# Chapter 8. Toward a Sustainable and Resilient Future

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## Executive Summary

**Adapting to climate extremes associated with rapid and severe climate change without transformational social change will be difficult: If not chosen through proactive policies, forced transformations and crises are likely to result**. This chapter reviews the disaster risk management and climate change adaptation and development studies literature to describe knowledge on the risks of climate extremes for sustainable development and how society might face this challenge and so be made more resilient.

**Current climate variability and projected changes in climate extremes pose different challenges to affected human and natural systems than those caused by changes in the means of climate variables.** Where changes in extremes cause greater stresses on human and natural systems than changes in averages, direct impacts may be more unpredictable, and associated adaptation challenges are often greater. On the ground, the impacts of climate extremes are experienced alongside risks associated more directly with social, political and economic forces. Managing the impacts of extremes without taking multiple-stressors into account may lead to sub-optimal strategies and trade-offs; measures implemented to reduce one risk may end up enhancing others.

**Building resilient and sustainable development pathways** requires integrated, systemic approaches that enhance the capacity of social-ecological systems to cope with, adapt to, and shape unfolding processes of change, while taking into consideration multiple stressors, different prioritized values, and competing policy goals.. Evidence of the success and limitations of these approaches indicate that disaster risk management and adaptation policy can be reinforcing and supportive – but this requires careful coordination that reaches across domains of policy and practice.

**Developing synergies between disaster risk reduction and adaptation to climate change requires a closer look at the values and interests that underpin development, including recognition of winners and losers, and implications for human security**. Key challenges for both disaster risk reduction and climate change adaptation are to reassess and transform institutions and governance arrangements; create synergies across scales; and, increase access to information, technology, resources and capacity, particularly in countries and localities with the highest climate-related risks and weak capacities to manage those risks.

**Interaction between climate change mitigation, adaptation and disaster risk reduction will have a major influence on the ways in which development transforms towards resilient and sustainable pathways.** Trade-offs and synergies between the goals of mitigation and adaptation in particular will play out locally, but have global consequences in aggregate.

**Generic approaches to disaster risk management and climate change adaptation, especially at the local scale, are likely to be less successful than ones tailored to the unique opportunities and challenges of the local context.** Fostering flexible and sustainable livelihoods is one example of an important local and context-specific adaptation to climate change. Managing the risks associated with frequently occurring low-intensity events is one effective here-and-now strategy to adapt to climate change and build resilience to cope with future extremes. However, it is necessary to ensure that current risk reduction measures do not exacerbate current or future vulnerability, as choices made today can facilitate or constrain future responses. Even when ambitious risk reduction measures are implemented, there are often residual risks related to exceptional events.

**Development planning and post-disaster recovery have often prioritized strategic economic sectors and infrastructure over livelihoods and well-being in poor or marginalized communities.** This is partly a result of time-bound reconstruction funding and represents a missed opportunity for building local capacity and including local development visions in disaster risk reduction and climate change adaptation strategies. Technology transfer can help to reduce vulnerabilities to natural hazards and climate change, but needs to be accompanied by capacity development and anchored in local contexts.

**Short-term and long-term perspectives on both disaster risk reduction and climate change adaptation are often difficult to reconcile**. There are trade-offs between current decisions and long-term goals linked to diverse values, interests, priorities and visions for the future. Resilience thinking offers some tools for reconciling short-term and long-term responses, including integrating different types of knowledge, an emphasis on inclusive governance, and principles of adaptive management. Thresholds or tipping points exist in natural and socio-economic systems, and pose limits to resilience.

**Addressing the underlying causes of vulnerability and the structural inequalities that create and sustain poverty and constrain access to resources can be considered a prerequisite for sustainability.** This involves integrating disaster risk reduction in other social and economic policy problems, as well as a long-term commitment to managing risk.

**Where vulnerability is high and adaptive capacity relatively low, it is likely that changes in extreme climate events and climate extremes will make it difficult for systems to adapt sustainably without transformational changes, as contrasted with incremental changes or business as usual.** Such transformations, where they are required, represent significant challenges that call for increased emphasis on adaptive management, learning, innovation and leadership.

**Iterative learning, which includes anticipation, cross-scale analysis and reflection, is a key component of sustainability in the context of climate extremes.** However, few empirical results exist to demonstrate how to best facilitate and sustain such learning in practice. Developing new knowledge and innovation that supports transformation calls for adaptive leadership among a wide range of stakeholders; this includes questioning mindsets, assumptions and paradigms, and encouraging innovation and the generation of new patterns of response.

**There is no single approach or development pathway conducive to living with climate change extremes**. Choices and outcomes for adaptive actions to climate extremes and extreme events are complicated by divergent capacities and resources and multiple interacting processes. These are framed by trade-offs between competing prioritized values and objectives, and different visions of development that can change over time.

## 8.1. Introduction

This chapter focuses on the implications of climate change extremes and extreme events for development, and considers how disaster risk reduction and climate change adaptation together can contribute to a sustainable and resilient future. Changes in the frequency, timing, magnitude, and characteristics of extreme events pose challenges to disaster risk reduction and climate change adaptation, both in the present and in the future. Enhancing the capacity of social-ecological systems to cope with, adapt to, and shape change is central to building sustainable and resilient development pathways in the face of climatic change. Despite twenty years on the policy agenda, sustainable development remains contested, with well-defined tensions between understandings that emphasize its economic, social and environmental dimensions (Hopwood *et al*., 2005). Resilience refers to a systems concept and approach that examines how systems deal with and shape disturbance and surprise (Walker and Salt, 2006; Folke, 2006; Brand and Jax, 2007). Approaches that focus on resilience emphasize the need to manage for change, to see change as an intrinsic part of any system, social or otherwise, and to 'expect the unexpected'. Resilience thinking contrasts with the conventional engineering systems emphasis on capacity to control and absorb external shocks in systems assumed to be stable, towards managing the capacity of evolving social-ecological systems to cope with, adapt to and shape change (Folke, 2006). Resilience approaches offer three key contributions for living with extremes: First in providing a holistic framework to evaluate hazards in coupled human-environment systems; second, in putting emphasis on the ability to deal with hazard or disturbance; and third, in helping to explore options to dealing with uncertainty and future changes (Berkes, 2007).

Extremes are translated into impacts by the underlying conditions of exposure and vulnerability associated with development contexts. For example, governance weaknesses often transform extreme events into disasters (Ahrens and Rudolph, 2006; Hewitt, 1997; Pelling, 2003; Wisner *et al*., 2004). At root, this is a discussion about decision-making and its framing for those at risk and engaged in risk management. Global risk assessments show that the social and economic losses already associated with climate extremes are disproportionately concentrated in developing countries, and within these countries in poorer communities and households (UNDP, 2004; ISDR, 2009; World Bank, 2010a). The potential for concatenated global impacts of extreme events continues to grow as the world's economy becomes more interconnected, but most impacts will occur in contexts with severe environmental, economic, technological, cultural, and cognitive limitations to adaptation. A reduction in the risks associated with climate extremes is therefore a question of political choice, which involves addressing issues of equity, rights and access at all levels.

This chapter assesses a broad literature presenting insights on how diverse understandings and perspectives on disaster risk reduction and climate change adaptation can promote a more sustainable and resilient future. Drawing on many of the key messages from earlier chapters, the objective is to assess scientific knowledge on the transformative changes needed, particularly in relation to development policies and pathways. The chapter recognizes that outcomes of changing extreme events depend on responses and approaches to disaster risk reduction and climate change adaptation, both of which are closely linked to development processes. A key point emphasized throughout this chapter is that changes in extreme events call for greater alignment between climate change responses and sustainable development strategies, but that this alignment depends on greater coherence between short-term and long-term objectives. Yet there are different interpretations of development, different preferences and prioritized values and motivations, different visions for the future, and many trade-offs involved. Research on the resilience of social-ecological systems provides some lessons for addressing the gaps between these objectives. Transformative social, economic, and environmental changes can facilitate disaster risk reduction and adaptation (Kovats *et al*., 2005). A resilient and sustainable future is a choice that involves proactive measures that promote transformations, including adaptive management, learning, innovation, and build the leadership capacity to manage risks and uncertainty (Loorbach *et al*., 2008; Hedrén and Linnér, 2009; Pelling 2010a).

## 8.2. Disaster Risk Reduction as Adaptation: Relationship to Sustainable Development Planning

Earlier chapters discussed the concepts of and relationship between disaster risk reduction and climate change adaptation. Disaster risk reduction and climate change adaptation are concepts and practices that overlap considerably and are strongly complementary. Disaster risk reduction considers hazards other than those that are climate-related, such as earthquakes and volcanoes, while climate change adaptation considers vulnerabilities related to phenomena that would not normally be classified as discrete disasters, such as gradual changes in precipitation, temperature, or sea level. Examples of hazards that are addressed by both communities include flooding and droughts; and both are fundamentally rooted in localized, relatively bottom-up responses to vulnerabilities and impacts.

Disaster risk reduction is increasingly seen as one of the "frontlines" of adaptation, and perhaps one of the most promising contexts for mainstreaming or integrating climate change adaptation into sustainable development planning. However, it requires modifying development policies, mechanisms, and tools, and identifying and responding to those who gain and lose from living with and creating risk. This is of added importance, given that many of the impacts of current and future climate change will be experienced through extreme weather events (Burton *et al*., 2002). However, contested notions of development and hence differing perspectives on sustainable development planning lead to different conclusions about how disaster risk reduction can contribute to adaptation. This section reviews the definitions of some of the key concepts used in this chapter, and considers how different prioritized values, ways of approaching the future, and technologies can influence sustainable development. It also considers the trade-offs that are involved in decision-making.

### *8.2.1. Concepts of Adaptation, Disaster Risk Reduction, and Sustainable Development and How they are Related*

Adaptation and disaster risk reduction are complementary and often overlapping approaches for reducing risks to sustainable development from disruptive climate extremes and extreme events. Although climate change adaptation also deals with slow changes in average climate conditions, it includes a disaster-risk-reduction component, since a significant fraction of climate change impact may consist of increased or modified disaster risks (IPCC, 2007). Because disaster risk reduction is based on risk assessments that will be affected by climate change, it can no longer be carried out without taking adaptation in account (Milly *et al*., 2008). Therefore although they are not identical concepts and practices, adaptation includes a disaster risk reduction component, and disaster risk reduction includes an adaptation component.

Adaptation to climate change has been defined as adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate, climate variability and associated extreme weather events (IPCC, 2007). Adaptation involves changes in social and environmental processes, practices and functions to reduce potential damages or to realise new opportunities, based on perceptions of climate risk (Weber, 2010). Adaptation actions may be anticipatory or reactive and may be undertaken by public or private actors. In both principle and practice, adaptation is more than a set of discrete measures designed to address climate change; it is an ongoing process that encompasses responses to many factors, including evolving experiences with both vulnerabilities and vulnerability-reduction planning and actions (Tschakert and Dietrich, 2010; Wolf , 2011).

Adaptive capacity underlies action and is defined as “the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behavior and in resources and technologies.” [IPCC WG II, AR4, chapter 17, p727]. Adaptive capacity can also be described as the capability for innovation and anticipation (Armitage, 2005), the ability to learn from mistakes (Adger, 2003), and the capacity to generate experience in dealing with change (Berkes *et al.*, 2003). Enhancing adaptive capacity under climate change entails paying attention to learning about past, present, and future climate threats, accumulated memory of adaptive strategies, and anticipatory action to prepare for surprises and discontinuities in the climate systems (Nelson *et al.*, 2007).

