLPMs when calculating the flood risk of houses and setting premiums. This highlights one incentive that could be given to homeowners to invest in PLPMs either proactively or in response to a flood event. Figure 16.5 shows that for the baseline climate scenario average household flood premiums are reduced by 38% to £250 by year 30 when insurers consider PLPMs, compared to £400 when they are not accounted for.

In addition, by including other agents in the partnership the ABM allowed us to see if and how their actions could reduce flood risk. As future development could exacerbate current levels of surface water flood risk the role of the developer and hypothetical changes to regulations which would impact upon their decision-making and development of new homes was analysed. The level of surface water flood risk was highest in the model when no developer restrictions were in place, and lowest when the developer was required to build all new properties with SUDS. The reduced flood risk subsequently resulted in reduced average household flood insurance premiums when accounted for by the insurer.

The effect of increased/decreased government investment in PLPMs and SUDS, and hypothetical changes to development regulations, were also investigated. Benefits of government investment in flood protection measures were larger when directed towards new build hous-

Figure 16.5.

The average SW flood insurance premium of houses when the insurer agent does/doesn't account for installed PLPMs.



es, which include properties in some of the higher flood risk areas in the model, and which are targeted for SUDS projects based on the favourable cost-benefit ratio. As above increased investment in flood protection measures had a positive effect on flood insurance premiums (although this remains much higher for new build houses as they are excluded from Flood Re).

However, as important in the partnership is the role of the local government in approving local developments. A 50% reduction in surface water flood risk of the area was seen when it was assumed that for every planning proposal the government lowers their level of maximum flood risk they would accept, or if this is exceeded requires the sale of the land for development to result in a higher level of profitability. Consequently, more stringent government criteria for approving new developments resulted in fewer new properties being built in areas of high flood risk. Figure 16.6 highlights the simulated increase in new build properties in east Camden compared to west Camden when more stringent regulations are placed on developers.

Overall, the most beneficial results in terms of flood risk reduction were seen when the full range of developer and government conditions were implemented together in the model. The analysis also highlighted the importance of co-ordinating the developer and local government risk reduction strategies. For example, if the developer builds all new properties with SUDS the resultant reduction in flood risk means that many are approved, even when the local government reduces the acceptable level of flood risk. However, while SUDS help reduce risk they may not mitigate it fully. The potential for counteractive effects when combining constraints and measures targeted to developers and the local government is a key finding of this research and an area which warrants further investigation.

Furthermore, the magnitude and trends in average flood premiums seen when different insurer, government, and developer conditions were implemented also differed largely when future climate change was considered. This suggests that there is no single long-term optimal approach to managing surface water flood risk and maintaining affordable premiums, with the benefits and trade-offs of options changing over time with climate change, changing levels of flood risk, and changes to the built environment.

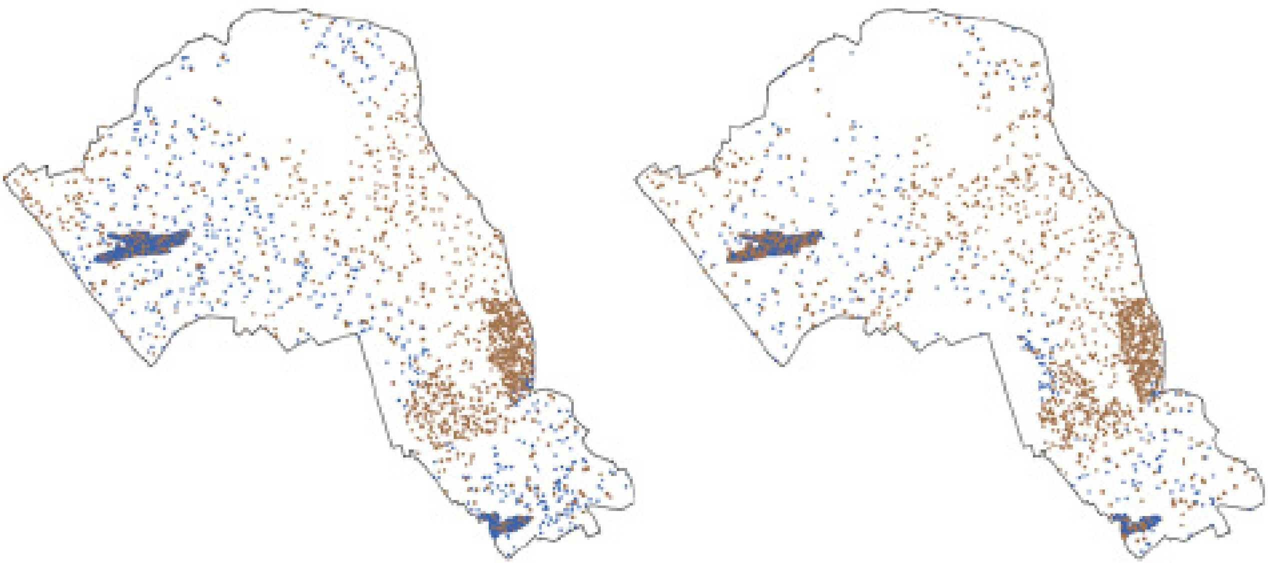


Figure 16.6.

The spatial location of new build properties in the London Borough of Camden built in flood risk (blue) and not built in flood risk (brown). The left panel shows results under the initial model setup, and the right panel results when there are stricter government criteria for approving development proposals (baseline climate scenario).

Recommendations

Insurers are seen as a key private actor who can play a greater role in reducing flood risks (Kunreuther & Michel-Kerjan, 2009; Surminski, 2014; Surminski et al., 2015) and the European Insurance industry also views public-private partnerships as vital for reasons of insurability, risk transfer and ensuring the use of appropriate adaptation and prevention measures (CEA, 2007). Yet, developing the right flood insurance arrangements or partnerships to incentivise flood risk reduction and adaptation to climate change has remained a key challenge.

