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Nonstructural Approaches to Coastal Risk Mitigations

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5.1 Introduction

The purpose of this chapter is to present measures that deal with the governance of coastal risks associated with climate change. The focus is on measures entailing collective action at the local, regional, or national levels, and involving the private sector, the public sector, and/or civil society. Key risk mitigation options that are the product of collective action include insurance schemes, spatial planning, business continuity planning, postflood recovery, risk communication, and evacuation planning.

Although there has been much analysis in the past regarding these mitigation options as standalone measures, in this chapter they are presented as part of a potential portfolio in which their combination transcends their sum. Furthermore, these approaches to risk mitigation are dual in the sense they may impact both vulnerability (Adger, 2006) and resilience (Berkes, Colding, & Folke, 2003) simultaneously.

Although the mitigation options presented here are the product of collective action, these options are part of a broader process: risk governance (Renn, 2008). Risk governance, ''structures and processes for collective decision making'' (Renn, 2008), is the application of governance principles to risk and risk-related activities, and as such may involve the state, economic interests, civil society, and academia, and at various institutional scales. At the core of the principle of governance lie the concepts of horizontal integration (i.e., among state, economic interests, civil society, and academia) and vertical integration (i.e., among local, regional, national, and global scales). Risk governance is composed of five elements: preassessment, appraisal, characterization/evaluation, management, and communication (Renn, 2008). The first four elements are sequential and may be iterative, whereas the fifth element, communication, interacts with all the others.

In this chapter, the overarching goal of ''safer coasts'' can generally be framed as a contribution to flooding and erosion risk governance principles. Because the focus is on risk mitigation, this chapter looks at the ''management'' and ''communication'' phases of risk governance. Risk management consists of the major components of decision making and implementation; risk communication crosses all phases of risk governance. A key element that guided the analysis and the associated recommendation is the dual nature of nonstructural risk mitigation. Mitigating risk simultaneously aims to reduce vulnerability and increase resilience.

Reducing vulnerability is associated with a paradigmatic stance regarding the function of the risk system. To reduce vulnerability a (quasi) deterministic representation of the risk system must be available (see Chapter 2, the Source Pathway Receptor Consequence model). In such a representation, a causal chain, often linear, connects the hazard to its associated consequences. Vulnerability reduction is associated with key points in such a causal chain, in which it is possible, through

mitigation, to reduce or break this connection to reduce the consequences. Although this approach to risk management can be quite powerful, it does not take into account the nondeterministic characteristics of the complex coastal risk system.

Increasing resilience is associated with a different way of thinking. Resilience is associated with nondeterministic complex system representations whereas a linear causal chain is not applicable (see Table 5.1).

TABLE 5.1 Resilience Principles of a Nondeterministic Complex System (After Wardekker, de Jong, Knoop, & van der Sluijs, 2010)

Resilience Principle	Description	Examples
Homeostasis	Multiple feedback loops within the coastal system counteract disturbances and stabilize the system.	Improving clarity of responsibilities, early warning systems, spatial planning strategies, flexible structures, infrastructures, and flood defenses.
Omnivory	The capacity to recover is increased by diversification of resources and means that may be mobilized in the event of a shock.	Diversifying and distributing power generation, diversifying transportation options, creating multifunctional spaces and buildings, and multiskilled planning teams.
High flux	A fast rate of movement of resources through the system ensures fast mobilization of these resources to cope with perturbations.	Reducing planning horizons, planning easy-to-modify land uses.
Flatness	The hierarchical levels relative to the base should not be top heavy, because overly hierarchical systems with no local formal competence to act are too inflexible and too slow (1) to cope with surprise and (2) to implement nonstandard highly local responses rapidly.	Enabling local populations to self-respond to disturbances (self-sufficiency, self-regulation, and self-organization), increasing public participation.
Buffering	Essential capacities of the system are overdimensioned such that critical thresholds in capacities are less likely to be crossed.	Creating low-elevation spaces (e.g., squares and parks) and ground floors, with nonessential functions that provide water storage capacity.
Redundancy	The system contains overlapping functions; if one fails, others can take over.	Creating multiple power supply routes and interlinked transportation, building access at multiple levels.

Another way to address this duality (i.e., reducing vulnerability and increasing resilience), which is also followed in this chapter, is to consider constantly that, ultimately, a coastal system is a complex, nondeterministic system, but some parts of the system may be treated as deterministic. This way of approaching risk governance allows for a clear dialogue between vulnerability reduction measures (such as those discussed in Chapters 3 and 4dlimited in scope but part of well-established causal descriptions) and resilience enhancement measures (broad in scope, but not amenable to a simplified causal representation).

The socially based mitigation options presented here cover six main optionsd insurance, spatial planning, business continuity planning, postflood recovery, risk communication, and evacuationdand are discussed in terms of both vulnerability reduction and resilience enhancement. The chapter concludes by underscoring the key overarching characteristics of nonstructural mitigation options.

5.2 Insurance

5.2.1 Reducing Vulnerability through Insurance

The objective of this section is to provide guidance to policymakers in the implementation of efficient insurance programs. Insurance can offer the potential of an ex ante mitigation mechanism through its policy conditions or through encouraging parallel measures that are deemed to reduce the occurrence, severity, or impact of a natural hazard. Insurance is expected to reduce property owners' vulnerability and exposure to flood hazards as a result of changes in behaviors and attitudes, thus contributing to speedy recovery and resilience while redistributing the costs of damage across the population and through time.

Insurers cannot control any hazard directly, although they rely, to a greater or less degree, on predictions and sea defense activities. In this context, when integrating insurance schemes into the Sources, Pathways, Receptor, Consequences (SPRC) model (see Chapter 2 and Zanuttigh (2011)), the most obvious link is the impact of the insurance market on consequences. In particular, by increasing risk awarenessdby linking the cost (premium) to the risk leveldand by creating incentives for mitigation actions, there is a direct impact on the expected damages and the number of people flooded as the result of a flood event.

The main intervention mechanism of insurance in the context of flooding is in its redistribution of the costs of damage across the population and through time. Insurance against flooding as a financial mechanism (1) may serve as a means of communicating risk and (2) may serve to persuade people to integrate it in their decision making by making its purchase compulsory in flood-prone zones (Dawson et al., 2011).

Insurance arrangements for flood risk may require households to undertake measures that mitigate damage or that stimulate households to undertake precautionary measures voluntarily (e.g., requiring valuable items to be kept above flood level or constructing flood-proof buildings). These measures may limit damage during floods and thus may be complementary to traditional flood protection (Kunreuther & Pauly, 2006). Moreover, insurance schemes can influence consequences by refusing coverage in a flood-prone area, making it more likely that risk-averse households and firms will chose not to establish in flood-prone areas.

In this way, insurance schemes reduce the consequences through their policy conditions and through encouraging self-help measures, which are deemed to reduce the occurrence, severity, or impact of a natural peril, and also by influencing the structure and development of economic activity on coastal areas prone to flooding (Botzen, Aerts, & van den Bergh, 2009). Therefore, it is important for insurance to provide the right incentives/disincentives to the residents of the coastal areas to modify their behavior in relation to the local levels of risk (Treby, Clark, & Priest, 2006).

The effectiveness of insurance as a mitigation measure depends on a range of factors, some of which are outlined in the following list. Decision makers should consider these factors when evaluating and implementing insurance schemes:

- The existence of actuarially effective premiums;
- How much the insurers are regulated by government;
- Existing policy arrangements for compensating flood damage;
- Issues that affect human behavior and determine an individual's risk perception and awareness;
- Whether insurance provides the right incentives/disincentives to the residents of the coastal areas to change their behavior in relation to risk;
- Overconfidence in ''hard'' measures such as dikes, resulting in the phenomenon of underinsurance in flood-prone areas;
- Early warning systems and evacuation plans that reduce flood damages and, consequently, flood insurance claims;
- The degree of exposure of decision makers to the victims of the hazards and, hence, to the emotional involvement with flood victims;
- Participation of communities in measures of flood preparedness (e.g., establishing a system to detect floods and warn people about them) and risk communication within a Community Rating System that could enable inhabitants to acquire credits and achieve flood insurance premium rate reductions.

Market incentives are possibly the most effective way of changing social behavior. Thus, flood insurers could play a critical role in risk reduction and avoidance (mitigation) via the use of financial (dis)incentives (Treby et al., 2006): lower deductibles and/or lower premiums for properties that take action to reduce

their exposure to flood risk, such as flood proofing; bonuses for nonclaims; premium pricing related to risk, placing the onus on clients to assess their reaction to the known risk as highlighted by premiums that are high or indeed lacking; resilient reinstatement (i.e., reconstruction undertaken as a result of insurance payouts that aims to reduce the risk of future losses); compensation and rehousing in an area of lower flood risk. However, for this (and the previous) strategy to be adopted requires a degree of government intervention.

Nevertheless, a government's intervention is of crucial importance because policies interact with the formation of risk behavior and are capable of creating incentives to both households and investors (Botzen et al., 2009). Hence, apart from exploring further a community's risk perception conditional on the factors mentioned previously, it is also important to acknowledge the interlinkage in coastal policy design. Last, although the role of insurance as a vulnerability reduction mechanism has been emphasized, it should also be acknowledged that its effectiveness is conditional on a number of parameters, such as socioeconomic and physical changes, and governance arrangements.

5.2.2 Enhancing Resilience through Insurance

In this section, implementation guidelines associated with resilience enhancement of coastal systems with respect to flood insurance are provided. As presented in Table 5.1, Wardekker et al. (2010) offer an interesting approach to climate change adaptation under uncertainty. They suggest that local actors could apply principles of resilience to make the system less prone to disturbances and to enable rapid and flexible responses. This approach is better capable of dealing with surprises than traditional predictive approaches because it is more flexible, and adaptation can be more suitable and better tailored to local situations than rigid top–down regulations.

Insurance may play a central role in terms of resources and means (the omnivory principle in Table 5.1). This means that multiple different approaches can be used alongside each other. In terms of insurance, this could mean hedging outside the insurance market. It is also possible to allocate part of the insurance fees to finance protection measures in the most affected areas. In case of a huge payout, diversification can be achieved by ensuring access to alternative funds/financial resources. Another way of achieving diversification is by helping people to implement different measures to protect their properties (special precautions) and helping local authorities to implement protection measures (using, for example, spatial planning and evacuation plans). Other suggested parallel measures are the promotion of the development and effectiveness of social networks in terms of cohesion to reduce risk and the size of payouts, and the promotion of public awareness on natural disasters and on the link between community vulnerabilities and policy options. Last, it is also

important to promote an alliance and to establish a common emergency plan with the public or private sector, or organizations.