Adaptive capacity is uneven across and within sectors, regions, and countries (O’Brien *et al*., 2006). Although wealthy countries and regions have more resources to direct to adaptation, the availability of financial resources is only one factor determining adaptive capacity (Moss *et al*., 2010; Ford and Ford, 2011). Other factors include the ability to recognize the importance of the problem in the context of multiple stresses, to identify vulnerable sectors and communities, to translate scientific knowledge into action, and to implement projects and programs (Moser and Ekstrom, 2010). The capacity to adapt is in fact dynamic and influenced by economic and natural resources, social networks, entitlements, institutions and governance, human resources, and technology (IPCC Working Group 2, Summary for Policymakers, p.69). It is particularly important to understand that places with greater wealth are not necessarily less vulnerable to climate impacts and that a socio-economic system might be as vulnerable as its weakest link (Tol and Yohe, 2007; O’Brien *et al,* 2006). Therefore, even wealthy locations can be severely impacted by severe events, socially as well as economically, as the United States learned from Hurricane Katrina (IPCC WG 2, Chapter 7) and Europe from the 2003 heat wave (e.g., Salagnac, 2007). These risks may increase, given the possibility for novel hazards associated with climate change and extremes.

Current adaptation planning in many countries, regions, and localities is identifying a wide range of options, although the available knowledge of their costs, benefits, wider consequences, potentials, and limitations is limited (NRC, 2010). In many cases, the most attractive adaptation actions are those that offer development benefits in the relatively near term, as well as reductions of vulnerabilities in the longer term (Agrawala, 2005; Klein *et al*., 2007; McGray *et al*., 2007; Hallegatte, 2008a; NRC, 2010). An emerging literature discusses adaptation through the lens of sustainability, recognizing that not all adaptation responses are necessarily benign; there are tradeoffs, potentials for negative outcomes, competing interests, different types of knowledge, and winners and losers inherent in adaptation responses (Eriksen and O'Brien, 2007; Ulsrud *et al*., 2008; Barnett and O'Neill, 2010; Beckman, 2011; Brown, 2011; Eriksen *et al*., 2011; Gachathi and Eriksen, 2011; Owuor *et al*., 2011). Sustainable adaptation represents a shift in the boundaries of current approaches to adaptation, viewing it as a process that address the underlying causes of vulnerability and poverty, and a way of generating social transformation (Eriksen and O'Brien, 2007; Eriksen and Brown, 2011). Similarly, sustainable disaster risk reduction initiatives can be considered those that provide a useful, long-term function in everyday life as well as resources that can be used at times of extremes events, e.g., bridges that provide market access or public schools that can transform into evacuation sites or shelters during disasters (Pelling, 2010b; IFRC, 2002).

Disaster risk can be defined in many ways (see Chapter 1). In general, however, it is closely associated with the three interlinked concepts of hazards, exposure, and vulnerability. Hazards are usually interpreted as effects of physical phenomena such as floods, landslides, cyclones, drought or wildfires that are potentially dangerous to exposed populations or systems, although they can interact with other sources of stress as well. Purposeful harm (e.g., terrorist attacks) and technological accidents (e.g., chemical spills) or misuse also constitute hazards. Hazards are changing, not only as the result of climate change, but also due to human activities. For example, hazards associated with floods, landslides, storm surges and fires can be influenced by declines in regulatory ecosystem services. The drainage of wetlands, deforestation, the destruction of mangroves and the changes associated with urban development (such as the impermeability of surfaces and overexploitation of groundwater) are all factors that can modify hazard patterns (MEA, 2005; Nicholls *et al*., 2008; Nobre *et al.* 1991; Nobre *et al*., 2005). Indeed, most weather-related hazards now have an anthropogenic element (Lavell, 1999, Cardona, 1996).

Vulnerability has many different (and often conflicting) definitions and interpretations, both across and within the disaster risk and climate communities (see Chapter 2). In the risk management community, it is often considered the propensity or susceptibility of people or assets exposed to hazards to suffer loss, which may be closely associated with a range of physical, social, cultural, environmental, institutional and political characteristics (Lavell, 2009). In the climate change community (IPCC, 2007), vulnerability is a more integrated concept, combining hazard, exposure, risk-management, and adaptive capacity (Füssel and Klein, 2006). Vulnerability can increase or decrease over time as a result of both environmental and socioeconomic changes (Blaikie *et al*., 1994; Leichenko and O'Brien, 2008). In general, improvements in a country's development indicators have been associated with reduced vulnerability (UNDP, 2004; Schumacher and Strobl, 2008). As countries develop, there is often a reduction in human mortality, yet an increase in economic loss and insurance claims (ISDR, 2009; Pielke *et al.* 2008; Economics of Climate Adaptation Working Group, 2009; World Bank, 2010b). However, some types of development may increase vulnerability or transfer it between social groups, particularly if development is unequal or degrades ecosystem services (Guojie, 2003). Even where growth is more equitable, vulnerabilities can be generated, for example when modern buildings are not constructed to prescribed safety standards (Hewitt, 1997; Satterthwaite, 2007).

Climate change can magnify many preexisting risks through changes in the frequency, severity and spatial distribution of weather-related hazards (Chapter 3), as well as through increases in vulnerability due to changing climate means (e.g., decreased water availability, decreased agricultural production and food availability, or increased heat stress) (Pouyaud and Jordan, 2001). Like adaptation, disaster risk reduction may be anticipatory (ensuring that new development does not increase risk) or corrective (reducing existing risk levels) (Lavell, 2009). Given expected increases in rural and urban populations in hazard prone areas, anticipatory disaster risk reduction is fundamental to reducing the risk associated with future climate extremes. At the same time, investments in corrective disaster risk reduction are required to address the accumulation of existing climate risks, for example those inherited from past urban planning or rural infrastructure decisions.

Sustainable development is an international goal that can be threatened in some areas by climate change extremes, thus climate change adaptation and disaster risk reduction are critical elements of long-term sustainability for economies, societies, and environments at all scales (Wilbanks and Kates, 2010). The generally accepted and most widespread definition of sustainable development comes from the Brundtland Commission Report, which defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). A number of principles of sustainable development have emerged, including the achievement of a standard of human well-being that meets human needs and provides opportunities for social and economic development; that sustains the life support systems of the planet; that broadens participation in development processes and decisions; and that accelerates the movement of knowledge into action in order to provide a wider range of options for resolving issues (WCED, 1987; NRC, 1999; Meadowcroft, 1997; Swart *et al*., 2003; MEA, 2005). Because sustainable development means finding pathways that achieve both economic and environmental goals without sacrificing either, it is concept which is fundamentally political" (Wilbanks, 1994).

Discussions of relationships between sustainable development and climate change have increased over the past decades (Cohen *et al*., 1998; Yohe *et al*., 2007; Bizikova *et al*. 2010). Literatures on development and underdevelopment have considered how development paths relate to vulnerabilities to both climate change and to climate change policies (e.g., Davis, 2001; Garg *et al*., 2009), as well as to other hazards. Clearly, some climate change-related environmental shifts are potentially threatening to sustainable development, especially if the trends or events are severe enough require significant adjustment of development paths, which have become unsustainable (e.g., the relocation of population or economic activities to less vulnerable areas). In such cases, both disaster risk reduction and climate change adaptation can be important--even essential--contributors to sustainable development.

In neither the case of disaster risk reduction or adaptation, however, has the record been encouraging to date in reducing vulnerabilities in practice, particularly in developing countries. The exception to this is the large number of lives saved over the last decade attributed to improved disaster early warning systems (IFRC, 2005). This success is instructive but there remains much more that can be done to reduce mortality and counteract growth in the number of people affected by disasters. For example, a recent self-assessment of progress by 102 countries against the objectives of the Hyogo Framework of Action (ISDR, 2009) indicates that few developing countries have conducted comprehensive, accurate and accessible risk assessments, which are a pre-requisite for both anticipatory and corrective disaster risk reduction. Likewise, there are limited examples to date of successful climate change adaptations, at least partly because the ability to attribute observed environmental stresses to climate change is still limited (Fankhauser *et al*., 1999; Adger *et al*. 2007; Repetto, 2008). Both the adaptation and the disaster risk reduction perspectives have strengths to offer in responding to climate change extremes and extreme events, yet neither approach alone is sufficient as a long-term response to climate change.

If development affects vulnerability to disasters and climate change, the reverse is also true, since disasters can have significant impacts on poverty and economic growth. Econometrics analyses at national scale have reached different conclusions on the impact of disasters on growth. Albala-Bertrand (1993) and Skidmore and Toya (2002) suggest that natural disasters have a positive influence on long-term economic growth, probably due to both the stimulus effect of reconstruction and the productivity effect. Others, like Noy and Nualsri (2007), Noy (2009), Hochrainer (2009), Jaramillo (2009), and Raddatz (2009), suggest exactly the opposite, that the overall impact on growth is negative. As suggested by Cavallo and Noy (2010) and Loayza *et al*. (2009), this difference may arise from different impacts from small and large disasters, the latter having a negative impact on growth while the former enhance growth. At the local scale, Strobl (2011) investigates the impact of hurricane landfall on county-level economic growth in the United States. This analysis shows that a county that is struck by at least one hurricane in a year sees its economic growth reduced on average by 0.79 percentage point, and increased by only 0.22 percentage point the following year. Noy and Vu (2010) investigate the impact of disasters on economic growth at the province level in Vietnam, and found that lethal disasters decrease economic production while costly disasters increase short-term growth. Rodriguez-Oreggia *et al*. (2009) focus instead on poverty and the World Bank's Human Development Index at the municipality level in Mexico. They show that municipalities affected by disasters experienced an increase in poverty by 1.5 to 3.6 percentage point. Considering these important links between disasters and development, there is a need to consider disaster risk reduction, climate change adaptation and sustainable development in a consistent and integrated framework (Schipper and Pelling, 2006; O'Brien *et al*., 2006).

### *8.2.2. The Role of Values and Perceptions in Shaping Response*

Values and perceptions are important in influencing action on climate change extremes, as they can have significant implications for sustainable development. The disaster risk reduction community has used several points of view for resolving decisions about where to invest limited resources. These points of view include, for example, considerations of economic rationality and moral obligation (Sen, 2000). Value judgments are embedded in problem framing, solutions, development decisions, and evaluation of outcomes, thus it is important to make them explicit and visible. Values describe what is desirable or preferable, and they can be used to represent the subjective, intangible dimensions of the material and nonmaterial world (O'Brien and Wolf, 2010). Values often inform but are also shaped by action, judgment, choice, attitude, evaluation, argument, exhortation, rationalization, and attribution of causality (Rokeach 1979), but values do not always clearly translate to particular behaviors (Leiserowitz *et al.*, 2005). Adaptation and disaster risk reduction intervene in development processes, either by seeking to support the status quo or effect changes in development, and in doing so surface values. Recognizing and reconciling conflicting values increases the need for inclusiveness in decision-making and for finding ways to communicate across social and professional boundaries (Rosenberg, 2007; Vogel *et al.* 2007; Oswald Spring and Brauch, 2011).

