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:**

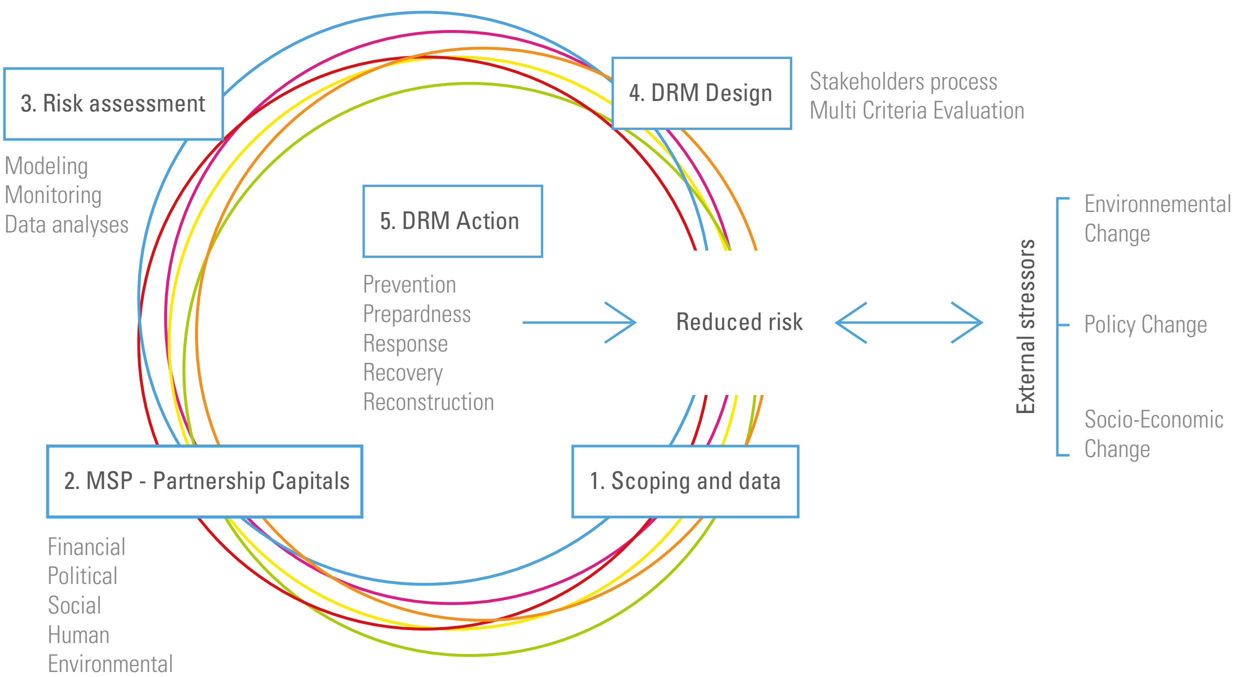
'Voluntary but enforceable commitments between partners from different sectors (public authorities, private services/enterprises, and civil society), which can be temporary or long-lasting. They are founded on sharing the same goal in order to gain mutual benefit, reduce risk, and increase resilience'.

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

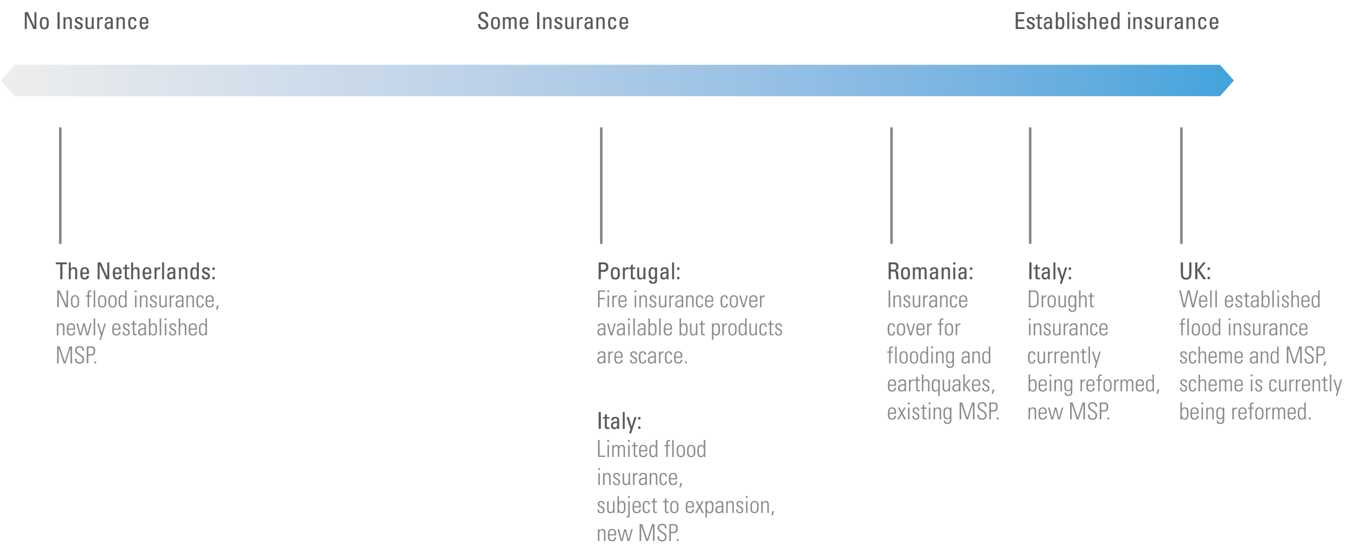
Insurance is a key economic instrument in the context of DRR, offering a shift in the mobilisation of financial resources away from ad hoc post-event payments, where funding is often unpredictable and delayed, toward more strategic and, in many cases, more efficient approaches that were arranged in advance 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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