Furthermore, insurance schemes should contribute to feedback loops (homeostasis principle, see Table 5.1) to counteract disturbances and stabilize the system. Insurance companies should be able to update their contracts and operations given previous experiences (their own and those garnered from around the world) so they are tailored to local conditions. More specifically, insurance schemes should be able to adopt measures that minimize the risk of the most vulnerable. Insurance companies should be able to (re)integrate local participation at different stages of the design of an insurance scheme after an event and to update knowledge regarding scientific data, research developments, and scenarios related to climate change, flooding, and so forth. They should also be able to cooperate with local authorities to update their protection measures given previous experiences (and so decrease the probability of risk and manage the size of payouts). Hence, cooperative or community (instead of individual) insurance schemes may reinforce social cohesion. Monitoring is a key issue to provide multiple feedback loops to counteract disturbances. Thus, there should be a monitoring capacity of insurance schemes on the impact they have on people with different levels of vulnerability, and a capacity to monitor the premium rate, the deductible level, and the insurance cap level to maintain demand for their policies.

Insurance implementation must allow for a fast rate of movement of resources through the system (high-flux resilience principle, see Table 5.1). This ensures fast mobilization of resources to cope with perturbations. In terms of insurance implementation, this means collaborating with different insurance companies to work together and make the claims process faster. Therefore, the aim should be to achieve a high standard in the quality of information and clarity given in the conditions under which a payout is received so it is done more quickly. A competitive insurance market can provide a wide availability of insurance coverage and contribute to a fast rate of movement of resources by ensuring a spreading of the risk and higher coverage of the population. Other related measures include keeping only a certain percentage of high-risk contracts among clients, allocating payouts and giving priority to the most affected or according to social criteria (e.g., income), and encouraging collaboration with local authorities (having already established a contingency plan) and with nongovernmental organizations, and so forth, to increase reliability and timeliness in case of flooding. Last, the facilitation of payouts is important in terms of a quick response that avoids bureaucracy and time-consuming paperwork.

To avoid a top-heavy insurance system (flatness resilience principle, see Table 5.1), there should be direct and easy personal contact of each beneficiary with the insurance institution. This can be promoted by insurance schemes tailored according to local conditions and the needs and characteristics of local stakeholders and households. Therefore, a participative process in identifying uninsurable high-risk

zones is always to be desired, and local participation in the design of insurance schemes to increase flexibility and response should be encouraged.

Buffering (as a resilience principle, see Table 5.1) capabilities can be achieved by linking the insurance premium to measures that promote risk reduction (e.g., flood-resistant functions on ground level) through economic incentives (reducing premiums for those who invest in mitigation or loss-reduction measures). Also, insurance companies and/or the government could keep a reserve fund to enable them to cope financially with natural disasters without collapsing. Ensuring that the money is available to pay for the losses can be achieved through indexed-based or parameterized catastrophe bonds. Insurance firms could also purchase an indemnity contract against claim payments more than a certain amount. Other measures include the possibility of sharing the risk of a huge payout by cooperating with other insurance companies, and the ability of insurance institutions to offer payouts that give priority to the most affected or according to social criteria (which means that at least the insured part of population is offered relief, and resources are allocated directly to the more disadvantaged). A cap on the maximum insured value could be set or an increase in deductible levels stipulated so that the payouts from any disaster would decrease. Nevertheless, all these measures require certain standards to be met (e.g., building codes) before issuing an insurance policy (the mitigation measure).

Last, having several alternative options is better in terms of resilience (redundancy resilience principle, see Table 5.1). It is always useful to have a backup plan in case something goes wrong, because there are always unseen circumstances that may disrupt activities and services. These overlapping functions are evident in the case of insurance programs. For example, if insurance companies fail, the government or the European Union intervenes with regard to residents and businesses (and this can be both in contracting and in reimbursing). Insurance companies can also offer the possibility of both individual and group/cooperative contracts (the risk-pooling option) for businesses, households, or communities. In a more global setting, international organizations and nongovernmental organizations can develop alarm systems that can help if the government fails. On the other hand, the insurance market may offer the possibility to participate in both multicountry and national ‘‘risk-pool’’ policies so if one fails, the other could counterbalance the effects. Furthermore, insurance is usually coupled with regulations and standards policies.

5.3 Spatial (Land Use) Planning

5.3.1 Land Use Planning: Structuring Space to Reduce Vulnerability

Spatial planning has the potential to reduce future impacts through controlling the type and extent of property built in flood or erosion risk areas and therefore to restrict the impact that hazards bring at the coast. This might, for example, be

effected by reducing inappropriate future development and by changing the standards or future use of current development (Deboudt, 2010; Pottier, Penning-Rowsell, Tunstall, & Hubert, 2005). Such measures could reduce the need for, or the design standards of, the kinds of major coastal defense structures that are now common, and that may need to become more widespread with future climate change-induced sea-level rises.

The use of the SPRC model (see Chapter 2) highlights the potential that spatial planning has as a mitigation option rather than providing evidence of how it currently operates. There is considerable effort still needed to incorporate Flood and Coastal Erosion Risk Management (FCERM) effectively into spatial plans (Richards, White, & Carter, 2008). Spatial planning is concerned primarily with the idea of exploring and making changes with the nature of the pathway, receptor, and, therefore, consequences rather than with the source (except perhaps marginally in the creation of urban ''heat islands'' that might exacerbate storminess and hence flooding). There is some potential to influence the pathway through the creation of ''green areas'' that would allow the flow of floodwater, or by the development of structures that inhibit the flow, but spatial planning and urbanization are most likely to have an impact through changes to the nature of the receptors within the flood plain. Spatial planning offers the potential to reduce or prevent development in areas most at risk of flooding and so reduce potential exposure. It may also be used to change the nature of buildings in a risk area so that they are more able to withstand and recover quickly from floods (see the case of HafenCity in the Elbe estuary, Section 7.5). This may be through physical measures or through changing use (e.g., example moving key functions to higher floors). There may also be an effect at a communal level; spatial planning could perhaps be used to influence where to locate essential services such as water, gas, electricity, transportation hubs, hospitals, and other emergency services so they are less likely to be interrupted by flooding or similar events. Planning could also be used to ensure the provisions and maintenance of suitable evacuation routes. It may also be possible to ensure that large communal buildings, which might be used as rescue centers, are suitably sited.

All of these measures have the potential to change the nature of the consequences. There is also the potential for changes that lead to the following:

- fewer people exposed to the risk;
- fewer properties exposed to the risk;
- more people evacuated safely in the event of an incident;
- more essential services maintained during an incident;
- faster restoration of essential services where they have been disrupted;
- shorter recovery times in restoring buildings and infrastructures to their usual use.

In an ideal world, spatial planning would take into account flood and coastal erosion risk, and decisions would be made accordingly so that future risk is reduced. In reality, the situation is much more complex. The integration of FCERM into

spatial planning is incomplete and inconsistent. Spatial planning has to balance many competing demands at a range of timescales, and residents may resist changes for a variety of reasons. Section 5.3.2 offers guidelines for addressing some of these issues.

5.3.2 Land Use Planning and Resilience

The mitigation option proposed is to ensure that an assessment of FCERM risk is included in spatial planning at a strategic and a local scale to reduce current risk and to restrict the buildup of potential damage from flood and coastal erosion in the future. Despite some moves toward integrating FCERM into spatial planning across Europe, this is far from being achieved effectively. Awareness of recent legislation is limited, and integration not fully realized. The suggestions in the following paragraphs provide ways in which FCERM may be integrated more effectively into the spatial planning process to achieve greater flood resilience. They are applicable at a number of different levels; some need tackling at a policy level whereas others could be adopted by individual planning teams.

First, planning teams should be comprised of more than professional spatial planners (in a move toward the omnivory resilience principle, see Table 5.1), and should include experts in conveying complex and uncertain information (e.g., future flood risk), experts in participatory community engagement, and experts in resilience.

Second, spatial planners should incorporate a more complex understanding and use of the concept of resilience into their working practice. The concept of resilience is being used at the theoretical level in planning, and in relevant areas such as flood/disaster-related research. The issue, however, is how to ensure it is being used by planning practitioners. In the United Kingdom, for example, individual and community resilience are being incorporated into ‘‘emergency management,’’ as is seen clearly in the Cabinet Office’s approach (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/60678/Cabinet-Office-continuous-improvement-strategy.pdf) and in the management plans of the Environment Agency (http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/geho0711btze-e-e.pdf).

Third, spatial planners should learn from and make use of the existing knowledge and expertise to ensure that genuine, participatory engagement is taking place. This will also lead to increase in homeostasis (allowing for more feedbacks to stabilize the system) and flatness (making the system less top heavy through subsidiarity). Community engagement is a key strand of the current understanding of subsidiarity in policymaking, not only for planning and FCERM, but also much more widely. Therefore, there exists a wide range of expertise in this area that could be harnessed usefully, which would avoid costly mistakes, would build on existing skills and

knowledge, and would be, potentially, a relatively inexpensive way to meet a key risk reduction requirement. In particular, efforts must be taken to ensure that engagement is a genuinely participatory process. Token forms of engagement that do not move beyond simple consultation may lead to cynicism, loss of confidence in the planning system, avoidance of planning regulations, and conflict.

Fourth, spatial planners should adopt a more nuanced understanding of place identity (in other words, meaning and significance of places for their inhabitants and users), collective memory (shared accumulated experience and history), and how they relate to resistance to change. This should be linked to community engagement processes and visioning. Collective memory can be an important constraint to building resilience. For example, some residents may be attached to a particular view (place identity) of their locality and thus resistant to some of the changes suggested to improve resilience. This is true of any locality, but coastal communities often have a special resonance for people, many of whom may be fiercely protective against unwanted changes. Conversely, collective memory of flooding or erosion may also enhance resilience through a shared knowledge of how to cope, and its loss can be a problem.

Fifth, a better understanding of the processes involved could enable the spatial planning process to build on and enhance existing resilience. There is a need to move beyond the current view that people simply do not like change. A more nuanced approach to understanding attachment to particular places might reveal which aspects are most valued and reveal those where change can be made. Understanding how such identities come to be constructed would enable spatial planners to intervene at points that are likely to have the most impact. The spatial planning process could contribute significantly to resilience building by creating new ways of exploring memory and linking this with envisioning processesdmaking links between ''backward'' and ''forward'' thinking.

Sixth, more focused and comprehensive training and capacity building needs to be developed for planners to improve their understanding about the nature of hazards and the role of land use (spatial) planning in reducing hazard risks, and to ensure that hazards are ''mainstreamed:'' into their daily work (Glavovic, Saunders, & Becker, 2010).

Seventh, ''climate proofing'' spatial development (Birkmann, 2007) would strengthen links between FCERM and spatial planning. It is problematic that spatial planning processes rarely take into account the extreme event.

Eighth, flexibility and variation could be incorporated further within the planning system. Instances of rigid inflexibility of FCERM policy is seen as one of the main reasons for the tensions created and why people may be prepared to build illegally in well identified high-risk areas. Furthermore, if community engagement is to be taken seriously, and people are to be genuinely involved in the decision-making process, then some variation in outcomes is to be expected, and innovative solutions would suggest going outside normal procedures.

