Chapter 5

Managing disaster risk

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5 Managing disaster risk

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Introduction

The European region is exposed to a wide range of natural hazards such as storms, droughts, heat waves, floods, earthquakes, avalanches and landslides that continuously cause human and economic loss.

Despite the European wealth of expertise, knowledge and know-how in disaster risk management (DRM), statistics show that vulnerability to hazards in the region is increasing.

DRM comprises a systematic process of using administrative decisions and organisational and operational skills and capacities to implement policies and strategies, and coping capacities of society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This concept includes all forms of strategies, policies, plans and activities aimed at minimising disaster impacts on individuals and society.

This chapter examines the scientific contribution to understanding these processes and institutions across Europe. These are described in four subchapters, divided up in a similar way to how DRM functions and are often separated conceptually across a disaster management cycle. The disaster management cycle commonly includes four types of measures needed to manage disasters: mitigation and preparedness (before a disaster) and response and recovery (after a disaster).

These measures are broadly aligned with the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR), which adopts the idea of managing disaster risk as opposed to managing disasters, whereby action is needed to do the following.

- Reduce existing risk: a set of measures, known as 'corrective risk management', similar to the commonly used concept of 'mitigation'.
- Avoid new disaster risk: activities to address and avoid the development of new or increased disaster risk, known as 'prospective risk management', similar to what are often referred to as 'prevention' measures.
- Manage residual risk: activities that strengthen the resilience of individuals and societies to risk that cannot be effectively reduced, including preparedness, response and sometimes recovery activities (those that do not actually avoid new disaster risk by, for example, relocating populations in the aftermath of a disaster) as well as risk transfer and financing activities.

Prevention and mitigation; preparedness and response planning; post-disaster recovery (to new risk); and risk transfer and financing are the major topics of this chapter. The focus in Chapter 5.1 is on studies of disaster mitigation and prevention presenting a range of structural (e.g. building codes and their enforcement and structural protection measures) and non-structural (e.g. land-use planning and zoning) measures. Critically, all disaster prevention and mitigation measures need to be identified on the basis of risk assessments, and the use of these across Europe is reviewed in this chapter.

Mitigation and prevention measures in Europe are widely considered to be more cost-effective than post-disaster interventions. This is predominantly based on an analysis of the benefits arising from avoided loss. Economic analysis methods have been applied to gain a better understanding of the economic benefits of mitigation and prevention. Yet recognising and appraising the wider co-benefits of investing in mitigation and prevention could make an even more convincing case. This chapter examines some of these broader benefits to society and to the economy.

Human exposure to natural hazard risk is mainly caused by settlement and other economic developments in hazard-prone areas, but this risk can be managed through spatial planning and regulations; national spatial planning policies may involve cooperation with other countries. Within cross-boundary river basins, countries may jointly seek for policies to control flood waters through spatial planning measures. An example are the flood retention areas in the Rhine basin, which aim at storing flood waters upstream in Germany to lower the risk of flooding downstream in the Netherlands.

Disaster preparedness and response addressed in Chapter 5.2 is embedded in complex ethical, legal, social and political contexts, and broad values and principles are needed for emergency response that transcends boundaries.

This necessitates cooperation between regional, national and international communities. The EU Community Mechanism for Civil Protection is developing several tools to support this, including the European Emergency Response Coordination Centre (ERCC) in Brussels as well as a Common Emergency Communication and Information System (CECIS). A key issue for preparedness is how societies can translate these broader values and principles of emergency response into social, organisational and technical innovation.

The professionalism and coordination of preparedness for response by civil protection agencies has significantly advanced in recent years alongside a desire to give citizens increasing responsibility for their own preparedness. There has been a strengthening of the value of citizens themselves in preparedness and response planning, with social groups playing an important role during a disaster to help manage emergency response. Strengthening social cohesion and trust before a disaster can increase the response's effectiveness. Extensive flooding in 2007 in Kingston upon Hull in the United Kingdom, for example, stimulated a range of spontaneous actions by local residents, including assisting with evacuation, giving care and support to vulnerable neighbours, protecting houses against floodwater and giving medical assistance.

Chapter 5.3 presents post-disaster recovery as an opportunity for economic development and regeneration. The recovery process is multidimensional and progresses at different rates for different people, businesses, institutions and places affected by a disaster. Institutional fragmentation and short-term planning can hinder recovery processes and often result in new risks being created. Thus, cross-scale and longer-term risk management strategies are needed in recovery, integrating different stakeholder perspectives and knowledge and coordinating across policy domains.

For earthquake and other types of reconstruction there is not a 'one size fits all' model, but decisions need to be discussed in advance with the citizens, taking into account suggestions and explaining the limits of time, space and budget. Territories are different, available scientific and technologic support evolves and the population's expectations can change through time: a mature civil protection system looks for tailored solutions building on previous experience while exploring new alternatives.

Economic recovery occurs at various scales after a disaster and the economic system will unlikely return to a pre-disaster state, yet measures can be taken to support and accelerate the recovery process. Higher levels of assets give a wider range of options and opportunities following a disaster and can speed recovery, as can access to formal credit and grants. Families, neighbours and social networks can help people to recover their assets.

Accessing financial resources after a disaster is critical to rebuilding and maintaining essential functions. Nonetheless, the policies supporting economic recovery should not focus solely on financing. A mix of policy initiatives is needed to build resilience after a disaster: from the design of early warning systems (EWS) tailored to specific audiences to the development of efficient regulations. Overall, combinations of financial support with other market support and service provision are needed.

People's psychosocial recovery after disasters is a complex, multidimensional process that is also linked to the measures taken before disasters occur, to the social and economic circumstances of those affected, to the actions taken to rebuild and restore assets and to the services provided after disasters. Research demonstrates that people's recovery in the short and medium term can be promoted through a psychosocial approach, with interventions made universally available to reduce suffering and risks of people developing mental disorders.
Disasters can undermine development progress and financial and economic stability and well-being, and so a sound risk financing strategy is needed to lessen these impacts and speed up recovery and reconstruction (Chapter 5.4). Risk financing complements regulatory and economic instruments such as prices, taxes, tradable permits and liability. There is ample consensus that insurance can and should play an increasingly important role in mitigating disaster impacts, not only through risk sharing, but also by improving risk identification and modelling, risk awareness and recovery.

5.1 Prevention and mitigation: avoiding and reducing the new and existing risks

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5.1.1 Introduction

In line with the United Nations Office for Disaster Risk Reduction (UNISDR) definitions used in this report, prevention is understood as the activities and measures to avoid existing and new disaster risks (UNISDR, 2007). Prevention (i.e. disaster prevention) expresses the concept and intention to completely avoid potential adverse impacts of hazardous events. While certain disaster risks cannot be eliminated, prevention aims at reducing vulnerability and exposure in such contexts where, as a result, the risk of disaster is removed. Examples include dams or embankments that eliminate flood risks, land-use regulations that do not permit any settlement in high-risk zones, seismic engineering designs that ensure the survival and function of a critical building in any likely earthquake and immunisation against vaccine-preventable diseases. Prevention measures can also be taken during or after a hazardous event or disaster to prevent secondary hazards or their consequences, such as measures to prevent the contamination of water (UNISDR, 2016).

Ex ante interventions aimed at reducing existing risk (mitigation) and avoiding a generation of new ones (prevention) are important elements in the DRM process.

Mitigation relates to 'the lessening or limitation of the adverse impacts of a hazardous event. The adverse impacts of hazards, in particular natural hazards, often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures include engineering techniques and hazard-resistant construction as well as improved environmental and social policies and public awareness. It should be noted that, in climate change policy, 'mitigation' is defined differently and is the term used for the reduction of greenhouse gas emissions, which are the source of climate change (UNISDR, 2016).

The SFDRR, adopted by the United Nations General Assembly, calls for 'a culture of prevention' and enhanced risk reduction. Priority 3 of the framework focuses on 'investing in disaster risk reduction for resilience' and proposing 'public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment' (UNISDR, 2015). The Sendai framework provides a set of guiding principles relevant for any efforts aimed at addressing rising disaster risks, from global to local levels.

This subchapter explores current institutions, policies and challenges for disaster prevention and mitigation in Europe across different hazards. We differentiate between structural and and non-structural measures as well as examine the political complexities and barriers that currently hinder mitigation and prevention efforts. We then look at the economics of investing in mitigation and prevention, considering how the costs and benefits of different strategies and measures could be weighed up and compared. The section concludes with a reflection on how mitigation and prevention goals can be supported.

Development of the concept and use of DRM

In this subchapter we focus primarily on the institutions, policies, incentives and applications of mitigation and prevention measures as the principle ex ante actions used to manage risk. The concept of DRM has been developed in the context of managing risk related to natural hazards.

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The gradual adoption of DRM as a name and a framework for dealing with disasters has brought with it the realisation that natural hazards can only be managed effectively at the local level. The theatre of operations for both mitigation and response is inevitably local, although no one would deny the need for coordination at the regional and national levels of public administration, if not also the international level. The system that arises out of concerted responses to hazard can be termed civil protection. Its counterpart is civil defence, a nationally organised system that nowadays is heavily orientated towards threat management and counter-terrorism (Alexander, 2011). The factor that links the two approaches is vulnerability. In threat management, it is seen as the defence of weak points in the human socioeconomic system, whilst in civil protection, it is regarded as a systemic factor that is socially constructed because it reflects decision-making in all realms: physical, social, economic, institutional, environmental and so on.

Disaster impacts can be instantaneous, rapid, stepwise, ramped, 'creeping' (i.e. insidious) or of long onset. Although it is tempting to classify impacts by their causes into natural, technological, social and intentional, very many disasters are composite in nature. Such is the complexity of modern society and its interrelations that this has become the age of the cascading disaster. Impacts are propagated through critical infrastructure (CI) failures, with escalation points that mark the interactions between factors that generate positive feedback and spread the impacts into new areas (Pescaroli and Alexander, 2016). Several basic principles underpin effective risk mitigation and prevention. First, the underlying risk drivers need to be tackled. This means reduction in poverty and underdevelopment, as these are barriers to the protection of communities against hazards. We may add climate change abatement, redistribution of wealth and reinforcement of rights, including access to information, self-determination and freedom to act.

Secondly, a multihazard approach to planning is favoured because it is more efficient than a single-hazards approach. Vulnerability should be considered the essence of disaster risk, and hazard the trigger. Hence, abatement of vulnerability is the primary need in disaster risk reduction. Vulnerability to disaster can be considered by sector (economic, environmental, institutional, physical, etc.), but this runs the risk of failing to embrace the connections between sectors. An alternative approach might consider vulnerability to be pristine (unaffected by mitigation and prevention), technocratic (resulting from the misapplication of technology), wilful (the result of corruption and exploitation), economic (deficiencies in livelihoods) or socio-psychological (oppression, community conflict, etc.). It is essential to recognise that there is a constant dialectic between forces that create vulnerability and those that reduce it (McEntire, 2001).

Academic studies of the social impact of disasters have been carried out systematically for about a century. In the latter part of the 20th century and the beginning of the 21st, the field grew at an accelerating rate. As a result, it is now a rich repository of lessons to inspire future efforts in prevention and mitigation, if the lessons are learnt.

5.1.2 EU structures, institutions, strategies and political instruments

In recent years, the EU has taken an active role in drawing together the collective expertise of its members for the purposes of disaster prevention and mitigation (see Chapter 1). The European Commission (JRC) has been a central coordination mechanism in this endeavour. It developed the European Flood Alert System (EFAS) in 2003, providing local water authorities with probabilistic flood forecasting for transnational European river basins (Thielen et al., 2009). It also helped to establish the European Drought Observatory, which since 2011 has been the 'leading disseminator on drought-related information' such as precipitation measurements and soil moisture content (Stein et al., 2016). Another significant resource is the European Forest Fire Information System (EFFIS), which combines information from across European, Middle Eastern and North African regions, including fire danger assessments, damage assessments and a fire news module (JRC, 2015).

In addition to working with the national authorities of Member States, the EU also works closely with other independent organisations to improve the level of research and publicly available information on disasters. One such organisation is the European Exchange Circle on Flood Mapping, which produced a comprehensive handbook of good practices in flood mapping in 2007 (EXCIMAP, 2007). The EU also has an agreement with the European-Mediterranean Seismological Centre to monitor seismological activity and provide early notifications for earthquakes (Papatheodorou et al., 2014). Additionally, progress has been made with regard to multihazard disaster risk prevention and mitigation. Meteoalarm, developed by the European Meteorological Services Network, is a collaborative platform providing 24-48-hour lead-time warnings for extreme weather events in participating European countries (Alfieri et al., 2012).

In recent years, the EU has taken an active role in drawing together the collective expertise of its members for the purposes of disaster prevention and mitigation.

These partnerships are frequently underpinned by EU directives and policies, which provide the impetus and strategic vision for their work. Examples include the Water Framework Directive (2000), which established an integrated EU-wide framework for water management (Stein et al., 2016) and monitoring to address the problem of water scarcity and drought affecting many European countries (Quevauviller and Gemmer 2015). The issue of water scarcity and drought was later taken up as a main priority during the Portuguese Presidency in 2007, culminating in a formal communication by the European Commission on this topic (Stein et al., 2016). Other examples include the Flood Directive (2007), which aimed to standardise the level of flood protection that European citizens receive by prompting states to review their risk assessment policies and take deliberate steps to reduce flood risk (Alfieri et al., 2012). In April 2013 the European Commission also adopted an EU strategy on climate change adaptation to support adaptation planning and policies at all levels (Quevauviller and Gemmer, 2015).

These mechanisms and policies are, to a large extent, the result of broader commitments by the EU to protect civilian populations from disasters both within Europe and worldwide. The European Union Civil Protection Mechanism (UCPM), for instance, was established in 2001 to harness cooperation between the national civil protection authorities from all 28 Member States to respond quickly to civilian emergencies and assist in prevention and mitigation by allowing information sharing between countries.

In many EU countries, different hazards are still handled by different organisations and ministry lines, particularly in the prevention and mitigation phases. However, the methodologies, tools (e.g. EWS) and data are often common across many hazards (e.g. both land use planning and weather forecasts are crucial for floods, landslides, hurricanes as well as for drought and wildfires). Effective coordination mechanisms, such as the national platforms promoted by the SFDRR, are aimed at ensuring a joined-up understanding of risks, including the cascade effects of hazards, as well as coordinated resource allocation and integration of roles and responsibilities. The EU has adopted the SFDRR and developed an action plan accordingly (European Commission, 2016a).

5.1.3 Structural and non-structural measures and innovation in Europe

A common distinction is made between structural and non-structural measures. Structural measures are commonly derived from the engineering and physical sciences and include the following (Coppola, 2015):

- building resistant structures, such as dams and sea walls;
- using certain materials in buildings and adopting building codes that require structures to be disaster-resistant;
- relocating populations to safer areas;
- modifying the natural environment, such as slope terracing and draining.

Non-structural measures are generally described as 'soft methods' (Palliyaguru et al. 2014), or man adapting to nature (Coppola 2015). These may include the following:

- adopting regulations designed to prevent people from engaging in risky behaviour (for example, zoning laws);
- community initiatives such as flood warning systems (although these are usually classified as preparedness measures);
- modifying the natural environment without causing a structural change to it (for example, controlled burning of bushland to prevent bushfires);
- encouraging people to change their behaviour, such as providing tax incentives to plant trees.

Although most EU Member States implement mitigation measures at the national or local level, the European Commission will co-finance projects that enhance mitigation and preparedness through an annual call for proposals under the UCPM (European Commission, 2016b). In 2016, its total budget for assisting EU Member States was EUR 29 366 000 (European Commission, 2016c). This represents a slight increase from 2015, where the total budget was EUR 28 068 000.

Only a small percentage of this budget, however, is available for prevention and mitigation. In 2016, EUR 2.8 million was available for co-financing prevention projects (European Commission 2016c) and this amount did not increase from 2015. By comparison, EUR 5 million was made available for training EU civil protection teams and EUR 3.6 million was made available for planning, conducting and evaluating disaster simulation exercises (European Commission 2016c). Furthermore, although the maximum co-funding rate for a project is high (75 % of a project's cost), it only applies up to a maximum of EUR 800 000 for each project that is co-financed (European Commission, 2016c).

The list of projects that were co-financed in 2015 shows a focus on non-structural measures and improving response capability. This is in response to the clear domination of structural measures across the EU. The emphasis on non-structural measures by the UCPM can be seen as an attempt to balance the structural measures taken at the national level with non-structural assistance at the regional level. Supported projects include the following:

- improving evacuation preparedness in Romania and Slovenia in case of a nuclear accident (non-structural);
- improving knowledge against seismic risk through the KnowRISK project (non-structural);
- improving the capacity for addressing the impact of natural disasters on cultural heritage (non-structural); and
- a programme for improving the self-help capabilities of young people in times of disaster (non-structural).

Ex ante disaster mitigation and prevention can be achieved through a range of structural (e.g. building codes and their enforcement and structural protection measures) and non-structural (e.g. land-use planning and zoning) measures.

Technological innovation is recognised by the SFDRR as an important part of the arsenal available for reducing a society's disaster risk. In Europe, technological innovation is promoted in a number of ways, including but not limited to the following:

- The European Commission (JRC) has researched and produced a number of technological advancements (particularly computer-based systems) that have contributed to minimising the impacts of disasters on a global scale (JRC, 2014). For example, The European Commission (JRC) has conducted research on the vulnerability of buildings to seismic activity through its experimental reaction wall, which has also been used in other projects (e.g. the Series project) to test retrofitting techniques (JRC, 2014).

- The European Commission (JRC) also operates the European Crisis Management Laboratory for the development of information and communications technology as well as annual workshops addressing bespoke technological issues such as the use of unmanned aerial vehicles for rapid mapping (JRC, 2016). It used such vehicles to support the post-disaster needs assessment (PDNA) mission in Bosnia following the May floods in 2014 (JRC, 2014). The laboratory forms part of the Disaster Risk Management Knowledge Centre's 'innovation' stream, which also includes the European Network for Innovation Test Beds (DRMKC, 2016a). The innovation stream is focused on 'advancing technologies and capacities in disaster risk and crisis management' (DRMKC, 2016b).

- Horizon 2020, the largest EU research and innovation programme ever (European Commission 2016d), provides funding for projects improving societal resilience against natural and man-made disasters. These calls are made under its 'secure societies' stream. The following are examples of projects that have received funding and relate to DRR:

  1. The Brigaid project, which seeks to 'bridge the gap for innovations in disaster resilience' by providing a platform for the testing of resilience innovations (TU Delft, 2016). The EU contributed approximately EUR 7.7 million to the project (CORDIS, 2016a).

  2. The Liquefact project, which seeks to address the effects of earthquake-induced liquefaction disasters (CORDIS, 2016b).

Data innovations are increasingly supporting decision-making on mitigation measures at the national level. In the United Kingdom, for example, the Department for Environment, Food and Rural Affairs (EFRA) will be making greater use of crowdsourced data on regional flood risk thanks to improvements in data technology (UK Space Agency 2016). Further, innovation is also coming from areas outside the EU; for example, innovators seeking to provide technology solutions to mitigation regularly attend the annual Geneva-based International Exhibition of Innovations (Fowler, 2015).

5.1.4 Identifying appropriate prevention and mitigation measures

Risk assessment plays an important part for prevention and mitigation strategies, for example through applying risk information in decision support, evaluation and cost-benefit analysis (CBA) processes (Watkiss et al., 2014). Mitigation and prevention measures seem more likely to be adopted when an effective information-sharing programme is in place. For example, the EU seeks to foster the development of mitigation and prevention measures across different countries by reviewing their risk assessments and promoting best practice. Since 2012, eight such peer reviews have occurred across Europe (European Commission 2016b). Indeed, the EU has issued guidance for other states on how to prepare national risk assessments as part of the UCPM (European Commission, 2016b). Risk information also plays an important role in assessing the appropriateness of risk management activities/strategies in anticipation of future risk conditions. Information requirements about risk and the kind of risk assessment applied may differ depending on the needs of the decision-maker (Surminski et al., 2012).