Values are closely linked to worldviews and beliefs, including perceptions of change and causality (Rohan 2007; Leiserowitz 2006; Weber 2010). Losses from extreme events can have implications beyond objective, measurable impacts such as loss of lives, damage to infrastructure, or economic costs. They can lead to a loss of what matters to individuals, communities, and groups, including the loss of elements of social capital, such as sense of place or of community, identity, or culture. This has long been observed within the disaster risk community (Hewitt, 1997; Mustafa, 2005) and in more recent work in the climate change community (O'Brien, 2009; Adger *et al.*, 2010; Pelling, 2010). A values-based approach recognizes that socio-economic systems are continually evolving, driven by innovations, aspirations and changing values and preferences of the constituents (Simmie and Martin, 2010; Hedlund-de Witt, forthcoming). Such an approach raises not only the ethical question of 'Whose values count?', but also the important political question of 'Who decides?'. These questions have been asked both in relation to disaster risk (Blaikie *et al.*, 1994; Wisner, 2003; Wisner *et al.*, 2004) and to climate change (Adger, 2004; Hunt and Taylor, 2009; Adger *et al.*, 2010; O'Brien and Wolf, 2010), and are significant when considering the interaction of climate change and disaster risk, including the complexity of the temporal consequences of decisions (Pelling, 2003).

Two important frameworks have dominated attempts to establish priorities for risk management: human rights and economic approaches. Human rights approaches (Gardiner, 2010; Wisner, 2003) emphasize moral obligation to reduce avoidable risk and contain loss, and this has been recognised in the UN Universal Declaration of Human Rights since 1948: Article 3 provides for the right to 'life, liberty and security of person', while Article 25 protects 'a standard of living adequate for the health and well-being... in the event of unemployment, sickness, disability, widowhood, or old age or other lack of livelihood in circumstances beyond his [sic] control'. The humanitarian community, and civil society more broadly has made most progress in addressing these aspirations (Kent, 2001), perhaps best exemplified by The Sphere standards. These are a set of self-imposed guidelines for good humanitarian practices that require impartiality in post-disaster actions including shelter management, access and distribution to relief and reconstruction aid (Sphere, 2004). The ethics of risk management have also been explored in adaptation through the application of Rawls' theory of justice (Rawls, 1971). This logic argues that priority be given to reducing risk for the most vulnerable even if this limits the numbers who can be raised from positions of vulnerability (Grasso, 2009, 2010; Paavola, 2005; Paavola and Adger 2006;Paavola *et al.*, 2006). This is in contrast to the approach broadly taken in meeting the UN Millennium Development Goals, where global targets encourage support for the number of people to meet each standard rather than focussing on the most excluded or economically poor.

Economic rationality provides a range of frameworks for investment decisions built on cost-efficiency, and can help to reveal where calculated economic benefits are perceived to exceed costs as part of wider decision-making contexts. The calculated benefits of investing in risk reduction vary, but are often considered significant (see Ghesquiere *et al.*, 2006; World Bank 2010). There are, however, extreme difficulties in accounting for the complexity of disaster costs and risk reduction investment benefits (Pelling *et al.*, 2002). The probabilistic risk assessments that form the basis for current models of cost-benefit analysis rarely take into account the extensive risks that account for a substantial proportion of disaster damage for poorer households and communities (Marulanda *et al.*, 2010; ISDR, 2002, 2009). At the same time, outcomes such as increased poverty and inequality (Fuente and Dercan, 2008), health effects (Murray and Lopez, 1996; Grubb *et al.*, 1999; Viscusi *et al.*, 2003), cultural assets and historical building losses (ICOMOS, 1993), environmental impacts, and distributive impacts (Hallegatte, 2006) are very difficult to measure in monetary terms. Other types of valuation emphasise institutional elements such as the 'moral economy' associated with the collective memory and identities of people living in non-western cultures in many parts of the world (Scott, 2003; Rist, 2000; Hughes, 2001; Trawick, 2001).

### *8.2.3. Planning for the Future*

This section considers the tools that are available for helping decision-makers and planners think about and plan for the future in the context of climate change and extremes. Planning for a future with heightened uncertainty when the stakes are high, values disputed, and decisions urgent, creates tensions among different visions of development. Indeed, disaster risk reduction and climate change adaptation are fundamentally about planning for an uncertain future, a process that involves combining one's own aspirations (individual and collective) with perspectives on what is to come (Stevenson, 2008). Typically, decision-makers (representing households, local or national governments, international institutions, etc.) look to the future partly by remembering the past (e.g., projections of the near future are often derived from recent or experiences with extreme events) and partly by projecting how the future might be different, using forecasts, scenarios, visioning processes, or story lines – either formal or informal (Miller, 2007). Projections further into the future are necessarily shrouded in larger uncertainties. The most common approach for addressing these uncertainties is to develop multiple visions of the future (quantitative scenarios or narrative storylines), that in early years can be compared with actual directions of change (Boulanger*et al*., 2006a, 2006b).

Scenario development has become an established research tool both in the natural sciences (e.g., the SRES scenario of the IPCC) and in the social sciences (in political science, economics, military strategy and geography), based on different spatial scales (global, national and local) and temporal scales (from a few years to several decades or centuries). The challenge for disaster risk reduction and climate change adaptation is to produce realistic regional and sub-national scenarios at longer timescales (see Gaffin *et al*., 2004; Theobald, 2005; van Vuuren *et al*., 2006, azerty2010; Bengtsson *et al*., 2006; Grübler *et al*., 2007; Hallegatte *et al*., 2011a). Scenario development in the social sciences is often done in several stages. As a first step, structural projections of key determinants (population changes, urbanisation, etc.) are developed. Next, storylines reflecting different mind-sets or worldviews are designed through consultative processes, resulting in qualitative and contrasted visions of the future. Later, numerical models or expert judgements (e.g., Delphi exercises) may produce quantitative and qualitative scenarios, covering socioeconomic changes, scientific and technological developments, and changes in political mindsets, worldviews and cultural preferences. Because drivers of socio-economic change (e.g., demography, population preferences, technologies) and the behaviour of local climates are highly uncertain, scenarios must consider a wide range of possible futures (Lempert, 2007; Lempert and Collins, 2007; WGBU, 2008) to design adaptation strategies and analyze trade-offs (e.g., Dessai *et al*., 2009a; Dessai *et al*., 2009b; Hall, 2007; Hallegatte, 2009; Brauch and Oswald Spring, 2009). To do so, several approaches have been proposed to deal with uncertainty. These approaches are based on robust decision-making (e.g., Groves and Lempert, 2007; Groves *et al*., 2007; Lempert and Collins, 2007); or on the search for co-benefits, no regrets strategies, flexibility and reversibility (e.g., Fankhauser *et al*., 1999; Goodess *et al*., 2007; Hallegatte, 2009).

With climate change, difficult choices may become increasingly necessary. In many locations, for example, adapting to reduced water availability may involve increased investments in water infrastructure to provide enough irrigation to maintain existing agriculture production, or a shift from current production to less water consuming crops (see ONERC, 2009; Rosenzweig *et al*., 2004; Gao and Hu, 2011). The choices among different options depend on how the stakeholders see the region in coming decades, and on adaptation decisions that are informed by political processes. An approach that explicitly acknowledges both social and environmental uncertainties entails identification of flexible adaptation pathways for managing the future risks associated with climate change (Yohe and Leichenko, 2010). Based on principles of risk management (which emphasize the importance of diversification and risk-spreading mechanisms in order to improve social and/or private welfare in situations of profound uncertainty) this approach can be used to identify a sequence of adaptation strategies that are designed to keep society at or below acceptable levels of risk. These strategies, which policy makers, stakeholders, and experts develop and implement, are expected to evolve over time as knowledge of climate change and associated climate hazards progresses. The flexible adaptation or adaptive management approach also stresses the connections between adaptation and mitigation of climate change, recognizing that mitigation will be needed in order to sustain society at or below an acceptable level of risk (Yohe and Leichenko, 2010).

In contrast to predictive scenarios and risk management approaches, exploratory and normative approaches can be used to develop scenarios that represent desirable alternative futures, which is particularly important in the case of sustainability, where the most likely future may not be the most desirable (Robinson, 2003), and where poverty, inequity, and injustice is recognized by many as incompatible with a sustainable future (St. Clair, 2010; Redclift 1987, 1992). Pathways that require considerable transformation to reach sustainable futures of this kind can be supported by backcasting techniques. The process of backcasting involves developing normative scenarios that explore the feasibility and implications of achieving certain desired outcomes (Robinson, 2003; Carlsson-Kanyama *et al*., 2008). It is concerned with how desirable futures can be attained, focusing on policy measures that would be required to reach such conditions. Participatory backcasting, which involves local stakeholders in visionary activities related to sustainable development, can also open deliberative opportunities and inclusiveness in decision-framing and making. Where visioning is repeated it can also open possibilities for tracking transitional development and learning processes that make up adaptive strategy for risk management, based on surfacing the values and preferences of citizens (Robinson 2003).

Adding an anticipatory dimension to planning for the future is critical for striving towards transformational actions in the face of multiple and dynamic uncertainties. The literature on anticipatory action learning provides some experience on what this might look like (Kelleher, 2005; Stevenson, 2002). The framing and negotiation of decision-making and policy is made inclusive and reflexive through multiple rounds of stakeholder engagement to explore meanings of what different futures may involve, reflect upon unavoidable trade-offs and the winners and losers, and establish confidence to creatively adapt to new challenges (Inayatullah, 2006). This type of learning stresses the skills, knowledges, and visions of those at risk and aims to support leadership from even the most vulnerable..

Experiences in scenario building emphasize their usefulness for raising awareness on climate change (Gawith *et al.*, 2009). While much progress has been made by employing scenario building and narrative creation to explore uncertainties, surprises, extreme events, and tipping points, the transition from envisioning to planning, policy-making, and implementation remains poorly understood (Lempert, 2007). Similarly, more wide-spread uptake of even scientifically highly robust scenarios may be hampered by conflicting understandings of and practical approaches to uncertainty, differential scalar needs, and lack of training among users (Gawith *et al.*, 2009). Moreover, to move from framing public debates to policy-making and implementation, ultimately useful scenario building requires procedural stability, permanent yet flexible institutional and governance structures that build trust and experience to take advantage of new insights for effective and fair risk management (Volkery and Ribiero, 2009).

Changing core beliefs, including those on climate change, its causes and consequences, is a slow process (Volkery and Ribiero, 2009). This may be especially true for poor, marginalized, and vulnerable populations. Work in West and East Africa has shown that rural communities tend to underestimate external forces that shape their region while overestimating their own response capacity (Enfors *et al*., 2008; Tschakert *et al*., 2010). Misjudging external drivers may be explained by the low degree of control people feel they have over these drivers, resulting in reactions that range from powerlessness to denial. A combination of local- and global-scale scenarios that link storylines developed at several organizational levels (Biggs *et al*. 2007), personalizing narratives to create a sense of ownership (Frittaion *et al.*, 2010), and providing safe and repeated learning spaces (Kesby, 2005) can reduce such learning barriers.

While scenarios, projections and forecasts are all useful and important inputs for planning, actual planning and decision-making is a complex socio-political process involving different stakeholders and interacting agents. Developing the capacity for adaptive learning to accommodate complexity and uncertainty requires exploratory and imaginative visions for the future that support choices that are consistent with values and aspirations (Miller, 2007). Combinations of disaster risk reduction and climate change adaptation, and synergies between the two, can contribute to a sustainable and resilient future, but this involves expanding the diversity of futures that are considered and identifying those that are desirable, as well as the short-term and long-term values and actions that are consistent with them (Lempert, 2007).