The consideration of the insurance design principles highlights trade-offs between affordability, availability, and vulnerability reduction, particularly when considering the political realities that drive the reform or development of the new insurance scheme. The most commonly considered determinants of natural disaster insurance are affordability, commercial viability or availability of cover, and financial sustainability or solvency. **We argue that a fourth determinant should be recognised when assessing or designing insurance**: **the risk reduction potential of insurance**. Effective prevention is expected to play a significant role for affordability and availability of disaster insurance, but it is far from clear how these concepts interact, and where the scope for future reform is. As the example of UK flood insurance shows there are significant challenges in investigating and utilising the prevention role of insurance.

Our particular interest in the interactions between flood insurance in the UK and surface water flood risk management stems from the current changes facing the industry with the introduction of the new Flood Re pool in Spring 2016. We note that efforts to reform the insurance arrangements have been predominantly focused on dealing with the affordability of insurance, without considering the implications of alternative mechanisms for managing and reducing the underlying risks. Reflecting on evidence emerging from other European and international flood insurance schemes, we notice that this is not an exception, but rather the norm (Surminski and Eldridge, 2015). Yet, depending on its design and implementation, an insurance scheme can send signals to policy makers in support of flood risk management policies, which would address risk levels, for example through changes in the planning system and building regulations.

Our investigation finds that the new Flood Re scheme does not enhance this policy link nor the incentivisation of home resilience, which presents a missed opportunity. Analysis and engagement with stakeholders revealed a range of barriers (Table 16.1) for achieving risk reduction through the SoP or Flood Re, which need to be addressed if the current MSP is to improve its ability to manage and reduce surface water flood risk.

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Table 16.1.

Barriers to risk reduction under the Statement of Principles and Flood Re (Source: Surminski and Eldridge, 2015).

Barriers to risk reduction	Detail of barrier
Risk information	Insurers' concerns about confidentiality of their claims data, licensing questions regarding public flood data when used for commercial purposes, communicating probabilities and flood risk information to individuals, reaching those most vulnerable; large group of data-owners; cost of collating and streamlining data
Information about risk reduction measures	Unclear cost-benefits
Financial incentives for risk reduction measures	Unclear cost-benefits, behavioural barriers, hassle factor, size of premium not big enough to trigger investment, difficulty in tracking/data implementation of PLPM, affordability challenge, contract length
Resilient repairs	Unclear cost-benefits, might take longer than standard repairs
Incentives for public policy	Difficulty of tracking and monitoring enforcement
Compulsory measures	Unclear cost-benefits, competitive market, affordability
Incentive for new build	Limited interest by property developers to consider insurability, administrative burden for insurers, lack of data

The qualitative and quantitative analysis also raises concerns about issues of moral hazard as Flood Re could de-incentivise flood risk reduction at a household level and dissuade homeowners from investing in PLPMs while in place (Surminski and Eldridge, 2015).

However, **for incentives to reduce surface water flooding to be successful they need to target those who can take action**. This goes beyond the homeowner and government and needs to include all those who determine if, where and how houses are being built, refurbished or repaired, including property developers, mortgage providers and local planning officials. Thus, one aspect that warrants further investigation is how this partnership could be strengthened or expanded to contribute more significantly to flood risk reduction, in particular in the face of rising risks due to climate change. The ABM provides a novel tool to help analyse how the actors in the MSP could incentivise flood risk reduction, and highlights a range of options for strengthening this partnership in the face of rising surface water flood risk.

Results from the ABM highlight how climate change and socio-economic development can exacerbate current levels of surface water flood risk in the London Borough of Camden. The most beneficial results seen for surface water flood risk reduction are a combination of investment in both PLPMs and SUDS by the developer and local government, alongside more stringent conditions for approving new development proposals. This highlights the need for further investment and provision of grants for PLPMS and adds support to the current reviews and government led pilot schemes into PLPMs being undertaken in the UK. However, even with SUDS and PLPMs in place the average surface water flood risk continues to increase over time, and under no experiment does it stabilise or decline. Given the implications of climate change on surface water flood risk this illustrates the danger of further trade-offs between future development plans and flood risk management.

The provision of flood insurance is influenced by public policy – directly through regulation such as mandating cover or instigating the development of new schemes. And indirectly by providing the enabling infrastructure and environment, for example through a broad risk reduction framework, including building codes and better flood risk data provisions. This point is particularly relevant in the context of surface water flooding and underlines the need to engage with a broader range of stakeholders and decision makers. **A stronger policy approach to flood risk management (planning, defence, resilience measures, data etc.) will make the MSP more viable**. Collaboration between the national and local authorities, planners, and developers is crucial. Planning guidelines have been tightened under the National Planning Policy Framework (DCLG, 2012) and subsequent amendments for inclusion of SUDS in developments of 10 or more properties in 2015 (DCLG, 2014). However, the economic benefits of developments and demand for housing provide a case for developers to continue to build on high flood risk land, and for Local Authorities (LA) to approve such developments. While the EA is able to oppose developments at high levels of flood risk it is ultimately down to the LA to make the decision. The Adaptation Sub-Committee (2012) has raised concerns that there is still limited consideration of future risk under climate change within the approval process, and the actual levels of uptake of the EAs recommendations is not sufficiently transparent or accountable.

Furthermore, the magnitude and trends in average flood premiums seen when different insurer, government, and developer conditions are implemented also differ largely when future climate change is considered. This suggests that there is no single long-term optimal approach to managing surface water flood risk and maintaining affordable premiums, with the benefits and trade-offs of options changing over time with climate change, changing levels of flood risk, and changes to the built environment. This highlights the importance of including multiple actors in the MSP, and allowing a flexible framework that can be modified over time as different risk thresholds are passed. A **pathways approach** that sequences the implementation of actions over time, to ensure the system adapts to the changing social, environmental and economic conditions, would act to build flexibility into the overall flood risk management strategy (Ranger et al., 2010; Haasnoot et al., 2012).

For insurance our model shows that Flood Re is likely to achieve its aim of securing affordable flood insurance premiums. However, our findings also highlight that the new pool would be placed under increased strain if challenged with increasing risk as highlighted by the future climate change projections. Several of the questions addressed in our analysis have particular relevance for Flood Re's transition process, which determines if and how the new scheme operates over time. The transition plan highlights the challenges posed by rising risk and outlines who within and outside the partnership will have to address these issues. Flood Re acknowledges that in its current form it has no direct levers to deliver risk reduction, but it commits to working with other stakeholders, including policy makers and insurers to support greater flood resilience (Flood Re 2016). Our findings show how important this collaboration for resilience is.