In Europe, FP7-funded ENHANCE project has shown that the kind and scale of a risk assessment depend on how the results are used by decision-makers. For example, the EU-wide flood risk assessment informs the design of the EU solidarity fund, while the local assessments of surface water flooding in the United Kingdom and drought risk in the Jucar provide useful information for local risk management policies, such as insurance and water pricing (Botzen et al., 2015).

In addition to risk information and data, mitigation and prevention measures require support and interaction between stakeholders, whether it be at the local, regional or international level. This includes public and private stakeholders. Engaging with communities at the local level can foster the adoption of risk-reduction techniques by individuals engaged in that community (Wittyorapong et al., 2015). This also requires a combination of both 'top-down' and 'bottom-up' strategies (European Commission, 2013). For example, utilising a 'bottom-up' approach, communities in the Pacific Islands have developed their own techniques to combat tropical hazards (e.g. cyclones). The implementation of these techniques is monitored by Red Cross volunteers, allowing the transition of information from the local to the international. This is referred to as 'participatory DRR' (European Commission, 2013).

Tools and models for understanding risk are well advanced within Europe and can be used as the basis for identifying and prioritising action to reduce risk and avoid risk creation in the future.

The recent emphasis on resilient cities is another example where action at the local level can inform international-level thinking. Carmin et al. (2013) present several examples of city-based, stakeholder engagement partnerships for supporting adaptation to climate change and resilience in diverse contexts, including large cities such as Toronto, Quito and London and smaller urban centres such as Walvis Bay in South Africa (Carmin et al., 2013). This coincides with the realisation that cities form a pivotal part in pursuing internationally agreed policy goals, including climate mitigation and adaptation, as well as DRR (Bulkeley and Castán Broto, 2013). Cities are of importance in managing climate risks as they serve as centres of economic activity, technology and innovation hubs while often being exposed to a range of climate risks, including potential infrastructure failure, urban blight and loss to both populations and assets (Surminski and Leck, 2016). Recent examples of initiatives that promote mitigation and prevention (Geneva Association, 2016; Golnaraghi et al., 2016) include city-level and industry collaboration.

- **Encouraging mitigation and prevention in urban areas**
  The UNISDR (n.d.) global campaign for resilient cities has focused on raising awareness about risks and comprehensive approaches to risk preparedness and reduction among local governments and authorities and urban communities. The 100 resilient cities initiative, launched by the Rockefeller Foundation, is supported by a number of international associations such as the International Consortium of Local Governments for Sustainability, other foundations (such as the Clinton Foundation), the United Nations and other non-governmental organisations (NGOs). It has been instrumental in raising awareness, sharing experiences and facilitating global cooperation among local governments to develop resilient cities based on seven key principles that allow them to withstand, respond to and adapt more readily to shocks and stresses. This initiative provides member cities with four types of support: assistance to develop a comprehensive 'resilience strategy'; access to a USD 100-million-plus (EUR 91.7-million-plus) pool of best-in-class services from partners in the private, public, NGO and academic sectors; and connection through a peer-to-peer network so that cities can learn from each other's success and failures. It also offers funding and support for hiring a chief resilience officer, a top-level advisor who reports directly to the city mayor. Their task is to establish a compelling resilience vision for their city, working across departments and with the local community to maximise innovation and minimise the impact of unforeseen events. To date, this initiative has led to the designation of chief resilience officers in 68 cities.

- **Collaboration with industry**
  In several countries the private sector is funding technical development as well as testing facilities for building materials, designs and techniques. In Germany the prevention and safety testing institute, VdS, was initially set up by insurers as a way to support fire resilience in businesses and industry. Insurers in the United Kingdom are collaborating with the Environment Agency (the government agency responsible for flood risk management) to provide guidance and information about flood resilience techniques to home owners. In France the insurance industry formed the Mission Risques Naturels association to foster disaster risk awareness and reduction activities across public and private stakeholders. Triggered by concerns about rising disaster loss, the Japanese insurer Tokio Marine is focusing on ecosystem-based solutions for DRR, or 'Eco-DRR.' As the United Nations environment programme

(UNEP) pointed out in its 2014 report, natural ecosystems, such as mangroves, can demonstrate physical and economic effectiveness in reducing the impact of storm surge or tsunami. The 8 994 hectares of mangroves in nine Asia-Pacific countries planted by the company since 1999 are being studied for the shelter effect and its consequential economic benefits so far generated to improve the living standard of the local inhabitants (Geneva Association, 2016).

If and how effective all these advances in risk information, knowledge sharing and technology are remains somewhat unclear. Moving towards implementation and changing existing behaviour in terms of home construction and building design requires a range of incentives as well as legislative support, for example through building codes (Surminski, 2014). Governments, organisations and people are not inherently interested in mitigating disasters unless they perceive a direct benefit, and greater effort is needed to draw attention to these benefits and to improving the incentives for investing in mitigation and prevention.

Furthermore, the effectiveness of mitigation and prevention measures must be weighed against, amongst other things, their social cost (Vorhies and Wilkinson, 2016).

5.1.5 The economics of mitigation and prevention

Economic analysis methods have been applied to gain a better understanding of the economic benefits of mitigation and prevention. Building a home on an elevated platform between 0.5 metres and 1.5 metres, for example, could reduce loss due to flooding by 10 % and 80 % below present-day levels in coastal areas, respectively, even in the context of a sea level rise that would otherwise increase the 1-in-200-year loss by 20 % (Lloyd's, 2008).

CBA is a popular and oft-advocated tool to choose between alternative DRM options. Ideally, it compares advantages (benefits) and disadvantages (costs) of options in a systematic and objective way, so that the option that provides the greatest net gain to society can be selected. The EU Floods Directive 2007/60/EC requires that flood risk management plans 'take into account relevant aspects such as costs and benefits' (European Union, 2007), and this has undoubtedly given an incentive to apply CBA in regions where it was not common before.

CBA has often been criticised, however, because it requires all costs and benefits to be expressed in a money metric to compare them, and that it is biased towards those options that can most easily be expressed in monetary terms, to the disadvantage of options that provide intangible benefits in the form of greater social or environmental quality (Vorhies, 2012). Yet the United Kingdom Foresight report, Reducing risks of future disasters (UK Government, 2012) argues that, especially in times of austerity, CBA continues to be an important tool for prioritising efficient DRM measures. However, with a shifting emphasis from infrastructure-based (hard) options to preparedness and systemic (soft) interventions, other tools such as cost-effectiveness analysis, multicriteria analysis and robust decision-making would deserve more attention (Mechler, 2016). In the context of adaptation to climate change, the Intergovernmental Panel on Climate Change of 2012 concluded for such reasons that the applicability of 'rigorous' CBA for evaluations of climate adaptation would be limited.

Mitigation and prevention measures are widely considered more cost-effective than ex post disaster interventions. This is predominantly based on an analysis of the benefits arising from avoided loss.

Recently, there has been a push towards studies taking a probabilistic approach for addressing disaster risk, particularly those arising from low-frequency, high-impact events. This is a promising development for two reasons: 1) disaster risk is probabilistic in 'nature', which means that looking at one flood event only does not capture the entire distribution of possible flood events and their respective return periods; and 2) DRR options are efficient for certain levels of risk but not necessarily for all; e.g. risk reduction is more effective for frequent events (up to 50- or 100-year return periods), while insurance tackles higher-level risk. Indirect ef-

BOX 5.1

Examples of using risk assessment for improving mitigation and prevention

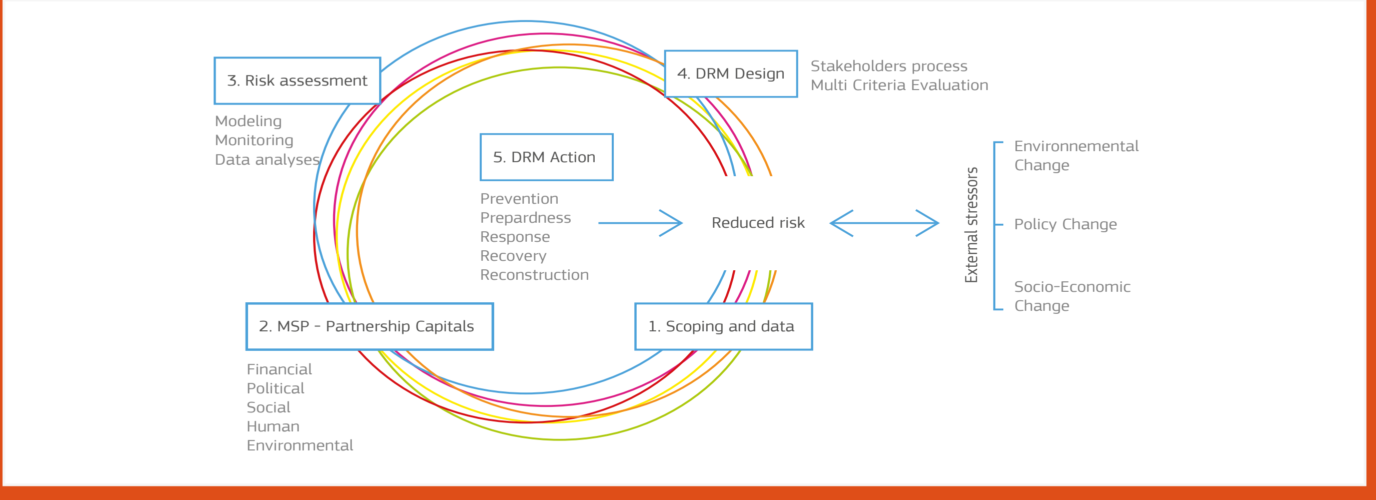
Risk assessment and information is key to any mitigation or prevention decision. Risk assessment looks to understand future permutations, constantly updating projections on risk scenarios through risk assessment and reflection (Tschakert and Dietrich 2010). The Enhance project has deployed a range of new risk scenarios and information in selected hazard cases in close collaboration with stakeholders. The project focusses on selected cases of high-profile catastrophic hazards in a variety of countries, including multihazard events (EU wide) as well heatwaves (EU wide), forest fires (Portugal), surface water flooding (United Kingdom, Italy and Romania), droughts (Spain and Italy), storm surges (Wadden Sea and Rotterdam), flash floods and landslides (Austria) and volcanic eruptions (Iceland with Europe-wide effects).

One example is surface water flood risk in London, United Kingdom. Through the Enhance project, the latest London flood risk analysis data was fed into an agent-based model (ABM), which is a useful method for understanding systems and individual behaviour. This ABM has been developed to demonstrate the effects of flood risk and mitigation and prevention measures on risk levels, household wealth, potential shifts in inequality caused by flood damage and insurance (un) availability (Jenkins et al., 2017).

Results of the ABM highlight how development of properties in certain areas can become unsustainable as well as how there is a need for a consistent framework between different stakeholders to promote flood risk reduction (Jenkins et al., 2015).

FIGURE 5.1

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.
Source: Novel Multi Sectoral Partnerships. EU Enhance project. (Aerts and Mysiak, 2016)



fects (i.e. impacts on livelihoods and the local and regional economy) are being considered more strongly, while accounting for intangible effects, such as on health or impacts on natural resources, has remained a challenge.

Another important consideration is the data needs for calculating the net benefits of a measure. This requires information about the costs: both direct costs as well as opportunity costs of other investments or even other DRM measures. However, data on these indirect costs are not always readily available (Vorhies, 2012).

One further aspect is how to account for the benefits of any mitigation or prevention activities: at local or project level the benefits are directly linked to a certain location where the mitigation or prevention activity takes place, while at national level an aggregate, macroeconomic view is applied, considering the implications on economic growth, national employment, federal budgets or poverty-reduction efforts.

This distinction is important as a project may show the potential for benefits to a local area, while substitution effects may mean it does not show benefits nationally. For large countries, establishing impacts at a national level may prove difficult. Hence the usefulness and robustness of a CBA generally declines as time and scale increases (Mechler, 2008). Recognising and appraising the wider co-benefits might deliver an even more convincing case for mitigation and prevention. Table 5.2 highlights the range of co-benefits that can arise.

An interesting extension of the existing approaches to appraising mitigation and prevention measures is the 'triple resilience dividend' concept. It provides a much broader approach to appraising investment in DRR efforts, citing positive spillovers that even create economic gains in the absence of disasters (Tanner et al., 2015; Tanner and Surminski, 2016).

5.1.6 Policies, institutions and incentives for investing in mitigation and prevention

Exposure to hazards has increased faster than our vulnerability has decreased (UNISDR, 2015). Indeed, since the 1970s research has argued that disasters are manifestations of unresolved developmental problems because most hazards are constructed through the same processes (economic, social and territorial) that produce exposure and vulnerability (Lavell and Maskrey, 2014). In addition, there is growing economic evidence of the cost-effectiveness of many mitigation and prevention measures, particularly when compared to ex post disaster support.

However, this has not yet triggered a significant shift of political and financial focus away from ex post towards ex ante measures: although the European Commission estimates that every EUR 1 spent on DRR measures saves EUR 4 to EUR 7 (European Commission, 2016b), significantly more (indeed, up to 95 % of total funds) continues to be spent on post-disaster recovery (Aakre et al., 2010). Prevention and mitigation requires buy-in and action from across a variety of institutional bodies, political entities and stakeholders.

Understanding the incentives and disincentives to investment is key to the promotion of ex ante investment in mitigation and prevention. An expanding body of scientific evidence on the benefits of these investments can help improve the business case.

The literature provides a long list of barriers and challenges for a greater ex ante focus on mitigation and prevention, which Coppola (2015) summarises as financial, political, technical and sociocultural. In addition, effective prevention and mitigation requires community engagement across the entire suite of stakeholders, as it cannot be provided by any single authority or agency (Palliyaguru et al., 2014). Indeed, local communities tend to be the first responders to natural disasters and therefore might have valuable information about the best mitigation practices (Genovese and Przyluski, 2013). Similarly, the private sector, while dominating the financing and delivery of infrastructure investments, does not seem to be fully aligned with the prevention and mitigation principles when it comes to day-to-day business operations (UNISDR, 2013). Even the insurance industry views disaster prevention and mitigation as a domain of the state, which can be supported by private sector action, but only through better public/private collaboration (Surminski et al., 2015). Involving the private sector is particularly relevant in the context of infrastructure. The World Energy Council (2015) provides critical evidence on the impacts of extreme events and emerging risks associated with climate change on energy infrastructure and recommends that the industry work together with the financial community, investors and policymakers to share and promote measures that must be incorporated into energy infrastructure design and investment decisions (Golnaraghi et al., 2016).

A key to successful resilient partnerships between policymakers, private sector actors and scientists is a common understanding of the risks, preferences and needs of actors and the implications of proposed economic and regulatory policy instruments (National Research Council, 2011).

Successful examples of such resilient partnerships include the joint implementation of non-structural measures such as building codes (CEA, 2007). Several EU-funded projects, such as MOVE, Ensure, Conhaz, Matrix, Catalyst and emBRACE, have significantly advanced scientific knowledge and produced methodological innovations with respect to assessing and managing risk and exploring resilience to natural hazards. They have developed scenarios of risk for different natural hazards and have examined risk management measures and how the concept of resilience can be used to reduce the negative impacts of those hazards on society. As a result, resilience to natural hazards is becoming a more integral component of current policymaking and implementation, both at the country as well as at EU scale. This has also informed policy drivers, such as the EU Floods Directive, and to a lesser extent the EU Agricultural and Regional Policy.

Despite considerable disincentives to investing in prevention and mitigation, an increase in mitigation investment has occurred in some European countries (See Box 5.2 on seismic investment in Italy), but the lack of public and therefore political interest in prevention and mitigation remains a problem.

5.1.7 Achieving mitigation and prevention through land-use planning

TABLE 5.1

Benefit-cost ratios for a global review compared to a prominent United States study only (MMC, 2005)
Source: Mechler (2016)

Hazard	Review. Simple average (number of studies)	Review. Range of estimates	MMC (2005). Average
Flood (riverine and coastal)	4.6 (21)	0.1-30	5.0
Wind (tropical and extratropical)	2.6 (7)	0.05-50	3.9
Earthquake	3.0 (8)	0.08-15.6	1.5
Drought	2.2 (1)	1.3-2.2	na
Landslide	1.5 (2)	0.1-3.7	na
Overall	3.7 (39)	0.08-50	4.0

Human exposure to natural hazards risk is mainly caused by settlement and other economic developments in hazard-prone areas. For example, many large urban centres are located in low-lying floodplains prone to floods and storm surges (Jongman et al., 2012) and in earthquake zones (Daniell et al., 2011). The reason for developments in hazard-prone areas is often the economic attractiveness of these locations. For example, port cities in low-lying coastal areas are historically centres of economic activity and therefore attractive for urban development, despite being vulnerable to storm surges (e.g. Brown et al., 2014). In the case of mountainous areas, valleys are the only suitable areas for urban development and form the economic basis for tourism development, although they are threatened by landslides and avalanches.

The question that arises is how to develop these areas so that vulnerability to natural hazards is managed in a way that it limits risks to human life, physical structures and the economy in general? Protection measures, such as levees and avalanche shields, are mainly targeted to limiting the magnitude and probability of hazards. In addition, measures can be developed that lower exposure and vulnerability. With respect to the latter two, spatial planning policies and regulations play an important role as they determine where and how people and economic assets will be located (King et al., 2016). Hence, spatial planning directly influences the exposure of people and economic assets as well as how vulnerable these exposed assets and people are (Greiving et al., 2006). During the last 10-15 years, there has been increasing attention within spatial planning policy to address the is-

TABLE 5.2

The range of co-benefits associated with DRM measures
Source: adapted from the Environmental Resources Management and the Department for International Development (2005)

DRM activity	Possible co-benefits
Flood protection structures	Provision of irrigation or potable water and hydro-electric power Dual-purpose road infrastructure
Strengthening DRM capacity of civil society	Improved governance, more organised social structures
Ecosystem-based DRM approaches	Environmental conservation, improved air quality, climate change mitigation
Shelters	Community facilities (e.g. clinics or schools) in non-disaster periods
Improving water supply systems in rural areas	Water supply systems improved regardless of a disaster occurring
Construction and use of drainage pipes, canals and water retention basins	Improved irrigation practices, possibly improved agricultural practices Dual purpose road tunnel or parking lot infrastructure
Community-based disaster preparedness	Improved women's involvement in community-level activities
Installing more resilient wireless communications	Enhanced access to telephony and electronic data services
Training farmers to diversify the use of crops	Reduced vulnerability to poverty
Better monitoring of food supplies	Improvement to the food supply chain, possibly making it more cost-effective

BOX 5.2

The Italian national seismic prevention programme

Over the last 50 years, earthquakes with a magnitude between 5.5 and 6.9 in Italy have resulted in thousands of victims and monetary losses of over EUR 160 billion. Even considering the present condition of the building stock and the possible occurrence of future earthquakes, expected direct costs are of the order of EUR 2-4 billion per year.

Similar to other countries subject to seismic hazard with high population exposure and high vulnerability of constructions, a huge effort would be needed to mitigate seismic risk, which requires different and parallel lines of action to be pursued: the improvement of the knowledge, the reduction of the vulnerability and exposure and the mitigation of the effects. Seismic prevention remains, however, a difficult objective to achieve fully due to the high costs implied, long time frame and lack of public and political interest.

After a destructive earthquake, some seismic risk mitigation measures are usually taken, mainly consisting of the improvement of seismic codes and classification, but with little economic effort to directly reduce vulnerability in areas not affected by that earthquake.

In Italy, since 1986 very few investments have been made in structural seismic prevention, and almost exclusively on strategic and important public buildings (hospitals, schools, etc.). A change of perspective occurred after the earthquake on 6 April 2009 in Abruzzo. Two articles of Law 77/2009, issued for reconstruction in the damaged areas, have instead been devoted to seismic prevention in the entire nationalterritory.