The TE2100 Flood Risk Management Plan is an interesting example of a plan that is designed to be flexible enough to cope with various climate change scenarios (EA, 2012). Led by the UK Environment Agency, the Thames Estuary 2100 project (TE2100) was established in 2002 with the aim of developing a long-term tidal flood risk management plan for London and the Thames estuary. Public consultation was used and the comments received were fed into the final draft. The plan sets out recommendations for managing flood risk across the estuary through to the end of the century, and it contains recommendations on what actions the Agency and others need to take in the short term (2020s), medium term (2050s), and long term (2080s). The plan is based on current guidance on climate change, but is adaptable to changes in predictions of sea-level rise and climate change throughout the century. This illustrates that it is possible to plan flexibly at the coast or in estuaries for a variety of scenarios in a way that takes local views into account.

Last, special coastal zone designations must be used to create momentum for resilience building (Chouinard, Baztan, & Vanderlinden, 2011). The fact that Integrated Coastal Zone Management does not have effective links to spatial planning is a key issue. Creating special spatial planning designations for at-risk areas at the coast might be one practical means of facilitating more focus on coastal issues and mutual learning (Bastien-Daigle, Vanderlinden, & Chouinard, 2008). There is evidence that such a designation can create momentum to work with local communities for new, innovative ideas.

5.4 Business Continuity Planning

5.4.1 Reducing Businesses Vulnerability through Recovery Planning

Coastal flood risk zones are often the sites of business activities. Waterfront sites or locations close to the coast are attractive for cargo storage and handling, marine transport, marine businesses and businesses linked to them, tourism businesses, and coastal urban settlement business and service functions. Coastal flooding leads to these businesses being vulnerable to physical damage caused by floods as well as to the disruptive effects of consequential losses (e.g., business interruption, loss of value added and loss of business to flood-free competitors) (Penning-Rowsell et al., 2013).

Business disruption and response planning (BDRP) has the potential to reduce business disruption in a variety of ways, including through (1) enhancing ‘‘resilience thinking,’’ (2) reducing or eliminating ill-considered location decisions, (3) developing contingency plans linked to early warnings designed to avoid or minimize direct physical and consequential disruptive impacts, and (4) spreading and sharing risks and consequences (Barnes, 2001; Hiles, 2011; Snedaker, 2007; Wallace & Webber, 2010).

A first element to consider here is supply chain vulnerability. Almost all businesses are backward and forward linkeddbackward to suppliers and forward to customersd and businesses often depend on a supply chain in which those who supply them with raw materials/components are dependent on other businesses, and in which they in turn may be the supplier of another business (Parker, 2007). A business located in a flood risk zone but that is not flooded may have its business operations disrupted when a supplier in a different flood risk zone (possibly in another country) is disrupted by flooding. BDRP has the potential to reduce supply chain vulnerability by using critical impact analysis tools in which (1) dependencies that exist both internally and externally to achieve critical objectives of the business are identified and (2) steps are taken to diversify supply chains with flood risks in mind. Businesses should be strongly encouraged to adopt these approaches (Syed & Syed, 2003).

Second, utility and transportation disruption vulnerability must be taken into account. Electricity supply outages caused by flooding (or accompanying high winds), and damage to electricity distribution stations and networks, are frequent causes of business interruption and economic loss in coastal zones. Some businesses may also be dependent on the continuous functioning of other utilities (e.g., public water supplies) that may be equally vulnerable to flood damage or contamination. Similarly, businesses depend on a transport infrastructure (often the first to be flooded) for their employees to get to and from work, and for supplies and products to be transported. BDRP should be much more widely adopted because it has the potential to avoid or minimize these vulnerabilities by identifying the critical dependencies and, for example, by developing backup power supplies and alternative transportation routes and/or modes.

BDRP knowledge and skills concerning vulnerability are critical for small and medium enterprises (SMEs). Business continuity planning (BCP) is most used by large businesses with professionally trained managers who have been educated in BCP. SMEs have a much greater proportion of owners/managers without the benefit of this education and who do not fully comprehend the potential value of BCP to reducing flood (or any hazard) disruption. Increasing the proportion of SME owners and managers with professional skills in BCP can therefore help reduce the disruptive impacts of floods (Business Continuity Institute, 2005).

Furthermore, businesses are particularly vulnerable if their business data (e.g., data on customers, debtors, supplies, stock, accounts, and so on) are damaged, lost, or otherwise unavailable during a flood (Snedaker, 2007). Data vulnerability needs very careful attention.

Last, the lives of customers are at risk when flooding threatens. For example, retail stores may have hundreds of customers and their vehicles onsite at any one time. Similarly, the lives and welfare of staff may be at risk. The risk is high in rapid inundation zones (e.g., low-lying areas behind seawalls that may be overtopped or breached).

Considering all the issues identified here, the following recommendations on implementing measures to reduce key vulnerabilities are made:

- When balancing decisions about (1) growth and development, and (2) risks, spatial planning processes should take account of the potential for business damage and disruption consequences caused by flooding in coastal risk zones, including the consequences for individual businesses and the wider consequences of business losses on local coastal economies;
- As they evolve, businesses should consider relocating the whole or part of their operations (critical business elements in particular) to more elevated locations, including the following options: beyond the coastal flood risk zone to lower risk locations in the coastal flood risk zone or to higher elevations in situ;
- Businesses located in coastal flood risk zones should be strongly encouraged to prepare generic business disruption and response (BDR) plans that take into account the risks from all relevant sources of flooding (i.e., sea flooding, surface water flooding, tidal fluvial flooding). These BDR plans should be tailored to the type of business and risks involved, and should include risk assessment, business impact and dependency analysis, disruption mitigation, and recovery, and they should be proportionate to the degree of risk, potential consequences, and the resources available to the firm;
- Corporate (i.e., group) businesses that have branches located in coastal flood risk zones should develop generic and flood-specific contingency plans for the temporary relocation of a branch threatened with flooding or a branch that has been flooded to maximize business continuity. These plans should consider relocating employees temporarily and should include plans to accommodate transferred workers (Richardson, Gordon, & Moore, 2008, pp. 253–278, chap. 14);
- Individual businesses located in coastal flood risk zones should, when feasible, identify temporary or mobile buildings to which parts of their operations could be transferred temporarily to maintain business continuity. This is particularly important for businesses that provide essential services to the community, including vulnerable groups. Examples are doctor's surgeries and dispensing pharmacies;
- Where feasible, businesses should organize building space so that nonessential and noncritical business functions are on the ground floor, and essential and critical functions are on higher floors. When practicable, businesses should also identify alternative site access and transport routes in and out of the area among employees' homes, suppliers, and customers to reduce the vulnerability of their business sites to flooding disruption;
- Where available, businesses should subscribe to a flood warning service to create sufficient lead time for BDR plans to be implemented effectively (Kreibich et al., 2011). Lead time may be enhanced by monitoring severe weather warnings for coastal zones that may be used to bring key staff or emergency procedures to a

greater state of readiness than would otherwise be the case should a flood warning be disseminated subsequently. This will save valuable time in the event of a flood and should result in reduced disruption;

- Businesses should develop flat internal organizational and responsibility structures with as few intermediaries as possible and with appropriate discretion to make damage and disruption-saving responses located at the ''local'' level to allow early warnings and updated warnings to be communicated rapidly and to allow timely emergency decisions to be made. Normally, incoming flood warnings should be received by one responsible individual who is able to disseminate the warning rapidly and internally to those who need it. These arrangements must be available on a 24/7 basis;
- In flood risk zones, wherever feasible, businesses should acquire equipment that is mobile and should ensure that critical facilities, such crisis management centers, are portable;
- Businesses located in coastal flood risk zones should have flood insurance with coverage for both direct physical damage and consequential loss (i.e., business interruption loss). The following alternatives should be considered: a business consortium indemnity scheme, private insurance coverage, and corporate (business group) internal ''self-insurance'';
- Businesses should protect themselves from supply chain disruption by developing parallel or contingency arrangements with alternative suppliers that are not at risk from flooding and/or should require businesses that have supply contracts with them to be able to demonstrate their flood resilience plans. Supply chains need to be ''switchable'';
- Businesses should consider ways of protecting themselves and their brands from ''leakage'' or loss of customers in the event of flooding. Ways of achieving this include regularly storing products at an alternative location outside the flood risk zone and establishing a means of communicating professionally with customers to reassure and update them;
- Businesses should establish backup business data storage facilities in a location outside the flood risk zone, and data should be backed up regularly. Adequate backup electricity generation and distribution arrangements should be made by businesses to maximize business continuity during flood events. When feasible, similar arrangements should be made for other business-critical utility supplies. Businesses should acquire knowledge and skills in BCP so that appropriate and effective BDR plans can be created (Wallace & Webber, 2010);
- Businesses that have customers on their premises (e.g., large retail outlets) should make contingency plans to protect the lives of their customers as well as their staff at times when there is a flood threat. Special attention should be given to flows of people and vehicles, bottlenecks, basements, car parks, exits, and underpasses. They must be able to communicate with customers and staff rapidly and

simultaneously using a range of signage and communication media designed to reach everyone, and staff should be rehearsed in evacuation procedures suitable for flooding (these procedures may be different for other hazards, such as high wind). Failure to do so could pose serious legal liability and business/brand consequences as well as adverse human and social consequences. These plans need to be based on a risk-to-life assessment.

5.4.2 Enhancing Resilience through Business Recovery Planning

5.4.2.1 Resilience through a Collective, Nondeterministic System Approach to Coastal Safety

Businesses have the potential to collaborate and to combine to ''buy'' or ''acquire'' collective security in the same way that (1) businesses and coastal towns/local/regional economies and (2) businesses and local communities do. However, with some notable exceptions, related mainly to their supply chains, all too often businesses exhibit tunnel vision when it comes to an ecosystem perspective (discussed next) and the potential for resilience that it presents.

Business companies do not exist in isolation. They are part of nested ecosystems: (1) the business ecosystem (of coastal settlements and business environments extending beyond the flood risk zone), (2) the local and regional economic ecosystem, and (3) the coastal settlement, local, regional population, and community ecosystem. These ecosystems exhibit multiple interdependencies among businesses, among businesses and their employees and customers, and among businesses and the economies of which they are part. The consequences of flooding of businesses will ripple through other parts of these ecosystems, creating financial and other implications on a scale from minor to major (Parker, 2007), in the same way that flooding of employees' and customers' homes will impact local businesses (in possibly both negative and positive ways).

Business forums (e.g., business breakfast clubs, business workshops) led by local chambers of commerce, local and regional trade associations, and government departments should be used to communicate flood risk using a cognitive pathway sequence (THESEUS OD4.8, 2013; Vorst, 2010, pp. 15–21). A cognitive pathway is a succession of steps that allows for the sharing of information, with the goal of a progressive increase of knowledge sharing that, in this case, commences with consequences for businesses and that generates a shared understanding of the probabilistic nature of flooding and a progressive change of perception.