A key issue will be how the increasing gap between the level of premiums paid by high risk properties and the risk-based value they would face outside this scheme is addressed and managed over time. This is particularly important as Flood Re has been designed to be a transitional solution, with an anticipated run time of 20-25 years, smoothing the way to more risk-based pricing in a competitive insurance market in the future. Until now this issue has not received sufficient attention due to lack of data or analysis.

These issues are likely to become more apparent under climate change and urbanisation and need to be considered within the framework if areas like the London Borough of Camden are to become more resilient to surface water flood events in the future.

The development of the ABM as a tool for such an analysis is beneficial in that it provides a framework to further investigate the transitional mechanisms recently proposed as part of the Flood Re scheme (Flood Re, 2016), as well as how changes to regulatory measures and the roles and behaviour of different stakeholders could be enhanced to support surface water flood risk reduction under future climate change. The ABM has been demonstrated to stakeholders to highlight the value of such a modelling approach and outputs have been cited in a recent report by the insurance regulator PRA (Prudential Regulation Authority, 2015) on the impact of climate change on the insurance sector, triggering extensive stakeholder debate.

The ability of the framework to incorporate different agents with their own behaviours; flexibility for testing different conditions and behavioural rules; flexibility to test and evaluate different policies and options; and the ability to visualise and quantify this in a spatial and dynamic manner, highlights the potential benefits of such a modelling approach to support and inform decision-making. The flexibility of which would benefit from updates to account for updated information on the Flood Re Scheme and the mechanisms for the transition process, further expansion of the agents considered within the model to better reflect the potential MSP, and on-going and future stakeholder engagement, input, and evaluation.

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Building railway transport resilience to alpine hazards

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Introduction

The transportation system in Alpine countries plays an important role in the European transit of passengers and freights from north to south and east to west. Moreover, the Austrian railway network is also essential for the accessibility of lateral Alpine valleys and is thus of crucial importance for their economic and societal welfare. If traffic networks are (temporarily) disrupted, alternative options for transportation are rarely available.

The harsh mountainous nature of the Eastern Alps, within which 65% of the national territory of Austria is situated (Permanent Secretariat of the Alpine Convention, 2010), poses a particular challenge to railway transport planning and management issues. Due to limited usable space or for reasons of economic or technical feasibility, railway lines often follow rivers in valley plains and along steep unsteady slopes, which considerably exposes them to flooding and, in particular, to alpine hazards such as debris flows, rockfalls, avalanches or landslides. **Such events can cause substantial damage to railway infrastructure and pose a risk to the safety of passengers, wherefore they are a great issue of concern for the Austrian Federal Railways (ÖBB)**. In recent years, the ÖBB had to cope with financial losses on the scale of several hundreds of million euros as a result of alpine hazard impacts. Herein, a significant part is constituted by the severe flooding in May and June 2013, which cost more than €75 million (ÖBB Infrastruktur AG, 2014). Some historical catastrophic events even led to fatal railway accidents, e.g. the disastrous avalanche event near Böckstein in the year 1909 caused 26 fatalities. More details on the risk profile of railway transportation in Austria are presented in Thieken et al. (2013).

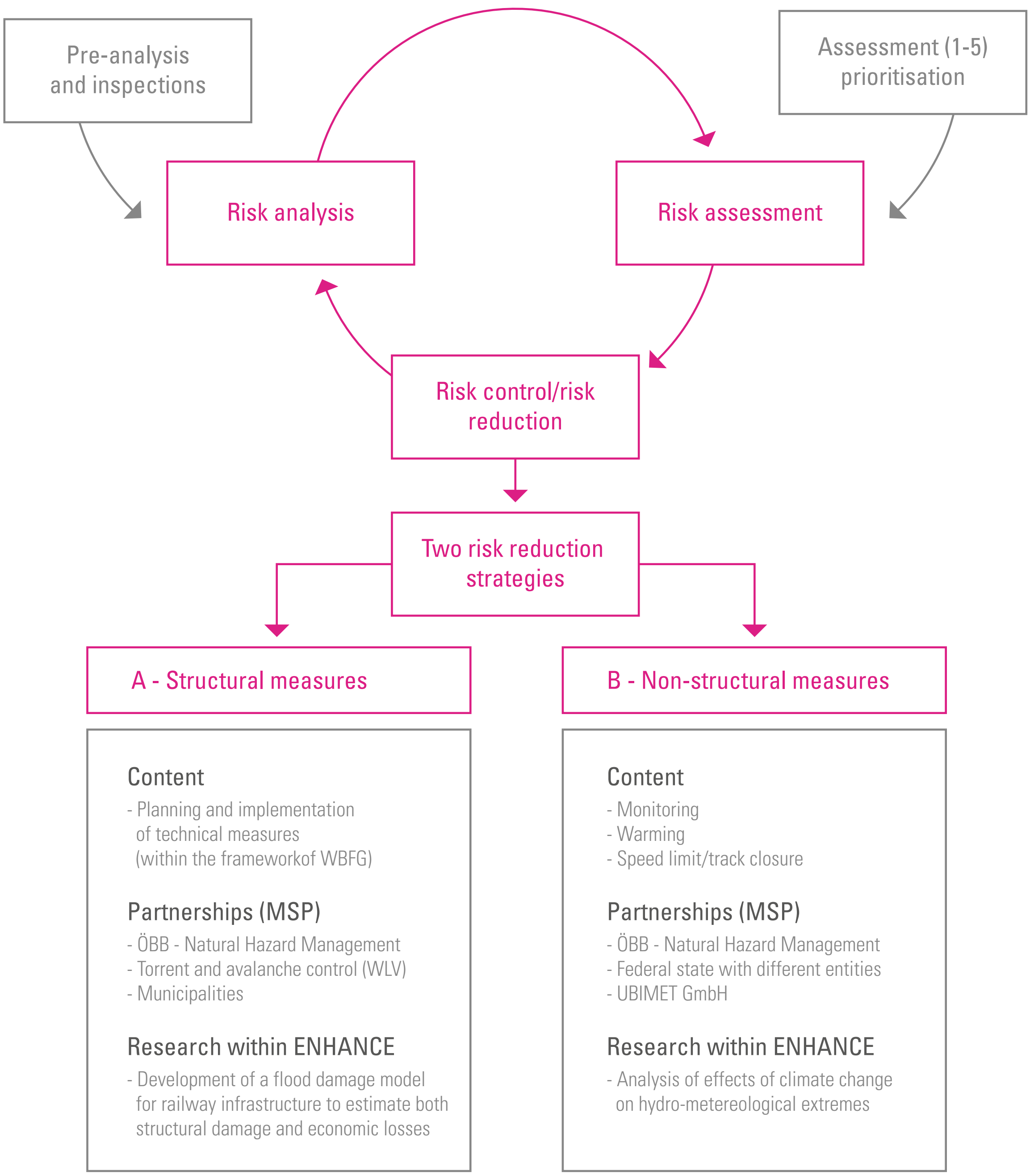
Hence, risk analysis and management are important issues of railway operation in Austria, which is indicated by the fact that the ÖBB maintains an own department for natural hazard management and partnerships with various stakeholders at different administrative levels. In this context, the ÖBB follows two main risk management strategies, namely:

(1) the prevention of alpine hazards through the implementation of *structural protection measures;*
(2) the use of *non-structural/organisational risk reduction strategies* such as a weather monitoring and warning system.

Both strategies, the multi-sector partnerships (MSPs) collaborating in the respective risk reduction strategies, and the research conducted within the ENHANCE project are depicted in Figure 17.1 and described in greater detail below.

Figure 17.1.
Two main strategies of risk reduction in railway transport and according work strands in ENHANCE (Source: own illustration. Information derived from interview/consultation with the ÖBB Natural Hazards Management Department). [WBFG = Hydraulic Engineering Assistance Act; MSP = Multi-sector partnerships; ÖBB = Austrian Federal Railways].

"Alpine railways are key for freight and travellers transport and subject to multi-hazard risks. In August 2005, floods blocked a section of an Alpine railway, it took €30 billion and 100 days to get it back in operation."



ÖBB risk management strategies

Structural protection measures

To protect their railway infrastructure from Alpine hazards, the ÖBB plans and implements structural (protection) measures on its own. If other stakeholders are affected by these protection measures, the ÖBB engages in partnerships to jointly plan and implement them. The core of these partnerships on structural measures lies in cost-sharing and, in preparation for it, also in information exchange. It includes formal, standardised processes fixed in regulations, as well as informal elements and ad-hoc negotiations. Further details on the strategies and specifications of the multi-sectoral-partnerships identified in this case study can be found in Otto et al. (2014).

Taking the core of partnerships on structural risk reduction measures into account, this ENHANCE case study focussed on supporting strategic decision-making regarding structural protection measures via provision of quantitative information on risks by means of **a statistical modelling approach derived from empirical damage data**, i.e. photo-documented structural damage on the Northern Railway in Lower Austria caused by the March river flood in 2006, and simulated flood characteristics, i.e. water levels, flow velocities and combinations thereof. A model was developed which enables the estimation of 1) expected structural damage for the standard cross-section of railway track sections and 2) resulting repair costs. The first step in particular is usually skipped in existing flood damage models, since only (relative or absolute) monetary losses are computed. However, the localisation of significant structural damage potentials at specific track section and, coupled therewith, the identification of risk hot spots creates great added value for railway operators in terms of network and risk management. Such information allows, for example, the targeted planning and implementation of (technical) risk reduction measures. In this regard, the results of the risk assessment indicate that the model performance already proves expedient as the mapped results plausibly illustrate the high damage potential of the track section located closely adjacent to the course of the river March as well as a general accordance with inundation depths. The estimates of financial losses (i.e. repair costs) amount to a plausible order and scale as the total costs increase for lower probability events and the results for the flooding in 2006 only overestimate the real expenses by approximately 2 %. The findings, furthermore, show that the development of reliable flood damage models for infrastructure is heavily constrained by the continuing lack of detailed event and damage data. This affects also the estimation of indirect damage, which can be indicated by the availability of a railway line. To feed a process-oriented methodology, sufficient input data is still missing. Therefore, only a rough estimation can be carried out to give an indicator for the worst case scenario when interpreting all processes as being independent. More details on the structural risk assessment results are presented in the ENHANCE case study deliverable 7.3 and in Kellermann et al. (2015c, 2016a).

Photo by Emi Christea/Shutterstock.

Non-structural/organisational risk reduction strategies

Since the possibility to address the risks from natural hazards in the Alpine topography by means of technical protection measures such as dikes or avalanche protection is limited, due to the sheer number of torrents and avalanche paths, the ÖBB additionally engages in non-structural/organisational risk reduction measures (see Figure 17.1). This strategy focusses on risks occurring from meteorological hazards (i.e. extreme weather) and alpine hazards (e.g. avalanches, torrential processes, debris flows).

The main idea of partnerships following this precautionary strategy is to gather and exchange information in order to better evaluate risk situations. Herein, a key element is the weather monitoring and early warning system called **Infra:Wetter**, which is jointly operated by the MSP[25] between ÖBB and the private weather service Ubimet GmbH. Also information from the national meteorological office (ZAMG) is included in this system. In addition to providing individualised and route-specific warnings to approximately 1500 users, Infra:Wetter is also used to identify so-called critical meteorological conditions (CMCs) in advance: weather conditions that potentially lead to larger disruptions of train traffic and thus require coordinated action by the Natural Hazards Management Department of the ÖBB.