Article 1bis established the immediate enforcement of the new technical standards promulgated at the beginning of 2008, but not fully enforced yet, while Article 11 allocated around EUR 1 billion for seismic prevention, to be spent in the following 7 years. This is a small fraction of what is needed to solve the problem of seismic risk in Italy and less than half the expected average annual cost of earthquakes. Nevertheless, Italy now has a national seismic prevention programme and EUR 965 million has been spent in 7 years on reducing seismic risk.

The National Seismic Prevention Program essentially focuses on the following points:

- Reducing the risk of human loss rather than economical loss, especially for private buildings.
- Stimulating the attention of private owners and administrators towards the different problems of seismic risk (vulnerability of buildings, importance of local amplification and co-seismic effects and use of microzonation studies to improve urban and emergency planning and correct implementation of civil protection plans considering the vulnerability of the strategic elements and of the interconnection routes).
- Seeking co-funding by local public administration and by private owners to at least duplicate the actual effects of the allocated fund of the state. At present, the funding programme is approaching its end. The evaluation of the results provides some positive feedback, but also emphasises some difficulties that are related to the spending capability of local administrations.

This experience confirms that a prevention programme has to be based on a strong scientific background and developed through a long time horizon, so that public administrators and private owners can adequately make their prevention plans and put them in effect.

Source: Dolce (2012)

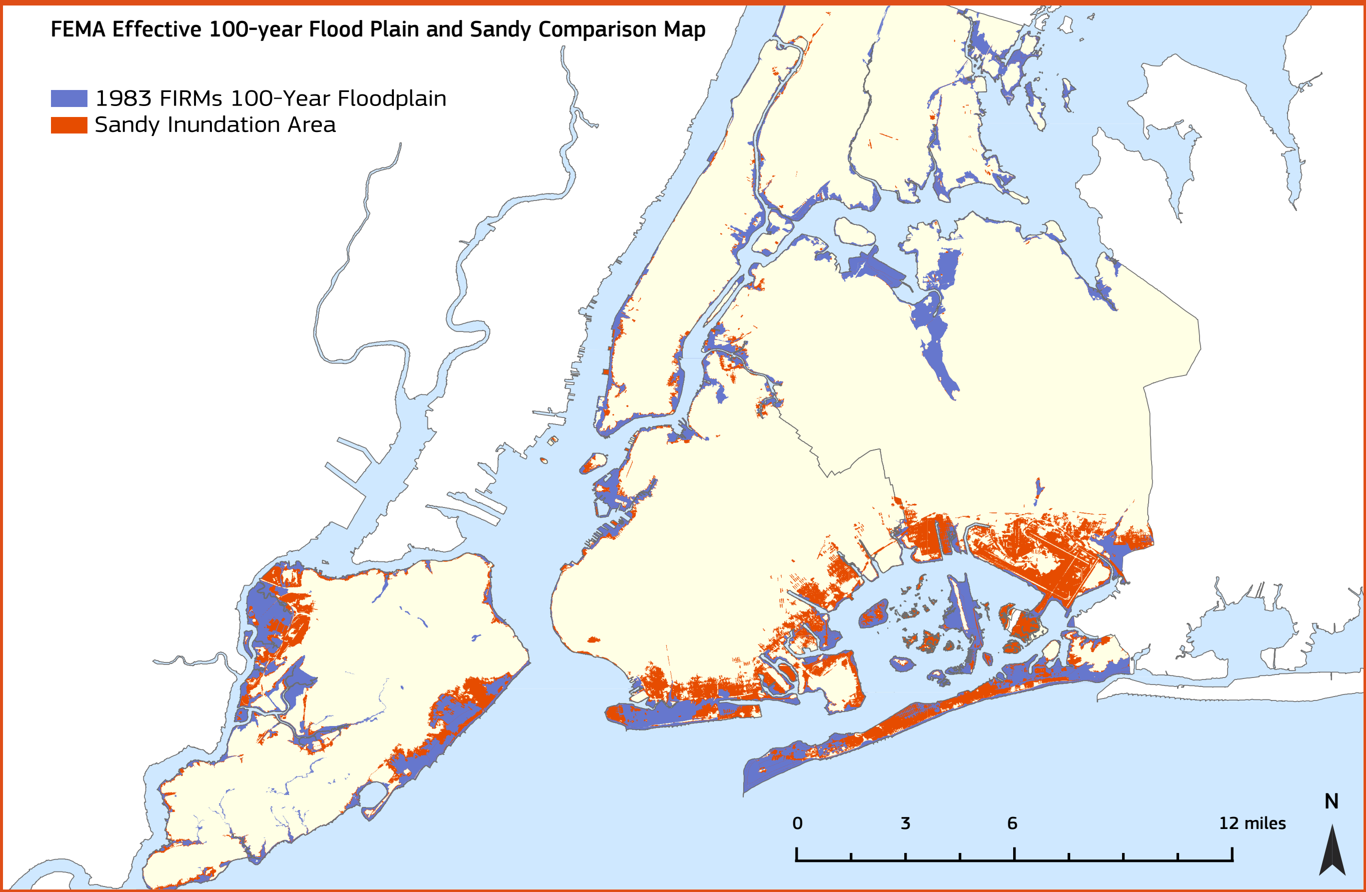
BOX 5.3

Importance of risk assessment for land use

Where inaccurate risk information can lead to is exemplified in the Figure 5.2. This figure shows a map of New York City for the actual flooding due to Hurricane Sandy in 2012 (in red) and the official 1/100 flood zone (in blue) 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 5.2

New York City – a comparison of the actual flooding due to Hurricane Sandy in 2012 (in red) and the official 1/100 flood zone (in blue) provided by the government before the hurricane occurred.
Source: Aerts and Mysiak (2016)



sue of disaster prevention, but there is still a need to further integrate risk assessment within spatial planning processes; this has been advocated by the SFDRR (Mysiak et al., 2015).

5.1.7.1 National Policies

Spatial planning involves different scales of policy- and decision-making. Regulations at the national and even continental scales (such as the EU) prioritise the importance of the use of space for different land uses and, for example, lay out what areas should be protected from further development (e.g. national parks; Natura 2000 sites; e.g. Mikkonen and Moilanen, 2013). Spatial planning policies at the highest levels also set out guidelines and benchmarks for safety against natural hazards. As an example, although not directly targeted at natural hazards, the EU Seveso III directive (European Union, 2012) states that 'Member States shall ensure that the objectives of preventing major accidents through hazards and limiting the consequences of such accidents for human health and the environment are taken into account in their land-use policies or other relevant policies'. In addition, the EU Flood Directive (European Comission, 2007) aims at reducing flood risk by encouraging cross-border integrated flood risk management plans for all European river basins. These plans should cover all aspects of flood risk management, integrating spatial planning policies and physical-hydrological measures such as protection and preparedness, including flood forecasts and early warning. These policies include making sure that the siting of new transport lines and the development of new buildings or modifications of new establishments must address risk from hazards.

Human exposure to natural hazards risk is mainly caused by settlement and other economic developments in hazard-prone areas. This risk can be reduced through spatial planning and regulations that should take into consideration opportunities for economic growth, development of communities and well-being.

National policies often involve cooperation with other countries within river basins. An example is the flood retention areas in the Rhine basin, which aim at storing flood waters upstream in Germany to reduce the risk of flooding downstream into the Netherlands. These retention measures use space, which has to be reserved, or require land-use change to create space (Te Linde et al., 2010). Another example is the efforts in Germany after the 20o2 floods. These floods showed that retention areas that can be flooded in a controlled manner can be effective. In addition, floodplain surface in Germany has been reduced by one third, and policies were developed to further install retention areas through reserving space in spatial planning policies to bring back resilience to floods in the hydrological system (Thieken et al., 2016).

Since the basis for prevention and mitigation is the availability of accurate risk data, national policy within the spatial planning domain plays an important role in initiating risk mapping activities to assess areas that are at risk from natural hazards. Risk maps can be used to prioritise land-use planning, to restrict development in some high-risk areas or to impose additional measures in areas above certain risk thresholds to lower vulnerability.

For flood risk management, this process has been geared up in the EU through the EU floods directive (European Comission, 2007). This directive requires Member States to assess flood risk by developing spatial flood risk maps (De Moel et al., 2008) and to prepare catchment-based Flood Risk Management Plans (FRMPs), that include spatial planning actions and measures (Office of Public Works, 2009). Flood risk maps must show information on the flood extent, water depths/level and flow velocities. On the basis of these maps, Member States are to develop flood risk management plans aiming at the 'reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity, and, if considered appropriate, on non-structural initiatives and/or on the reduction of the likelihood of flooding' (Van Rijswick and Havekes, 2012).

Another opportunity to include disaster risk in spatial planning processes stimulated at the national scale is to further integrate risk assessments in Environmental Impact Assessment (EIA), which is a procedure that ensures that the environmental implications of decisions are taken into account before decisions are made. In principle, it can be undertaken for individual projects such as the development of a new airport or for plans and programmes (Strategic Environmental Assessment - SEA). An example for SEA includes the assessment of a regional spatial plan in which risks from natural hazards are ideally considered (Greiving et al., 2006). The recent EU Environmental Impact Assessment directive has acknowledged the need for greater integration of risk information in this kind of assessment (European Union, 2011).

5.1.7.2 Zoning

At the regional to local scales, national DRM guidelines and policies are commonly elaborated in zoning- and building-code policies. Zoning regulations are set to control land use and setting development standards throughout urban areas. Zoning makes it possible to create transitional land-use patterns so that incompatible uses are separated and buffered. Zoning regulations determine what land can be used for, or combinations of use for available space, and what kinds of buildings can be developed, including how they address natural hazard risk management. In terms of utilising space for especially urban areas, zoning policies and building codes are powerful tools for controlling land use and urban development, and hence (changes in) future land use (Burby et al., 2000). As such, zoning is increasingly seen as an important tool in climate adaptation and managing changes in natural extremes due to climate change (Aerts and Botzen, 2011).

Zoning encompasses the following general policies related to urban development and risk management:

- Restrictions: based on hazard maps and/or additional risk information (See Box 5.3), zoning policies may indicate that in certain areas urban development is not allowed.

- Conditional development: urban development is allowed in risky areas, but only when certain conditions are met, for example by:
  a. implementing building codes;
  b. homeowners have purchased insurance against natural hazard risk;
  c. buffer zones are respected, whereby building development is only allowed when appropriate distances between establishments and vulnerable risk areas are maintained.

Zoning and land-use planning is also used to create space for other risk management measures, for example by creating structural space for escape lanes (e.g. in case of flooding) or by providing space for structural measures such as dikes, avalanche protection or forest protection against landslides (e.g. Dorren et al., 2004).

In special cases, spatial planners may decide to 'retreat' or relocate the inhabitants of an area. Such rare cases exist, for example in the aftermath of extreme events (e.g. the Tsunami events of 2004 and 2011), when the costs of rebuilding an area elsewhere are lower than rebuilding urban settlements on original (but devastated) land. In addition, inhabitants who have been evacuated from the disaster area do not want to return to their previous living area because they have found a home elsewhere or because reconstruction takes too long (Ranghieri and Ishwatari, 2014). Retreat, as an alternative option to lower exposure without having had a disaster, is rarely considered a feasible option for policymakers. Only few examples are known where people have moved voluntarily to another location; an example is the creation of an extension of a floodplain in the Netherlands (Schut et al., 2010). People were compensated either to leave the area, or were subsidised to elevate their homes a few metres, which in practice meant completely rebuilding their homes. Although the area only comprised some 30-40 households, it took more than 15 years to develop and implement the project. Some authors, however, argue that sea level rise will initiate an increase in relocation of low-lying urban centres near floodplains and coastal waters (Hauer et al., 2016). Again, politics here is important.

5.1.7.3 Object level and building codes

Zoning regulations, and in particular zoning for conditional development, can be further refined in building codes regulations for the development and maintenance of buildings in risk zones. Building codes are meant for the adaptation of building structures to lower their vulnerability to natural hazards. Building codes are anchored in planning law, which is operationalised in legally binding land-use or zoning plans. These zoning plans lay out the areas where building codes will be enforced.

Specific measures to comply with building codes pertain to different hazards. For example, in the United States, buildings that lie in flood-prone areas need to elevate their base floor to a minimum height. Flood zones are mapped by the Federal Emergency Management Agency (FEMA) as Flood Insurance Rate Maps (FIRM), representing the 1/100 flood zone. In these flood zones, building codes apply and homeowners need to seal basements or crawlspaces to avoid the entrance of flood waters. Furthermore, electric facilities (sockets and heating systems) must be installed above certain elevations to avoid power outages and short circuits (Aerts and Botzen, 2011).

A study by De Moel et al. (2014) in the port area of the City of Rotterdam in the Netherlands shows that the current flood risk is about EUR 40 million per year. A large part of this risk can be attributed to industrial land use. Climate change and sea level rise may double the risk by 2100 if no additional measures are implemented. The research showed that by dry proofing all buildings in the port area by up to 1 m, risk would be reduced by 56 %. Elevating all buildings by only 0.5 metre would reduce the total flood risk by 50 % (De Moel et al., 2014).

Building codes for earthquakes may involve specific requirements to improve the seismic resistance of buildings. For example, the National Earthquake Hazards Reduction Program (NEHRP) in the United States shows how to design and construct practices that address the earthquake hazard and minimise the resulting risk to life and property (FEMA, 2009). For landslides, building codes focus on reinforcing walls and list specific requirements for the groundwork of the building (see, for example, the handbook of the Australian Building Codes Board on landslides, ABCB, 2015). Under Eurocodes, the EU standard for construction, structural design rules are laid out for seismic-resistant structures as well as resistance to hydrometeorological hazards, often replacing the national codes.

In some countries, zoning regulations, building codes and insurance policies are integrated. For example, in the United States, homeowners can buy flood insurance when their property complies with the prescribed building codes. Homeowners may even derive a discount on their flood insurance premium when they implement more stringent measures via a Community Rating Program (CRS) to lower vulnerability (see Aerts and Botzen, 2011). Building codes and zoning measures, however, also take quite some time to develop and to process them through all regulatory bodies. In many instances, building codes are not yet assessed against increases in risk through, for example, climate change (see Burby, 2006).

5.1.8 Conclusions and key messages

Partnership

National DRM policies increasingly involve cooperation with other countries. Within cross-boundary river basins, countries can jointly seek policies to control flood waters, for example, through spatial planning. Partnership for mitigation and prevention is particularly important in urban areas because of the disconnect between national and local responsibilities and resources. Horizontal city-to-city knowledge sharing and technology transfer is invaluable because of the unique context of urban systems. Resilience strategies can bring in the private, public, NGO and academic sectors.

Knowledge

However, identifying suitable investments is not enough. Presenting evidence of additional dividends to policymakers and investors could provide a narrative reconciling short- and long-term objectives. This will improve the acceptability and feasibility of DRM investments, enhancing the business case for investment in prevention and mitigation.

Innovation

Integration of policies and regulations across sectors such as zoning regulations, building codes and insurance policies would be a key innovation in mitigation and prevention, making the mitigation strategy more coherent and easier for stakeholders to implement.

5.2 Preparedness and response

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5.2.1 Policy and institutional architecture of preparedness and response in Europe

The DRM policy landscape has transitioned to 'civil protection', emphasising the importance of effective transboundary coordination and cooperation to manage transboundary disasters. This has been accompanied by a shift towards the role of policy in adaptive management and in protecting the rights of victims and survivors. Science plays an important role in better understanding the complexity of modern disasters and in devising suitable tools and approaches for preparedness and response.

5.2.1.1 Policy landscape and trends

Historically within European states, disasters were times when affected individuals had to self-organise, as external response was not systematically available, if at all. This changed in the 20th century when states started to organise loose structures of ordinary citizens intended to respond in times of crisis. For fires, this concept dates back to the Romans (Goudsblom, 2015). In recent history, the risk of aerial bombing across Europe led to a significant shift with the formation of civil defence organisations (Dynes, 1994; Van der Boom, 2000). By a decade or so after the Second World War, a transition had taken place from an essentially untrained volunteer-based response system to disaster management organisations staffed by paid professionals. Most European countries moved towards a professionalisation of disaster management and a centralised command-and-control structure (Dynes, 1994).

Command and control through civil defence centred on managing populations in the face of aggression and on emphasising top-down methods (Alexander, 2002). During the Cold War (1948-1989), the focus on possible relocation of civilian populations under threat of nuclear attack saw civil defence administered by military and paramilitary groups. Scientific critiques of civil defence point to the possibility for such institutions to become an instrument of repression and used to 'protect the state against its people' (Alexander, 2002).

Science played a key role in shaping the nature of civil protection.

Science played a key role in shaping the nature of civil protection through the 1960s to 2000s. Research questioned the role of the military in emergency management and helped to shape the non-military, civilian character of emergency preparedness that emerged (Alexander, 2002). A better understanding of the complexity of modern disasters has focused attention on adaptive emergency management as well as the rights of victims and survivors. The military still has a role to play; in redefining its role in disaster preparedness and response, military forces can be used in integrated ways with civil protection, or civil protection forces may contain pseudo-military organisations. For example, some fire brigades are partly organised along military lines, and non-governmental organisations such as the Salvation Army adopts a pseudo-military image (Alexander, 2002). Overall, 'modern civil protection is not inherently authoritarian' (Alexander, 2002), although the 11 September 2001 terrorist attacks altered emergency planning with a new focus on terrorist incidents and response operations in which police force or military units would usually be the lead agency (Alexander, 2002). Concerns over the possible remilitarising of civil protection in light of efforts to prepare for possible terrorist attacks are regarded as a threat to progress made in the 2000s in expanding civilian disaster response networks (Alexander, 2002).

5.2.1.2 Institutional architecture and coordinating mechanisms

European Union members have over time been drawn closer together by policies and legislation facilitating greater interstate cooperation (Boin et al. 2014b). The risks facing Member States have become increasingly

BOX 5.4

European Union Civil Protection Mechanism

When activated, the mechanism provides support via the ERCC, which provides 24/7 capacity to monitor and coordinate response to disasters. It is directly linked with the civil protection and humanitarian aid authorities in the participating states.

The centre also acts as the central 24/7 contact point in the eventuality that a Member State activates the solidarity clause (Article 222 of the Treaty on the Functioning of the European Union) or when the European Union presidency activates the integrated political crisis response arrangements and ensures coordination with other EU services and bodies for the response (ECHO, 2016).

Recent disasters such as the western Balkans flooding (2014), the eastern Ukraine conflict (2015), the forest fires in Greece (2015) and the European refugee crisis (2015-2016) have activated the mechanism and therefore the ERCC. Twenty-eight Member States plus a number of other European countries participate, providing additional response capabilities in times when the disaster exceeds those of the state in which the crisis takes place. Assistance deployed includes technical expertise, relief and equipment items, as well as advice on preparedness measures.

In 2013, legislative changes placed greater emphasis on preparedness (through the mechanism), including the establishment of a voluntary pool of pre-committed response capacities. In addition, EU funding helps address caps and temporary shortcomings in preparedness and response planning, including 'improving the quality of and accessibility to disaster information, implementation of prevention measures, raising of public awareness of risks and disaster management, supporting Member States in risk assessment and hazard mapping based on guidelines, encouraging research to promote disaster resilience and reinforcing early warning tools' (ECHO, 2016).

Source: ECHO (2017)

transboundary in nature and require greater cross-country collaboration to prepare and respond to crises (Boin et al. 2014a). Therefore, it has been necessary to create integrated institutions and coordinating mechanisms to manage these. We outline key institutions that have developed and explores how they have evolved and how they respond to the challenges of Europe's changing risk environment.
Crises in the future will be increasingly transboundary, transcending geographic and political borders and affecting multiple vital elements of infrastructure, and will not be contained in time (Ansell et al., 2009; Ansell et al., 2010; Boin and Ekengren, 2009; Boin and Lagadec, 2000). Recognising this, the European Security Strategy (ESS) declares: 'the EU's commitment to combat a variety of security threats, including failed states, energy security, terrorism, global warming and disasters. The ESS adopts a comprehensive view, explicitly linking internal and external threats, civilian and military capacities and natural and man-made disasters' (Boin and Ekengren, 2009). This points to the importance of effective cooperation between regional, national and international communities.