These forums should also be used to encourage engagement and to develop an understanding of ecosystem interdependencies, the consequences of flooding on them, practical and innovative ways in which resilience may be enhanced, and

practical forms of collaboration and constructive partnership to build collective resilience. The relevance of such an approach to shareholder and auditor perspectives should be explored by drawing them into discussions, because they usually have financial security and ethical interests. Leadership may also be required from local community leaders, the flood risk management agency, and/or local councils, who should be encouraged to draw business representatives into building collective local flood resilience using graphic examples of interdependencies.

A particular window of opportunity exists to stimulate system/ecosystem perspectives, as described in the previous paragraph, in the immediate aftermath of a flood either when businesses have experienced adverse consequences, when such consequences are apparent in neighboring coastal settlements, or when affected businesses are willing to share their experiences.

5.4.2.2 Integrating Coastal Flood Risk Resilience with Spatial and Economic Planning

Although Sections 5.3.1 and 5.3.2 dealt with spatial planning as a central governance activity, in this section the influence of the outcomes of spatial planning on business recovery are discussed. Coastal flood risk should be considered alongside and integrated with other spatial and economic planning issues such as transport, housing, economic and employment stimulation and growth, natural resources, economic and social regeneration, biodiversity, the historical environment, and the management of other hazards. Policies should recognize the positive contribution that flood risk avoidance and resilience management can make to the development of sustainable communities, including improved local amenities and better overall quality of life.

The adverse, localized, and wider disruptive consequences of floods on businesses and, in turn, on local economies and communities—which are often poorly understood and gauged in advance of flooding—should be a variable that is factored explicitly into coastal planning decision making concerning business development (Penning-Rowsell et al., 2013). This aspect should be drawn into professional education for planners so they have a more nuanced understanding of changing flood risks (including the more extreme risks) and flood risk-reduction opportunities.

Practical steps toward this objective include recognizing (1) the tension that exists among spatial and economic planning, their growth and development focus, and flood and coastal risk management, and (2) the opportunity that a specific focus on resilience for businesses presents for harmonizing these goals and solving planning problems.

It is important to ensure that spatial planning supports coastal flood risk management and that illegal business development does not take place. An effective working relationship is required between local development planning and control agencies and coastal flood risk management agencies, including some staff sharing

and making the best use of expertise and information that is available so that new business development proposals may be assessed in terms of both planning and flood risk management criteria with a view to adopting a scale of potentially multiple harmonizing interventions designed to alleviate yes/no development decision dilemmas. This scale should include (1) movement of proposed developments to areas with the lowest flood risk or beyond the flood risk zone, (2) the substitution of less vulnerable development types for those incompatible with the degree of flood risk, (3) implementation of measures to make buildings resistant to floods (using property elevation, and/or automatic and/or manual resistance measures) and to apply flood resilience treatments to building interiors, and (4) measures designed to mitigate loss of access and disruption to properties and local economies and communities.

5.4.2.3 Designing (and Redesigning) Businesses to be Resilient to Floods (as Well as to Other Hazards)

Architects currently design buildings with particular objectives in mindd for example, to minimize their carbon footprint, to minimize their visual intrusion, to minimize sound transmission, to maximize floor space, and so on. The same notion can be applied not only to designing buildings that are resistant or resilient to physical flood damage, but also to the design of businesses that are resilient to physical damage and to consequential or disruptive loss (Bowker, Escarameia, & Tagg, 2007). Indeed, the same design principle may be applied to business parks and to communities comprising businesses. However, flood-resilient design principles are currently rarely applied in this manner in part because architects, developers, and planners know little about the different disruptive impacts of floods and the disruptive commonalities that may be discerned.

Therefore, business leaders, architects, developers, planners, builders, and flood risk managers need to be drawn together to identify (1) what is already known through their pooled experience about how business buildings and operations may be designed or redesigned to enhance their resilience to floods and other common hazards, (2) the research and development that may be required to establish firmer proposals, (3) the regulatory codes of practice (e.g., for architects, developers, builders, business managers) that are required, and (4) new training that may be drawn up to feed new flood-resilient designs into practice. Existing building regulations and codes of practice should be examined critically to identify ways in which they may be strengthened to increase business resilience to flooding.

5.4.2.4 Insurance

In Section 5.2.2, it was noted that the resilience of the coastal system as a whole could be increased by the design and practice of insurance schemes. Insurance has a role to play at the business level, and a key entry point is that BCP and insurers

should be encouraged, or required, to adopt a systems perspective that stimulates business resilience.

A virtuous circle needs to be created by using insurance constructively for business damage and loss in which (1) insurance premiums reflect the degree of (changing) flood risk and (2) insurance is made available only to businesses that demonstrate regularly that they have taken steps to minimize their potential losses by creating and adopting a BCP that conforms to prescribed standards (but that is also proportionate to the degree of risk, consequences of flooding, and size/resources available to the business). Alternatively, a higher premium could be charged to companies that do not demonstrate that they have BCPs in place. This may be easier to achieve when flood insurance is provided by a business consortium or local insurance consortium or by the state than by private insurers, although they, too, could be coerced by the state into adopting these principles.

It may prove difficult to achieve but, when possible, flood risk consequence assessment and related insurance coverage (if it exists) should not be ''individualized'' completely and it should factor in the wider, secondary risks, consequences, and costs of business disruption on coastal towns and their communities.

5.4.2.5 Integration into Flood Crisis Response and Evacuation Plans

Postflood recovery and evacuation (described as activities in their own right, respectively, in Sections 5.5.5 and 5.5.7) have a direct impact on the efficiency of BCPs. Businesses located in and adjacent to coastal flood risk zones should be as fully integrated as possible into flood crisis response and evacuation plans. It is important that all available, necessary financial, human, and material resources are available in a timely manner when crisis response and evacuation becomes necessary. This means the resources of the local business, government, and community system need to be drawn together and used collectively to achieve the desired outcome. There are two elements. First, businesses should be fully prepared to enact their flood crisis plans and to evacuate their own premises that, in some cases, may involve many staff and/or customers. Second, businesses and others within the community (including the military) should be prepared to offer each other mutual aid to maximize the positive effects of crisis response and evacuation.

Practical steps to ensure a timely, systems-oriented, resilient approach to flood crisis response and evacuation should be based on principles of (1) appropriate flows and volumes of timely information and (2) fast, timely mobilization of resources. The principles are as follows.

Flood crisis and evacuation plans should be premised on flat organizational systems that integrate businesses and that make decision-making processes as short, as uncomplicated, and as fast as possible; and that transmit and accept flood warnings rapidly, provide accurate and reliable flood information updates, including quick

‘‘in-event’’ feedback; and identify the threats to businesses (including their staff and customers) as well as to municipal and utility facilities. The plans should also be based on (1) threats to transportation facilities and to the residential population (including tourists), including the linkages among them (e.g., traffic flows to and from business premises that may conflict with population evacuation flows); (2) the collective resources of the entire community, which should include business organizations that have technical, equipment, machinery, and transportation resources that may be useful in a flood crisis and during evacuation; and (3) agreement over the roles assigned to each player, including businesses (some businesses adjacent to flood risk zones may be able to act as a refuge or evacuation center). Business organizations should also be prepared to participate in community flood crisis and evacuation exercises as well as undertake their own ‘‘internal’’ exercises. All resources should be focused on moving resources and people quickly, and on plans that identify, in advance, all potential bottlenecks and areas of friction that may slow down crisis response and evacuation.

5.5 Postflood Recovery, Vulnerability, and Resilience

Postcrisis management includes the processes, policies, and procedures related to preparing for recovery and ensuring the continuity of an infrastructure that is vital to an organization after a natural or human-induced disaster. Postcrisis management has a strong impact on how effectively a flood is managed.

What seems crucial for vulnerability reduction in terms of effectiveness and efficiency is how the flood risk is understood in the logical framework of intervention, and how the different instruments for immediate and long-term risk reduction are chosen. Thus, the central element for addressing and reducing vulnerability in postcrisis management is the implementation of a method for interventions. A participatory approach is required. Involvement of local stakeholders and organizations is recommended to increase trust and communication effectiveness. Risk perception and safety culture among coastal managers and citizens needs to be investigated and, when necessary, addressed. The level of flood preparedness needs to be investigated. This involves the degree to which people know what to do in case of flooding and know where they can acquire relevant information, and whether drills and education programs have been implemented properly. It also involves checking the adequacy of the skills, resources, and facilities of first responders and rescue personnel.

How a community perceives nonstructural flood mitigation measures is highly relevant to the appropriate integration of such measures with traditional structural measures such as flood barriers. For example, in some communities a warning system can be perceived as needed only when ‘‘push’’ and ‘‘pull’’ technologies (THESEUS OD4.8, 2013) are used together. Similarly, mobile barriers are unlikely

to be completely effective unless warning systems are available and if these systems are associated with high levels of trust.

Postcrisis management is characterized by the presence of qualitative and quantitative changes in the SPRC structure (Samuels, 2006; Zanuttigh, 2011) (see Chapter 2). Four main mitigation solutions may be identified in the causal chain, and all of them modify the receptors by changing the expected consequences of the event. They are as follows.

1. Information, education, and training: The implementation of safe practices, training, and increased effectiveness in dissemination systems influence citizens' capacity to act and react during emergencies. Furthermore, these factors condition the effectiveness of nonstructural measures such as warning systems and evacuation plans. The effectiveness of these plans is also related to people's cultural perception of risk and to the skills of disaster managers. Education and dissemination plans, therefore, need to be developed that take into account the characteristics of the local population. Demographic data, data on mean levels of education, and data on the diffusion of the Internet may be used to guide education and dissemination plans, and to target those groups that require the most attention. Clearly, in a village community with a concentration of elderly people with low levels of education but well-developed social capital (e.g., good social networks), the education and warning dissemination strategy should rely more on face-to-face information and informal social networks than on other means. A flood risk and flood warning dissemination process focused on Web technologies alone will probably be a failure in such a community, and traditional modes of alerting people using members of local associations or groups is likely to be more effective.
2. Warning systems: Warning systems provide flood alerts and should be designed to allow people to react beforewater reaches urban areas. They can affect the amount of physical losses (death or injuries), psychological consequences (stress levels), and economic losses (damages). As said earlier, to be effective, warning systems have to be implemented together with information/education interventions that explain what warning messages mean and what should be done when a warning is delivered. The analysis of channels of flood risk and warning information should be undertaken in ''quiet'' periods between flood events to support and build preparedness levels. Ideas concerning the creation of shared meanings in warning and alert messages need to be tested first by using volunteers. Questions about how alert messages are best conveyed should be developed using focus groups that involve both volunteers and coastal managers. If passing information by word of mouth is considered to be a primary channel of information, informal dissemination channels and stakeholder participation can be used to control this channel.
3. Critical facilities: According to Wu, Yarnal, and Fisher (2002), the survival of a community depends on the essential services provided by critical facilities such

as schools, utilities, hospitals, shelters, fire and rescue departments, communication hubs, and transportation depots. These facilities are not only crucial to the everyday functioning of a community, but also they provide extremely important and necessary services during emergencies. Indeed, the total number of these facilities subject to flood risk is considered to be a useful indicator of the overall community's vulnerability to flood hazards (Kleinosky, Yarnal, & Fisher, 2007; Wu et al., 2002). The notion of critical facilities can be adopted at different levels. On the one hand, facilities are an instrument for social planning; they introduce the idea that damages to particular buildings could condition the responses of the community. On the other hand, facilities are a useful instrument for emergency and emergency planning as used in the United States (Kleinosky et al., 2007).