Since knowledge and information are the main focus of the partnership on the non-structural risk reduction measure Infra:Wetter, the case study at hand delivered new insights into possible climate change impacts on frequencies of extreme events to support decision-makers in the comprehensive and sustainable natural hazard management. The frequency analysis of CMCs in a changing climate revealed a noticeable to strong alteration of the current hazard profile in Austria. Notwithstanding the fact that climate change impacts can also have positive effects on some sectors (e.g. winter service), the occurrence of the most relevant type of CMCs analysed, i.e. very intensive rainfall events, is likely to increase considerably in the future, which overall leads to new challenges for the ÖBB natural hazards management. If no action is taken, the costs due to extreme weather events must be expected to rise in the future. Based on historical experiences, e.g. from the extreme rainfall event in 2013, the weather monitoring and warning system Infra:Wetter proved to be a rather cost-effective non-structural risk mitigation measure. However, the modification of the thresholds for the identification of CMCs revealed that frequencies of extreme weather events are quite sensitive to changes of this decisive factor. In the context of climate change, this result emphasises the importance to carefully define and constantly adapt and validate the thresholds in order to optimise the effectiveness as well as the adaptive capacity of a weather monitoring and warning system. Since the necessary data for an empirical evaluation of the threshold are currently not available in respect to data quality and temporal coverage, the importance to continuously collect detailed event and damage data following a standardised procedure is striking. Event documentation including 'near misses' can enable risk managers to better understand and learn from historical events and, thus, to adapt natural hazards management to future changes. More details on the non-structural risk assessment results are presented in Kellermann et al. (2015b, 2016b).

[25] MSPs as defined by McLean et al., 2013, p.1.

Photo by Pavel L/Shutterstock.

Using the risk assessment results described above as a basis, the non-structural risk reduction solution Infra:Wetter and the MSP addressing the risk from CMCs were then further discussed and evaluated against several criteria (Kellermann et al., 2015a):

- Currently, CMCs are defined using a threshold approach, which was defined by experts of the MSP, i.e. ÖBB and Ubimet GmbH. Given the importance of these thresholds, potentially resulting in precautionary operational measures such as track closures and/or temporary speed limits, an empirical examination of these thresholds would provide important insights into the suitability of these thresholds. Therefore, a method to assess the suitability of the current thresholds is provided and exemplified. For a real application of this method, a more detailed longitudinal damage data base would be required, though, which again highlights the importance of event and damage documentation.
- An application of the risk layer approach (Mechler et al. 2014), which evaluates the suitability of risk reduction strategies based on disaster risk characteristics shows that Infra:Wetter in combination with a risk absorption mechanism provided by the federal government, is generally an appropriate solution for addressing risk from CMCs.
- After Infra:Wetter was established in 2006 in the aftermath of a major flood event in 2005, the system was stress-tested for the first time in June 2013, when extreme rainfall resulted in floods and debris flow events obstructing and interrupting train transportation in large parts of Austria. An analysis of this stress test showed that the system generally performed well also under extreme conditions. The event was predicted with a sufficient warning time and operational measures such as track closures and temporary speed limits reduced the risk to passengers and staff. An evaluation of the potential impact of climate change on CMCs furthermore revealed that such extreme situations could become more frequent in the future. This could mean additional stress for the risk absorption mechanism currently provided by the federal government.

The evaluation presented in this report builds upon the work that was conducted within the case study over the last three years. The basis for the scientific work in the project was the close cooperation with and support by the principal stakeholder ÖBB and included several internal project meetings, workshops and the provision of data as well as their feedback. Moreover, several interviews were conducted with additional stakeholders such as the Federal Ministry of the Interior, the Disaster Unit Salzburg, Water Management and Flood Control Unit of Salzburg and the Forest Engineering Service in Torrent and Avalanche Control (Otto et al., 2014). A full list of interviewed stakeholders can be found in Otto et al. (2014). Further details on the MSP evaluations can be found in Kellermann et al. (2015a).

Photo by ÖBB.

Policy recommendations

Based on the risk assessments, MSP evaluation and the stress test during the 2013 event, several recommendations for further improvement and expansion of the current MSP for non-structural risk reduction are provided. Parts of these recommendations/improvements are currently already implemented by the ÖBB.

Within the ENHANCE project, the so-called 'capital approach' has been introduced to assess the healthiness of MSPs addressing the risk from natural hazards (McLean et al. 2013). This concept was also the basis for the evaluation provided in terms of MSP development for the ENHANCE case studies (Thieken et al. 2013, Otto et al. 2014). According to this approach, the following five capitals provide partnerships with the capacity of being able to react to natural hazards: social capital, human capital, political capital, financial capital and environmental capital. A more detailed explanation of the five capitals is given in McLean et al. (2013).

The recommendations provided in the following sections will be discussed against the background of the five capitals.

Improving internal risk and crisis management

While the extreme event in 2013 generally demonstrated that Infra:Wetter worked well, it also revealed potential for improving internal risk and crisis management. One aspect that was identified was the need for clearly defined responsibilities during such a long-term event. Being an infrastructure manager with a complex organisational structure, it is important for the ÖBB to have a clear picture of the persons in charge at different levels of the organisation. At the beginning of an event, this is usually the head of the organisational unit responsible for taking decisions at the respective level. However, in case of a longer-lasting crisis, as it was the case in 2013, it is important to share responsibilities and to appoint and communicate deputies that are available in times when the head of the division is not available. In order to strengthen the social capital internally, strategic plans were developed that shall further improve the effectiveness of the crisis management and the preparedness of the responsible staff. For instance, it was decided to appoint an officer in charge on the spot during future events of such a magnitude.

An organised and structured hazard management depends on regular training and continuous education of personnel. For instance, the ÖBB has its own avalanche warning service and commissions that consist of trained avalanche specialists. These experts evaluate the avalanche risk and give advice to decision makers. They have instruction-freedom and receive training and equipment to examine the in-situ conditions of the snow cover in the avalanche starting zones. Based on their advice, the track managers then decide whether the railway service will continue operation, or, if there will be restrictions or even track closures. The avalanche commissions work in cooperation with the ministries, the national disaster management, the avalanche warning services of the federal states, the district administrations and the municipalities. Against the background of the good experiences made with this system and to strengthen the social and human capital, the Natural Hazard Management section of the ÖBB started a project to set up similar institutions for water-related hazards, such as floods and torrential processes. These commissions shall ensure an effective and regulated workflow during crisis situations and a legal basis for imposing safety measures, which is immensely important for the field staff as well as for the decision-makers. If critical decisions are taken by commissions, this would also mean an improvement for ÖBB staff members in terms of liabilities for these decisions. Clear regulations regarding the legal liability of these commissions for certain decisions, such as false alarms, would further improve legal certainty. Although the field personnel showed an enormous work effort to bring the situation under control during the event in 2013, such structured operating instructions help to further optimise and accelerate decision-making processes for an even quicker response during extreme weather events.