The UCPM, established in 2001, seeks to enhance and strengthen cooperation and coordination between Member States and to jointly respond to major emergencies — including pooling capabilities (Morsut, 2014). The mechanism has evolved from preparedness for response, and response, to include preparedness and prevention, and in supporting international relief efforts, for example to the 2004 Indian Ocean tsunami and the 2010 Haiti earthquake (Morsut, 2014).

Evidence points to the value of information sharing in disaster response, with studies showing that failure to do so '… during interagency disaster response has a negative influence on collective decision-making and actions' (Bharosa et al., 2010). This has been recognised by European members, including the Dutch Ministry of the Interior and Kingdom Relations (Bharosa et al., 2010). The UCPM promotes a coordinated response to disasters across Europe (see Box 5.4) supporting countries when capacity if surpassed. However, empirical evidence is sparse on the challenges and obstacles to effective coordination and information sharing, limiting understanding of the means to address barriers between community, agency and individual levels (Bharosa et al. 2010).

Overall, Europe's approach to preparedness and response can be categorised as a 'networked approach' reflecting the complexity of recent disaster events (Boin et al., 2014a). Europe's recent experience with disasters that cross traditional geographic and policy boundaries — referred to as 'transboundary crises' — include the bovine spongiform encephalopathy crisis in 1996; the Erika and Prestige tanker disasters in 1999 and 2002, respectively, with devastating environmental, social and economic impacts; flooding in central and eastern Europe in 2002; and fires in southern Europe in 2003 (Boin et al., 2014a). Throughout 1990 and 2000 the European Union developed its transboundary coordination and cooperation in response to different crises, harnessing European capacity and leading to the establishment of several agencies: the European Food Safety Authority, the European Maritime Safety Agency and three European financial supervisory authorities (Boin et al., 2014a). The development of tools, approaches and institutions has therefore been largely reactive, whereby 'The EU developed all of this capacity in a punctuated and fragmentary manner: with each crisis, Member States invested additional authority in the Union's budding crisis management apparatus. There is, in other words, no institutional blueprint' (Boin et al., 2014a). It can therefore be characterised as a 'network' or governance approach (Boin et al., 2014a).

This networked approach is supported by a number of tools, including the ERCC in Brussels (Box 5.4) and a Common Emergency Communication and Information System, which facilitates communication between the ERCC and national authorities. These centres seek to align with the European Union's core values — respect for human dignity, liberty, democracy, equality, the rule of law and human rights.

Progress over the past 20 years has seen research initiatives move from a focus on cross-border cooperation between Member States to methodological development. The latter includes hazards such as earthquakes, floods and landslides, as well as more effective management plans linked to EWSs employing those new technologies (Papatheodorou et al., 2014). Papatheodorou et al. (2014) note that '… harmonisation of methodologies used to assess ELF Hazards (earthquake, landslide, flooding), easy or even free access to reliable and accurate harmonised data and reliable and accurate hazard maps on a local scale are needed in order to effectively design preventive measures, to plan an effective management strategy and finally to raise public awareness'.

Initiatives such as EFAS support improved preparedness to flooding in transnational European river basins (Thielen et al. 2009). Starting with a 2003 prototype, local water authorities were provided with 3-10 days advance notice of medium-range and probabilistic flood forecast information. Initiatives such as these involve collaboration with national hydrological and meteorological services linking research, action and continual development of a model supported by information exchange and linking meteorologists with national water authorities. When initiated, EFAS was one of the few flood warning systems in existence to utilise ensemble prediction systems to increase predictability of floods and enhance preparedness capacity (Thielen et al., 2009). The importance of cross-border cooperation is especially important for flood hazards, providing means to strengthen knowledge, information and selection of cost-effective mitigation strategies. The lack of a legal framework for cooperation, of capacity and resources and of differing institutional structures and public awareness present challenges to be addressed (Papatheodorou et al., 2014). Effective cross-border action is limited without comparable pan-European methodological approaches to hazard assessment and risk mapping (Papatheodorou et al., 2014).

BOX 5.5

European community urgent radiological information exchange (Ecurie)

In the wake of the Chernobyl accident, Council Decision 87/600/Euratom was adopted. This decision essentially obliges a Member State to notify the European Commission without delay in the event of enacting measures to protect its population from the effects of an event with radiological consequences. This legislation was the legal basis for what became known as the 'European community urgent radiological information exchange', or Ecurie, and was a major step forward in the field of radiological emergency preparedness in Europe.

The information to be shared not only covers the basic characteristics of the event itself but also the foreseeable development of the emergency and its potential effects, the results of radiological monitoring in the affected country and the measures taken to provide information to the general public. On receipt of such a notification, the European Commission promptly forwards the information to all Ecurie contact points. The intention is for the system to provide a continuous flow of information during the emergency.
In the years since, the system has matured both in terms of stakeholder network and operational status. A new information exchange software application, 'Web-Ecurie', was developed and first made operational in 2012, replacing its predecessor, which was based on point-to-point secure email communication. Users only require internet access in order to enter the application, which may be used on a variety of platforms. Submitted information is organised in a modern status board arrangement. 'Event' or 'National' status boards allow for either a broad or a country-specific view, with particular focus on the display of national protective measures.

Much attention has been and continues to be given to harmonising the underlying procedures and technology with that of the International Atomic Energy Agency, and the transfer of valuable experience gained over the decades in Europe to countries and regions outside the European community is actively being pursued.

Source: De Cort et al. (2015)

5.2.1.3 Developing effective early warning systems

EWSs form an important part of DRM and are essential features of UCPM (Alfieri et al., 2012). Greater recognition of the role of EWSs have contributed to the move from an ex post response towards a culture of risk prevention and preparedness (Alfieri et al., 2012). The shift to greater stakeholder participation in preparedness and response (described earlier in this chapter) can be seen in more accessible and open information in EWSs including the ability of systems to be accessed remotely and stakeholders to input data that improves the quality of early warnings (Alfieri et al., 2012).

EWSs provide timely warnings to minimise loss of life and to reduce economic and social impact on vulnerable populations (Garcia and Fearnley, 2012). In 2006, the UNISDR platform for the promotion of early warning published the Global survey of early warning systems, identifying existing capacities and gaps in EWSs in over 23 countries with 20 international agencies (United Nations, 2006). The report advocates that an EWS should be 'people centred' (i.e. community based) and should include many systematic approaches and diverse activities spanning four key elements: risk knowledge, monitoring and warning service, dissemination and communication, and response capability (Basher, 2006). The operation of an EWS presents numerous challenges due to variations in scale (global, national, regional or local), temporality (rapid onset or slow onset and frequent or infrequent), function (safety, property or environment) and hazard (weather, climate and geohazards).

An EWS needs to fit within the broader mitigation and preparedness actions of the DRM cycle. Researchers and other stakeholders frequently work independently on EWS subsystems in a multitude of non-coordinated strategies with no structure or linking, compromising the effectiveness of the EWS. An effective EWS can only be achieved once stakeholders recognise their relative contribution and work together to link efforts in order to achieve effective DRM.

With the increasing impact of global warming on extreme natural hazards, EWSs are increasingly required to cater for multiple hazards (Basher, 2006) or even cascading hazards (Pescaroli and Alexander, 2015). This is reflected in the SFDRR — and its European signatories — which aims to 'substantially increase the availability of and access to multihazard EWSs and disaster risk information and assessments to the people by 2030' (UNISDR, 2015). This requires a greater examination of the role of EWSs as a whole within preparedness strategies.

5.2.2 Ethical, legal and social principles in preparedness and response

We review some of the core ethical, legal and social (ELSI) considerations in emergency preparedness and response. Recent efforts have begun to draw interdisciplinary research together and engage closely with practice (Campbell 2012; Boin and Ekengren 2009) to discuss ELSI. Debates about responsible research and innovation (Nowotny et al., 2001; Von Schomberg, 2013; Stilgoe, 2015) have brought a reflexive dimension to research and practice in DRM.

DRM is embedded in complex ethical, legal, social and political contexts, and disasters should not justify exceptions in moral standards. Shared values and principles are needed for emergency response that transcend national boundaries and strengthen social cohesion and trust before a disaster can increase the effectiveness of response.

Debates about responsible research and innovation (Nowotny et al., 2001; Von Schomberg, 2013; Stilgoe, 2015) have brought a reflexive dimension to research and practice in DRM.

5.2.2.1 Legal frameworks

National legal frameworks for disaster preparedness and response in Europe are based on European Commission directives or international initiatives. As in the case of the Flood Directive (Alfieri et al., 2012), these policy developments often respond to global change or large-scale disasters. The Flood Directive, for example, shows how major European floods have resulted in a move towards uniform protection for all European Union citizens and call on Member States to review their flood risk management approaches (Alfieri et al., 2012). Directives urging Member States to strengthen preparedness measures are often closely linked to mitigation strategies and environmental protection actions, including the Strategic Environmental Assessment (Papatheodorou et al., 2014). This is largely the case for earthquakes, floods and landslides (Papatheodorou et al., 2014).

With a shift towards a risk management approach to dealing with disasters, the legal frameworks under which preparedness and response are situated have broadened. The attraction of 'risk-based regulation' has been discussed by scholars reflecting on the increased adoption of 'risk' by policymakers — including the European Commission, which regards risk as a 'crucial' component of public policy, and the Organisation for Economic Cooperation and Development's recommendation of risk-based approaches (Krieger, 2013). Disaster preparedness and response has evolved in this context of risk-based governance, regarded as a means to operate more efficiently with finite resources in a context of austerity and accountability in the context of a narrative of 'good governance' (Krieger, 2013).

Increased incidents of flooding and economic damage since the 1990s — and, in particular, USD 11 billion (EUR 10.1 billion) of damage as a result of the Elbe/Danube flood in 2002 and USD 4 billion (EUR 3.7 billion) in the United Kingdom in 2007 — have reinforced this paradigm shift and there has been a clear move from flood defence to flood risk management across Europe (Krieger, 2013). This can be seen in the United Kingdom's 'Making space for water' (DEFRA, 2004) and Germany's 'Room for rivers' approaches (Krieger, 2013).

As with many EU Member States, the United Kingdom emergency management approach is 'all hazards' and incorporates mitigation, preparedness, response and recovery (O'Brien, 2008). Emergency management is characterised as 'legally based, professionally staffed, well funded and organised' (O'Brien, 2008). Reforms to United Kingdom emergency management have replaced discretion with a duty to prepare plans, standardising procedures for risk assessment and supporting a more integrated approach. Emergency management in the United Kingdom has, however, been criticised for focusing largely on institutional resilience and organisational preparedness where a greater emphasis on societal resilience and public preparedness is regarded as necessary (O'Brien, 2008). Greater emphasis on a preparedness and emergency planning that moves beyond the focus on the continuity of emergency services and commercial activities could entail greater inclusion of the public (O'Brien, 2008).

5.2.2.2 Ethics and moral standards for emergencies

Disasters are often still seen as justifying exceptional decisions. Sorrell (2002), for example, argues that in emergencies, societies may be 'sucked into a moral black hole'; meaning a breakdown of moral and social order that justifies the use of extraordinary powers. These positions are, however, challenged by a number of analysts. At the root of these debates are questions about whether moral standards should ever be disregarded in emergency situations.

As part of its code of ethics, the International Committee of the Red Cross (ICRC) provides detailed guidance on how to engage local populations in conflict areas in the production, protection and sharing of sensitive information (ICRC, 2013). These approaches make the case that preparation can protect societies from exceptions that go against ordinary morals, integrity and dignity, from unintended consequences or from entrusting decisions solely on experts or governments without public engagement. This resonates strongly with calls for responsible research and innovation, process-oriented, 'post-ethical, legal and social issues' approaches (Balmer et al., 2016) that develop forms of disclosure and ethics (Introna, 2007), collective experimentation (Petersen et al., 2016) and collaborative design (Liegl et al., 2016) to address ELSI as they emerge in DRM.

Community involvement in DRM is generally agreed to be essential and is widely promoted internationally. While states have an ethical and often legal responsibility for preparedness and response, effective action requires society as a whole to engage and the government to partner with civil society and private sector organisations. The shift towards civilian disaster preparedness and response recognises that 'disasters can only be mitigated successfully if ordinary people are empowered to take responsibility for their own safety. Disasters, therefore, are as much about democracy as they are about security' (Alexander, 2002). Guiding principles for state interaction with society in preparedness and response have been highlighted by international agencies, including 'empowering and inclusive participation', 'accessible and non-discriminatory support' and the 'special attention [needed for] those disproportionately affected by disasters' (UNISDR, 2015). Indeed, emergency preparedness is considered by some as a means to ensure and safeguard democratic rights, not to circumvent them. Thus, civil protection often explicitly includes principles of equity (Wisner et al., 2004; Alexander, 2002) and the Council of Europe's European and Mediterranean Major Hazards Agreement has published extensive guidance on the application of ethical principles to all aspects of DRM (Prieur, 2012).

Accountability, which is a key principle behind community participation and involvement, is encouraged by international, regional and national codes, charters and standards (Twigg, 1999). For international humanitarian response, the International Federation of the Red Cross/International Committee of the Red Cross has a code of conduct, a voluntary code of principles for humanitarian actors (IFRC/ICRC, 1994), while the Sphere Project has developed a set of minimum standards in core areas of humanitarian assistance (Sphere Project 2011) and the Inter-Agency Standing Committee has prepared operational guidelines on human rights and natural disasters (IASC, 2006). In Europe, the 1998 Aarhus Convention established public rights to information on the environment and associated human safety as well as to participate in relevant decision-making (UNECE, 1998). Such instruments may be linked to or supported by broader principles and agreements on human economic and social rights and to institutions that monitor and support them. The idea of a 'right to safety' is supported implicitly in some international covenants and charters, although it is rarely recognised in national legislation (Twigg, 2003).

Public debates regarding ethical aspects of preparedness and response are often triggered by disasters, such as the L'Aquila earthquake trial (Alexander 2014, Newberry 2010), but are also ongoing, wider discussions about social justice and vulnerability, both internationally (Wisner et al., 2004; Morrow, 2008) and within the European Union (Brisley et al., 2012; Fielding, 2007; Lindley et al., 2011).

5.2.2.3 Social capital and social cohesion

Research points to the very important role of social capital as a primary base for community disaster response and is vital in reducing the impact of disasters and facilitating recovery (Dynes, 2002; Ko and Cadigan, 2010; Murphy, 2007; Aldrich, 2012). In crises, social networks provide mutual assistance and access to support and resources, thereby reducing disaster impacts and facilitating recovery. This has been demonstrated by research in a number of countries, notably Japan and the United States, but there is a need for further research in Europe (Comfort, 1996; Dynes, 2005; Murphy, 2007; Airess et al. 2008; Aldrich, 2012; Aldrich and Meyer, 2015; Nakagawa and Shaw, 2004; Shaw and Goda, 2004; Wallace and Wallace, 2008; Minamoto, 2010; Mimaki and Shaw, 2007).

Disasters often encourage or reinforce social capital formation (Putnam, 2000; Gordon, 2004; Shaw and Goda, 2004; Bankoff, 2007; Yamamura, 2010). Studies mostly show a strong association between , levels of social capital and post-disaster mental health outcomes, particularly a reduction in post-traumatic stress (Wind et al,. 2011; Wind and Komproe, 2012; Ritchie and Gill, 2007; Adeola and Picou, 2014; Ganapati, 2012a, b). Conversely, an acute lack of social capital — social isolation — can contribute significantly to vulnerability, as documented with regards to the European heatwave of 2003 (Keller, 2015; Klinenberg, 2002; Ogg, 2005; Romero-Lankao et al., 2012).

5.2.3 Professionalization of citizen engagement in preparedness and response

At a national and regional scale, over

the past decade the professionalism and coordination of preparedness for response by civil protection mechanisms, including across states, has advanced significantly. Some of these tendencies and an analysis of the changing roles of different preparedness and response actors are described below.

The professionalism and coordination of preparedness and response by civil protection agencies has advanced significantly in recent years alongside a desire to give citizens increasing responsibility for individual preparedness and response. New social groups can emerge during a disaster to help manage emergency response measures — their role could be better harnessed if appropriately planned for informal responses.

5.2.3.1 Citizen engagement and volunteerism

Locally organised, trained and equipped responders are considered a societal asset and a means to enlist significant social capital and capability in preparedness and response. Thus, in some contexts, citizens are encouraged to play a more active role in preparedness and response. The 2014 Dutch National Council for all safety regions — the decentralised bodies responsible for disaster management — recognised the value of untrained citizens and their role in preparedness (Veiligheidsberaad, 2014).

Encouraging preparedness for rare disasters, however, remains a policy challenge. Citizens primarily prepare for incidents perceived to be a significant threat and/or the most recent disaster they encountered (Major, 1999; Tierney, 1989). Government programmes aiming to boost resilience therefore need to focus on dominant and regularly experienced risk. For example, in areas that regularly experience small earthquakes, citizens can be more easily persuaded to prepare for the risk of a more severe earthquake, but less for other risks. This raises questions about, for example, preparedness measures by citizens for flood risk in the Netherlands where the perception of flooding from the sea is low, having not occurred since 1953. In spite of government flood risk preparedness programmes, further efforts are needed to engage citizens (Engel et al., 2012).

5.2.3.2 Emergent groups

Emergencies stimulate informal responses by spontaneous, self-organising and voluntary groups and individuals from within and outside disaster-affected communities. These groups may carry out a wide variety of activities including search and rescue, first aid, damage assessment, debris removal, handling of bodies, relief supplies distribution, food provision, translation, counselling and presenting survivors' grievances (Quarantelli, 1994; Stallings and Quarantelli, 1985). This 'emergent' and 'convergent' behaviour in disasters has been documented over several decades across the world, in different cultures and under a variety of governance structures (Comfort 1996; Drabek and McEntire 2003; Dynes et al. 1990; Linnell 2014; Neal et al. 2011; Quarantelli 1993; Rodriguez et al. 2006; Whittaker et al. 2015). In some cases large sections of populations are involved (Quarantelli, 1993). Extensive flooding in Kingston upon Hull in the United Kingdom in 2007 stimulated a range of spontaneous actions by local residents, including assisting with evacuation, giving care and support to vulnerable neighbours, protecting houses against floodwater and giving medical assistance (Neal et al. 2011).

Large numbers of spontaneous volunteers can present significant coordination, integration, communication and logistical and health and safety challenges to emergency managers, especially in rigid 'command and control' disaster management structures that do not plan for community engagement.

Improvisation and creativity are required to build networks and relationships between organisations and incorporate volunteers within organised efforts (Alvinius et al., 2010; Cone et al., 2003; Drabek and McEntire, 2003; Kendra and Wachtendorf, 2006; McEntire, 2002; Majchrzak et al., 2007; Uhr et al., 2008). Nevertheless, emergency volunteerism offers longer-term opportunities for more structured citizen response through training and creation of community preparedness and response teams as well as through formal voluntary organisations (Alexander, 2010; Barsky et al., 2007; Helsloot and Ruitenberg, 2004; Pardess, 2005), although efforts are necessary to maintain volunteer motivation (Brand et al. 2008). Red Cross national societies are a major provider of organised volunteer support in disasters, with approximately 17 million active volunteers in 190 national societies worldwide (IFRC, 2016). Technisches Hilfswerk, a German government agency, has over 80 000 volunteers (99 % of its membership) who assist in disaster response in their own countries as well as in others (THW, 2016).

Recognition of the contribution that social groups can make in emergen-

BOX 5.6

Digital humanitarianism and citizen mobilisation

There has been a 'digital tsunami' (European Commission, Future Group, 2007), with individuals, objects and environments generating vast amounts of data through self-disclosure and sensors, while advances in data processing make this data amenable to analysis for commercial, governance and security purposes — and DRM (Thrift, 2011). Together, these advances can enable improvements in preparedness and disaster response because they provide communities with more broad-based and detailed monitoring and timely feedback on their situation and support predictive modelling and more precise targeting of assistance.