### *8.2.4. Technology Choices, Availability, and Access*

This section describes the scope and framing effect of technology. Technology choices can contribute to both risk reduction and risk enhancement, relative to climate extremes and extreme events. The continuing transitions from one socio-technological state to another frame many aspects of responses to climate change risks. Assessments of roles of technology choices in responding to climate extremes are enmeshed in the wide range of technologies considered within a broad range of development contexts, where technology development and use are key to many development pathways. However, in nearly every case issues are raised about the balance between risk reduction and risk creation, including how limitations on access to emerging technologies can shape climate risks.

Technology choices can significantly increase risks and add to adaptation challenges (Jonkman *et al.*, 2010), as in the case when modern energy systems and centralized communication systems are dependent on physical structures that can be vulnerable to storm damage. It has been suggested that relatively centralized high-technology systems are “brittle,” offering efficiencies under normal conditions but subject to cascading effects in the event of emergencies (Lovins and Lovins, 1982). In some circumstances, technologies put in place to reduce short term risk and vulnerability can increase future vulnerability to extreme events or ongoing trends. For example, the use of irrigation has reduced farmer vulnerability to low and variable precipitation patterns. However, when the irrigation water is from a non-renewable source (e.g., the Ogallala-High Plains aquifer system of the U.S), the foreseeable reduction in future irrigation opportunities will mean an increase in vulnerability and the risk of increasing crop failures (AAG, 2003; Harrington, 2005).

In other cases, technologies are considered to be an important part of responses to climate extremes and disaster risk. This includes, for example, attention to physical infrastructure, including how to “harden” built infrastructures such as bridges or buildings, or natural systems such as hillsides or river channels, such that they are able to withstand higher levels of stress (Larsen *et al.*, 2007; CCSP, 2008; UNFCCC, 2006). Another focus is on technologies that assist with information collection and diffusion, including technologies to monitor possible stresses and vulnerabilities, technologies to communicate with populations and responders in the event of emergencies, and technology applications to disseminate information about possible threats and contingencies – although access to such technologies may be limited in some developing regions. Seasonal climate forecasts based on the results from numerical climate models have been developed in recent decades to provide multi-month forecasts, which can be used to prepare for floods and droughts (Stern and Easterling, 1999). Modern technological development is exploring a wide variety of innovative concepts that may eventually hold promise for risk reduction, for example through new food production technologies, although ecological, ethical and human health implications are often as yet unresolved (Altieri and Rosset, 2002).

Attention to technology alternatives and their benefits, costs, potentials, and limitations for both risk creation and risk reduction involve two different time horizons. In the near term, technologies to be considered are those that currently exist or that can be modified relatively quickly. In the longer term, it is possible to consider potentials for new technology development, given identified needs (Wilbanks, 2010). Nonetheless, in some circumstances technology put in place to reduce short-term risk and vulnerability can increase future vulnerability to extreme events or ongoing trends. For example, while large dams could mitigate drought and generate electricity, well known costs of social and ecological displacement may be unacceptable (Baghel and Nusser, 2010). Furthermore, unless dams are constructed to accommodate future climate change, they may present new risks to society by encouraging a sense of security that ignores departures from historical experience (Wilbanks and Kates, 2010). In the Mekong region, dykes, dams, drains and diversions established for flood protection have unexpected consequences on risk over the longer term, because they influence risk-taking behavior (Lebel *et al.*, 2009). In the United States, past building in floodplain areas downstream from dams that have now exceeded their design life has become a major concern; tens of thousands of dams are now considered as having high hazard potential (ASCE, 2010; FEMA, 2009; McCool, 2005).

Investments in physical infrastructure cast long shadows through time, because they tend to assume lifetimes of three to four decades or longer. The gradual modernization of a city’s housing stock, transport or water and sanitation infrastructure takes many decades without targeted planning. If they are maladaptive rather than adaptive, the consequences can be serious. This suggests a re-appraisal of technology that might promote more distributed solutions, for example multiple, smaller dams that can resolve local as well as more distant needs. This has been expressed in part of Thailand's Sufficiency Economy approach, where local development is judged against its contribution to local, national and international wealth generation (UNDP, 2007).

### *8.2.5. Tradeoffs in Decision-Making*

Visions for the future represent an important part of adaptation, as trade-offs will always be involved, and tensions inevitably arise between competing interests and visions. The ethical implications of these trade-offs are increasingly discussed, both in terms of intra- and inter-generational equity (Gardiner, 2006). Questions of justice and fairness have been raised, including the need to rethink social contracts to redefine rights and responsibilities in a changing climate (Pelling and Dill, 2008; O'Brien *et al.*, 2009; Dalby 2009; Brauch, 2009a, 2009b).

There is no single or optimal way of adapting to climate change or managing risks. Often, trade-offs between short-term and long-term objectives are ambiguous. For example, focusing on and taking actions to protect against frequent events may lead to greater vulnerability to larger and rarer extreme events (Burby, 2006). This is a particular challenge for investing in fixed physical infrastructure. Social investments and risk awareness, including early warning systems, can be strengthened by more frequent low impact events that maintain risk visibility and allow preparedness for larger, less frequent events. In discussing trade-offs between addressing short-term and long-term risks context is important, and even in well-governed systems, political expediency will often distort the regulatory process in a way that favors the short term (Platt, 1999).

Trade-offs and conflicts between economic development and risk management have been discussed in the literature (Kahl, 2003, 2006). The current trend of development in risk-prone areas (e.g., coastal areas in Asia) is driven by socio-economic benefits yielded by these locations, with many benefits accruing to private investors or governments through tax revenue. For example, export-driven economic growth in Asia favours production close to large ports to reduce transportation time and costs. Consequently, the increase in risk has to be balanced against socio-economic gains of development in at-risk areas. Additional construction in at-risk areas is not unacceptable a priori, but has to be justified by other benefits, and sometimes complemented by other risk-reducing actions (e.g., early warning and evacuation, improved building norms, specific flood protection). This introduces the possibility for those benefiting financially to offset produced risk through risk reduction mechanisms ranging from fare wages and disaster resistant housing to enhance worker resilience to support for early-warning, preparedness and reconstruction. Such approaches have become mainstreamed in some businesses through corporate social responsibility agendas (Twigg, 2001), though these remain unusual.

Another example of trade-offs linked to climate change and development is the future need for risk reduction infrastructure that would require changes in ecologically or historically important areas. For example, when considering additional protection (e.g., dikes and seawalls) in historical centres, aesthetic and cultural elements as well as building costs will be taken into account. Existing planning and design standards to protect cultural heritage or ecological integrity may need to be balanced with the needs of adaptation (Hallegatte *et al.*, 2011a). Difficulties in attributing value to cultural and ecological assets mean that cost-benefit analyses are not the best tool to approach these type of problems. Multi-criteria decision-making tools (Birkmann, 2006) that incorporate a participatory element and can recognise the political, ethical, and philosophical aspects of such decisions can also be useful (Mercer *et al.*, 2008).

Disaster events surface additional needs for trade-offs. During disaster reconstruction, tensions frequently arise between demands for speed of delivery and sustainability of outcome. Response and reconstruction funds tend to be time limited, often requiring expenditure within 12 months or less from the point of disbursement. This pressure is compounded with multiple agencies working with often limited coordination. Time pressure and competition between agencies tends to promote centralised decision-making and the sub-contracting of purchasing and project management to non-local commercial actors. Both outcomes save time but miss opportunities to include local people in decision-making and learning from the event with the resulting reconstruction often failing to support local cultural and economic priorities (Berke *et al*., 1993; Pearce, 2003). At the same time it is important not to romanticise local actors or their viewpoints, which might at times be unsustainable or point to maladaptation, or to accept local voices as representative of all local actors. When successful, participatory reconstruction planning has been shown to build local capacity and leadership, bind communities and provide mechanisms for information exchange with scientific and external actors. As part of any participatory or community based reconstruction, the importance of a clear conflict resolution strategy has been recognized.

The impacts of climate change extremes across multiple scales also raises the issue of trade-offs. The challenge is to find ways to combine the strengths of multiple scales rather than having them work against each other (Wilbanks, 2007). Local scales offer potentials for bottom-up actions that assure participation, flexibility, and innovativeness. At the same time, efforts to develop initiatives from the bottom up are often limited by a lack of information, limited resources, and limited awareness of larger-scale deriving forces (AAG, 2003). Larger scales offer potentials for top-down actions that assure resource mobilization and cost- sharing. Integrating these kinds of assets across scales is often essential for resilience to extremes, but in fact integration is profoundly impeded by differences in who decides, who pays, and who benefits; and perceptions of different scales by other scales often reflect striking ignorance and misunderstanding (Wilbanks, 2007). In recent years, there have been a number of calls for innovative co-management structures that cross scales in order to promote sustainable development (e.g., Brasseurs and Rosenbaum, 2003; Cash *et al*., 2006; Sayer and Campbell, 2006).

What might be done to realize potentials for integrating actions at different scales, to make them far more complementary and reinforcing? Many top-down interventions (from international donor development and disaster response and reconstruction funding to new adaption fund mechanisms and national programming) may unintentionally discourage local action by imposing bureaucratic conditions for access to financial and other resources (Christoplos *et al*., 2009). Top-down sustainability initiatives are often preoccupied with *input* metrics, such as criteria for partner selection and justifications (often based on relatively detailed quantitative analyses of such attributes as “additionality”), rather than on *outcome* metrics such as whether the results make a demonstrable contribution to sustainability (regarding metrics, see NRC, 2005).

To manage trade-offs and conflicts in an open, efficient and transparent way, institutional and legal arrangements are extremely important. The existing literature on legislation for adaptation at the state level is not comprehensive but those countries studied lack many of the institutional mechanisms and legal frameworks that are important for coordination at the state level (Richardson *et al*., 2009). This has been found to be the case for Vietnam, Laos and China (Lin, 2009). In the South Pacific, high exposure to climate change risk has yet to translate into legislative frameworks to support adaptation - with only Fiji, Papua New Guinea and Western Samoa formulating national climate change regulatory frameworks (Kwa, 2009). Where there is no national legislative structure, achieving local disaster reduction and climate change adaptation planning is very difficult. Still, where local leadership is determined, skilful planning is possible, even without legislation. This has been the experience of Ethekwini Municipality (the local government responsible for the city of Durban, South Africa) which has developed a Municipal Climate Protection Programme with a strong and early focus on adaptation without national level policy or legal frameworks to guide adaptation planning at the local level (Roberts, 2008, 2010).

One way around the challenges of trade-offs is to “bundle” multiple objectives through broader participation in strategy development and action planning, both to identify multiple objectives and to encourage attention to mutual co-benefits. In this sense both the pathway and outcomes of development planning have scope to shape future social capacity and disaster risk management. Policies and actions to achieve multiple objectives include stakeholder participation, participatory governance (IRGC, 2009), capacity-building, and adaptive organizations, including both private and public institutions where there is a considerable knowledge base reflecting both research and practice to use as a starting point (e.g., NRC, 2008).