To enhance the ability of the ÖBB to implement (temporary) speed limits or stop trains also as far as small-scale convective weather events are concerned, it was furthermore proposed that each train should be equipped with a GPS system so that it can be readily and exactly located.

Enhancing the management of CMCs through enlarging the MSP

In addition to internal improvements of the risk and crisis management, the flood event of 2013 was also a trigger for the ÖBB to further enhance risk management by building up and enhancing cooperation with additional external partners from the public sector, university and industry, improving the social and human capital of the MSP.

For instance, the hydrographic services of the federal states maintain a dense hydrographic monitoring system in Austria and are also responsible for issuing regional flood warnings.[26] To make best use of this information resource, specific thresholds for inundation levels posing a risk to railway infrastructure, for instance in the Salzburg region, were recently defined and integrated into Infra:Wetter. Based on these thresholds, the hydrographic services can provide railway-specific flood warnings to the ÖBB.

[26] http://ehyd.gv.at/

Photo by Dr Madra/Shutterstock.

The event had also revealed that a good knowledge of the situation on the ground is very important. While the state of flood protection measures and embankments is usually well known due to their good visibility, the situation for torrents is different: catchment areas are difficult to monitor, because the amount of debris is constantly changing. Moreover, there is also the risk of drift-wood blockage. To improve also this aspect of risk management, a pilot project that is concerned with the optimisation of the current observation of torrential catchments, for example, with drones was set up by the ÖBB in collaboration with the University of Natural Resources and Life Sciences (BOKU) in Vienna.

Also the EU Floods Directive provided impetus to the ÖBB to develop additional and more context-specific flood risk maps, which identify and visualise track sections prone to flooding. The maps that were produced for the Floods Directive are usually not of sufficient detail as far as rail infrastructure is concerned. For instance, tunnels under the railway tracks or bridges are not reflected correctly at the tracks, suggesting inundation of railway infrastructure while it is not, in fact. Moreover, to reflect the exact height of the railway tracks, a very detailed digital elevation model (DEM) is needed giving their linear feature. To better account for the specific features of the railway network and to improve the level of detail, the maps of the Floods Directive are currently being enhanced by the ÖBB in collaboration with the engineering company riocom[27] by using e.g. a detailed DEM. The resulting maps illustrate the flood plains with a return period of 30, 100 and 300 years and take the specific details of the railway network into account. They thus help to create specific flood risk management plans and monitoring as well as early warning systems where they are useful and needed.

Enhancing the MSP

After the large-scale flood in 2005, the ÖBB considerably built up its human and social capital in terms of knowledge on hazard occurrence as well as its monitoring and early warning capacity. Following the event in 2005, Infra:Wetter was initiated and implemented; it provides weather warnings on the basis of meteorological parameters. This system is currently being enhanced by adding rail-specific flood warnings that are provided by the hydrographical services of the federal states. Moreover, existing flood hazard maps that were developed in the framework of the EU Floods Directive are further enhanced to comprise the required level of detail for the railway sector. Also knowledge on other hazards such as information on torrential process has been improved through cooperation between the ÖBB and the BOKU in Vienna.

To enhance risk management and strategic planning, this knowledge on the hazard side could be complemented by further strengthening the social and human capital of the partnership in terms of impact assessments (e.g. in terms of direct damage) and finally risk (i.e. probability times damage). Insights into damage and the expected annual damage (EAD) of different natural hazards such as flood and debris flow events would also help to prioritise different risk mitigation measures. For this, models that capture the damaging processes of natural hazards to railway infrastructure would be needed. Damage models that are specifically developed for the infrastructure sector in general and the railway sector in particular, are still scarce (Kellermann et al., 2015c). A few established flood damage models, e.g. the Rhine Atlas damage model (RAM) or the Damage Scanner model (DSM), actually do also consider direct damage to infrastructure by use of depth-damage curves. However, only aggregated CORINE land-use data containing a large variety of urban infrastructure and lifeline elements are used therein (Bubeck et al., 2011). Hence, within the present ENHANCE case study, a railway-specific damage model was empirically derived by Kellermann et al. (2015c) on the basis of the March flood event in 2006 at the Austrian Northern Railway. Its application to a wider railway network was investigated by Kellermann et al. (2016a) and demonstrates its usefulness in a risk management context.

Enhancing the MSP through improved damage data collection

At present, the damage reporting and documentation system comprises three steps. All incidents that occur during railway operations are reported directly by the train conductor and recorded in the internal database on Railway Emergency Management (REM). This includes incidents caused by natural hazards but also other events such as, for instance, deer crossing. As incidents are also recorded from moving trains, identifying the exact reason for an incidence is not always an easy task. Therefore, incidents are examined further by the ÖBB and are then included in the damage database of the ÖBB. Those events that are considered as serious and are thus worth being registered

[27] http://www.riocom.at/_english/about_us.htm

are further examined and verified by ÖBB staff and then included in the ÖBB accident statistics. In this data base, it is also classified whether the incident was caused by a natural hazard and what type of natural hazard.

However, in the current classification scheme, several natural hazards that are characterised by different damaging processes to rail infrastructure are integrated into a single category. For instance, one category comprised the alpine hazards debris flow, landslide and rock fall. This makes the database use difficult in order to gain insights into the specific damaging processes of these individual hazards. A good understanding would be needed, though, to develop impact and risk models that can support risk-based decision making.

In order to be better quantify damaging processes and to enhance the human capital in terms of impact assessments, the Natural Hazards Department of the ÖBB currently works on restructuring the reporting system in such a way that insights into damaging processes from different natural hazards can be drawn. Moreover, it was considered to also include 'near-misses' and their causes in the data base.