4. Evacuation plans: Evacuation plans affect potential physical and human losses, and the recovery of the community. Lessons learned from the response to Hurricane Katrina as well from three flood basins of the Tisza river in Hungary (Vari, Linnerooth-Bayer, & Ferencz, 2003) documented the importance of evacuation plans. Thevenaz and Resodihardjo (2010) highlight the importance of contingency plans (which include evacuation plans) as a condition that enables effective community emergency response during disasters.

Effective community involvement is required to reduce vulnerability. Furthermore, the roles and responsibilities of municipal stakeholders need to be defined in a contingency plan. Special attention should be given to their different social values before, during, and after the flood to increase accountability levels and to establish a clear partnership between citizens and institutions. Different instruments and strategies have to be developed to enable effective feedback mechanisms regarding interventions while providing complete information capable of activating self-help and self-protection strategies. The complementary use of traditional dissemination tools and new technologies is recommended to reach as many people as possible.

It should be emphasized that the involvement of local stakeholders in planning ad hoc meetings in public spaces, especially during critical periods of the year (e.g., the early winter season) is important. Such events need to be used to inform and educate people about safety measures to adopt in households (e.g., emergency packs) and enterprises (e.g., recovery business plans). Recommended actions should be explained in clear, simple language, whereas the importance of cooperative behavior during the different phases of floods should be highlighted to reinforce community self-help strategies. Similarly, discussion groups should be used so that questions may be raised and explanations provided, and these discussions should be supported with open-access learning material.

The implementation of warnings should integrate effective technology designed to gain additional flood lead time and to provide instructions on how to respond safely and effectively to the warning. First, formal and informal channels of warning

dissemination need to be used together, and their combined use needs to be codified in terms of good practice. This is especially the case in areas with a high presence of tourists, because tourists typically do not have experience of local flood conditions and are likely to be unaware of the flood risk and flood warning codes. Indeed, the delivery of alert messages must rely on employees and owners of hotels or campsite hosts who have direct contact with the public. This requirement should be supported properly by the long-term establishment of a legal framework that recognizes community responsibility and the integration of formal and informal networks in warning dissemination processes.

Thus, community resilience can be improved with the development of multihazard early warning systems (UNISDR, 2005). A multihazard approach can address simultaneously flood as well as other coastal hazards. For example, flood alerts could be used during tourist season for heat waves or fires, as long there is no danger of them being confused. The implementation of warning systems requires an additional focus on local features, especially in the gray area between agency procedures and citizens. Specific ''pre-alert'' codes have to be created for high-risk areas to allow the creation of ''cushion'' zones for first evacuation or faster emergency intervention supported by the population. Simple instruments such as checklists for face-to-face operators can be useful in maximizing reaction and persuasion capacities, according to the priorities defined by end users for warning systems.

Bottom–up strategies could be used to gain information in relief and rehabilitation phases, because the social media provide a means of relevant information acquisition and data refreshing. Similarly, instruments to provide feedback on the ground, such as smart phones and related applications, may be used to provide real-time updates on actions implemented during the postdisaster period.

Increased coordination among levels of intervention (Ferraris, 2007, Nivolianitou & Synodinou, 2011) is recommended for the management of risk in critical facilities. Personnel working in buildings should be involved in regular drills with emergency operators to verify communication procedures and the different ''learn-by-doing'' practices related to the evacuation of facilities and to the use of emergency barriers (Simpson, 2002). Moreover, multifunctional spaces and buildings can provide specific water-retention areas that reduce overall damages in core zones, whereas disturbance-proof, low-elevation spaces and ground floors with nonessential functions may be created. The diffusion and use of materials that are resistant to water, heat, and ice drift in critical buildings may be encouraged by financial incentives for such measures. Last, some particular suggestions for the adoption of evacuation plans may be made from psychosocial perspectives. Strategies should be adopted for community participation (Newport & Jawahar, 2003) in all evacuation planning phases.

As much as feasible, all local associations and agents should be involved in raising risk awareness and trust levels. Community-based approaches (Simpson,

2001) could be used for determining places where information on safety measures should be positioned, as well as determining suitable symbols to be used in evacuation signals. Community-based training programs should be developed that are designed to teach residents basic emergency response skills using drills and simulations (Simpson, 2001).

5.6 Risk Communications at the Crossroads of Vulnerability Reduction and Resilience Enhancement

Risk communication, as a transverse activity of risk governance, may be framed as part of several, quite distinct, causal chains, some of which have already been touched in the preceding sections (THESEUS OD4.8, 2013). First, overexposure to risk has often been framed as a poor understanding of the causes and consequences of floods. Under this hypothesis, knowledge gaps are viewed as the key factor explaining poorly designed policies and overexposure. Yet this framing, relying on what is known to be the ''knowledge gap hypothesis,'' does not withstand empirical analysis (Kahan et al., 2012). Although robust knowledge is a necessary condition, the sharing of this knowledge is not a sufficient condition. Recent analyses (Pennings & Grossman, 2008; THESEUS OD4.8, 2013) demonstrate that beyond knowledge, attitudes toward risk in general, and toward coastal risk in particular, can also be explained by issues of diverging material and moral values. In the light of these results, it is now widely accepted, if not yet often implemented, that risk communication entails the creation of safe, deliberative space where knowledge may be shared in a way that is respectful and attuned to risk stakeholders' understanding and paradigmatic representations, material constraints and value, and moral values.

In other words, risk communication entails addressing the three following challenges (Kane, Vanderlinden, Baztan, Touili, & Claus, 2014):

1. Heuristic diversity: high diversity of experience with the coastal system and associated risk, leading to a variety of understandings of the way the coastal system functions (i.e., addressing potential knowledge discrepancies)
2. Diversity in material terms: differing priorities regarding what should be protected and what deserves attention (i.e., making sure that the risk issue corresponds whether you are a risk scientist, a risk manager, or a member of the general population at risk)
3. Diversity in normative terms: differing moral statements regarding how values may be threatened by the risk or by the risk governance/mitigation options envisioned (i.e., envisioning risk management as a potentially value-laden activity leading to the assessment of mitigation not only in scientific or material terms, but also in moral terms)

In coastal settings, these challenges may be specified. First, stakeholders associate risk with the modified state of the receptor or the consequences of flooding and erosion. Very seldom do stakeholders mention the probabilistic nature or flooding and erosion risk. Therefore, it seems safe to consider that, for most coastal stakeholders, risk ''equals'' consequences (Touili et al., 2014). Furthermore, work with stakeholders indicates that normative claims are central to risk governance for stakeholders. The following line of thought is followed most often when envisioning coastal risks. First, risk management is seen as a political process; as such, it entails the weighing of many factors, some of them external to the risk governance process (such as the odds of a politician of being reelected). Therefore, coastal risk stakeholders consider that authorities will act only if their proposal is accepted by the affected population or by the affected economic agents, regardless, sometimes, of the efficiency of the choice being made. Acceptability by affected stakeholders and economic agents is seen as contingent on the redistributive nature of the decision to be made (THESEUS OD4.8, 2013). Therefore, coastal flooding and erosion boils down to the normed acceptability of the options envisioned. Stakeholders understand that a specific risk may very well not be managed in a way that makes sense in terms of increased safety, but that does make sense in terms of social acceptance.

Although the normative statement made here is essentially associated with risk management options, it seems critical from the onset to allow as much space as possible for deliberations about the nature of the risk, and on its redistributive nature (as opposed to the redistributive nature of its mitigation). This allows for a clearer understanding of the normative challenges associated with risk management and associated options. This is especially true when normative statements regarding the consequences of a specific risk enter in conflict with a normative statement regarding the management options that are envisioned.

Another challenge in terms of risk communication lies in the sharing of the probabilistic nature of the source. This challenge has two dimensions. First, the probabilistic nature of events with relatively low occurrence is often not well understood by stakeholders. Second, society tends to be forgetful of events with low occurrence. Within a cognitive pathway (see Section 5.4.2.1), the sharing of the probabilistic nature of an event is, therefore, a critical hinge point.

Risk communication should therefore be envisioned as a cognitive pathway that addresses the following challenges:

- the cognitive chain is C-R-P-S for the stakeholders whereas the causal chain underlying the conceptual integrated risk assessment model is S-P-R-C;
- The probabilistic nature of the averse event is a subsidiary to other considerations for stakeholders whereas it is critical for risk managers;
- The causal evidence embedded in the SPRC model is completely secondary for the stakeholders (their priority lies in the normative claims associated with the

consequences under scrutiny); yet, for risk managers, the causal evidence lies at the core of their interventions.

To address these challenges, the deliberative space should be structured around a CRPS–probabilistic dimension–SPRC loop. First, consequences are envisioned and associated normative, pertinence, and evidence declarations are identified and discussed (THESEUS OD4.8, 2013). The same is then done for the receptor, the pathway, and the source. After this first sequence, a shared understanding of the probabilistic dimensions must be achieved. Then, the SPRC sequence is followed in this order to envision all associated mitigation possibilities, documenting, again, normative, pertinence, and evidence dimensions.

After the cognitive loop just described is completed, the options for risk mitigation will be generated. The generation of these options will be contextualized by the various pertinence, evidence, and normative claims that have been collected. This allows for an initial assessment of the choices that are possible in terms of societal acceptance. A critical dimension of the framework lies in the identification of a risk indicator portfolio that makes sense for all involved. This is another element that calls of a clear expression of the stakeholders' pertinence, evidence, and normative claims.

This risk communication scheme, which is deeply structured around an SPRC–vulnerability-centered approach contributes to the resilience principles outlined in Table 5.1.

By providing a series of feedback loops during the course of the cognitive pathway that allows for information flow between stakeholders, risk managers, and stakeholders, the proposed risk communication scheme will increase the homeostatic features of the coastal system. By giving access to and mobilizing several knowledge bases (scientific, public, and expert), the proposed risk communication scheme will enhance the system's omnivory. The proposed communication scheme will also, by giving a space for the expression of all stakeholders' values, contribute to the system's flatnessdflatness that, in turn, will be more efficient through the appropriation of robust knowledge by stakeholders.