## 8.3. Integration of Short-Term and Long-Term Responses to Extremes

When considering the linkages between disaster management, climate change adaptation and development, time-scales play an important role. Disaster management is increasingly emphasizing disaster risk reduction in addition to the more traditional emergency response and relief measures. This requires addressing underlying exposure and vulnerability issues in the context of hazards with different frequencies and return periods. Consequently there is now a converging focus on vulnerability reduction in the context of disaster risk management and adaptation to climate change (Sperling and Szekely, 2005).

Cross-scale (spatial and temporal) interactions between actions focusing on the short-term and those required for long-term adjustment can potentially contribute to both synergies and contradictions between disaster risk reduction and climate change adaptation. This section reviews the literature regarding synergies and trade-offs between short- and long-term adjustments. First, we review the implications of present day responses for future well-being. The barriers to reconciling short-term and long-term goals are then assessed. Insights from research on the resilience of social-ecological systems are then considered as a means of addressing long-term considerations.

### *8.3.1. Implications of Present-Day Responses for Future Well-Being*

The implications of present-day responses to both disaster risk and climate change can be either positive or negative for human security and well-being in the long-term. Positive implications can include increased resilience, capacity-building, broad social benefits from extensive participation in risk management and resilience planning, and the value of multi-hazard planning (see Chapter 5 and 6). Negative implications can include threats to sustainability if the well-being of future generations is not considered; issues related to the economic discounting of future benefits; "silo effects" of optimizing responses for one system or sector without considering interaction effects with others (see an example on the conflict between urban containment and risk management in Burby *et al*., 2001); equity issues regarding who benefits and who pays; and the "levee effect," where the adaptive solution to a current risk management problem builds confidence that the problem has been solved, blinding populations to the possibility that conditions may change and make the present adaptation inadequate (Burby, 2006; Burby *et al*., 2006).

The terms coping and adaptation reflect strategies for adjustments to changing climatic and environmental conditions. In the case of a set of policy choices, both coping and adaptation denote forms of conduct that aim and indeed may achieve modifications in the ways in which society relates to nature and nature to society (Elsevier 2005). As discussed in Chapter 2, coping actions are those which take place in trying to alleviate the impacts or to live with the costs of a specific event. They are usually found during the unfolding of disaster impacts, which can continue for some time after an event - for example if somebody loses their job or is traumatized. Coping strategies can help to alleviate the immediate impact of a hazard, but may also increase vulnerabilities over the medium to longer term (Swift, 1989; Davies, 1993; Sperling *et al*., 2008). In developing countries, a focus on coping with the present is often fuelled by the perception that climate change is a long-term issue and other challenges, including food security, water supply (Bradley *et al*., 2006), sanitation, education and health care, require more immediate attention (Adly and Ahmed, 2009; Kameri-Mbote and Kindiki, 2009; Klein *et al*., 2005). Particularly, in poor rural contexts, short-term coping may be a trade-off that increases longer-term risks (ISDR, 2009; Brauch and Oswald, 2011). Adaptation, on the other hand, is often focused on minimizing potential risk to future losses (Oliver-Smith, 2007).

The different time-frames for coping and adaptation can present barriers to risk management. Focusing on short-term responses and coping strategies can limit the scope for adaptation in the long-term. For example, drought can force agriculturalists to remove their children from school or delay medical treatment, which in aggregate undermines the human resource available for long-term adaptation (Norris, 2005; Santos, 2007; Alderman *et al*., 2006; Sperling *et al*., 2008). The long-term framing of adaptation can also constrain short-term coping, for example when relocation of settlements to avoid coastal hazards undermines social capital and local livelihoods, limiting household coping and adaptive capacity (Hunter, 2005). There is a large literature and much experience related to slum relocation that is of direct relevance now to urban adaptation and coping (Gilbert and Ward, 1984; Davidson *et al*., 1993; Viratkapan and Perera, 2006).

Disasters can destroy assets and wipe out savings, and can push households into "poverty traps", i.e. situations where productivity is reduced, making it impossible for households to rebuild their savings and assets (Zimmerman and Carter, 2003; Carter *et al*., 2007; Dercon and Outes, 2009; López, 2009; van den Berg, 2010). The process by which a series of events generates a vicious spiral of impact, vulnerability and risk was first recognized by Chambers (1989), who described it as the ratchet effect of disaster, risk and vulnerability. These micro-level poverty traps can also be created by health and social impacts of natural disasters: it has been shown that disasters can have long-lasting consequences on psychological health (Norris, 2005), and on child development from reduction in schooling and diminished cognitive abilities (see Santos, 2007; Alderman *et al*., 2006; Bartlett, 2008).

Poverty traps at the micro level (i.e., the household level) may lead to macro-level poverty traps, such that entire regions are affected. Such poverty traps could be explained by an amplifying feedback: Poor regions have a limited capacity to rebuild after disasters, and if they are regularly affected by disasters, they do not have enough time to rebuild between two events, and they end up in a state of permanent reconstruction, with all resources devoted to repairs instead of new infrastructure and equipment; this obstacle to capital accumulation and infrastructure development leads to a permanent disaster-related under-development. This can even be amplified by other long-term mechanisms, such as changes in risk perception that reduce investments in the affected regions or reduced services that make qualified workers leave the region (see a discussion on the role of hurricane Betsy in triggering the decrease in New Orleans population). These effects have been discussed by Benson and Clay (2004), and investigated by Noy (2009) and Hochrainer (2009). They have been modeled by Hallegatte *et al*. (2007) and Hallegatte and Dumas (2008) using a reduced-form economic model that shows that the average GDP impact of natural disasters can be either close to zero if reconstruction capacity is large enough, or very large if reconstruction capacity is too limited, which may be the case in less developed countries. There are, however, many uncertainties in the ways in which people's spontaneous and organised responses to increasing climate-related hazards feed-back to influence long-term adaptive capacity and options. Migration, which can be traumatic for those involved, might lead to enhanced life chances for the children of migrants, building long-term capacities and potentially also contributing to the movement of populations away from places exposed to risk (UNDP, 2009; Ahmed, 2009; Oswald Spring, 2009b; IOM, 2007, 2009a, 2009b).

A broad literature on experiences of community-based and local-level disaster risk reduction indicates options for transiting from short-term coping to longer-term adaptation, at least to existing frequently occurring risk manifestations (ISDR, 2009, Lavell, 2009). Such approaches, many of which are based on community empowerment, have progressively moved from addressing disaster preparedness and capacities for emergency management, towards addressing the vulnerability of livelihoods, the decline of ecosystems, the lack of social protection, unsafe housing, the improvement of governance and other underlying risk factors (Bohle, 2009). Addressing and *correcting* existing risk will *per se* contribute to a reduction in future risk to climate extremes. Addressing the underlying risk drivers and *anticipating* future risk will contribute to a reduction of future risk to climate extremes associated with increases in exposure, vulnerability and hazard.

### *8.3.2. Barriers to Reconciling Short- and Long-Term Goals*

Although there is convincing evidence in the literature to support disaster risk reduction as a strategy for long-term climate change adaptation, there are numerous barriers to reconciling short-term and long-term goals. Many poor countries are very vulnerable to natural hazards but cannot implement the measures that could reduce this vulnerability for financial reasons, or due to a lack of governance capacity or technology. The recent national self-assessments of progress towards achieving the ISDR Hyogo Framework for Action indicated that some Least Developed Countries lack the human, institutional, technical and financial capacities to address even emergency management concerns (ISDR, 2009). The development deficit in many cities in developing countries, where 40 – 70% of the population live in informal settlements with low levels of access to sanitation, drainage, water and health services, is an underlying driver of much urban disaster risk. Addressing this development deficit, through for example investments in storm drainage, would reduce by a significant amount the consequences of many natural hazards (e.g., urban floods) in the current climate and under future conditions (Ranger *et al*., 2011). Doing so, however, would require very large amounts of funding and careful governance especially where land titles are contested or some of the vulnerable might face relocation (Satterthwaite *et al*., 2007, Bicknell *et al*., 2009).

The World Bank, the UNDP and the UNFCCC estimated that the financial needs for adaptation will amount to between US$9 and US$166 billion per year, up to 2030. This is consistent with the MDG financing gap, which was estimated at US$73 billion in 2006, rising to US$135 billion in 2015 (Sachs, 2005). Similarly, the cost of upgrading the 800 million to 1 billion people living in informal settlements has been estimated at US$532 – 665 billion (ISDR, 2009). Even though the methodologies that have been used to calculate these estimates are questionable, the orders of magnitude are large enough to support the idea that funding will be a significant obstacle to adaptation in the future. The possibility that adaptation funding may be taken from development funding is counterproductive with development of basic and critical infrastructure being that basis upon which adaptation, and coping depend.

Another obstacle to reconciling short- and long-term goals is access to technology and maintenance of infrastructure. An example is the introduction of water reuse technologies, which have been developed in a few countries, which could bring a great improvement in the management of droughts if they could be disseminated in many developing countries (Metcalf and Eddy, 2005). Even in those regions where development has prioritized short-term gain over long-term resilience, agricultural productivity is in decline because of drought and groundwater depletion, rural indebtedness is increasing and households are sliding into poverty with particularly insidious consequences for women, who face the brunt of nutritional deprivation as a result (Moench et al., 2003; Moench and Dixit, 2007).

Governance capacities and the inadequacy of and lack of synergy between the institutional and legislative arrangements for disaster risk reduction, climate change adaptation and poverty reduction are as much a part of the problem as the shortage of resources. In other words, money and technology are not enough to implement efficient disaster risk reduction and adaptation strategies. Differences in resources cannot explain the difference among regions (Nicholls *et al*., 2008). Indeed, within the same country changes over time show the impact of national funding regions on the likelihood that municipal and regional authorities will shift their management of disaster risk from proactive to reactive modes. This has been noted for example in a historical study of hurricane risk in the US (Birkland, 2007).

A change in the culture of public administration towards creative partnerships between national and local governments and empowered communities had been found to dramatically reduce costs (Dodman et. al., 2008). Institutional and legal environments and political will are also very important, as illustrated by the difference in risk management in various regions of the world (Pelling and Holloway, 2006). In many countries disaster risk management and adaptation to climate change measures are overseen by different institutional structures. This is explained by the historical evolution of both approaches. Disaster risk management originated from humanitarian assistance efforts, evolving from localized, specific response measures to preventive measures, which seek to address the broader environmental and socio-economic aspects of vulnerability that are responsible for turning a hazard into a disaster in terms of human and/or economic losses. Within countries, disaster risk management efforts are often coordinated by Civil Defence, while measures to adapt to climate change are usually developed by Environment Ministries. Responding to climate change is originally more of a top-down process, where advances in scientific research led to international policy discussions and frameworks. Adaptation is now being recognized as a necessary complementary measure to mitigation (e.g. AfDB *et al*. 2003). While the different institutional structures may represent an initial coordination challenge, the converging focus on vulnerability reduction represent an opportunity of managing disaster and climate risks more comprehensively within the development context (Sperling and Szekely, 2005).