Risk absorption by the federal government

As described above, natural hazards can be associated with substantial damage that makes additional funding from the federal government necessary. A review of recent annual reports of the ÖBB reveals that additional funds were provided by the government in 2006 (no amount specified), in 2013 (€18.4 million) and in 2014 (€7.2 million) to cover damage from natural hazards.

With the projected increase in the frequency and intensity of CMCs, also the demand for additional finance from the budget earmarked by the ministry for calamities or extra subsidies according to the Bundesbahngesetz could rise. These dynamics are currently not taken into account by the risk-absorbing mechanism, which builds upon past experiences in terms of costs due to natural hazards.

To better account for the dynamics in CMCs associated with global warming but also changes in exposure and vulnerability could be achieved by a periodic review of the earmarked budget reserved by the responsible ministry. Based on this revision, it could then be decided whether the risk-absorbing finances or procedures in general need to be adjusted. Such a dynamic component was, for instance, integrated in the European Floods Directive in Article 14 No. 1-3. Here, fixed intervals of six years for a revision of preliminary risk assessments, flood hazard and risk maps and risk management plans are prescribed. Such periodic revisions could have positive effects in terms of the financial and political capital of the partnership.

Moreover, also the application of risk analyses (i.e. probability times damage) for the entire rail network for the current situation and future scenarios could inform this process. Such analyses would provide insights into the estimated annual damage (EAD) that can be expected for extreme events and thus the human capital. The RAIL flood damage model developed by Kellermann et al. (2015c) within the ENHANCE project could be one of the building blocks of such a risk-informed decision making as demonstrated for the Mur catchment by Kellermann et al. (2016a).

Recommendations for the European level: European damage database

The present case study of the ENHANCE project demonstrated the importance of damage data for enhancing risk management: for instance, damage data can be used to derive railway-specific damage models (e.g. Kellermann et al. 2015c), which can be used to calculate EAD for floods that support the evaluation of different risk mitigation strategies. Moreover, a detailed and consistent long-term damage database could furthermore be used to assess the adequacy of thresholds defined in an early warning system and to inform risk absorption mechanisms provided by national governments.

While the ÖBB already collects detailed damage data due to natural hazards, and, currently further elaborates this system, no such system exists in many other European member states or at the European level. The existence of a European damage database could, however, significantly contribute to improving the understanding of damaging processes to railway infrastructure, the proportional share of different natural hazards to overall losses and the development of strategic risk management. For instance, a risk assessment of the Trans-European Transport Network (TEN-T) could provide guidance on where to invest European Community funds in risk reduction. This appears especially important given the substantial investments of €26.25 billion into transport infrastructure up to 2020.[28] EU financial support is provided by the Connection Eu-

[28] http://ec.europa.eu/transport/themes/infrastructure/ten-t-guidelines/index_en.htm
[29] http://ec.europa.eu/transport/themes/infrastructure/ten-t-guidelines/project-funding/index_en.htm

rope Facility (CEF), the Cohesion Fund and the European Regional Development Fund.[29]

On a European level, information on railway accidents are currently collected based on Regulation (EC) 91/2003 of the European Parliament and of the Council on rail transport statistics. The statistics on rail safety are required by the Commission 'in order to prepare and monitor Community actions in the field of transport safety' (EC 91/2003). The national statistics are reported by the member states to Eurostat, which is also responsible for their dissemination (Article 7).

According to Article 4 in combination with Annex H, statistics on the type of accident are broken down into the categories collisions, derailments, accidents involving level crossings, accidents to persons caused by rolling stock in motion, fires in rolling stock and 'others'. As can be seen from this list, no information is provided on natural hazards and their impacts, or even on damaging processes. To enhance risk management of railway infrastructure also at the European level, this reporting system could be complemented with information on the impacts of natural hazards. How and what type of information to include could be informed by the experience gathered by national railway operators such as the ÖBB.

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Stakeholder feedback and impact assessment

A central idea of the research conducted throughout the project was to respond to the specific needs and requests of the main stakeholder and the existing partnerships. Addressing this, different stakeholder interactions were conducted in the form of several meetings and semi-structured interviews, as well as a workshop in order to continuously and purposefully revise the research concept, where needed.

The process started with a meeting with the main stakeholder ÖBB, whose support continued throughout the project. The goals of this first kick-off meeting were to: 1) specify the concept and objectives of the case study, and 2) get a detailed overview of the stakeholder`s perspective, strategies and existing partnerships in the framework of hazard and risk management.

Subsequently, several interviews were held with other stakeholders in the professional network of the ÖBB on different administrative levels to further investigate the existing structures and identify potentials for PPP/MSP improvements. More detailed descriptions of the management structures and strategies of the ÖBB as well as existing MSPs for risk reduction are given in Thieken et al. (2013) and Otto et al. (2014).

Throughout the project, several internal project meetings including representatives of the ÖBB continued on a regular basis in order to constantly evaluate results and when needed, steer the research in the right direction. For example, the research on the Arlberg test track (see Thieken et al., 2013) was discarded and, instead, more focus was put on the development and application of a flood damage model in order to better address this specific interest of the stakeholder ÖBB. On the basis of these investigations and evaluations, targeted risk assessments were conducted addressing both the structural and the non-structural risk reduction strategies of the ÖBB's natural hazard management and focussing on (stress-) testing its current risk reduction schemes. Further details on the risk assessment results can be found in Kellermann et al. (2015b).

In a final step, a stakeholder workshop was organised to present and discuss all results of the risk assessments. This event finally paved the way for the derivation of (policy) recommendations for enhancing the case study-specific risk management Kellermann et al. (2015a). To summarise, the numerous interactions and collaborations with the ÖBB proved to be fruitful, which is also indicated by the fact that different ÖBB representatives contributed as co-authors to various project reports and scientific articles.

Stakeholder feedback

During the final stakeholder workshop in September 2015 in Vienna, the main results of the risk assessments conducted in the course of this ENHANCE case study were presented. The general stakeholder feedback can be rated as very positive, since most of the insights gained from this research have the potential to improve or have already enhanced current risk management strategies.