Implementation-wise, the following elements need to be taken into account. Stakeholders that will be affected by the risk management envisioned should be involved in the process as early as possible. Involvement includes the proactive management of iterative exchange and communications. All people involved follow a cognitive pathway where new knowledge is acquired. This knowledge acquisition process is the proposed risk communication scheme. This cognitive pathway is designed explicitly to take stock of the current knowledge of risk perception. Ideally, this cognitive pathway should be discussed explicitly with all stakeholders to integrate it into their individual and collective heuristics.

At each step of the cognitive pathway, and for all information that is mobilized, the answer to the following questions should be gathered and associated with the

information under scrutiny (this should be documented unfiltered, and exchanged among stakeholders):

- What is the phenomenon that is under scrutiny and why does one find it important or not?
- What are the causal linkages expressed?
- On what basis are these causal linkages expressed?
- Are there ways of associating judgment with this information?
- Is this information threatening to values held dear by a group of stakeholders?

Moving up the cognitive pathway sequence, the most critical dimension lies in the sharing of the meaning associated with the probabilistic nature of the source. The critical recommendation here is *not to proceed* until all stakeholders develop a common understanding of the probabilistic nature of the source. An understanding of how future probability density functions are obtained should be part of this sharing process. One of the key challenges here lies in the nature of climate change. First, attribution issues may very well be questioned. These questions must be faced. Second, accepting climate change may be a challenge for some. When envisioning mitigation options, they should be assessed not only in terms of risk reduction, but also in terms of compatibility with stakeholders' values and beliefs. These stakeholders' values and beliefs should be documented as part of the indicator system. If the mitigation option conflicts with these values and beliefs it is critical not to proceed before deliberation occurs to assess the mitigation option acceptability. After the cognitive pathway sequence has been iterated once, all stakeholders should convene and assess collectively whether their perceptions have changed in terms of causality, relevance, and norms. This is the point where the deterministic and nondeterministic characteristics of the coastal system must be discussed. This is also the point where the blending of resilience enhancement and vulnerability reduction measures should be discussed collectively.

5.7 Evacuation Plans

5.7.1 Evacuation Plans and Vulnerability Reduction

Evacuation planning is a risk mitigation option designed to protect people from the effects of a flood (Jonkman, Vrijling, & Vrouwenvelder, 2008). It helps to reduce the vulnerability of coastal areas by providing some directions about how to prevent people from drowning when all other structural measures fail.

Evacuation planning is part of an emergency management strategy. In this regard, it supplements other classic mitigation options ''in real time''dthat is, when the event actually strikes. By reducing the number of people in the exposed area at the

start of the disaster, evacuation planning reduces the vulnerability of the area and the consequences of the flood.

The methodology created for planning a preventive mass evacuation can be effective when the disaster can be predicted with sufficient forewarning (usually at least 24 h). This is normally the case for coastal storms, when meteorological and hydrological elements responsible for a flood can be forecast by numerical models combined with real-time observations (Morel, Hissel, & Bouchrit, 2011). Fully accurate predictions with precise water levels and velocities are not necessary as long as the models allow identification of the part of the coastal region that is likely to be flooded and the extent to which it will be flooded.

Preventive evacuation cannot be improvised. To be effective, the authorities should have a clear idea of which areas are expected to flood, how many people must be evacuated, how many of them will not be able to do so by themselves, and where people should go to be safe (Keys & Opper, 2002). Many problems are likely to arise during an evacuation because of equipment or staff not being available to fulfill the needs of evacuees, or because of traffic jams on routes used by evacuees fleeing from the exposed area. Disseminating the warning and advice for an evacuation and for them to be heard and understood by as many people as possible in a short amount of time is a major issue. If these problems are not addressed fully before a flood disaster, the warning period (or lead time) may be insufficient to allow all residents to leave the exposed area. Sound evacuation planning must address all these issues so that everything is ready when a disaster is anticipated.

Ensuring evacuation is rapid and effective usually leads to the number of human casualties being reduced (Jonkman et al., 2008; Lumbroso, Gaume, Logtmeijer, Mens, & van der Vat, 2009). Goods and animals (e.g., pets) may also be included in evacuation plans if it is felt necessary, although priority should be given to humans. The indirect effects of a flood will decrease as a consequence in much the same way as direct effects. Firms may still need to cease activity during a flood, but if their employees are safe and unharmed, they may be able to return to work more rapidly after an event, limiting business disruption time. Also, if there are no human casualties, the attractiveness of the exposed region for residents and tourists is less likely to suffer. The psychological impact of the event will also be reduced.

However, evacuation is a complicated and risky process that brings with it a number of negative issues that must be taken into account when deciding to use such a loss mitigation option (Litman, 2006; Pine, Marx, Levitan, & Wilkins, 2003). The first complication is that people who are forced to leave their homes by car or by using a public transportation option are placed temporarily at a greater level of risk before they leave the exposed area. For example, in addition to the risk of motor vehicle accidents, there is the potential for them to be trapped in traffic jams when flooding commences. The probability of survival is then lower than if the evacuees had stayed at home. Also, if the evacuation is not prepared carefully, shelters may

lack essential items such as food, potable water, medicine, and so forth. Such events can cause panic, which increases quite rapidly when evacuees encounter difficulties. Last, making people leave their homes is not always easy and has a psychological cost no matter how it is done.

A key step in preparing an evacuation plan is collecting data. To make an evacuation plan as realistic as possible and to take advantage of all the facilities in the coastal region, the plan has to provide a clear understanding of the composition of the coastal region. The number of inhabitants and their spatial distribution is a key variable; other important parameters include the location of public facilities that may be used as shelters, the characteristics of transportation routes, and the media available to communicate to the people. Such data may be collected either from national databases or by surveys of residents, including face-to-face interviews (Hissel et al., 2014).

The evacuation plan should be established during ''quiet'' times, when no storm is likely to occur. The plan should present a sorted and prioritized list of actions to be taken prior to the flood and, as soon as evacuation is decided, together clear allocation of responsibilities for actions (Beaulieu & Marchand, 2001). It is recommended that different lists of actions be formulated for different kind of risks or combination of risks that may be anticipated (Morel et al., 2011). It is infeasible to address all possible situations, because, even if the meteorological and hydrological processes can be reasonably well predicted, dealing with the behaviors of human beings often generates the unexpected. Much may occur during an emergency that is impossible to predict and that can change the way the evacuation evolves, or even prevents it from evolving. One cannot predict such uncertain events, but at least the evacuation planner should assess the possible events that can interfere with an evacuation. Scenarios may then be prepared to reflecta wide scope of possible occurrences. Each scenario should contain a set of assumptions that describe how the evacuation evolves. The meteorological conditions responsible for the disaster are obviously included among these values, but in addition it is possible to include factors such as the likely number of people choosing to evacuate by vehicle, the season (which affects the number of tourists in the coastal region), and the time of the day, because this is likely to affect the extent of the reception of an evacuation order.

An evacuation plan must identify clearly the structure of the emergency response and the organizations involved in the process, along with the responsibilities of each key stakeholder (Beaulieu & Marchand, 2001; EMA, 2005). This is not always established clearly in national regulations, but there is no time to discuss or argue about this during a disaster. Therefore, everyone involved in emergency management should agree to their roles during a crisis before it actually happens. Even if public authorities are the first to be concerned with emergency management, private organizations may also be involved (Beaulieu & Marchand, 2001). To guarantee their

involvement during disasters, contracts with private organizations, which describe their role during the crisis, should be sought and signed on before a crisis occurs.

With all the data collected, the list of actions to be carried out before the crisis may be prepared. Each action is associated with one or more of the organizations involved in emergency management. The evacuation plan is the collection of the documents associated with the steps that described earlier. This plan should be communicated carefully to all those who will contribute to emergency management. Part of the plan should be disseminated to citizens so they are prepared to receive an evacuation order and understand what it means. The plan must be tested during exercises and must also be updated on a regular basis.

5.7.2 Evacuation Plans Associated with Resilience Enhancement

Evacuation planning contributes to the coastal system homeostasis (Table 5.1). First, the data collection stage includes interviews with stakeholders and citizens, and surveys of the population. Not only are such actions necessary to generate realistic action plans, but also they contribute to risk and evacuation awareness of the population at risk. Inhabitants who are better informed about the risk are more likely to accept the instructions of local authorities when a flood is approaching, and they may also be more inclined to take individual measures to protect their homes against the flood to supplement the measures taken by local authorities. Evacuation plans usually insist on the need to educate people about appropriate response behaviors when confronted by a flood threat. Well-prepared plans should consider citizens as actors in their own safety (Litman, 2006; Townsend, 2006). Inhabitants are part of the protection system; emergency management units often have insufficient time and resources to take fully into account all individual situations, but they are able to provide advice and recommendations, and provide assistance to those residents who need it most. Apart from this, they have to trust citizens and hope they will behave in a responsible manner. In this sense, an evacuation plan based on the methodology described in (Hissel et al. 2014) helps to create a feedback loop between authorities and organizations involved in crisis management, as well as the citizens who are included in the emergency management process.

Effective evacuation planning relies on a considerable amount of data about flood risk and those exposed to it, but this information is usually insufficient to predict reliably whether a plan is likely to produce the expected results, which is to bring all people to a safe place before the flood actually strikes. To this aim, lessons learned from previous floods and from realistic emergency exercises are invaluable (EMA, 2005; Morel et al., 2011). Exercises will pinpoint issues with actions plans and will help planners understand which kind of unforeseen events might hinder their application. Action plans can also benefit from homeostasis of the system. For example, a feedback loop between emergency management and urban planning,

incorporating risk-aware spatial planning of new districts, may facilitate evacuation by providing well-equipped shelters close to every district that are capable of accommodating the number of people expected. Acquiring information about the way the evacuation is taking place also helps authorities to adapt time their action plans in real time to the current situation.

Evacuation plans include considerations regarding the system's omnivory and, in this way, contribute to this resilience principle. The very basic process that a flooded city is unable to deliver is providing its residents with the primary goods they need to survive: food, potable water, medicine and medical equipment, warm places to sleep, and safety through law enforcement, hygiene, and power. A sound evacuation provides a new way of fulfilling these needs when people are relocated in shelters that offer decent accommodation. The functioning of the system depends on the capacity of people to move from place to place, for example, to see their relatives and to keep working. This may be seriously compromised in the case of a major disaster in which a city is mostly under water. However, if only a part of a city's territory is flooded, the evacuation plan should include measures to supplement normal transportation options that are disrupted because of a flood. Evacuation planning may also benefit from different strategies regarding the ways by which people are brought to safety. In fact, a mass evacuation is seldom a solution, and it is likely to put more people in danger than a more targeted and selective evacuation. One should consider different kinds of relocation based on the actual characteristics of the flooded districts (Kolen, Kok, Helsloot, & Maaskant, 2013). In some places where the flood duration is not too long, a vertical evacuation to higher levels may be rapid and effective; in other districts where water levels and velocities are lower, in-place sheltering may be an appropriate option. These alternative strategies are likely to have less psychological impacts than others, and a lower concentration of people on evacuation routes also involves a lower probability of critical accidents occurring. Preventive horizontal evacuation should be used only when there is no alternative.