In addition to the barriers described above, there is also tendency for individuals to focus on the short-run and to ignore low probability high impact events. Studies have identified a set of psychological and economic barriers shaping how people make decisions under uncertainty (Kunreuther *et al*. forthcoming). Some of the most important elements include:

*Underestimation of the risk:* Even when individuals are aware of the risks, they often underestimate the likelihood of the event occurring (Smith and McCarty, 2006). This bias can be amplified by natural variability (Pielke *et al*., 2008), where there is expert disagreement, and where there is uncertainty. Magat *et al*. (1987), Camerer and Kunreuther (1989) and Hogarth and Kunreither (1995), for example, provide considerable empirical evidence that individuals do not seek out information on probabilities in making their decisions.

*Budget constraints*: If there is a high upfront cost associated with investing in adaptation measures, individuals will often focus on short-run financial goals rather than on the potential long-term benefits in the form of reduced risks (Kunreuther *et al*. 1978:; Thaler, 1999).

*Difficulties in Making Trade-offs*: Individuals are also not skilled in making trade-offs between costs and benefits of these measures, which requires comparing the upfront costs of the measure with the expected discounted benefits in the form of loss reduction over time.

*Procrastination*: Individuals are observed to have deferred chosing between ambiguous choices (Tversky and Shafir 1992; Trope and Lieberman, 2003).

*Samaritan's Dilemma*: Anticipated availability of post-disaster support can undermine self-reliance when there are no incentives for risk reduction (Burby et al., 1991).

*The Politician's Dilemma*: Time delays between public investment in risk reduction and benefits when hazards are infrequent, and the political invisibility of successful risk reduction can be pressures for a NIMTOF (Not in My Term of Office) attitude that leads to inaction (Michel-Kerjan, 2008).

Another issue that makes it difficult to reconcile short-term and long-term goals arises from the difficulty in projecting the long-term climate and corresponding risks. Examples of this challenge are reflected in the demographic growth of Florida in the 1970s and 1980s which unfolded during a period of low hurricane activity but now represents a significant population at risk, and major engineering projects with long lead-times from planning to implementation have difficulty factoring in climate change futures and have been planned on historic hazard risk (Pielke *et al*., 2008). Managing natural risks and adapting to climate change requires anticipating how natural hazards will change over the next decades, but uncertainty on climate change and natural variability is a significant obstacle to such anticipation (Reeder *et al*., 2009). An inability to acknowledge the collective long-term consequences of individual decisions is a principal reason that societies are not well-equipped to deal with climate change. Climate change is viewed as a slow-onset, multigenerational problem. Consequently, individuals, governments and businesses have been slow to invest in adaptation measures.

### *8.3.3. Connecting Short- and Long-Term Actions to Promote Resilience*

The previous section highlighted the importance of linking short-term and long-term actions as disaster risk reduction and climate change adaptation come to support each other. A systems approach that emphasizes cross-scale interactions can provide important insights on how to realize synergies between disaster risk reduction and climate change adaptation. Resilience, a concept fundamentally about how *a system* can deal with disturbance and surprise, increasingly frames contemporary thinking about sustainable futures in the context of climate change and disasters (Bahadur *et al*. 2010). It has developed as a fusion of ideas from several bodies of literature: ecosystem stability (e.g., Holling, 1973), engineering robust infrastructures (e.g., Tierney and Bruneau, 2007), psychology (e.g., Lee *et al*., 2009), disaster risk reduction (e.g., Cutter *et al*., 2008), vulnerabilities to hazards (Moser, 2009) and urban and regional development (e.g., Simmie and Martin, 2010). Resilience perspectives can be used as an approach for understanding the dynamics of social-ecological systems and how they respond to a range of different perturbations. The literature on resilience encompasses a range of concepts; complexity, transformability and thresholds, dynamics and disequilibria, adaptation, renewal, re-organisation and learning (e.g. Carpenter *et al*., 2001; Walker *et al*., 2004).

'Resilience thinking' (Walker and Salt, 2006) may provide a useful framework to understand the interactions between climate change and other challenges, and in reconciling and evaluating trade-offs between short-term and longer-term goals in devising response strategies. Resilience thinking contrasts with the conventional engineering systems emphasis on capacity to absorb external shocks. It suggests a move "away from policies that aspire to control change in systems assumed to be stable, towards managing capacity of social-ecological systems to cope with, adapt to and shape change" (Folke, 2006, p. 254). For social-ecological systems (examined as a set of interactions between people and the ecosystems they depend on), resilience involves three properties: the amount of change a system can undergo and retain the same structure and functions; the degree to which it can re-organise, and; the degree to which it can build capacity to learn and adapt (Folke, 2006).

Social-ecological systems have to deal with both gradual and abrupt changes (Folke, 2006). There are substantial uncertainties about how ecosystems will respond to increasing levels of human exploitation (Steffen *et al*. 2004), although most assessments agree it will likely increase the magnitude and frequency of large, abrupt, persistent changes in system structure and function, known as regime shifts (Steffen *et al*., 2004, MEA, 2005, Rockström *et al*., 2009). Gradual changes may erode system resilience to the point that even small disturbances may trigger large changes in social-ecological systems with significant social consequences (Adger, 2006) where vulnerability is high (Blaikie *et al*., 2004). Innovative modeling approaches of complex adaptive social-ecological systems illustrate the tight feedbacks or integrated nature of the systems including economic and ecological dimensions. These feedbacks are generally neglected in most policy decisions. Furthermore, economic models used in management of e.g. fisheries, agriculture, forestry need to be significantly changed and broadened to more realistically capture the often non-linear features of social-ecological systems (Dasgupta and Mäler, 2003).

Disturbances are not always considered bad: Folke (2006) emphasizes the capacity for renewal, re-organization and development in resilient social-ecological systems, whereby "disturbance has the potential to create opportunity for doing new things, for innovation and for development". This understanding of resilience embraces both the potential for development goals and practices to persist in the face of change and for innovation and transformation into new more desirable configurations. The implication for policy is profound and requires a shift in mental models toward human-in-the environment perspectives, acceptance of the limitation of policies based on steady-state thinking and design of incentives that stimulate the emergence of adaptive governance for social-ecological resilience of landscapes and seascapes. Key to much resilience thinking is a focus on learning, innovation, and experimentation, with valid applications for climatic uncertainties and extreme events. Combining different types of knowledge, memory, the willingness to experiment, and flexibility for navigating complex feedbacks, non-linearities, thresholds, and system changes are all well recognized (Berkes *et al.*, 2003; Davidson-Hunt and Berkes, 2003; Folke, 2006).

Resilience thinking is being applied to address disaster risk reduction and adaptation issues, and also to examine specific responses to climate change in different developed and developing country contexts. However, Pielke *et al*. (2007) warn that locating adaptation policy in a narrow risk framework through concentrating only on identifiable anthropogenic risks can distort public policy because vulnerabilities are created through multiple stresses. Yet, Eakin and Webbe (2008) use a resilience framework to show the interplay between individual and collective adaptation can be related to wider system sustainability. Goldstein (2009) uses resilience concepts to strengthen communicative planning approaches to dealing with surprise. Nelson *et al*. (2007) have shown how resilience thinking can enhance analyses of adaptation to climate change. As adaptive actions affect not only the intended beneficiaries but have repercussions for other regions and times, adaptation is part of a path-dependent trajectory of change. Resilience thinking also considers a distinction between incremental adjustments and system transformation which may broaden the expanse of adaptation and also provide space for agency (Nelson *et al*., 2007). They see resilience approaches as complementary to agent-based analyses of climate change responses looking at processes of negotiation and decision-making, as they can provide insights into the systems-wide implications.

Recent work on resilience and governance has focused on the communication of science between actors and depth of inclusiveness in decision-making as key determinants of the character of resilience. In support of these approaches it is argued that inclusive governance facilitates better flexibility and provides additional benefit from the decentralisation of power. On the down side, greater participation can lead to lose institutional arrangements that may be captured and distorted by existing vested interests (Adger *et al*., 2005; Plummer and Armitage, 2007). Still, the balance of argument (and existing centrality of institutional arrangements) call for a greater emphasis to be placed on the inclusion of local and lay voices and of diverse stakeholders in shaping agendas for resilience through adaptation and adaptive management (Nelson *et al.*, 2007). This is needed both to raise the political and policy profile of our current sustainability crisis and to search for fare and legitimate responses. Greater inclusiveness in decision making can help to add richness and value to governance systems in contrast to the current dominant approaches which tend to emphasize management control. When inevitable failures occur and disasters materialise less inclusive approaches risk public trust in science, undermine government legitimacy and public engagement in collective efforts to change practices and reduce future risk. Striking the right balance between command-and-control, which offers stability over the short term, but reduced long-term resilience is the core challenge that disaster risk management brings to climate change adaptation under conditions of climatic extremes and projected increases in disaster risk and impact.

Resilience thinking is not without its critiques (Nelson, 2009; Pelling, 2010). Shortcomings include the downplaying of human agency in systems approaches and difficulty in including analysis of power in explanations of change, which combine to effectively promote stability rather than flexibility, i.e., maintaining the *status quo* and thus serving particular interests rather than supporting adaptive management, social learning or inclusive decision-making. One challenge to enhancing resilience of desired system states is to identify how responses to any single stressor influence the larger, interconnected social-ecological system, including the system's ability to absorb perturbations or shocks, its ability to adapt to current and future changes, and its ability to learn and create new types or directions of change. Responses to one stressor alone may inadvertently undermine the capacity to address other stressors, both in the present and future. For example, coastal towns in eastern England, experiencing worsening coastal erosion exacerbated by sea level rise, are taking their own action protect against immediate erosion in order to protect livelihoods and homes, affecting sediments and erosion rates down the coast (Milligan *et al*., 2009). While such actions to protect the coast are effective in the short-term, in the long-term investing to 'hold-the-line' may diminish capital resources for other adaptations and hence reduced adaptive capacity to future sea level rise. Thus dealing with specific risks without a full accounting of the nature of system resilience can lead to responses that can potentially undermine long-term resilience. Despite an increasing emphasis on managing for resilience (Walker *et al*., 2002; Lebel *et al*., 2006), the resilience lens alone may not sufficiently illuminate how to enhance agency and move from the understanding of complex dynamics to transformational action.

## 8.4. Interactions among Disaster Risk Management, Adaptation to Climate Change Extremes, and Mitigation of Greenhouse Gas Emissions

In many instances, climate change adaptation and mitigation may be synergistic, such as land-use planning to reduce transport-related energy consumption and limit exposure to floods, or building codes to reduce heating energy consumption and enhance robustness to heat waves (McEvoy *et al*., 2006). There is an emerging literature exploring the linkages between adaptation and mitigation, and the possibility of approaches that address both objectives simultaneously (IPCC, 2007, Wilbanks and Sathaye, 2007; Wilbanks, 2010; Hallegatte, 2009; Yohe and Leichenko, 2010; Bizikova *et al*., 2010). In this section we enlarge the scope of the interactions to include disaster risk reduction. The extent of adaptation required will depend on the mitigation efforts undertaken, and it is possible that these requirements could increase drastically as levels of climate change exceed systemic thresholds; whether in the geophysical system or in the socio-economic.

### *8.4.1. Adaptation, Mitigation, and Disaster Management Interactions*

The extent to which future adaptation will be required is dependent on the extent and rapidity with which climate change mitigation actions may be taken and resulting risk unfolds for any given development context. This section reviews the ways in which mitigation and adaption interact with development in urban and rural contexts.