The main achievement of the risk assessment conducted in the context of structural protection measures (see Fig. 1) was the provision of the flood damage model RAIL

(Kellermann et al., 2015c). The RAIL model can be used to estimate both structural damage to railway infrastructure exposed to flooding and related repair costs. This two-stage approach allows a consideration of both structural damage types and direct economic losses. Particularly the first step provides new information on the occurrence of specific flood damage grades at exposed track sections. These can then be used for different risk management purposes, e.g. for the planning of (targeted) technical protection measures. Hence, the tool has potential to support the stakeholder ÖBB in terms of e.g. conducting cost-benefit analyses or identifying risk hot spots along the entire Austrian railway network (see Kellermann et al. 2016a). Another positive feedback was given with regard to the model structure, which is characterised as simple and easy to understand, but at the same time appropriate for being used in the context of railway infrastructure and operation. This feature facilitates the practical and effective application of the tool also for less-experienced users.

The research conducted in the context of non-structural protection measures focussed on the analysis of effects of climate change on the frequency of meteorological extremes (see Fig. 1). The risk reduction strategy of the ÖBB regarding extreme weather events is based on the weather monitoring and warning system Infra:Wetter implemented and operated in cooperation with the private weather service Ubimet GmbH. The new insights on potential future changes of CMC frequencies due to climate change and related implications for railway transportation in Austria gained from the ENHANCE case study research is seen by the stakeholder as a significant benefit. The results can support the development of targeted adaptation strategies for railway infrastructure and service.

Additionally, in order to enable an accurate identification of CMCs that potentially cause damage to the railway network, a methodological approach was developed to empirically analyse the suitability of CMC thresholds in a weather monitoring and warning system (see Kellermann et al., 2015a; 2016b). The stakeholder and partners agree that given the importance of such thresholds, an empirical examination of thresholds defined by expert judgement would further substantiate their adequacy, providing important insights for the MSP on weather monitoring and early warning. For such an empirical validation, a detailed and long-term damage database would be required. However, such longitudinal databases with a high level of detail and accuracy in terms of damage caused by natural hazards are currently not available to the ÖBB. Hence, the application of the approach using the available event and damage data for railway infrastructure did not allow drawing certain conclusions regarding the validity of the specific thresholds currently applied in Infra:Wetter. Consequently, although the ÖBB damage documentation procedure can already be regarded as best practice, the stakeholder concludes that there is still potential and need to further enhance the approach to make it suitable for an empirical examination of CMC thresholds and, hence, the performance of this risk reduction strategy.

Impact assessment

Since this ENHANCE case study also tried to focus on the needs of the principal stakeholder ÖBB, it was expected that the results of the project, as well as discussions triggered by these, will have an impact. This was the case in several instances, as outlined in greater detail in what follows.

A main achievement of the present case study was the development of one of the first railway-specific damage models, namely: RAIL. The ÖBB signalled interest to apply the RAIL model on a larger scale to gain insights into risk hot spots of the entire network and, therefore, priorities in terms of risk reduction measures. For this, detailed data on potentially inundated railway infrastructure in the Mur catchment were provided and the risk was assessed for the related subnetwork (see Kellermann et al., 2016a). Furthermore, the ÖBB initiated discussions on how the RAIL model could be transferred also to other natural hazards than floods. The ÖBB would be especially interested in developing a similar method for debris flow events, for which hazard maps but no damage and risk model are available. Discussions with the ÖBB and other stakeholders such as the BOKU Wien already took place to investigate the feasibility of this plan.

The fact that the RAIL model shall be applied on a larger scale and be transferred to other hazards shows that the developed methodology is easy to understand and is considered useful also in the practical context of railway operation.

The work conducted within this ENHANCE case study on the empirical evaluation of the thresholds currently used in the weather monitoring and warning system Infra:Wetter revealed that the high data quality needed for such an analysis did not exist. For an accurate assessment of thresholds, a detailed, consistent and long-term (longitudinal) damage database would be required. Such databases with a high level of detail and accuracy in terms of damage caused by natural hazards are currently not available for railway infrastructure in Europe. Even the ÖBB, which has invested considerably in event and damage documentation over recent years, does not dispose such a detailed longitudinal damage database. The experience made with the damage data during the ENHANCE project, among other things, prompted the ÖBB Natural Hazards Department to restructure their damage documentation system. The ÖBB realised that the existing damage database needs modification and has already started working on improving the way data is collected. It reaffirmed the ÖBB that historical damage data are an important foundation of the risk management planning process and that the analysis of previous experiences is a valuable factor in risk management. In the future, damage data collection shall be organised in such a way that better insights into damaging processes from different natural hazards can be drawn. It was considered to also include 'near-misses' and more detailed information on their causes in the data base.

The ÖBB also became aware of the fact that such a damage documentation system does not exist on a European level and many member states. As a result, there is a high possibility for sharing knowledge and experiences and having Austria as the 'best practice example' when developing innovative tools for natural hazard management strategies and, consequently, to open doors for collaboration on the European level.

Following the flood event in 2005, the ÖBB had already considerably built up its knowledge in terms of hazard occurrence as well as its monitoring and early warning capacity. With the ENHANCE project, the ÖBB started to complement this knowledge with further insights into impacts (e.g. in terms of direct damage) and finally risk (i.e. probability times damage). This complement was perceived as an added value for strategic risk management and is currently further pursued by the ÖBB, by integrating additional partners to the MSP working on risk assessments.

In addition, the ÖBB was interested to gain further insights into indirect damage arising from natural hazards. Indirect damage occurs if train services are disrupted or delayed because parts of the railway infrastructure are blocked or destroyed, for instance, through a debris flow event. It was initially planned to model these effects by means of an 'availability analysis' of the network on the basis of the graph theory (Schöbel and Blieberger, 2010). This approach has been successfully applied for crossovers and even larger railway stations (see Schöbel and Blieberger, 2010) but, unfortunately, it does not cover the complexity of dependent natural hazards along a railway line. Hence, due to this complexity as well as lacking data, this assessment could not be realised within the ENHANCE project.

Photo by Peter Gudella/CanStockPhoto.

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