The high-flux principle for resilient systems is associated with the fact that a resilient system should provide a rapid response to threats and changes. This is the main purpose of evacuation planning as a mitigation option. Indeed, when faced with an extreme event involving a large flood extent, regardless of whether they are well prepared, the authorities will always tend to decide on evacuation. However, collection of data before a crisis and the planning of actions beforehand when there is time to consider consequences and risks, can expedite decision-making processes during an event. Here, planning is key to speeding up the flux of information in real time. An evacuation plan should also be based on establishing a warning system based on detection and forecasting of a flood. Modern information and communication technologies should be harnessed alongside some low-tech ones to keep informed those citizens and organizations responsible for emergency management (Litman, 2006). By following these recommendations, flows of information are

likely to be more rapid. Evacuation benefits from high flux in the system, when this flux allows for a rapid dissemination of risk information and evacuation orders across the population.

Flatness, as a resilience principle, is the characteristic of an organization that is not overly hierarchical and heavy. The mitigation option related to evacuation planning facilitates the introduction of this characteristic in the system by clearly identifying the persons and organizations responsible for the different stages of the emergency response and by promoting citizen involvement in a coordinated response. If all those responsible for the different actions comprising evacuation plans are clearly identified, this reduces the need for hierarchical pyramids to be involved in making decisions, thus producing a faster reaction. The involvement of citizens is crucial because they are usually willing to help the authorities and their relatives, but they do not always know how to be useful, as has been shown during recent events (Litman, 2006). Thus, a well-informed public, the actions of which are channeled toward priority actions through preventive information and planning, can prove to be highly useful in supplementing the actions of regular emergency organizations (Keys & Opper, 2002).

Evacuation planning may contribute to an improving buffering quality by identifying places that are most likely to get flooded during an event and focusing on evacuating them very rapidly when the event is forecast. Those districts are then less vulnerable to the flood, and the evacuated areas can be used as a buffer to reduce the level of flooding in other districts. Thus, an evacuation in multiple stages can be planned, during which the most exposed but less vulnerable places are evacuated first and the most vulnerable places are protected for a longer time. However, this strategy only works if one can estimate the dynamics of the flood and if the arrival of the flood is not so fast that it becomes impossible to distinguish between evacuation sectors. In evacuation plans, it is advisable to elevate vital functions as much as possible (EMA, 2005). The shelters and transportation networks, which play a central role in the evacuation process, should be protected against rising water levels and elevated above the level of the adjacent ground. Nonessential functions or flood-resistant infrastructures can remain at ground level. To this end, evacuation planning should be combined with risk-aware spatial planning.

Evacuation planning contributes to improving the redundancy of the flood-prone area when it is combined with other nonstructural measures, with the same purpose of limiting the number of human casualties of a flood event, such as early warning, educating people about the consequences of the risk, and so on. Evacuation planning also benefits from redundancy in all the components of the system. For instance, the provision of different transportation options for people who wish to evacuate can reduce the number of individual vehicles on roads and may help avoid traffic congestion. The addition of a number of shelters spread across a territory also contributes to reduce the risk of a major problem should the authorities be unable to

accommodate all evacuees. Multiple communication media help in addressing more people in disseminating evacuation orders and information about which shelter to move to and which route to take. Using several sources of energy helps to avoid a total power blackout in shelters. Therefore, redundancy is a crucial element of an effective evacuation plan.

5.8 Conclusions

The mitigation options presented here share the potential to increase coastal safety in the face of climate change. From general principles of reducing vulnerability and increasing resilience, key criteria need to be met to maximize risk reduction.

The first element central to all options lies in the need to adopt approaches that incorporate stakeholders in the implementation process. Involving stakeholders reduces vulnerability by increasing insurance scheme efficiency, accepting spatial planning processes, reinforcing the implementation of evacuation plans and BCPs, and allowing for better organized postflood recovery planning. It is central to develop communication schemes allowing for the development of a shared understanding of coastal risks. Involving stakeholders also increases the resilience of coastal systems by (1) contributing to the coastal system homeostasis by fostering multidirectional information flow, (2) promoting high flux through the multiplication of information transfer channels, and (3) increasing flatness by creating bypasses in hierarchical governance systems.

A second element that is central to all nonstructural mitigation options is the fact that they increase safety through a reduction in consequences. As such, they cater to the priority of individuals at risk. This has a double benefit. First, it allows the correct prioritization of investments in cognitive and material resources. Second, by focusing on the central concern of those at risk, it contributes to their involvement in the mitigation choices.

A third element that nonstructural mitigation options share is the fact that they interact strongly, showing the potential to transcend the sum of their individual contributions. Insurance schemes that are designed according the discussion in Section 5.2.2 must internalize the premiums' existing land use, BCP, and other individual-level risk-reduction behavior. Land use planning must take into account business continuity planning, postflood recovery and evacuation planning, and vice versa. Risk communication applies to all mitigation options.

These three characteristics lead to three overarching recommendations in the implementation of nonstructural mitigation options:

1. Participatory approaches to mitigation choice and implementation should be favored as much as possible.

2. When envisioning coastal risk management, the entry point should be the reduction of consequences.
3. When envisioning mitigations options, they should always be thought as a part of a system comprising several mitigation possibilities.

When facing the choice of mitigation options, it is critical to move stepwise by envisioning key questions. Considering specific mitigation options, these questions are focused on site specificities. A clear understanding of the site specificities in terms of insurance, spatial planning, business continuity planning, postflood recovery, risk communication, and evacuation plan should be conducted as part of the risk assessment phase (see Chapter 2).

On the insurance front, effectiveness is conditional on the current insurance framework within which a specific community or region is embedded. If formal insurance does not exist, historical compensation schemes (mostly public) should be explored to determine how they may be improved by following the approaches described in Section 5.5.2, including how a more formal system may be put into place. If formal insurance exists, they should be assessed in the light of the discussion in Section 5.5.2. For land use planning, planners should be involved in a formal exercise that evaluates the inclusion of FCERM within their practice. In terms of BCP, SMEs should be approached to assess their capacity for implementing the BCP, and the existence of BCPs for large businesses should be confirmed. The central elements emphasized in Section 5.5.4 should not be overlooked. The recommendations associated with postflood recovery are an integral part of any risk assessment procedure. In terms of risk communication, there is an emphasis on the importance of not focusing solely on knowledge gaps as a key driver for risk communication. A much richer approach is needed for which not only evidence is discussed, but also norms and material constraints are considered. Last, when envisioning evacuation plans, a data needs and availability assessment should be conducted. After these steps have been taken, an explicit assessment should be undertaken of the most adaptable options and their synergies.

The options presented in this chapter may give the impression that guidance is lacking on how to respond to a flood threat at the site level (i.e., that guidance is lacking decisions regarding a given measure, or combination of measures, and their implementation). This is the result of a choice made by us, through our collective experience as social scientists. We recognize that, in terms of nonstructural options, such recommendations cannot be made. The diversity of institutional coastal settings means that establishing dichotomous choices is misleading at best and, potentially, counterproductive. Nonstructural mitigation options should therefore be regarded as highly adaptable approaches to the fostering of safer coasts. All nonstructural options have a potential role, provided that stakeholder participation is nurtured, that the

central entry point is the reduction of consequences, that cross-influences among mitigation options are always analyzed, and that vulnerability and resilience are envisioned jointly.

References

Adger, W. N. (2006). Vulnerability. *Global Environmental Change – Human and Policy Dimensions, 16*(3), 268–281. http://dx.doi.org/10.1016/j.gloenvcha.2006.02.006.

Barnes, J. C. (2001). *A guide to business continuity planning*. London, UK: J Wiley and Sons.

Bastien-Daigle, S., Vanderlinden, J.-P., & Chouinard, O. (2008). Learning the ropes: lessons in integrated management of coastal resources in Canada's maritime provinces. *Ocean & Coastal Management, 51*(2), 96–125. http://dx.doi.org/10.1016/j.ocecoaman.2007.04.006.

Beaulieu, P., & Marchand, J.-F. (2001). *Guide de planification strate´gique des ope´rations d'e´vacuation en milieu hautement urbanise´*. Publication préparée pour Bureau de la protection des infrastructures essentielles et de la protection civile, Gouvernement du Canada. Groupe de Recherche Interdisciplinaire en Gestion de l'Environnement (GRIEGE), Université de Québec. http://publications.gc.ca/collections/Collection/D82-42-2003E.pdf. Accessed 05.11.13 (in English).

Berkes, F., Colding, J., & Folke, C. (Eds.). (2003). *Navigating social ecological systems, building resilience for complexity and change*. Cambridge, UK: Cambridge University Press.

Birkmann, J. (2007). *Climate change and vulnerability: Challenges for spatial planning and civil protection*. Forum DKKV/CEDIM: Disaster Reduction in Climate Change. Karlsruhe, Germany: Karlsruhe University http://www.unisdr.org/files/8020_03Birkmann1.pdf. Accessed 28.10.13.

Botzen, W. J. W., Aerts, J. C. J. H., & van den Bergh, J. C. J. M. (2009). Willingness of homeowners to mitigate climate risk through insurance. *Ecological Economics, 68*(8–9), 2265–2277. http://dx.doi.org/10.1016/j.ecolecon.2009.02.019.

Bowker, B., Escarameia, M., & Tagg, A. (2007). *Improving the flood performance of new buildings. Flood resilient construction*. London, UK: Department for Communities and Local Government, Department of Environment, Food and Rural Affairs, Environment Agency and CIRIA.

Business Continuity Institute, B. C. R. (2005) (www.thebci.org).

Chouinard, O., Baztan, J., & Vanderlinden, J.-P. (2011). *Zones co^tie`res et changements climatiques (in French)*. Québec, Canada: Presses de l'Université du Québec.

Dawson, R. J., Ball, T., Werritty, J., Werritty, A., Hall, J. W., & Roche, N. (2011). Assessing the effectiveness of non-structural flood management measures in the Thames Estuary under conditions of socio-economic and environmental change. *Global Environmental Change-Human and Policy Dimensions, 21*(2), 628–646. http://dx.doi.org/10.1016/j.gloenvcha.2011.01.013.

Deboudt, P. (2010). Towards coastal risk management in France. *Ocean & Coastal Management, 53*(7), 366–378. http://dx.doi.org/10.1016/j.ocecoaman.2010.04.013.

EA. (2012). *Thames Estuary 2100: Managing flood risk through London and the Thames estuary*. London, UK: Environment Agency. http://www.environment-agency.gov.uk/homeandleisure/floods/125045.aspx. Accessed 19.11.13.