'Digital humanitarianism' (Starbird and Palen, 2011; Munro, 2013; Burns, 2015) can be extremely useful if addressed within a framework for resilience that places an emphasis on data ownership, community-based analytical authority and community-based data skills (Crawford et al., 2013). Social media is one aspect of the role of technology in citizen mobilisation and awareness raising.

Social media can also service self-organised mobilisation and coordination of local resources, knowledge and efforts. During the floods in Germany in 2013, for example, 29 % of Twitter messages focused on coordinating help and resources locally (Zipf, 2013). Reports from sandbag-filling stations appeared alongside calls for help and a crowdsourced map of the current need for volunteers in different places (Mildner ,2013). Lüge (2013) suggests that these examples index a shift in the use of social media for emergency management. The informational service function for official response is increasingly seriously complemented by a practical service function for self-organised community help and resources, especially for members of the public. Recent studies find that in Europe generally, social media are growing and supporting the emergence of new forms of 'social resilience' (Flizikowski et al., 2014, Reuter and Spielhofer, 2016).

The use of social media in crises can give rise to rumours (Mendoza et al., 2010), vigilantism and 'do-it-yourself' justice (Rizza et al., 2014, Tapia and LaLone, 2014). However, attempts at structuring digital volunteer work and crisis mapping through the UN co-founded Digital Humanitarian Network (Meier, 2015) and Virtual Operations Support Teams or 'VOST' (St. Denis et al., 2012) have begun to create bridges between crisis mappers and formal emergency agencies (Kaminska et al., 2015). They establish networks of trust: mechanisms that combine standardisation, training, and agreed channels of communication that enhance risk governance. These include engagements around air pollution (Mosley, 2009) and radiation risks from Chernobyl where 'descriptive standards', 'alignment', 'unblackboxing' and 'mobile measuring' proved central to prevent risks from becoming 'twice invisible' (Kuchinskaya, 2012).

cy response has stimulated positive changes in state-civil society relationships for disaster planning. Yet governments sometimes resist in order to maintain control (Jalali, 2002), and extensive government activity and spending can crowd out voluntary activity, especially where autonomous civil society is not well developed (Deng, 2009; Teets, 2009).

5.2.3.3 The role of social media in citizen engagement

Knowledge of crisis communication in Europe is growing rapidly (Palttala et al., 2012). A complex field in itself, crisis communication links to societal expectations over the role of public authorities to effectively communicate risk and educate citizens on effective preparedness and response. Coordination has become increasingly important, as responsibility for managing crisis moves from solely the government and emergency services to include the role of media, social media and other actors (Palttala et al., 2012). Despite differences between countries — including different levels of financial resource for public crisis communication — the growing body of evidence, a plethora of guidelines and best practice, suggests there remain gaps in ensuring communication is integrated into disaster management practice and an integral part of decision-making (Palttala et al., 2012). Gaps remain in relation to cooperation across actors, i.e. the media, with citizens and across the response network (Palttala et al., 2012).

New forms of self-help, partnership and cosmopolitan 'digital humanitarianism' become possible with technology. Watson and Finn (2014), for example, examine information flows between corporations and their customers during the Eyjafjallajökull eruption, the most severe global flight disruption since 9/11. This empowered improvised self-help, including self-organised information services, and support for actively coordinating alternative travel. It widened people's networks through 'virtual social convergence', and Watson and Finn (2014) conclude that 'such activities are able to enhance citizen resilience by mobilising social capital'.

5.2.4 Conclusions and key messages

Partnership

Cooperation between regional, national and international communities is needed for preparedness and response planning given the complex and transboundary nature of modern day disasters. ELSI are dimensions of DRM that need to be addressed together with practical efforts to prepare and respond. Effective preparedness can protect societies from exceptions that go against ordinary morals, integrity and dignity, from unintended consequences and from entrusting decisions solely on experts, or governments without public engagement.

Knowledge

A move away from command-and-control approaches to managing disasters has opened up more opportunities for citizens to participate in preparedness and response. Strong bonds and trust within and between communities facilitates a more effective response in emergencies and can be harnessed by authorities. Social media can also be used to enhance self-organised mobilisation and coordination of local resources, knowledge, and efforts for disaster preparedness and response.

Innovation

Research and innovation in process-oriented approaches to ELSI will improve collective experimentation and collaborative design, to address issues as they emerge in the dynamic contexts of disaster preparedness and response.

5.3 Recovery and avoiding risk creation

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5.3.1 Introduction

Most disasters are difficult to predict in the short term, but research to quantify the impact and understand recovery processes can help reduce the uncertainties associated with these events. Recovery is, however, the least understood aspect of DRM (Smith and Wenger, 2006). It is considered a complex, non-linear process with physical, social, economic and institutional dimensions (Johnson and Hayashi, 2012; Alexander, 2016). The recovery period is also an opportunity to facilitate economic, social and physical development long after the disaster (Berke et al., 1993); and the promotion of social and intergenerational equity is a key principle for sustainable recovery.

In this subchapter we examine scientific knowledge of recovery processes and the policies that have been implemented to enhance recovery, focussing primarily on Europe. Europe has experienced a range of disasters in recent years, though perhaps with less frequency and intensity than other parts of the world.

It is important to be prepared to live with the possibility that disasters may occur in one's lifetime or in that of the next generation. Anticipating the multiple dimensions of recovery is key to effective risk management.

The aim is not to provide an extensive coverage of all disasters or hazard types but rather cases that have been illustrative of the recovery process and that have led to scientific innovations and advances in theory. Not all recovery processes are covered here, but authors have attempted to cover a range of physical reconstruction and economic, social and psychological aspects, as well as knowledge about the planning and coordination of measures aimed at assisting recovery.

Europe is the focus of analysis, but whenever experience from other locations helps to understand recovery processes and policies in Europe, these are mentioned. Within Europe there are differences between north and south, not only in the types of hazards that are prevalent, but also in the cultural processes shaping recovery. These are mentioned here but not explored in detail due to space restrictions.

5.3.2 Planning for recovery

The recovery process is multidimensional and progresses at different rates for different people, businesses, institutions and places affected by a disaster (Wein et al., 2011). Institutional fragmentation and short-term planning can hinder recovery and often result in new risks being created. Thus, cross-scale and longer-term strategies are needed in recovery, integrating different stakeholder perspectives and knowledge and coordination across policy domains. Innovations in our understanding of recovery planning are discussed in this section and provide a starting point for a deeper exploration of recovery processes later in the subchapter.

5.3.2.1 Recovery plans

The core purpose of disaster recovery planning is to offer a vision of the future after a disaster, provide a direction-setting framework (strong fact base, goals and policies) to achieve the vision; ensure that even short-term actions build longer-term resilience and that community needs are linked to broader regional, state and national disaster response and reconstruction policies (Berke and Campanella, 2006). Successful plans maintain both a combination of as well as distinct short-term recovery and long-term planning goals (Ingram et al., 2006).

Recovering from damage, loss and social disruption involves different types of activities. Categorising the impact can provide focus for both planning and research activities. Common recovery sectors are: reconstruction of buildings, restoration of livelihoods, system repairs, human and social rehabilitation, amongst others, to restore society back to being a well-functioning community, and preferably a better functioning community. Lindell and Prater (2003) define disaster impact sectors as physical (both built and human) and social (psychosocial, sociodemographic, socioeconomic and political); while Davis (2006) divides the process into five sectors, psychosocial, economic, physical, environmental and administrative/institutional sectors. Overall, identifying and classifying areas of recovery is best done on the basis a Post-Disaster Needs Assessment (PDNA). PDNA is a common assessment approach to support governments to assess damage and recovery needs. It is an inclusive process that builds on the capacity and expertise of national and international actors (GFDRR, 2013). PDNA provides damage and loss estimates and quantifies needs. A recovery framework is then needed to build on the damage and loss assessment for detailed sequencing, prioritisation, financing and implementation of recovery efforts.

Pre-disaster planning, participatory planning, capacity building, scheduling and process coordination can all help improve recovery and build more resilient communities.

Recovery goals commonly include the timely restoration of normal living conditions (Alexander, 2004; Lu and Xu, 2014); however, there is a trade-off between speed and deliberation (Olshansky, 2006; Lu and Xu, 2014). Pressure to urgently address complex, difficult decisions can result in reactive policies that may increase long-term vulnerability of affected populations (Ingram et al., 2006). Time compression has thus been identified as an important overarching characteristic of the recovery process (Olshansky et al., 2012).

5.3.2.2 Integrating mitigation in recovery plans

Disaster recovery provides opportunities for reducing risk through mitigation measures (Ingram et al. 2006). Mitigation measures should be integrated into pre-disaster recovery planning (NGA, 1979; Alexander, 2004; Lu and Xu, 2014) and can include proposals to reform building codes and land-use plans as one of the steps needed to meet recovery objectives (along with reconstruction, restoring systems, rehabilitation of people and re-establishment of livelihoods) (Thorvaldsdóttir and Sigbjornsson, 2014). Methodologies developed for evaluating benefits and costs of disaster mitigation measures (e.g. Chang, 2003) can also be used to guide the recovery process, although CBA needs to be used carefully (see Chapter 5.1.5).

5.3.2.3 Promoting participation

Recovery is also considered an interactive problem requiring coordination between numerous agencies and stakeholders (Berke and Campanella, 2006; Lu and Xu, 2014). Research on actors includes: the role of local officials (Rubin and Barbee, 1985), affected people (Ingram et al., 2006), citizen participation (Kweit and Kweit, 2004), the private sector (De Tura et al., 2004), community participation in general (Johnston et al., 2012) and auditors of the planning and implementation of recovery (Labadie, 2008). The role of partnerships (Mitchell, 2006) and management types (normal line ministries, special task force of government and new organisation) (Davis, 2006) are also addressed in the literature.

5.3.3 Reconstruction, building and urban design in post-disaster contexts

5.3.3.1 Principles for reconstruction

In post-disaster reconstruction, location and exposure to risk are important considerations, as are the type of construction materials, the constraints on materials (due to environmental conditions), timing of execution and access. Understanding the appropriateness of different materials that would be needed for reconstruction prior to a disaster can speed up reconstruction decisions, although the disaster itself will create new challenges. In the 1755 Lisbon earthquake (Oliveira, 2012), for example, scientific knowledge was lacking and guidelines for reconstruction (new urban design, introduction of seismic and fire-resistant techniques, new sanitary system, etc.) were drawn up quickly alongside a large number of decrees dealing with feeding, healthcare, defence, property jurisdiction, commerce activities and taxes. In comparison, discussion on the types of new defences needed for future tsunamis in the zones affected by the Tohoku tsunami have occurred over several years (Ieda, 2012), culminating in the decision to build big barriers made of concrete or soft dunes to dampen the energy of waters (Figure 5.3).

Disasters affect communities for varying periods of time and reconstruction is often required. Rebuilding poses various challenges, from defining suitable locations to merging tradition with modern construction techniques.

Reconstruction time varies tremendously depending on the level of resilience and the degree of impact of the event. There are cases where reconstruction has been greatly influenced by low pre-existing levels of development and will take a very long time, as is the case of the earthquake in Haiti in 2010. In these cases, the urban systems themselves need to be developed at the same time as reconstruction is happening. In other cases, the value and ownership of property has to be correctly identified and agreed before reconstruction or rehabilitation can begin.

For the historical centre of L'Aquila a roadmap for housing reconstruction was developed and building has been carefully monitored (Murao et al., 2007; Ishikawa, 2012; Chern, 2012). Considerable attention has been paid to discussing options with the affected population to ensure reconstruction decisions are acceptable to them (see Box 5.7).

5.3.3.2 Local construction practices

The process of rebuilding residential property, industrial stock, critical infrastructures and historical buildings is shaped by existing arrangements for urban planning as well as educational, technical and financial resources available. Pre-disaster construction practices, including the mix of 'engineered structures' versus 'low-cost structures' and how building is guided by regulations and land-use/urban plans, all affect the type of reconstruction activity that is appropriate and necessary. The political system also affects the success of a reconstruction process (Lucas et al., 1992; Oliveira et al., 2008).

Table 5.3 provides an intentional oversimplification of reconstruction options and the norms guiding these in countries of 'higher income' and of 'lower income'. Understanding the most common reconstruction techniques used and other considerations influencing reconstruction patterns is really important. For engineered structures, codes of practice and technological tools can help guide reconstruction. In particular, EN-1998-3 (2005) is a code of practice to guide reconstruction and rehabilitation of structures, but needs to be adapted to a country in accordance with material properties, techniques of reconstruction, etc.

The knowledge contained in codes needs to be communicated to the technical community and to practical contractors through manuals as well as training courses, and even using the media to reach a broader population. Codes that are efficient but not too complex are more likely to reduce non-compliance. For 'low-cost structures', on the other hand, building techniques that are compatible with traditional practices are more effective, adjusting the codes to local materials and local traditions.

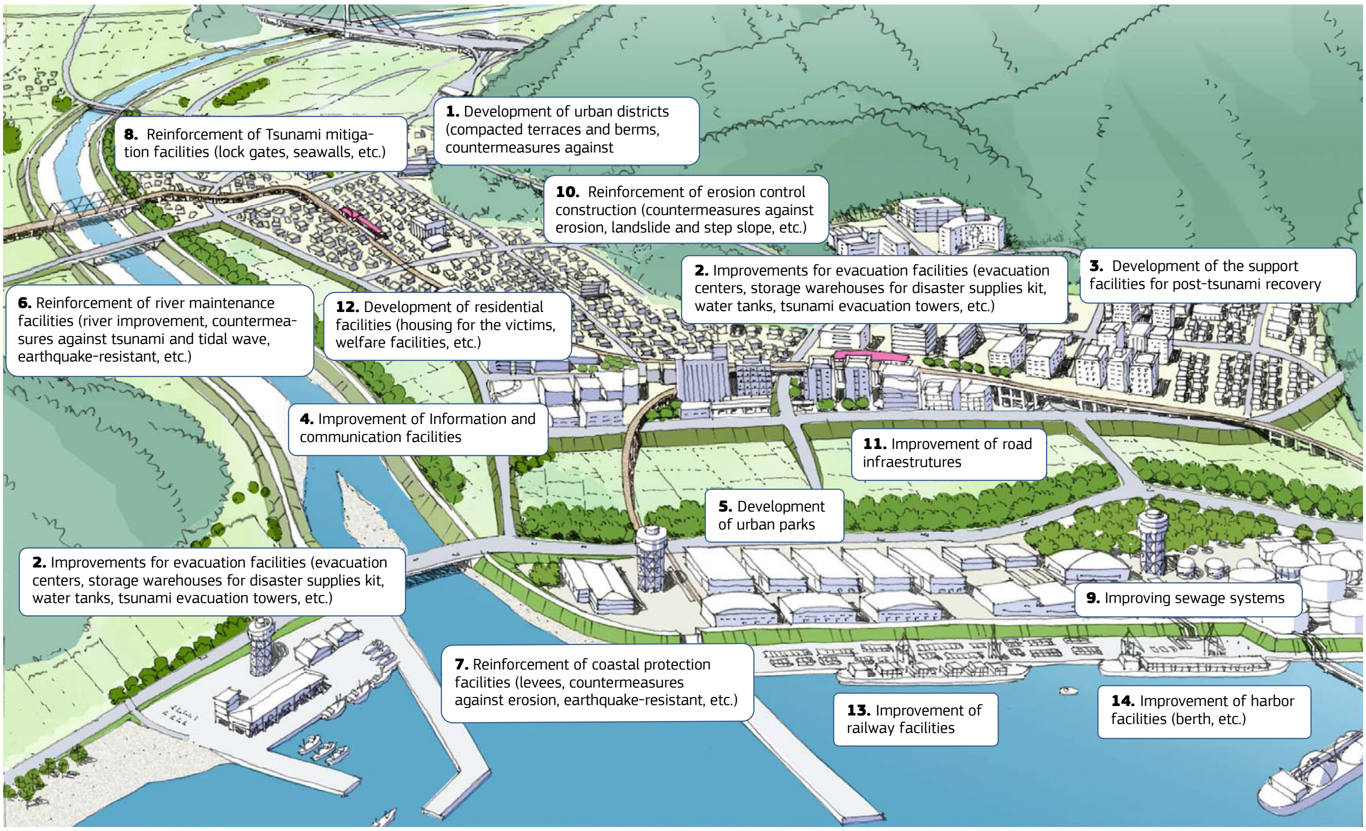
5.3.3.3 Avoiding future risk

Housing and other structures can be relocated to areas where exposure to hazards and other sources of risk is a lesser problem. Techniques can be used to weigh the various components of risk. For instance, 'Sirius' (Mota de Sá et al., 2013) is an indicator referring to geographic zones which are more prone to urban impact in case of an event. It deals with two variables, one concerning the vulnerability of the existing housing and the other reflecting the human concentration. It is organised into several plateaus which define the level of impact for that event. The opinions of those affected on whether to rebuild in the same place or move to another environment is also of great importance.

Reconstruction can be used to correct urban development problems, such as high population concentrations, and to widen roads for more

FIGURE 5.3

Sketch of possible solutions for Tohoku earthquake.
Source: MLIT (2013)



effective drainage. The case of Italy, with the several earthquakes in the last 25 years, is critical (Dolce and Bucci, 2015), and the project C.A.S.E. (Costruttori ForCase, 2009) is particularly relevant for avoiding future risk, where new buildings have been constructed in a short period of time with base isolation.

Similarly, the Guidelines for seismic microzonation (SM Working Group, 2015) and the European Floods Directive (European Parliament and Council, 2007) are good examples of how to minimise risk through reconstruction after major disasters (European Parliament and Council, 2007; IPCC, 2014; Thaler and Hartmann, 2016). Reconstruction after the floods in the Netherlands in 1953 is, however, perhaps the most striking example of taking measures to control flood risk in the future (See Box 5.8).

Another example of significant mitigation measures being taken to limit risk in the future in the wake of a high-impact disaster can be found in Madeira (see Box 5.9).

BOX 5.7

Temporary housing construction in recent Italian earthquakes

On 24 August 2016, a M6.0 earthquake started a seismic sequence in central Italy, which included a M6.5 event on 30 October 2016. There were at least 299 fatalities, essentially caused by the collapse of buildings during the first main shock.

So, how should long-term temporary housing be managed after an initial period in tent and caravan campsites or hotels and before reconstruction takes place? A variety of responses can be seen after the three strongest earthquakes occurred in Italy in the past 30 years: Umbria-Marche in 1997, Abruzzo in 2009 and Emilia in 2012. Due to the long lapse of time typically required in Italy to complete the repair and reconstruction process — especially for the historical centres — housing arrangements are needed for homeless families for several years. Different solutions have been adopted (Dolce and Di Bucci, 2015). In Umbria-Marche and Emilia, the temporary solution consisted of public contributions to autonomous construction or, alternatively, pre-fabricated homes. In Abruzzo, four different alternative solutions were conceived for about approximately 45 000 people.

The first two consisted in the requisition of unused apartments and in a monetary contribution for autonomous lodging arrangement. Moreover, two ad hoc projects were set up and realised. The project C.A.S.E. consists of seismically isolated three-story buildings that can host around 15 000 people in 4 449 apartments. It was completed 10 months after the event. The limited land needed made them suitable for the city of L'Aquila. The project M.A.P. consisted principally of single-family timber houses in small settlements near the original villages. In total, 3 535 houses were erected in 141 areas, for approximately 8 500 people. For the Amatrice sequence, the choice was to use monetary contributions or 'Emergency housing solutions' similar to the M.A.P.s housing.

All of the described choices have a sound rational basis and could be adopted under different conditions. For the earthquake disaster recovery there is no 'one size fits all' model. Territories are different, available scientific and technologic support evolves and the expectations of the affected population change over time. A mature civil protection system looks for tailored solutions, building on previous experience while exploring new alternatives.

5.3.4 Economic recovery processes from households to the macro economy

Economic recovery refers to the process by which an economic unit (household to country) returns to conditions of stability following a disaster (Chang and Rose, 2012). Recovery does not require returning to a pre-disaster state; in fact, economic systems may never return to pre-disaster states, but rather achieve a new equilibrium (DFID, 2011).