In an increasingly urbanised world, global sustainability in the context of a changing climate will depend on achieving sustainable and climate resilient cities. Urban spatial form is critical for energy consumption and emission patterns, influencing where and how residents live and the modes of transport that they use. Thus urban planning is a tool that can be used to pursue many goals (Newman and Kenworthy 1989; Bento *et al*., 2005; Handy *et al*., 2005; Grazi *et al*., 2008; Brownstone and Golob, 2009; Ewing and Rong, 2008; Glaeser and Kahn, 2008). Urban form also influences urban heat islands and flood risks, thereby contributing to vulnerability to climate extremes (Desplat *et al*., 2009). But besides climate change aspects, urban form also influences access to jobs, leisure and amenities, and city attractiveness to professionals and businesses, with consequences for spatial and social inequalities (Leichenko and Solecki 2008; Gusdorf *et al*., 2008). The historical failure of urban planning in most developing country cities has had tremendous environmental and social consequences (World Bank, 2010c; UN-HABITAT, 2009). Since urban forms influence both GHG emissions and climate vulnerability (McEvoy *et al*., 2006), urban planning may benefit from synergies (e.g., reduced car use may decrease GHG emissions and reduce air pollution in a way that enhance robustness to heat waves), but also face conflicts (e.g., expanding air conditioning to cope with heat waves may lead to higher GHG emissions if electricity is not decarbonized (Lindley *et al.*, 2006); a denser city may reduce GHG emission but increase heat wave vulnerability (Hamin et Gurran, 2009).

Disasters create opportunities to adopt more sustainable and risk-reducing technologies during reconstruction, including those that support mitigation. The 2005 Hurricane Katrina disaster in New Orleans, Louisiana, has been followed up with recovery efforts that include rebuilding to Green Building Council 'Leadership in Energy and Environmental Design' (LEED) standards (U.S. Green Building Council, 2010). Greensburg, Kansas, was virtually destroyed by a tornado in May, 2007. Although a disaster, the event also created an opportunity to rebuild the community from the ground up: the city has received significant attention and support in its rebuilding, and a variety of businesses and community organizations have been rebuilding to LEED Platinum standards (Harrington, 2010). Unfortunately, (echoing the trade-offs between speed and sustainability presented in 8.2.5) these actions have slowed rebuilding of the town, leading to loss in social capital while attempting to create a model 'green' community.

While urban sites offer opportunities for mitigation through diversified (household) production and energy conservation, rural areas are a focus for concentrated low or no-carbon energy production ranging from HEP to solar and wind farms, biofuel crops and carbon sink functions associated with forestry in particular and REDD+ projects. These investments can have significant local impacts on disaster risk through changes in land-use and land-cover that may influence hydrology or through economic effects and consequences for livelihoods. Some impacts can even go beyond local places. Recent impacts of biofuel production on rural livelihoods and global food security indicate the sensitivity of rural and urban systems, and the care required in transformations of this kind (Dufey, 2006; de Fraiture *et al.*, 2008).

### *8.4.2. Implications for Sustainable Development and Resilience*

Reducing risk that takes mitigation into account is most likely to be sustainable if it considers social and ecological outcomes, as well as economic outcomes of development. Failure to do so could amplify the development failures that allow poverty and environmental problems to persist. This section examines trends in urban and rural development that interact with the goals of resilience and sustainable development.

Urbanization offers great opportunities, but these are seldom realized, especially by those most marginalized and vulnerable. More typically, urbanization compounds environmental problems. As countries urbanise, the risks associated with economic asset loss tend to increase (through rapid growth in infrastructure, productive and social assets, etc.) while mortality risk tends to decrease (Birkmann, 2006). As cities grow they also modify their surrounding rural environment, and consequently generate a significant proportion of the hazard to which they are also exposed. For example, as areas of hinterland are paved over, run-off increases during storms, greatly magnifying flood hazard. As mangroves are destroyed in coastal cities, storm-surge hazard increase. Likewise, the expansion of informal settlements onto steep hillside and can lead to increased landslide hazard (Satterthwaite, 1997, UNDP, 2004). Global risk models indicate that this expansion is primarily due to rapidly increasing exposure, which outpaces improvements in the capacities to reduce vulnerabilities (such as through improvements in building standards and land-use planning), at least in rapidly growing low and middle income nations (ISDR, 2009). As a consequence, risk is becoming increasingly urbanised (Mitchell, 1999; Pelling, 2003; Leichenko and O'Brien, 2008). There are dramatic differences, nonetheless, between developed and developing countries. In most developed countries (and increasingly in a number of cities in middle-income countries (e.g., Bogota, Mexico, City), risk reducing capacities exist which can manage increases in exposure. In contrast, in much of the developing world (and particularly in the poorest LDCs) such capacities are incipient at best, while exposure may be increasing rapidly. Financial and technical constraints matter for risk management, but difference in wealth cannot explain difference in risk reduction investments, which also depend on political choice and risk perceptions (e.g., Hanson *et al.*, 2010).

Urban planning can reduce disaster risk, but it takes time to produce significant effects. It requires anticipation of future climate change, taking into account how climate will change over many decades and the uncertainty on this information. Urban forms imply strong inertia and irreversibility: when a low-density city is created, transforming it into a high density city is a long, expensive, and difficult process (Gusdorf *et al*., 2008). This point is crucial in the world's most rapidly-growing cities, where urban forms of the future are being decided based on actions taken in the present, and where current trends indicate that low-density, automobile dependent forms of suburban settlement are rapidly expanding (Solecki and Leichenko, 2006). Recent work has started to investigate these aspects of adaptation and mitigation (Newman, 1996). At the same time, there are specific opportunities when cities enter periods of large scale transformation. This is happening in Delhi, Mumbai and other cities in India as private capital redevelops low-income city neighbourhoods into commercial districts and middle- and high-income housing areas. There is rare scope here to build disaster risk reduction and climate change adaptation and mitigation alongside existing demands for social justice into urban and building design. There are also a growing numbers of large-scale slum/informal settlement upgrading programmes that aim to improve housing and living conditions for low-income households (Boonyabancha 2005; Satterthwaite 2010). Although the results for urban livelihoods, quality of life and sustainability have been mixed at best, these remain rare opportunities to insert adaptation and mitigation planning into urban strategic development.

Rural livelihoods and risk contexts are also being transformed by multiple pressures, including globalisation and changes in the scale of farming; contributing amongst less competitive smaller farms to a need for non-farm income; shifting demands for, availability of, and controls on the exploitation of natural resources (partly due to globalisation and partly due to enhanced concerns for environmental quality), and; access to remittances resulting from migration (either within or across national boundaries); (Chouvy and Laniel, 2007). Non-farm income now represents a substantial proportion of total income for many rural households and can, in turn, increase resilience to weather and climate related shocks (Brklacich *et al*., 1997; Smithers and Smit, 1997; Wandel and Smit, 2000). The implications of these transitions on local rural risk, and how far they may provide scope for mitigation has not been fully explored in the literature. Existing principles of coping can be applied, for example in arguing that diversification into non-agricultural livelihoods could enhance coping (Ellis, 1998; Marschke and Berkes, 2006).

The existence of multiple, intersecting stressors in rural and urban contexts draws attention to the importance of addressing the underlying drivers of risk as a means of both disaster risk management and adaptation, and of enabling mitigation.

### *8.4.3. Thresholds and Tipping Points as Limits to Resilience*

Recent literature suggests that climate change could trigger large-scale, system-level regime shifts that could significantly alter climatic and socio-economic conditions (Lenton *et al*., 2008; Hallegatte *et al*., 2010, MEA, 2005). Examples of potential large-scale climate tipping points include dieback of the Amazon rainforest, decay of the Greenland ice sheet, and changes in the Indian summer monsoon (Lenton *et al.,* 2008). At smaller scales, climate change is likely to exacerbate well-established examples of regime shifts, such as freshwater eutrophication (Carpenter, 2003), shifts to algae-dominated coral reefs (Hughes *et al*., 2003), and woody encroachment of savannas (Midgley and Bond, 2001). In combined social-ecological systems the exceeding of certain thresholds can also lead to large, dramatic changes (Scheffer *et al*., 2001; Scheffer, 2009). The abruptness and persistence of these changes, coupled with the fact that they tend to be difficult and sometimes impossible to reverse, means that they tend to have substantial impacts on human well-being. The notion of regime shifts therefore contrasts with traditional thinking about gradual change in a linear fashion by emphasizing the possibility of multiple self-organizing system states, threshold effects and nonlinear dynamics (Gunderson and Holling, 2002; Levin, 1998). The notion of regime shifts extends into the socio-economic realm, here tipping points are exemplified by profitability limits in economic activities (e.g., Schlenker and Roberts, 2006; OECD, 2007).

Observations and analysis of disaster events have also begun to identify tipping points for systems change. Disasters themselves are threshold-breaching events, where coping capacities of communities are overwhelmed (e.g. Blaikie *et al*., 1994; Sperling *et al*., 2008). Disasters may lead to secondary hazards, e.g., when the impacts from one disaster triggers others, as when hurricane impacts trigger landslides or when different disasters produce concatenated impacts over time. For example losses associated with droughts and firesduring the 1997/1998 ENSO event in Central America that increased landslide and flood hazard during Hurricane Mitch in 1998 (Villagrán, 2011). Critical social thresholds may be crossed as disaster impacts spread across society. For the poor, life and health are immediately at risk; for those living in societies that take measures to protect infrastructure and economic and physical assets, the lives and health of the population are less at risk. However, this threshold can be crossed when hazards exceed anticipated limits, are novel and unexpected, as in the 2003 European heatwave (Beniston, 2004; Schär *et al*., 2004; Salagnac, 2007), or when vulnerability has increased or resilience decreased due to spill-over from market and other shocks (Wisner, 2003).

The issue of thresholds or tipping points is related to the larger issue of potentials for high consequence/low probability events to occur with climate change. In general, both the climate science community and the climate policy community have focused on very high-probability, usually relatively low-consequence incremental contingencies, rather than on possibilities for abrupt climate change or tipping points within affected systems, which are much more uncertain and difficult to analyze. Recently, however, climate science has been increasing its attention to the "fat tails" of impact probability density functions. This is in contrast to the disasters research community which, after focusing on major extremes, is now recognizing the importance of small or local disasters (landslides, flashfloods or local flooding), many of which are low impact but high frequency and can have a devastating impact on those affected, with a compound erosive impact on development (UNDP, 2004; ISDR, 2009). Both lenses are valuable for a comprehensive understanding of the interaction of disaster impact with development and the ways in which capacity is eroded or built in the face of potential thresholds.

Tipping points in natural and human systems are more likely to arise with relatively severe and/or rapid climate change than with moderate levels and rates (Wilbanks *et al*., 2007). Such non-linear change may lie beyond the capacity of adaptation to avoid serious disruptions. Examples include the disappearance of glaciers, effects of climate change on traditional livelihoods of indigenous cultures, widespread loss of corals in acidifying oceans, and profitability limits for important economic activities like agriculture, fisheries and tourism. When socio-economic systems are already under stress (e.g., fisheries in many countries), thresholds are likely to be reached earlier Responses to potential thresholds or tipping points range from efforts to establish monitoring systems to provide early warning of an impending system collapse (Scheffer *et al*., 2009; Biggs *et al*., 2009), to researching the balance of risks associated with geo-engineering to avoid such climate points (Kiehl, 2006; Virgoe, 2002).