EMA. (2005). *Evacuation planning*. Australian emergency manual series, No. 11. Dickson, ACT, Australia: Emergency Management Australia, Attorney-General's Office, Australian Government http://www.em.gov.au/Documents/Manual11-EvacuationPlanning.pdf. Accessed 05.11.05.

Ferraris, D. P. (2007). The role of coordination and the ability of interaction among civil protection operators into international experiences, in case of tunnel accident and flood risk. In *Pre-emergencies, preparedness, management, communication and lesson learnt in emergencies* (pp. 11–56).

Glavovic, B. C., Saunders, W., & Becker, J. (2010). Realising the potential of land-use planning to reduce hazard risks in New Zealand. *Australasian Journal of Disaster and Trauma Studies*. Online journal http://trauma.massey.ac.nz/issues/2010-1/glavovic.htm. Accessed 28.10.13.

Hiles, A. (2011). *The definitive handbook of business continuity management*. London, UK: J Wiley and Sons.

Hissel, F., Morel, G., Pescaroli, G., Graaff, H., Felts, D., & Pietrantoni, L. (2014). Early warning and mass evacuation in coastal cities. *Coastal Engineering, 87*, 193–204.

Jonkman, S. N., Vrijling, J. K., & Vrouwenvelder, A. C. W. M. (2008). Methods for the estimation of loss of life due to floods: a literature review and a proposal for a new method. *Natural Hazards, 46*(3), 353–389. http://dx.doi.org/10.1007/s11069-008-9227-5.

Kahan, D. M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L. L., Braman, D., et al. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change, 2*(10), 732–735. http://www.nature.com/nclimate/journal/v2/n10/abs/nclimate1547.html#supplementary-information.

Kane, I. O., Vanderlinden, J.-P., Baztan, J., Touili, N., & Claus, S. (2014). Communicating risk through a DSS: A coastal risk centred empirical analysis. *Coastal Engineering, 87*, 240–248.

Keys, C., & Opper, S. (2002). On the proper conceptualisation of the warning, evacuation and community education tasks in the context of planning for dam failure. In *Presented at the Australian national committee on large dams (ANCOLD) 2002 Glenelg, Australia*. http://www.ses.nsw.gov.au/resources/research-papers/dams/on-the-proper-conceptualisation-of-the-warning.

Kleinosky, L., Yarnal, B., & Fisher, A. (2007). Vulnerability of Hampton roads, Virginia to storm-surge flooding and sea-level rise. *Natural Hazards, 40*(1), 43–70. http://dx.doi.org/10.1007/s11069-006-0004-z.

Kolen, B., Kok, M., Helsloot, I., & Maaskant, B. (2013). EvacuAid: a probabilistic model to determine the expected loss of life for different mass evacuation strategies during flood threats. *Risk Analysis, 33*(7), 1312–1333. http://dx.doi.org/10.1111/j.1539-6924.2012.01932.x.

Kreibich, H., Seifert, I., Thieken, A., Lindquist, E., Wagner, K., & Merz, B. (2011). Recent changes in flood preparedness of private households and businesses in Germany. *Regional Environmental Change, 11*(1), 59–71. http://dx.doi.org/10.1007/s10113-010-0119-3.

Kunreuther, H., & Pauly, M. (2006). Rules rather than discretion: lessons from Hurricane Katrina. *Journal of Risk and Uncertainty, 33*(1–2), 101–116. http://dx.doi.org/10.1007/s11166-006-0173-x.

Litman, T. (2006). *Lessons from Katrina and Rita, Victoria transport policy institute*. Victoria, BC, Canada: Victoria Transport Policy Institute. http://www.vtpi.org/katrina.pdf. Accessed 31.10.13.

Lumbroso, D., Gaume, E., Logtmeijer, C., Mens, M., & van der Vat, M. (2009). *Evacuation and traffic management*. Floodsite Report T17-07-02. Delft, The Netherlands: Delft Hydraulics http://www.floodsite.net/html/partner_area/project_docs/T17_07_02_Evacuation_and_traffic_management_D17_1_V4_4_P01.pdf. Accessed 05.11.13.

Morel, G., Hissel, F., Juan Jia, X., & Bouchrit, A. (2011). Aide à la planification des évacuations de masse en cas d'inondation ou de submersion majeure. In *Presented at the 7th Ge´orisques: Plan communal de sauvegarde, retour d'expe´riences et bilan, outils de gestion de crise 26–27 January*. Montpellier 3: Université Paul-Valéry.

Newport, J. K., & Jawahar, G. G. P. (2003). Community participation and public awareness in disaster mitigation. *Disaster Prevention and Management, 12*(1), 33–36. http://dx.doi.org/10.1108/09653560310463838.

Nivolianitou, Z., & Synodinou, B. (2011). Towards emergency management of natural disasters and critical accidents: the Greek experience. *Journal of Environmental Management, 92*(10), 2657–2665. http://dx.doi.org/10.1016/j.jenvman.2011.06.003.

Parker, D. J. (November 2007). *Evaluating business interruption losses caused by flooding*. London, UK: Presentation to the Lighthill Risk Network.

Penning-Rowsell, E. C., Priest, S., Parker, D. J., Morris, J., Tunstall, S. M., Viavattene, C., et al. (2013). *Flood and coastal erosion risk management: A manual for economic appraisal*. London, UK and New York, USA: Routledge.

Pennings, J. M., & Grossman, D. B. (2008). Responding to crises and disasters: the role of risk attitudes and risk perceptions. *Disasters, 32*, 434–448.

Pine, J., Marx, B., Levitan, M., & Wilkins, D. (2003). Comprehensive assessment of Hurricane shelters: lessons from Hurricane Georges. *Natural Hazards Review, 4*(4), 197–205. http://dx.doi.org/10.1061/(ASCE)1527-6988(2003)4:4(197).

Pottier, N., Penning-Rowsell, E., Tunstall, S., & Hubert, G. (2005). Land use and flood protection: contrasting approaches and outcomes in France and in England and Wales. *Applied Geography, 25*(1), 1–27. http://dx.doi.org/10.1016/j.apgeog.2004.11.003.

Renn, O. (2008). *Risk governance: Coping with uncertainty in a complex world*. London, UK: Earthscan.

Richards, J., White, J., & Carter, J. (2008). Local planning practice and flood risk management in England: is there a collective implementation gap? *Environnement Urbain/Urban Environment, 2*, 11–20.

Richardson, H. W., Gordon, P., & Moore, J. E. (Eds.). (2008). *Natural disaster analysis after Hurricane Katrina. Risk assessment, economic impacts and social implications*, Chapter 14 (pp. 253–278). Cheltenham, UK: Edward Elgar.

Samuels, P. G. (2006). A European perspective on current challenges in the analysis of inland flood risks. In J. Schanze, E. Zeman, & J. Marsalek (Eds.), *Flood risk management: Hazards, vulnerability and mitigation measures*. Dordrecht, The Netherlands: Springer Netherlands.

Simpson, D. (2001). Community emergency response training (CERTs): a recent history and review. *Natural Hazards Review, 2*(2), 54–63. http://dx.doi.org/10.1061/(ASCE)1527-6988(2001)2:2(54).

Simpson, D. M. (2002). Earthquake drills and simulations in community-based training and preparedness programmes. *Disasters, 26*(1), 55–69. http://dx.doi.org/10.1111/1467-7717.00191.

Snedaker, S. (2007). *Business continuity and disaster recovery planning for IT professionals*. Burlington, MA, USA: Syngress and Elsevier Publishing.

Syed, A., & Syed, A. (2003). *Business continuity planning methodology*. Washington DC, USA: Sentry.

THESEUS OD4.8. (2013). *Structured portfolio of tested operational innovative tools and protocols for policy and management purposes of coastal flooding risks*. http://www.theseusproject.eu/resources/documents/Deliverables/Official-Deliverables-(OD)/OD4.8-(M36)-Structured-portfolio-of-tested-operational-innovative-tools-and-protocols-for-policy-and-management-purposes-of-coastal-flooding-risks./.

Thevenaz, C., & Resodihardjo, S. L. (2010). All the best laid plans . conditions impeding proper emergency response. *International Journal of Production Economics, 126*(1), 7–21. http://dx.doi.org/10.1016/j.ijpe.2009.09.009.

Touili, N., Baztan, J., Vanderlinden, J.-P., Kane, I. O., Diaz-Simal, P., & Pietrantoni, L. (2014). Public perception of engineering-based coastal flooding and erosion risk mitigation options: lessons from three European coastal settings. *Coastal Engineering, 87*, 205–209.

Townsend, F. F. (2006). *The federal response to Hurricane Katrina: Lessons learned*. Washington DC, USA: The White House. http://library.stmarytx.edu/acadlib/edocs/katrinawh.pdf. Accessed 05.11.13.

Treby, E. J., Clark, M. J., & Priest, S. J. (2006). Confronting flood risk: Implications for insurance and risk transfer. *Journal of Environmental Management, 81*(4), 351–359. http://dx.doi.org/10.1016/j.jenvman.2005.11.010.

UNISDR. (2005). *The Hyogo Framework for Action 2005–2015: Building the resilience of nations and communities to disasters*. Geneva, Switzerland: United Nations Office for Disaster Risk Reduction. http://www.unisdr.org/we/inform/publications/1037. Accessed 05.11.13.

Vari, A., Linnerooth-Bayer, J., & Ferencz, Z. (2003). Stakeholder views on flood risk management in Hungary's Upper Tisza Basin. *Risk Analysis, 23*(3), 585–600. http://dx.doi.org/10.1111/1539-6924.00339.

Vorst, H. C. M. (2010). *Evacuation models and disaster psychology*. In *Procedia engineering* (Vol. 3). http://ac.els-cdn.com/S187770581000473X/1-s2.0-S187770581000473X-main.pdf?_tid¼c4d78278-72e8-11e3-9ea7-00000aacb35d&acdnat¼1388583161_9b031dd08a472dabd69e4da0165bef2e.

Wallace, M., & Webber, L. (2010). *The disaster recovery handbook: A step-by-step plan to ensure business continuity and protect vital operations, facilities and assets*. New York, USA: AMACOM.

Wardekker, J. A., de Jong, A., Knoop, J. M., & van der Sluijs, J. P. (2010). Operationalising a resilience approach o adapting an urban delta to uncertain climate changes. *Technological Forecasting and Social Change*, 987–998.

Wu, S. Y., Yarnal, B., & Fisher, A. (2002). Vulnerability of coastal communities to sea-level rise: a case study of Cape May County, New Jersey, USA. *Climate Research, 22*(3), 255–270. http://dx.doi.org/10.3354/cr022255.

Zanuttigh, B. (2011). Coastal flood protection: what perspective in a changing climate? The THESEUS approach. *Environmental Science & Policy, 14*(7), 845–863. http://dx.doi.org/10.1016/j.envsci.2011.03.015.