In this section we examine knowledge on recovery processes that take place at different scales after a disaster. This literature draws on a wide range of post-disaster experiences in many different countries.

5.3.4.1 Economic recovery processes at the microlevel

The processes that enable households to recover levels of wealth after a shock or a disaster have been extensively studied (see, for instance, Christiaensen et al., 2007; Dercon and Christiaenen, 2011). In the short term after a disaster, incomes drop and the loss in income can lead to a reduction in consumption, with direct impact on individuals within the households, including higher levels of malnutrition (Alderman et al., 2006; Beegle et al., 2006).

The recovery process begins immediately but partially depends on the initial economic situation of the household: diversified sources of income and relatively high income levels are found to be beneficial for recovery across a range of countries and contexts (Adger et al., 2002; Morris et al., 2002). High levels of assets as well as access to credit, government grants and social protection give people a wider range of options and opportunities following a disaster and can speed up recovery (Twigg, 2015).

Measures can be taken to support and accelerate the economic recovery process at various scales, although the economy may not return to the pre-disaster state.

Social networks, safety nets and remittances play a particularly important role. These mechanisms are often ignored by DRM policies (Gaillard and Le Masson, 2007), yet social and physical connections are a major factor in people's vulnerability to disas-

TABLE 5.3

Matrix of construction types
Source: courtesy of authors

Structures, technologies and related norms	Higher-income countries	Lower-income countries
"Engineered"	Home made	Imported
"Low-Cost"	Contracts	Self-construction
Construction legislation	Comply if compulsory	Need supervision
Urban design considerations	Comply if discussed	Low priority

BOX 5.8

Improving flood defence after the Dutch flood disaster of 1953

Its geographical position means the Netherlands is not only threatened by the sea but also by major (international) rivers (Figure 5.4).

On 1 February 1953, there was a major flood causing significant losses due to high water on the North Sea and a severe northwestern storm. A total of 800 km of dikes were severely damaged and 200 000 hectares of land flooded. The Netherlands was not prepared and the condition of the dikes was inadequate. A more structural approach to preventing damage in the future was needed and a Delta Commission was appointed, the Delta Act passed (Bulletin of Acts, 1958) and the Delta Works project initiated to close off all tidal waters between the Western Scheldt and the Rotterdam Nieuwe Waterweg and to strengthen primary dikes along the coast and the Western Scheldt. The central government decided to fund a massive investment in flood defense: the Eastern Scheldt barrier, with its sliding gates, was considered a technical and expensive innovation at the time but was considered a good investment, saving dike-strengthening costs and promoting Dutch hydraulic engineering.

In 2008 the Delta Commission produced new advice on water safety in the context of climate change and sea level rise. Yearly, delta programmes and a fund have been established and new rights-based legislation passed, guaranteeing Dutch citizens a safety standard (likelihood of dying in a flood disaster is no bigger than 1: 100 000 per year) and stimulating further investment in dike projects. The legal water safety standards are unique in the world and (much) higher than in other countries, and knowledge on water safety is also high. Recent research also suggests that water safety is affordable, costing the ministry (from 1954 to the present day) approximately EUR 35 per capita.

FIGURE 5.4

Netherlands' flood hazard map
Source: Bulletin of Acts (1958)

ters and their capacity to recover from them. Families, neighbours and social networks can help people to recover their assets (Twigg, 2015), while remittances from family members not affected by a shock often increase after disasters (Ebeke and Combes, 2013). Families that have access to remittances can recover more quickly (Savage and Harvey, 2007), as remittances act in a similar way to insurance for people who have no access to these financial services.

Transport and communications infrastructure and support, for instance, in helping people to access credit, as well as other key services, are essential for household recovery.

5.3.4.2 Economic recovery at the business and sectoral level

Disasters can cause long-term structural changes in local economies. According to the Federal Emergency Management Agency in the United States, more than 40 % of businesses never reopen after a disaster (natural or man-made). Over the period 2006-2010, the average commercial flood claim amounted to USD 85 000 (FEMA 2016). Small businesses and financially marginal businesses in particular tend to have greater difficulty in recovering from disasters (Webb et al. 2002; Alesch et al. 2001; Alesch et al. 2009). A recent national survey in the United States estimates that 52 % of small business owners consider it would take at least 3 months to recover from a disaster (Nationwide Insurance 2016). Thus, research on business continuity highlights the importance of strengthening capacity for pre-disaster mitigation and preparedness (Webb et al. 2002; Chang 2010). A business continuity strategy is considered a relevant response to natural disasters for businesses. Cerullo and Cerullo (2004) showed that of all the businesses damaged by Hurricane Andrew in 1992, 80 % of those lacking a business continuity plan failed within 2 years of the storm. In 2014, regarding a Forrester's survey (Balaouras, 2015), the most common scenarios of these plans mentioned by private sector decision-makers included natural

BOX 5.9

Debris flow in 2010 in Madeira Island

Madeira is a mountainous island prone to landslides and debris flow risks. On 20 February 2010 a strong storm occurred with intense rainfalls, provoking flash floods and a mixture of water and sediments came down the very narrow valleys of five streams, killing around 50 people and causing EUR 1 billion of damage. The capital, Funchal, is built on the common alluvial fan of three of these small rivers and was severely hit by the debris. The reconstruction process began, but safe space is very scarce and further measures had to be taken to limit debris floods:

- removal of damaged buildings that were in dangerous flood-prone areas in the valleys;
- rehabilitation and reinforcement of defence walls in the vulnerable areas and in the main urban areas;
- several retention structures (slit dams) were built upstream to reduce the volume of sediment;
- the EU inundation directive is being adapted to Madeira (inundation and risk maps) as well as flood risk management guidelines (land-use guidelines) for 27 critical valleys;
- a warning system based on meteo radar and prediction models, as well as rainfall triggers, is being developed;

Despite the strong difficulties to guarantee completely safe areas against floods, due to prediction uncertainties and the potential high energy flows that can be induced and propagated into densely occupied valleys, it is believed that the protection measures will be able to mitigate future debris flood risk in Madeira.

Source: Gouveia-Reis et al. (2016)

disasters/extreme weather (83 % over 118 business continuity decision-makers and influencers that have or will have scenario-based plans in 2014). The sample is based on a self-selected group of respondents (predominantly Disaster Recovery Journal subscribers and Forrester clients).

Contingency plans can ensure, for instance, the continuity of key activities during a crisis, while recovery plans accelerate the recovery process and limit loss in the aftermath of a shock. A recent study in the United States, for example, found that having an emergency plan was significantly associated with reduced levels of physical damage after Hurricane Ike in 2008 on the Gulf Coast (Xiao and Peacock, 2014). If disaster recovery plans (DRP) and business continuity plans (BCP) are recognised as efficient tools to reducing the impact of natural disasters, most small businesses still do not have any disaster plan. This share is decreasing with the size of the firm. Thus, the nationwide insurance survey showed that 75 % of small business owners who settle do not have such a plan, whereas for one third of them it is a low priority (34 %). For companies with fewer than 50 employees, only 18 % have a disaster recovery plan (National Insurance, 2016).

Disaster can also have a major impact on key sectors. For instance, during the Eyjafjallajökull eruption, the European airlines industry was heavily affected. The International Air Transport Association estimated that airlines lost GBP 130 million (EUR 154 million) per day while flight disruptions cost airlines USD 1.7 billion (EUR 1.56 billion) in total (BBC News, 2010). Other transport companies benefited, however, from the airline disturbance (passengers looking for alternative transport means), but specific fragile and perishable product importation such as flowers was reduced during the crisis period.

The overall recovery process is closely linked to the characteristics of the sector and the value chain. Thus, very large firms, such as multinational corporations are more likely to be well diversified, and localised disasters are unlikely to affect the overall organisation (Stevenson et al., 2016). Horwitz (2009), for example, shows that although Wal-Mart temporarily closed 126 stores after Hurricane Katrina due to major damage, there was little long-term effect on income.

The August 2002 flood in Germany, with a total damage of EUR 11.6 billion, became one of the most expensive natural hazard events in the country (Thieken et al., 2016a). In June 2002, Fischerdorf, across the Danube, was inundated after several levees collapsed, leaving the entire town's small industrial and commercial businesses under 3 metres of water with important consequences on small businesses and individuals. Similarly, a recent survey on German businesses affected by flood in 2013 (557 business interviewed) shows that 60 % were affected by staff absences due to problems of reaching the workplace. Around 80 % of businesses mentioned they were affected by turnover loss and 88 % faced interruption of their operations, sometimes lasting up to 8 weeks with long-term consequences on their activities (Thieken et al., 2016b; OECD, 2016). The 'commerce, hotels, restaurants and transportations businesses' seem to have been the most affected by the event, whereas manufacturing and construction firms mainly suffered 'own delivery problems', highlighting the importance of value chain and vertical integration in supporting recovery. Thus, Thieken's analysis suggests linkages between geographical sectors organisation and unbalanced regional impact of 2013's floods. Consequences of natural disasters on a sector can be regional or global (OECD, 2016). For example, the flooding in Thailand in 2011 had global and regional impacts in the automotive and electronics sectors as global companies such as Toyota, Honda, Nissan, Ford, Apple, Sony, Canon and Toshiba faced disruptions to production as a result of their linkages to sites located in the flood zone. According to Schanz and Wang (2015), global industrial production declined by 2.5 % as a result of the floods (OECD, 2016). These examples suggest that both the sector's organisation and the firm's echelon interplay within the value chain, in addition to the firm's characteristics to influence businesses' recovery pattern.

Economic stimuli are also provided by the reconstruction process and can have a significant impact on key sectors: in particular, construction and other sectors involved in reconstruction often benefit from this (Chang, 2010; Chang and Rose, 2012). Similarly, trade can play an important buffering role in recovery (Bierkandt et al., 2014; Meng et al., 2015), compensating for the lack of products after a disaster. The role of market in the recovery process is essential and is often poorly understood or biased by recovery policies.

5.3.4.3 Economic recovery process at the national level

At the national level, pre-disaster trends are accelerated or exacerbated during the recovery period (Alesch et al., 2009; Chang, 2010), with impacts on gross national product (GNP) or gross domestic product (GDP) and key economic sectors (agriculture; health) highly dependent on the initial level of income and financial penetration (as highlighted after Hurricane Katrina). After a disaster, new investments made in infrastructure and human capital can increase productivity and growth (Skoufias et al., 2011) — a phenomenon known as 'creative destruction', but disasters can also have negative impacts on the economy more than 1 year after the shocks, affecting early recovery (Simonet et al., 2016). Nonetheless, the financial capacity of the country is usually lessened by the recovery process (Cochrane, 2004).

Finally, external funds such as humanitarian assistance can influence the recovery process in both ways (Raghuram and Subramanian, 2008). The absorptive capacity of the country and its ability to smooth temporary and volatile external financial inflows will determine its ability to make efficient use of external assistance.

5.3.4.4 Supporting economic recovery

Accessing financial resources after a disaster is critical to rebuilding and maintaining essential functions (Haworth et al., 2016; World Bank, 2012; World Bank, 2016). Financing at all scales is needed (see Chapter 5.4).

The European Union Solidarity Fund (EUSF) is a good example of efficient risk sharing at the regional level. Created in 2002, the EUSF's objective is to assist the EU Member States in recovering from natural disasters. The fund primarily aims to cover non-insurable loss and to support critical infrastructure such as energy and drinking water during the recovery phase. Since 2002, 24 different European countries have received aid for an amount of over EUR 3.784 million for the recovery (see list of beneficiaries by EUSF (2017)). Flood events are the main disasters leading to the EUSF's assistance to date, which supports the recovery of major natural events (damages exceed EUR 3 billion and the total loss is up to 0.6 % of gross national income of the Member State). National or local events can be considered if the two economic conditions are fulfilled. The annual budget of EUSF is EUR 500 million in addition to the unallocated funds of the previous year. Moreover, rules for disbursement and funds used across each year ensure its sustainability. The EUSF can be combined with other national risk transfer measures such as the one implemented in the Czech Republic, where aid for recovery and reconstruction is provided to municipalities and regions if their budget is not sufficient (OECD, 2015). Thus the combination of national and regional risk transfer measures provides a more efficient coverage of loss in case of disasters. If the fund is a good example of regional, fair and effective risk transfer mechanisms (OECD, 2015; Olsson, 2009), the criteria of the fund's categories, thresholds issues and a significant delay in the fund delivery (Olsson, 2009) could prevent its efficiency. The EUSF is to date the only funds available to support recovery after disasters even if other funds (such as rural development funds) can provide financial aid for prevention activities (Olsson, 2009).

Nonetheless, the policies supporting economic recovery should not focus solely on financing. A mix of policy initiatives is needed to build resilience after a disaster (Twigg, 2015): from the design of Early Warning Systems (EWSs) tailored to specific audiences to the development of efficient regulations. For instance, the work of the European Commission (ECHO) on DRR through providing trainings and policy guidelines, as well as economic support is also essential to support efficient recovery (ECHO, 2016). Overall, combinations of financial support with other market support and service provision are needed. Building an efficient and flexible private sector will speed up the recovery. A good knowledge of the vulnerabilities along the value chain will help to anticipate fracture points and key actions to be taken when there is a disaster. Providing vouchers, for example, is known to have a destabilising effect on local prices.

External assistance after a major disaster can overcome local financial resource constraints but can have what is known as 'a Dutch effect'. If a country cannot smooth or absorb the financial support provided, growth patterns can be destabilised. This occurred after the 2004 tsunami in the

Indian Ocean (De Ville de Goyet and Morinière, 2006).

Overall, economic recovery strategies need to not only consider the short-term impacts of disaster, but also avoid indirect and destabilising effects. Strategies need to consider and avoid environmental impacts and find ways to improve sustainability and resilience. Global Facility for Disaster Reduction and Recovery (GFDRR) frameworks guide of the World Bank provides a good summary of how the combination of policy and strategy settings, financial support, institutional frameworks and implementation arrangements can ensure an efficient economic recovery as well as relevance of timely activities (GFDRR, 2013; 2015).

5.3.5 Psychosocial recovery

Recovery originates in social relationships before disasters occur and more marginal groups usually find it harder to recover (Nigg, 1995; Tierney and Oliver-Smith, 2012). Gender, disability, income and ethnicity are strongly associated with differential recovery trajectories (Cutter et al., 2006; Fothergill, 1996; Fothergill and Peek, 2004; Priestley and Hemingway, 2007; Bolin, 2007; Pomonis, 2002).

Other influences are the severity of the impact of each disaster, the effectiveness of initial responses, the quality of governance systems and the strength of the civil societies in which the events occur (Tierney and Oliver-Smith, 2012), as well as the pressure to make quick decisions with long-term consequences (Ingram et al., 2006; Olshansky et al., 2012). Overall, psychological recovery underpins broader social recovery and vice versa: the relationships between all aspects of recovery are reciprocal.

5.3.5.1 The psychosocial approach to disasters

Understanding the behaviour and the psychosocial and mental health needs of people affected by disasters is vital to disaster recovery because it affects how:

- societies, governments, communities and families prepare for disasters;
- responsible authorities work with communities to meet people's needs and preferences and ensure their continuing agency;
- governments and responsible authorities communicate with the public;
- the responsible authorities and agencies manage responses in the immediate, short and medium terms.

Patel (2014) identifies the gap between mental health specialists' use of the terms 'mental health' and 'mental disorder' and public conceptualisations of psychosocial suffering that affects many more people than those who require specialist mental healthcare. Thus, here, psychosocial refers to the psychological, social and physical experiences of people in the context of their social, cultural and physical environments.

5.3.5.2 The psychosocial and mental health impacts of disasters

There is a broad spectrum of ways in which people react emotionally, cognitively, socially, behaviourally and physically before, during and after a disaster. Research into these reactions has, however, identified some common psychosocial and mental health impacts (Box 5.10).

The majority of people are not likely to develop a mental disorder, but distress after emergencies is very common. In most cases, it is transient and not associated with dysfunction, and many people are psychosocially resilient despite their distress. People affected by large-scale events that destroy infrastructure may be immobilised by fear and hopelessness. In the immediate aftermath of most events, people behave in rational and altruistic ways, but the frequency of panic remains the most pervasive myth about disasters and is sometimes exaggerated in official policies (Carter et al., 2013).

Psychosocial resilience and trajectories of response

Social relationships have powerful influences on how people cope with disasters (Williams et al., 2014a). Most people recover reasonably well given social support from relatives, friends and acquaintances. Resilience is a dynamic process '… linking a set of adaptive capacities to a positive trajectory of functioning and adaptation after a disturbance' (Norris et al., 2009) and can be seen in differing trajectories of people's responses over time (Norris et al., 2009; Bryant et al., 2015; Fink et al., 2016) (Box 5.11).

Risk factors

Psychosocial impacts of disaster vary in severity with a number of factors, the most significant being the magnitude of the event and the degree of exposure to it, as well as gender, age, ethnicity, pre-existing psychosocial problems and the perceived quality of psychosocial support. Groups of people at greater risk of dysfunctional distress, social problems and mental disorders following disasters include: women; children and adolescents; older people; people who have pre-existing health problems and disorders; socially disadvantaged people; and staff of rescue and responding services.

5.3.5.3 Policies and interventions for psychosocial recovery

BOX 5.10

The psychosocial and mental health effects of disasters

Direct effects on people

1.Immediate and short term
   a. Short-term distress and dysphoria (a state of feeling unwell or unhappy)
   b. Acute stress reactions
2. Medium and longer term
   a. Persisting distress and dysphoria maintained by secondary stressors
   b. Grief
   c. Mental disorders (NB: these disorders are very frequently comorbid with each other)
      i. Substance use disorders
      ii. Adjustment disorders
      iii. Post-traumatic stress disorder
      iv. Anxiety disorders
      v. Depression
      vi. Impacts on personality

Direct effects of complicated, sustained and/or multiple events

1. Sustained distress and dysphoria that impacts on people's functioning
2. Exacerbation of existing mental disorders
3. Precipitation of new episodes of previous mental disorders
4. Increased frequency of new mental disorders

Indirect effects on people

Disasters increase medium- and longer-term psychiatric and physical morbidity because of their effects on social conditions that affect physical and mental health. These social determinants of mental health include:
1. Increased poverty
2. Changed social and societal relations
3. Threats to human rights
4. Domestic and community violence

Priority 4 of SFDRR calls on states 'to enhance recovery schemes to provide psychosocial support and mental health services for all people in need'. Indeed, the European Network for Traumatic Stress – TENTS (2008), which surveyed 33 European countries in 2007-2008, found planning and delivery of psychosocial care after disasters was suboptimal and inconsistent, with wide variations in plans and interventions. It concluded that more effective and evidence-based services were needed. In 2014, the Royal College of Psychiatrists in the United Kingdom drew together the NATO guidance (NATO, 2009) and the TENTS findings and guidance to produce a comprehensive approach to developing the quality of comprehensive policy, planning and practice for delivering psychosocial and mental healthcare for people affected by disasters — called 'OP94' (Williams et al., 2014a). The approach taken by OP94 builds on guidance from the Inter-Agency Standing Committee (IASC, 2008), WHO (2013), IFRC et al. (2009) and publications from McFarlane and Williams (2012) and Williams et al. (in press). Operationalising Psychosocial Support in Crisis (OPSIC), another initiative supported by the EU, has produced comprehensive guidance on psychosocial and mental healthcare in disaster settings to support harmonisation of approaches across countries. It is based on an extensive survey of research and practices (OPSIC, 2015).

Flexible, generic approaches are needed that can be adjusted as events and people's needs evolve. The NATO guidance (NATO, 2009), for example, is constructed around a strategic framework that contains components including the following.

- Constructing an evidenced knowledge base: appropriate knowledge provides a baseline for creating and implementing plans before events occur and adjusting them later.
- Working from core principles: identifying evidence-informed and values-based principles ensures lessons are learned from past events when planning, designing and delivering services:
- Gathering information: emergency specialists require services to gather and supply information to adjust generic plans as events evolve.
- Using a model of care: a model enables resources and services to be treated efficiently and effectively against people's assessed needs.
- Providing psychosocial care for the staff of all responding organisations: the needs of all responding organisation staff require active consideration.
- Incorporating psychosocial recovery and mental healthcare in an integrated emergency management cycle: using a single, integrated management cycle for all responses to disasters enables planners to design, deliver, review and adjust the services that the public requires.

The number of people who require

BOX 5.11

Trajectories of psychosocial and psychiatric responses

Resilient responses: around 70 % of people show psychosocial resilience. They suffer mild or moderate distress that rapidly reduces in severity if they receive support they perceive as adequate.

Deteriorating responses: initially, up to 20 % of people have stress symptoms of low severity, which become more severe and/or associated with dysfunction over time. About half recover later on, while others develop more chronic problems or disorders.

High initial stress responses: around 10 % of people may have high levels of stress before and/or immediately after events. The symptoms of about half may run a chronic course, while others improve.

The percentages in this box are approximations made from drawing together several different studies. They are only intended to illustrate broad orders of magnitude.

supporting psychosocial interventions to assist them with distress after disasters is very substantial. Early intervention and interagency coordination are vital elements in psychosocial responses. Williams and Kemp (2016) summarise the principles: intervening early can reduce the risks of survivors developing disorders later; there is a great deal that family members and friends can do in the response phases to alleviate people's suffering; families and communities are the main sources of emotional and tangible social support that people exposed to disasters prefer and receive.

Psychosocial recovery after disasters is a multidimensional process linked to measures that are taken before disasters occur, to the social and economic circumstances and to actions taken to restore assets and services.

Most people do not require specialist mental healthcare, but a substantial minority may. They require timely personal mental healthcare and a small proportion of them require long-term mental health services. Survivors at particular risk require surveillance and clinical assessment. OP94 provides a summary of specific components of the responding services that are required within the first week, first month, first to third months, and beyond 3 months after a disaster.

Psychosocial first aid, assessment and surveillance is needed for people who appear to be at risk of developing a mental disorder, and biomedical clinical treatments for people who have specific disorders. Psychosocial care offers people safety, calm, connectedness, hope and self-efficacy with the intention of promoting psychosocial recovery (WHO et al., 2011; WHO, 2013). Education, consultation and discussion processes for survivors, communities and responders also play an important role (Eyre, 2006; Aloudat and Christensen, 2012). Mutual support groups, such as Disaster Action in the United Kingdom, help survivors of disasters to come to terms with their experiences and loss and can also be a platform for action to improve safety and emergency management practice (Eyre and Dix, 2014).

In summary, research demonstrates that people's recovery in the short and medium term after disasters can be promoted through a psychosocial approach, using a strategic framework and generic policies that can be adapted as each disaster evolves. Psychosocial interventions can be made universally available to reduce suffering and risks of people developing mental disorders. Those with mental disorders can be supported through surveillance, assessment and effective, timely and sustained evidence-based treatments.

5.3.6 Conclusions and key messages

Partnership

Governance is key to reconstruction and recovery processes, particularly intergovernmental relations and public participation and engagement in post-disaster policies. Close collaboration across sectors and with affected groups is beneficial for physical, economic and psychosocial recovery processes. People and systems may not return to their pre-disaster state, but strong multisectoral pre-disaster plans and flexibility in response can help improve the speed and efficacy of recovery, avoiding indirect and adverse impacts after the disaster.

Knowledge

While the impacts of disasters have been well studied, recovery is multifaceted and not well understood. Significant progress has been made in understanding the psychosocial impact of disasters and on (re)construction techniques to improve the built environment after a disaster.

Innovation

Innovation in recovery promotion is particularly seen in reconstruction and more comprehensive approaches to rebuilding in urban areas. Given the diverse scales at which impacts are felt, more research is needed on the relationship between the different aspects of recovery, that is physical, social, psychological and economic.

5.4 Risk transfer and financing

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5.4.1 Risk financing and transfer: introduction and typology

Natural hazard risks can undermine development progress (UNISDR, 2015), financial and economic stability and well-being (World Bank, 2013). A sound financial protection strategy can lessen these impacts, speed up recovery and reconstruction, and harness knowledge and incentives for reducing risk (IPCC, 2012). Amidst growing damage and losses caused by natural and human-made hazards, some of which are further amplified by global environmental (including climate) change (IPCC, 2014), a comprehensive financial strategy is conducive to a better framed and informed risk management and governance.

The SFDRR (UN, 2015a) substantially reduced disaster losses and reinforced resilience as a top priority of international and national efforts. As part of the transformational change in how natural and human-made risks are dealt with (van der Vegt, Essens, Wahlström and George, 2015; Wahlström, 2015), the SFDRR emphasised investing in DRR and financing. The Addis Ababa action agenda on financing for development erected a financial framework that fosters inclusive economic prosperity and lines up financing resources and flows with the priorities of the 2030 agenda for sustainable development (UN, 2015b). Similarly, the Paris Agreement on climate change (UNFCCC, 2015) addressed the issue of promoting sound risk financing as part of climate adaptation and a strategy for coping with damage and losses.

A comprehensive disaster financing strategy is equally important in the context of the European Economic and Monetary Union. In the absence of financial protection tools for coping with disasters, the incidence of major disasters in several EU Member States may exacerbate economic imbalances and deteriorate credit ratings (S&P, 2015).

A comprehensive strategy for disaster financing can moderate the impacts of natural hazard risks, speed up recovery and reconstruction, and harness knowledge and incentives for risk reduction. Private financial sectors play an important role, along with governments and civil society organisations, in designing innovative financial protection goals and sharing knowledge and capacity.

A recent debt sustainability analysis showed that marginal changes in nominal GDP growth and interest rates can lead to a much greater debt-to-GDP ratio than the one projected as a baseline (EC, 2016). By targeting residual risk that cannot be efficiently mitigated, risk financing complements regulatory and economic instruments such as prices, taxes, tradable permits and liability (see Chapter 5.1), which serve as a vehicle of DRR and transition to a low-carbon, resource-efficient and socially inclusive economy.

Recognising that in an increasingly interconnected world disasters can have far-reaching, spill-over effects, the G20 finance ministers invited the Organisation for Economic Co-operation and Development (OECD) to develop a voluntary framework helping governments to develop financial strategies for disaster risk. The ensuing methodological guide (OECD, 2012) defines risk financing as strategies and instruments used to manage the financial impact of disasters, ensuring adequate capacity to manage and mitigate the costs of disaster risk, thereby reducing the financial burden and economic costs of disasters and enabling rapid recovery in economic activity (ibid.). A thorough understanding of risk exposure and risk-bearing capacity, as well as institutional arrangements creating favourable regulatory and market infrastructure are the major constituents of the comprehensive disaster financing strategy, along with the choice of optimal risk financing and transfer instruments.

Here we introduce various instruments, their design criteria and their principles, carrying institutions and markets, as well as the different public and private roles of their realisation. Disaster financing embraces a variety of instruments that are intended for and capable of achieving different outcomes. Each of these instruments can efficiently handle only a certain type of risk, depending on their frequency, intensity and impacts. Consequently, a strategy that builds upon a diversified pool of mutually complementing financial tools and institutions is better equipped to cope with and respond to a variety of environmental and human-induced risks.

Risk layering means pairing the suitability of different instruments with

TABLE 5.4

Major categories of risk financing and transfer instruments
Source: Adapted based on G20 (2016), GFDRR (2014), MCII (2009, 2013), Okuyama (2010), UFCCCC (2016), World Bank (2012)

Categories	Examples of instruments
Saving and reallocation	— bank deposits and liquid securities — reserve/contingency/disaster relief funds — budget reallocation
Credit and assistance	— contingent credit facilities and microcredit — fiscal relief such as delayed or reduced tax and social security payments — external assistance and aid
Insurance	— catastrophe risk insurance (from micro- to macro-insurance) — indemnity vs index-based vs modelled insurance schemes
Catastrophe-linked securities	— cat bonds (catastrophe bonds)
Derivatives	— weather derivatives

levels of risk and risk-bearing capacity (Mechler et al., 2014). The contingent losses from frequent, low-impact risk can either be reduced or retained through adequate funds in the form of savings, set-aside reserves or credits. Medium- to high-level risk exceeding the risk-bearing capacity can be more efficiently managed by risk transfer via insurance or capital markets.

Comprehensive risk management (MCII, 2013) embraces a systematic identification of risk arising from multiple hazards and employs a combination of financial instruments that take into account hazard exposure and risk-bearing capacity of (national and subnational) governments, homeowners, enterprises and the most vulnerable populations. In a more comprehensive way, the total climate risk approach, as adopted by the methodology of the Economics of Climate Adaptation Working Group (ECA, 2009), first explores manifold risks arising at a specific location or region today, then looks at the projected increase in risk due to economic development before finally considering the aggravation of risk due to a range of future climate change scenarios. The working group then devises and assesses a portfolio of infrastructural, technological, behavioural and financial investments to adapt to these risks. The various instruments (Table 5.4) differ in terms of access prerequisites, (opportunity) costs and activation time. This approach thus provides decision-makers with a fact base which enables them to understand the impact of weather and climate on their economy — and helps to identify actions to minimise that impact at the lowest cost to society. It therefore allows decision-makers to integrate adaptation with economic development and sustainable growth.

Disaster risk financing and transfer stretches out over several functions of responsible and accountable government, including fiscal (risk) and

TABLE 5.5

Disaster risk financing and transfer policy areas and benefits
Source: Adapted from World Bank (2014)

Sovereign disaster risk financing — Increases response and reconstruction capacity — Eases public expenditure by reducing volatility of disaster costs — Clarifies contingent liability — Provides incentives for investing in risk reduction	Property catastrophe risk insurance — Provides access to compensation for damage — Increases awareness of risk and understanding of financial vulnerability — Helps distribute risk and burden of recovery — Can incentivise investments in risk reduction
Disaster-linked social protection — Mitigates shocks by providing compensation for losses through safety nets — Increases awareness and understanding of vulnerability to disaster risk — Can incentivise investments in risk reduction — Safeguards vulnerable people from poverty	

budgetary policies, public finance, market and business development, and social protection (OECD, 2015; World Bank, 2014). Disaster risk poses implicit and explicit liabilities (Cummins and Mahul, 2009); explicit liability arises from statutory and contractual obligations, while implicit liability results from public expectations and political pressures. The latter poses the greater fiscal risk (World Bank, 2012). Governments play multiple roles, on both the demand and the supply sides of risk financing. As rule makers they: (i) provide public insurance and financing recovery and reconstruction expenses for public assets; (ii) organise (and cover the costs) of post-disaster order, rescue and relief; (iii) ensure social protection for vulnerable populations; and (iv) regulate and supervise financial markets (including insurance) and institutions. Nonetheless, only few countries have sought protection against fiscal impacts of disasters (World Bank, 2012).

The United Nations Environment Programme (UNEP), the United Nations Office for Disaster Risk Reduction (UNISDR); multilateral institutions such as the World Bank and the OECD, and other major actors have played a catalysing role for private sector involvement in DRR and financing. The UNEP's finance initiative, principles for sustainable insurance (PSI) (UN-FI 2012), and the UN-backed principles for responsible investment (PRI) have promoted sustainable lending, investment and insurance practices and sensitised nations to the environmental, social and governance challenges involved in business decision-making.
Other insurance-oriented initiatives, such as Global Insurance Industry Statements and the Climate Risk Statement of The Geneva Association, have urged contemplating climate risk in business investments and risk management strategies. More recently, a joint report by UNEP PSI and Inquire (Bacani, McDaniels and Robins, 2015) outlined three major initiatives: an Insurance Network on Sustainable Development to stimulate innovation and partnerships, a Sustainable Insurance Policy Forum to scale up intergovernmental cooperation and Insurance Development Goals to make the ways in which the insurance sector can contribute to meeting Sustainable Development Goals (SDGs) more explicit.

Similarly, international collaboration among financial businesses and financial regulators is growing, focused in large part on knowledge sharing and capacity building. The Financial Stability Board (FSB) convened a Task Force on Climate-related Financial Disclosures (TCFD, n.d.) focusing on disclosing market-relevant information on climate-related financial risk, the results of which were released in December 2016 (TCFD, 2016). The International Capital Market Association (ICMA) has coordinated the development of the 'green bond principles', which have helped catalyse the rapid growth of the green bond market (G20, 2016).

5.4.2 The role of insurance: spreading risk

Insurance is the most common form of financial protection against risk of contingent losses. The insured party or policyholder transfers the cost of potential loss to the insurer in exchange for monetary compensation known as a premium. By acquiring the costs of contingent losses from many policyholders, the insurer absorbs, pools and diversifies the individual risks, making them assessable and manageable.

Insurance is the most common form of financial protection against risk of contingent losses. But not all risks are insurable or covered by insurers. Climate change amplified natural hazard risks, and raising vulnerability may make financial protection unaffordable for some people and business, and risks uninsurable in certain places.

When the loss occurs from specified contingencies under an insurance contract, the insurer indemnifies or compensates the insured party. The premium charged should reflect the level of risk each policyholder cedes to the insurer. The premium will reflect not only the 'pure premium', i.e. the average losses expected from the contract, but also allowances for expenses and the contract's impact upon the insurer's capital requirements (and so its required contribution towards target return on capital).

Not all risks are insurable or covered by insurers. Insurable risks are those that are quantifiable, in terms of both the probability of an event's occurring and the extent of losses incurred, and for which premiums can be set for each policyholder or group of policyholders (H. C. Kunreuther and Michel-Kerjant, 2007).

In addition, risk ambiguity, asymmetry of information (implying adverse selection and moral hazard) and correlation between losses influence the ability and willingness of insurers to underwrite risk and the level of premium sought (Charpentier, 2008; Jemli, Chtourou and Feki, 2010; Louaas and Goussebaile, 2016). If the latter are high, risks may be insurable but not affordable for low-income subjects who may benefit most from insurance.

Natural hazards that have been amplified by climate change may make financial protection unaffordable for some people and risks uninsurable in certain places. Recent estimates of the Bank of England (PRA, 2015) show that climate change and socioeconomic risk drivers may widen the gap between 'affordable' flood insurance premiums and premiums that reflect the technical price of flood insurance. Likewise, Kunreuther et al. (2011) demonstrated that climate change is likely to significantly increase premiums for building insurance in Florida. These studies also suggest that consistent risk reduction efforts may be effective in keeping premiums affordable. A better understanding of risk, product bundling and public interventions (see Chapter 5.4.4) contributes to making climate risk insurable.

Insurance is a financial service offering protection against the risks of contingent losses. However, directly or indirectly, it also serves other purposes. By facilitating prompt post-disaster recovery, insurance helps to contain the economic and social impacts of disasters. Beyond that, insurance serves public interests by promoting social protection and public welfare. Insurance makes it possible, for example, for individuals to get mortgage loans or compensation for injuries without going to court (Talesh, 2012). Insurance can also promote numerous economic activities in the higher risk/return market spectrum (Grant, 2012), thus contributing to higher productivity and innovation. And it can incentivise behaviour change and individual risk prevention, as shown in Chapter 5.4.3.

BOX 5.12

Role of insurance for better understanding of risks

The reinsurance industry has driven the development of catastrophe risk analytics over the last 30 years, moving from a position where hazard mechanisms, their impact and comparative risks were little understood, to one where sophisticated and integrated stochastic catastrophe models have become the norm in the industry. The models require and understanding and knowledge of:

- the likely hazard events, that is their frequency, severity and geographic scale;
- the buildings/goods insured, that is where they are, how they are built and how they are used;
- the vulnerability of these buildings/goods to the events;
- the financial/social loss caused.

The process of building and understanding these models, as much as the model results themselves, has lead to a transformation of the insurance and reinsurance industry, massively increasing technical understanding and financial resilience. The appropriateness of these modelling techniques, the ability of the models to provide objective rigour around risk mitigation and adaptation decision-making and the benefits of the consequential greater risk and hazard understanding are leading many governments and quasi-government organisations to consider adopting these methods. A catastrophe insurance scheme can be a catalyst to great risk understanding.

A variety of insurance schemes exists, depending on the type of risk and the protected asset (property, business assets and interruption, liability, sovereign risk, etc.). Natural hazard insurance is either an extension of property insurance (Bräuninger et al., 2011) or a stand-alone, for example agricultural (crop yield, revenue or income) and energy insurance. Sovereign insurance (Mahul and Ghesquiere, 2007) covers costs associated with damage to infrastructure and relief expenditure. Traditional insurance employs the principle of indemnity, claim payments are made to make good an actual loss ether in full or in part. However, indemnity insurance requires a thorough knowledge of the good(s) insured, how they react to a certain hazard and a post-event assessment of damage incurred, all adding to expense and delays in claim settlement. Parametric or index insurance schemes employ other, more easily measurable data (for example rainfall, yields or vegetation index) for determining pay-offs without the need to prove actual loss, requiring less detailed knowledge of the risk covered and enabling speedy payment (Collier et al., 2009; Hazell et al., 2010; IFAD and WFP, 2011).

Agriculture poses particular challenges for insurance because of the spatially correlated weather and climate risks and large information asymmetries (Porth and Seng Tan, 2015). Agricultural insurance schemes differ from country to country but often involve the public sector (Bielza et al. 2009; Capitanio, Bielza, Cafiero and Andolfini, 2011), either via premium subsidies or public participation in reinsurance systems. Insurance products can be classified according to the risks covered (named perils and multiple perils) and trigger of claim (e.g. indemnity or index based, crop revenue and farm income) (Iturrioz, 2009). More sophisticated insurance schemes include comprehensive income/revenue insurance packages also covering, besides production, market risks (e.g. price), although most insurance policies limit their coverage to yield variability risk (including single risk, combined, integral insurance and whole-farm integral insurance) unless the market risk can be transparently hedged in the commodities market. In the EU, farm risk management schemes are supported, among others, through rural development programmes (Bardají et al., 2016; EC, 2013c).

Based on 2015 data, the European insurance industry holds the largest share (32 %) of the global market (Insurance Europe, 2016). Property insurance accounts for about 8 % (around EUR 93 billion) of written premiums and 6 % (EUR 53 billion) of claims paid. Insurance coverage is very heterogeneous across the EU Member States and hazard types (A. M. Best, 2016; Maccaferri, Carboni and Campolongo, 2012). For natural hazard, some countries apply a free market system, others a centralised national or state scheme and others again an amalgam of public and private schemes. For example in the United Kingdom, natural hazard insurance is written competitively by private insurers, although with optional state-supported reinsurance for hazardous flood risks to ensure affordability. In contrast, in Spain, standardised natural catastrophe cover is provided by a public national pool.

On average over the period 1980-2015, out of the total registered natural hazard losses in Europe the share of those insured amounted to 30 % (EEA, 2015). Globally, written premiums in agriculture amount to around EUR 27 billion, an approximately fourfold increase since 2005 (Porth and Seng Tan, 2015).

In 2013 and as part of the EU Climate Adaptation Strategy package (EC, 2013a), the European Commission launched a broad consultation about which EU action could be appropriate for improving the performance of insurance markets (EC, 2013b). The responses cautioned against uniformising the regulation on natural hazard insurance across the EU (EC, 2014). Both the uneven distribution of hazard risk and the diversity of the economic standing and other requirements of customers have been brought up as reasons against an EU intervention (HM Treasury, 2013). Consequently, uniformised regulations could harm innovation and competition in insurance products. The European Parliament stressed that flexible markets should operate in a non-mandatory framework and that no 'one size fits all' solution would serve the magnitude of different risk and economic conditions in Europe (EP, 2014).

5.4.3 The role of insurance: incentivising risk reduction

Insurance can help dissuade policyholders from risky behaviour and incentivise risk reduction (Surminski and Oramas-Dorta, 2013; Surminski, 2009; Warner et al., 2009). Premiums and policy terms (e.g. deductibles) can be adjusted to reward good risks and penalise bad ones. The role that the insurance industry has played in deploying loss-prevention technologies such as automobile air bags and fire prevention/suppression systems is an example. Harnessing insurance for DRR becomes particularly significant in the context of increased frequency of disaster events, larger economic exposure, rising vulnerability and climate change.

Insurance and other financial instruments can contribute to reducing disaster risk, if designed and implemented to this end.

There is an ample consensus that insurance can and should play an increasingly important role in mitigating disaster impacts, not only through risk sharing, but also through all aspects of the risk management cycle, including risk identification and modelling, risk awareness, damage prevention, risk transfer and recovery (Michel-Kerjan and Kunreuther, 2011; Evan Mills, 2012; Swenja Surminski, 2014). However, practical evidence of whether insurance encourages risk reduction in a climate context remains inconclusive (Botzen and van den Bergh, 2009; E. Mills, 2009; Surminski and Oramas-Dorta, 2011; Surminski et al., 2015). Few existing national catastrophe insurance schemes directly include risk reduction incentives (Swenja Surminski and Oramas-Dorta, 2014; von Ungern-Sternberg, 2004). Nevertheless, progress is being made. Insurers are increasingly rewarding customers who take steps to reduce their risk with lower premiums (or avoid the risk if they do not). The regional natural catastrophe scheme, African Risk Capacity (ARC), mandates that clients, in this case African countries, undergo a period of risk analysis and policy design with ARC staff before they are allowed to buy a policy. Countries are also required to agree contingency plans to put in place in the case of loss and agree a revised final implementation plan when a loss occurs.

Existing studies, such as Thieken et al. (2006) in Germany and Poussin et al. (2013, 2015) in France, rely on isolated surveys of insured and uninsured parties. Whilst they suggest that insured parties are slightly more likely to undertake risk reduction efforts than uninsured ones, there are some methodological issues that limit comparability and scalability. Survey response methods often suffer from fundamental problems of reliability and internal validity, and even when considered sufficiently robust, they offer no consistent and comparable method for assessing the cost-effectiveness of insurance mechanisms. Hudson et al (2014) found that those buying natural catastrophe insurance are particularly risk averse, which suggests that the higher observed risk reduction of the insured may be an effect of selection.

Measuring if and how insurance contributes to direct risk reduction remains challenging, as it requires an understanding of disaster impacts and the scope of risk prevention measures that are induced by insurance, including measures influencing the policyholder's behaviour, directly promoting actions by the policyholder and directly or indirectly affecting actions by third parties (such as the government). Various metrics for assessing the insurance impact on promoting risk reduction/prevention have been proposed in the literature, including Chrichton (2008), Paudel et al. (2012), Surminski and Oramas-Dorta (2013)and Surminski and Eldridge (2015). In the latter study, elements of this approach were applied to United Kingdom flood insurance schemes through a set of qualitative assessments.

Recently, attention has been brought to harnessing insurance for better protection of the environment as well as ecosystem services for the sake of DRR. Ecosystems may mitigate natural hazard risks by mediation of flows and nuisances or through maintenance of physical, chemical and biological conditions in the face of pressures. Ecosystem services for DRR 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 pests, disease and alien species, water filtration, and dilution and detoxification of hazardous substances. The combination of increasing intensity and frequency of natural hazards, continuing conversion, uniformisation and simplification of (semi-)natural ecosystems and the footprint of built infrastructure may be contributing to the rapid increase in costs and damage from natural hazards. The European Commission research and innovation policy agenda on nature-based solutions (EC, 2015b) defined 'insurance value of ecosystems' as a 'sustained capacity of ecosystems to reduce risks to human society' caused by natural hazards, climate variability and climate change. The insurance value of ecosystems in this sense is equivalent to the net present value of avoided damage and losses obtained from the risk mitigation ESS. In other words, it is the monetary value that risk reduction by ecosystems would bring to risk transfer schemes such as insurance. One indicator could be a reduction in property insurance premiums in light of reduced risk; another could be the willingness of the private sector to underwrite a risk on the basis of confidence in ecosystem services.

Collective insurance schemes appear better equipped to deliver sizeable improvements of ecosystem services and to get around concerns about free riding. An example of a collective insurance reward under a state-subsidised insurance scheme is the Community Rating System (CRS) under the United States National Flood Insurance Program (NFIP), where households receive a premium discount if their community takes specified flood-mitigation measures; which can include nature-based solutions. Pollution insurance provided to businesses is another example of a positive relationship between taking out insurance and reducing harmful environmental damage (Surminski, 2015). A 2003 OECD study found that, with pollution insurance, the insurer may act as a private surrogate regulator aligning its interests with those of high environmental standards (OECD, 2003). More than that, properly priced insurance can help to internalise externalities (such as environmental risks) and hence improve or even secure more sustainable functioning of markets. The internalisation of environmental costs through the payment of premiums is compatible with the deterrence goal of any liability regime and with 'the polluter pays' principle. Conversely, Minoli and Bell (2003) found in an evaluation of two leading United Kingdom insurance companies' pollution claims that the insurers' initial underwriting assessments and post-loss investigations were insufficiently developed. The management practices of insured parties in connection with the prevention of pollution were also underdeveloped. Consequently, insurers' terms and conditions on policies were insufficient to work as an incentive to dissuade pollution losses.

The effectiveness of environmental insurance has been most extensively researched in the United States. For example, there is evidence that despite a range of practical barriers, environmental insurance can be efficient where government fines are not (Yin et al., 2011). The concept of liability for environmental damage, instituted in Europe by Directive 2004/35/CE (EC, 2004a), extended the law of tort to damage incurred to ecosystems. The directive points to sureties or bank guarantees but leaves it to Member States to guarantee financial solvency for damage rectification and clean-up. In the wake of this directive, insurers have developed data sets to map ecosystems and their characteristics with a view to facilitating restoration in case of accidental damage through an insured entity. This development points to a possible entry point for the more widespread incorporation of ESS concepts in an insurance.

5.4.4 Public–private partnerships for risk financing and transfer

A commercial insurance may not guarantee affordability and equitable access to insurance (EC, 2013b). Addressing affordability and equity issues in provision of disaster risk insurance combines business objectives with public policy goals (Solana, 2015). Consistently, the role of the public sector in this pursuit goes beyond the regulatory oversight to include an active involvement in insurance provision. Because public intervention may interfere with market equilibriums and undermine rather than encourage individual risk reduction (Surminski, 2009), reconciling the public and private roles and objectives necessitates a thorough analysis and organisation (Pérez-Blanco and Gómez, 2014).

'Public–private partnerships' (PPPs) is a term coined to denote different approaches to public and private cooperation for providing public services or projects (Bielza et al., 2009; CEA, 2011). PPP is a model for a joint bearing of responsibilities and efficient risk sharing intended to increase insurance coverage and penetration and guarantee a strong financial backing in view of uncertain tail distributions of risk (Johansen, 2006). PPPs are typically characterised as a long-standing relationship bringing forth mutually beneficial resource and risk-sharing arrangements (EC, 2004b).

Ideally, the PPPs should be designed so as to address market failures such as a lack of or a limited access to affordable insurance and low insurance penetration. In doing so they should limit, to the extent possible, market distortion and preserve competition. Private insurers (should) 'have the opportunity to carry on using their savoir faire in an environment of mutual understanding' (Johansen, 2006). The PPPs should be shaped through constructive dialogues and conscious of mutual principles and limitations. The partnerships should actively promote or at least not harm the incentive for risk reduction, for example by making the individual insurance costs reflecting those risks that result from each individual's choices (Mysiak and Pérez-Blanco, 2016). They should be built on principles of transparency, equal treatment and efficient use of public resources.

In Europe, the most longstanding insurance-related PPP is embodied within the extraordinary risks insurance scheme of Spain's Insurance Compensation Consortium (Consorcio de Compensación de Seguros - CCS). Instituted in 1954 after its provisional creation in 1941, the CCS is an independent public company attached to the Ministry of Economics, Industry and Competitiveness but with separate accounts and a certain degree of entrepreneurial freedom (CCS, 2016).

As a tool at the service of the Spanish insurance sector, CCS performs many different functions, among others the lynchpin of the Spanish Extraordinary Risk System. The extraordinary hazards covered are well defined in the statutes and include floods (before 1986 conditional on declared catastrophe zone, Barredo et al., 2012); cyclones, tornadoes and wind storms (with gusts exceeding 120 km/h); earthquakes; tidal waves; volcanic eruptions; meteor strikes; and other hazards such as acts of terrorism and civil unrest. Spain counts additionally with a comprehensive combined agricultural insurance, managed by a pool of private companies (Agroseguro) in which CCS participates both as a co-insurer and as a reinsurer. A bulk of the estimated EUR 6.4 billion paid in compensations over the 1987-2014 period referred to floods and windstorms (Espejo Gil, 2016).

Public–private partnerships (PPPs) are a model for a joint bearing of responsibilities and efficient risk sharing, capable of increasing insurance coverage and penetration and guaranteeing a strong financial backing in view of uncertain tail distributions of risk.

The scheme is financed by compulsory surcharge on designated insurance policies. Insurance policies covering property damage (with some exceptions), business interruption and personal life and accident.The flat rate surcharge is based on the total insured value and varies only across the type of underlying insurance policies. For example for dwellings and office building the surcharge amounts to 0.008 per thousand.The same rate applies without differentiation for any degree of exposure and any risk across the entire country, as it is calculated considering all claims and risks covered as a whole. Deductibles are applied to commercial policyholders but not to households (ibid.). Risk underwriting is the task of private insurers and the extraordinary risk cover is entirely transferred to CCS. In exchange, the insurers retain 5 % of the collected surcharges to cover administrative costs. Claims are managed and indemnified by CCS. The fact that the scheme has very low administrative costs (less than 10 % of the collected surcharges including the costs of claim processing) is an argument in favour of this arrangement (von Ungern-Sternberg, 2004). Half of the CCS Board of Administrators is composed of chief executive officers from Spanish insurance companies and the other half of senior officials of the public sector. All decisions affecting CCS or the Extraordinary Risk Coverage System emanate from the board, setting another example of PPPs, which is also a flexible mechanism to easily introduce modifications to the system.

France introduced the 'Catastrophes naturelles' (CatNat) insurance regime back in 1982 in the aftermath of the devastating Saône, Rhone and southwest France floods (CCS, 2008; Magnan, 1995). It is based on a mandatory extension of insurance policies against fire and damage to property (theft, water damage, etc.) and land vehicles, to protect also against damage caused by extreme natural hazard events deemed uninsurable. A defining characteristic of the CatNat regime is that the exceptional character of the natural hazard events, serving as a trigger for damage compensation, has to be sanctioned by an interministerial decree. What qualifies as natural disaster is not exactly specified by statutes and is indeed sanctioned case by case. The CatNat system usually applies to floods, landslides, subsidence, droughts, avalanches, earthquakes and tidal waves. CatNat exemplifies a system in which policyholders cannot exclude the natural hazard coverage, and the insurers have to supply it (Grislain-Letrémy et al., 2012). The additional premiums (or surcharges) are set by the government as uniform percentage rates of the underlying property insurance premium without any regional differentiation, equal for all risks covered and any degree of risk exposure. The government also determines the level of deductibles that are compulsory even if the underlying (base) policies do not envisage them. The deductibles serve as an incentive for risk prevention: the policyholders in districts without a risk prevention plan (Plans de Prévention des Risques - PPR) have to accept higher deductibles when exceptional events of the same hazard types occur consecutively (von Ungern-Sternberg, 2004). In addition, a levy on the CatNat premiums flows into aFund for the Prevention of Major Natural Hazards (Fonds de Prévention des Risques Naturels Majeurs - FPRNM), which finances prevention measures.

Private insurers underwrite the risk, collect premiums and process the claims. Except for the premium rates and deductibles, the natural disaster cover follows the terms and conditions of the underlying insurance policy. The insurers may choose to reinsure the underwritten risks by a Central Re-insurance Company (Caisse Centrale de Réassurance - CCR), initially a public entity of commercial nature and later turned into a state-owned limited company. The CCR offers two types of complementary and inseparable reinsurance contracts: (i) quota-sharing contracts under which the CCR accepts a share of the risk in exchange for a share of the collected premiums; and (ii) stop-loss contracts under which the CCR compensates the loss that exceeds the insurer's annual premium income by a certain factor (OECD, 2014). The CCR holds a dominant position in the reinsurance market in France (Grislain-Letrémy et al., 2012). In 2015 the French Insurance Federation (Fédération Française de l'Assurance - FFA), estimated that by 2040 the human induced climate change may increase the disaster losses by 90 % (EUR 44 billion) compared to losses over the past 25-year-long period (FFA, 2016a). To improve the sustainability and viability of the CatNat regime, the FFA made several suggestions about how to make DRR an integral part of the regime. Among other things, the FFA recommended that the insurers should be able to define the level of deductibles for major policyholders (with insured value beyond EUR 50 million) (FFA, 2016b).

The Flood Reinsurance Scheme (FR Scheme or Flood Re (n.d.)) in the United Kingdom is an example of a public–private reinsurance mechanism for flood components of housing policies. Private flood risk insurance in the United Kingdom has a long tradition and coverage of residential properties is among the highest in Europe (Maccaferri et al., 2012). Housing insurance typically covers a portfolio of risks in addition to floods and is compulsory for securing mortgage loans. Public–private cooperation in the flood insurance sector started in the 1960s and gradually evolved into a partnership entailing tangible commitments on both the public and private ends (Penning-Rowsell et al., 2014; Ball et al., 2013; Lamond, Proverbs and Hammond, 2009; Penning-Rowsell and Priest, 2015).

The FR Scheme had been designed as a publicly accountable but privately owned and managed, non-profit service organisation. The ownership and management of the scheme is entirely in the hands of the insurance industry, with a limited government membership role. The commercial insurers are free to choose whether to reinsure the written market risk or cede the flood-risk component of housing policies to the scheme at predetermined, capped prices. In the latter case, any and all damage claims are paid by the scheme and the primary insurers continue acting as a broker. The capped premiums are specified by the regulation (FR Regulation, 2016), annually updated by the consumer price index and revised every 5 years.

The FR Scheme is funded by an annual statutory levy set at GBP 180 million (EUR 213.5 million) for the first 5-year period, which is imposed on all home insurers operating in the United Kingdom. The total amount of the primary levy was decided as an equivalent level of current cross-subsidy, which amounts to an estimated GBP 10.5 (EUR 12.5) per household. The FR Scheme administrator can raise supplementary (top-up) levies or contributions in cases where it does not have sufficient resources to meet its non-reinsured claims.

Because the statutory and top-up levies constitute a state aid and the scheme entails a selective advantage, the European Commission had been notified and reviewed the FR Schemes. In its review, the Commission recognised the goal of ensuring affordable insurance against flood risk as a legitimate aim of public policy (EC, 2015a). Furthermore, it recognised that the FR Scheme promotes a free flood insurance market and rectifies market failures that might or eventually would compel insurers to stop providing insurance cover in some areas or only at high prices that would not be affordable by all households. Neither of these outcomes was deemed acceptable. The Commission acknowledged that the FR Scheme was designed in such a way as to minimise the (competitive) advantage granted to the insurers, and that the threshold above which the insurers will be able to cede the premiums to the Flood RE scheme will be attuned in a way that limits market intervention to only around 2 % of domestic insurance policies. Other design criteria have prompted a positive review of the scheme. The fact that the capped premium is differentiated by the Council tax band and is adjusted to inflation made the scheme proportional to its objectives. More importantly, the scheme is designed as a transitional measure to be phased out after 20-25 years. While the Government has publicly committed to continue flood risk defence efforts, Flood Re does not provide any incentives for risk reduction and resilience, which has been highlighted as a problem for ensuring future affordability and availability of flood insurance. (Surminski, 2017; Jenkins et. al. 2017).

5.4.5 Conclusions and key messages

Partnership

A comprehensive strategy for disaster financing can moderate the impacts of natural hazard risks, speed up recovery and reconstruction, and harness knowledge and incentives for risk reduction. Private financial sectors play an important role, along with governments and civil society organisations, in designing innovative financial protection goals and sharing knowledge and capacity. PPPs are a model for a joint bearing of responsibilities and efficient risk sharing, capable of increasing insurance coverage and penetration and guaranteeing a strong financial backing in view of uncertain tail distributions of risk.

Knowledge

Climate change has amplified natural hazard risks, and raising vulnerability may make financial protection unaffordable for some people and businesses as well as risks uninsurable in certain places. Insurance and other financial instruments can contribute to reducing disaster risk, if designed and implemented to this end. The reinsurance industry has driven the development of catastrophe risk analytics over the last 30 years, moving from a position where hazards mechanisms, their impacts and comparative risks were little understood to one where sophisticated and integrated stochastic catastrophe models have become the norm in the industry.

Innovation

Insurance can help dissuade policyholders from risky behaviour and incentivise risk reduction. Premiums and policy terms (e.g. deductibles) can be adjusted to reward good risks and penalise bad ones. Harnessing insurance for DRR becomes particularly significant in the context of increased frequency of disaster events, larger economic exposure, rising vulnerability and climate change. Comprehensive strategies for risk financing help to shed light on impacts of disaster risk on economy and society and facilitate identification of actions to minimise them. They allow decision-makers to integrate adaptation and risk reduction with economic development and sustainable growth.

Recommendations

National policies for disaster prevention and mitigation involve cooperation across sectors and scales. Partnership for mitigation and prevention is particularly important — there is a need for active engagement and commitment of the private sector, communities and academia as well as a need to share responsibilities for development and implementation of DRM strategies. Nevertheless, the main responsibility will remain with national governments, as also reaffirmed in the SFDRR. Some further efforts will be required in order to ensure that DRM is considered a cross-sectoral topic, which requires engagement and commitment on behalf of multi-stakeholders. Understanding direct and indirect costs is crucial to selecting and investing in preventive measures as well as the stakeholders to be involved and their roles and responsibilities.

However, identifying suitable investments is not enough; presenting evidence of additional dividends to policymakers and investors could provide a narrative reconciling short- and long-term objectives, thereby improving the acceptability and feasibility of DRM investments and enhancing the business case for investment in prevention and mitigation.

Integration of mitigation and prevention policies and regulations is a key innovation in mitigation and prevention, but it is rare. Where zoning regulations, building codes and insurance policies are integrated, the mitigation strategy becomes more coherent and easier for stakeholders to implement.

Cooperation between regional, national and international communities is particularly important for preparedness and response planning given the transboundary nature of modern-day disasters. ELSI are not a separate dimension of DRM that can be addressed in isolation. Good preparedness can protect societies from exceptions that go against ordinary morals, integrity and dignity, from unintended consequences and from entrusting decisions solely on experts or governments without public engagement.

A move away from command-and-control approaches to managing disasters has opened up more opportunities for citizens to participate in preparedness and response. Strong bonds and trust within and between communities favours a more effective response in emergencies and can be harnessed by authorities. Social media can also be used to enhance self-organised mobilisation and coordination of local resources, knowledge and efforts for disaster preparedness and response.

Close collaboration across sectors and with affected groups is beneficial for physical, economic and psychosocial recovery processes. Recovery is complex and people and systems may not return to their pre-disaster state, but strong multisectoral pre-disaster plans and flexibility in responses can improve the speed and efficacy of recovery, avoiding indirect and adverse impacts after the disaster.

Significant progress has been made in understanding the psychosocial impact of disasters and on (re)construction techniques to improve the built environment after a disaster. Scientific gaps still remain in understanding economic recovery given the diverse scales at which impacts are felt and potential problems created by external intervention for local economies post-disaster.

Innovation in recovery promotion is particularly seen in reconstruction and more comprehensive approaches to rebuilding in urban areas.

A comprehensive strategy for disaster financing can moderate the impacts of natural hazard risks, speed up recovery and reconstruction and harness knowledge and incentives for risk reduction.

Climate change has amplified risks and raising vulnerability may make financial protection unaffordable for some people and businesses as well as risks uninsurable in certain places.

Insurance and other financial instruments can contribute to reducing disaster risk if designed and implemented to this end.

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5.3 Recovery and avoiding risk creation

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