## 8.5. Implications for Access to Resources, Equity, and Sustainable Development

The previous section assesses the interlinkages between adaptation, disaster risk reduction and mitigation objectives. This section takes the idea of interlinkages further by exploring the relationship between climate change adaptation, disaster risk management and mitigation, and larger issues related to equity, access to resources, environmental and ecosystem protection and related development processes, including the relationship between the current spatial distribution of disaster risk and underlying processes of unequal socio-territorial development and environmental injustices (Maskrey, 1994; Sacoby *et al*. 2010). Issues related to capacity and equity are discussed, including the idea that there will be winners and losers, and implications for enhancing human security and the achievement of other international goals.

### *8.5.1. Capacities and Resources: Availability and Limitations*

The capacity to manage risks and adapt to changes are unevenly distributed within and across nations, regions, communities and households (Hewitt, 1983, Wisner *et al*., 2004, Beck, 2007). The literature on how these capacities contribute to disaster risk management and climate change adaptation emphasizes the role of economic, financial, social, cultural, human, and natural capital and with institutional context (Chapters 5-7). When the poor are impacted by disasters limited resources are quickly expended in coping actions that can further undermine household sustainability in the long-run, reducing capitals and increasing further rounds of hazard exposure or vulnerability. In these vicious cycles of decline households tend first to expend saving and then, if pressures continue, to withdraw members from non-productive activities such as school and finally sell productive assets. As households begin to collapse individuals may be forced to migrate or in some cases enter into dangerous livelihoods such as the sex industry. At each stage in this cascading series of actions household resources are lost and individuals exposed to greater levels of stress. This poverty and vulnerability trap means that recovery to pre-disaster levels of wellbeing becomes increasingly difficult (Chambers, 1989; Burton *et al*., 1993; Adger, 1996, Wisner *et al*., 2004).

Some demographic groups, such as children, children and the elderly stand out as more vulnerable to climate change-related extreme events. The vulnerability of children and their capacity to respond to climate change and disasters is discussed in Box 8-1. Importantly, an increasing number of elderly will also be exposed to climate change in the coming decades, particularly in OECD countries. By 2050, it is estimated that 1 in 3 people will be above 60 years in OECD countries, as well as 1 in 5 at the global scale (United Nations, 2002). The elderly are made additionally vulnerable to climate change related hazards by characteristics that also increase vulnerability to other social and environmental hazards (thus compounding overall vulnerability): deterioration of health, personal lifestyles, social isolation, poverty, and inadequate access to health and social infrastructures (OECD, 2006). These characteristics highlight well the ways in which social and environmental changes coevolve in the production of risk over time – in this case with changes in family structures and access to services in response to economic cycles, political and cultural trends evolving as the climate changes with potentially compounding effects.

_____ START BOX 8-1 HERE _____

**Box 8-1. Children, Extremes, and Equity in a Changing Climate**

Building sustainable and resilient societies in the future will require the inclusion of future generations in decision making, both as future inheritors of risks and as actors in their own right. The linkages between children and extreme events have been addressed through two principle lenses:

*1. Differentiated Impacts and Vulnerability*

The literature estimates that 66.5 million children are affected annually by disasters (Penrose and Takaki, 2006). Research on disaster impacts amongst children focuses on short- and long-term physical and psychological health impacts (Bunyavanich *et al*., 2003; Balaban, 2006; Bartlett 2008; del Ninno and Lindberg, 2005; Norris *et al.,* 2002; Waterson, 2006). Vulnerability to these impacts in part is due to the less developed physical and mental state of children, and therefore differential capacities to cope with deprivation and stress in times of disaster (Bartlett, 2008; Cutter, 1995; Peek, 2008).

Most literature points towards higher mortality and morbidity rates among children for climate stresses and extreme events (Bartlett, 2008; Sánchez et al., 2010; Telford *et al*., 2006; Cutter, 1995; Waterson, 2006; McMicheal *et al*., 2008; Costello *et al*., 2009). This is especially acute in developing countries, where climate-sensitive health outcomes such as malnutrition, diarrhoea and malaria are already common and coping capacities are lowest (Haines *et al*., 2006), although research in the USA found relatively low child mortality from disasters and considerable differences across age groups for different types of hazard (Zahran *et al*., 2008).

These studies underpin the need for resources for child protection during and after disaster events (Last 1994; Jabry 2002; Bartlett 2008; Lauten and Lietz, 2008; Weissbecker *et al*., 2008). These include protection from abuse, especially during displacement, social safety nets to guard against withdrawal from school due to domestic or livelihood duties, and dealing with psychological and physical health issues (Norris *et al*., 2002; Evans and Oehler-Stinnett, 2006; Bartlett 2008; Lauten and Lietz, 2008; Keenan *et al*., 2004; Peek 2008; Waterson, 2006; Davies *et al*., 2008).

*2. Children's Agency and Resource Access*

Rather than just vulnerable victims requiring protection, children also have a critical role to play in tackling extreme events in the context of climate change (Tanner, 2010). Children and youth movements have grown globally in campaigning for climate change mitigation actions in their own communities. They have also been increasingly active on the global policy stage, culminating in formal recognition of the Youth NGO Constituency (YOUNGO) within the UNFCCC process in 2009, giving young people a formal voice at the negotiating table (UNJFICYCC, 2009). There is also increasing attention to child-centred approaches to preventing, preparing for, coping with, and adapting to climate change and extreme events (Peek, 2008; Tanner, 2010).

While often centred on disaster preparedness and climate change programmes in education and schools (Wisner, 2006; Bangay and Blum, 2010), more recent work emphasises the latent capacity of children to participate directly in disaster risk reduction or adaptation supported through child-centred programmes (Back *et al*., 2009; Tanner *et al*., 2009). This emphasis acknowledges the unique risk perceptions and risk communication processes of children, and their capacity to act as agents of change before, during *and* after disaster events (see collections of case studies in Peek, 2008; Back *et al.,* 2009; and Tanner, 2010). Examples demonstrate the ability to reduce risk behaviour at households and community scale, but also to mobilise adults and external policy actors to change wider determinants of risk and vulnerability (Tanner *et al*., 2009; Mitchell *et al*., 2008).

_____ END BOX 8-1 HERE _____

Local knowledge (described variously in the literature as lay, traditional or indigenous knowledge) may reduce the risks of future hazard impacts. There is a long tradition of seeking to identify and bring such knowledges into planned disaster risk management in urban and rural contexts through participatory and community based disaster risk management (Pelling, 2007; Mercer *et al*., 2008; Bruner *et al*., 2001; Fearnside, 2001; Miles *et al*. 2004) and tools such as participatory GIS that explicitly seek to bring scientific and local knowledge together (Tran *et al*., 2009). Recent research on climate change has also identified the importance of culture, including traditional knowledge, in shaping strategies for adaptation (Heyd and Brooks, 2009; ISET, 2010).

Studies also show that gender matters, and poor households, particularly female-headed households, are more likely to borrow food and cash than rich and male-headed households during difficult times. This coping strategy is considered to be a dangerous one as the households concerned will have to return the food or cash soon after harvests, leaving them more vulnerable as they have less food or cash to last them the season and to be prepared if disaster strikes (Young and Jaspars, 1995). This may leave households in a cycle of poverty from one season to the next. Literature shows that this outcome is linked to unequal access to resources, land, public and privately provided services by women (Agarwal, 1991; Nemarundwe, 2003; Njuki *et al*., 2008; Thomas-Slayter *et al*., 1995). But women are also often the majority holders of social capital and the mainstay of social movements and local collective action providing important mechanisms for household and local risk reduction and potentially transformative resilience. Important here are local saving groups and microcredit/micro-finance groups some of which extend to micro-insurance. In a review of microfinance for disaster risk reduction and response in South Asia Chakrabarti and Bhatt (2006) identify numerous initiatives, including those that build on extensive social networks and connect to the formal financial services sector.

Both development planning and post-disaster recovery have tended to prioritise strategic economic sectors and infrastructure over local livelihoods and poor communities (Maskrey, 1989,1996). However, this represents a missed opportunity for building local capacity and including local visions for the future in planning the transition from reconstruction to development – opportunities which could increase long-term sustainability (Christoplos, 2006).

### *8.5.2. Sustainability of Ecosystem Services in the Context of Disaster Risk Reduction and Climate Change Adaptation*

Reducing human pressures on ecosystems and managing natural resources more sustainably can facilitate efforts to mitigate the rate and magnitude of climate change and to reduce vulnerabilities to natural hazards and climatic extremes. The degradation of ecosystems is undermining their capacity to provide ecosystem goods and services upon which human livelihoods and societies depend (MEA, 2005; WWF, 2010), and to withstand disturbances, including climate change. There is evidence that the likelihood of regime shifts in socio-ecological systems may be increasing in response to the magnitude, frequency, and duration of climate change and other disturbance events (Folke *et al.,* 2004, MEA, 2005). Large, persistent shifts in ecosystem services not only affect the total level of welfare that people in a community can enjoy, they also impact the welfare distribution between people within and between generations and hence may give rise to new conflicts over resource use. They could result in domino effects of increased pressure on successive resource systems, as has been suggested in the case of depletion of successive fish stocks (Berkes *et al*., 2006). However, the thresholds at which ecosystems undergo regime shifts remain largely unknown, partly due to variability over space and time (Scheffer, 2009; Biggs *et al*., 2009).

Ecosystems can act as natural barriers against climate-related hazardous extremes, reducing disaster risk (Conde, 2001; Scholze *et al*., 2005). For example, mangrove forests are a highly effective natural flood control mechanism which will become increasingly important with sea level rise, and are already used as a coastal defense against extreme climatic and non-climatic events (Adger *et al*., 2005). The benefits of such ecosystem services are determined by ecosystem health, hazard characteristics, local geomorphology, and the geography and location of the system in respect to hazard (Lacambra and Zahedi, 2011). In assessing the ecological limits of adaptation to climate change, Peterson (2009) emphasizes that ecosystem regime shifts can occur as the result of extreme climate shocks, but that such shifts depend upon the resilience of the ecosystem, and is likely to be influenced by processes operating at multiple scales. In particular there is evidence that the loss of regulating services (e.g., flood regulation, regulation of soil erosion) erodes ecological resilience (MEA, 2005).

Ecosystems and ecosystem approaches can also facilitate adaptation to changing climatic conditions (Conde, 2001; Scholze *et al*. 2005). Conservation of water resources and wetlands that provide hydrological sustainability can further aid adaptation by reducing the pressures and impacts on human water supply, forest conservation for carbon sinks, and alternative sources of energy such as biofuels to reduce carbon emission have multiple benefits (Reid, 2006), as do coastal defenses and avalanche protection (Silvestri and Kershaw, 2010). Such changes in the constituents of an ecosystem can be used as levers to, enhance the resilience of coupled socio-ecological systems (Biggs *et al*., 2009).

Biodiversity can also make important contributions to both disaster risk reduction and climate change adaptation. Functionally diverse systems may be better able to adapt to climate change and climate variability than functionally impoverished systems (Lacambra and Zahedi, 2011, Elmqvist *et al*., 2003; Hughes *et al*., 2003). A larger gene pool will facilitate the emergence of genotypes that are better adapted to changed climatic conditions. Conservation of biodiversity and maintenance of ecosystem integrity may therefore be a key objective in improving the adaptive capacity of society to cope with climate change (Peterson *et al*., 1997; Elmqvist *et al*., 2003).

Strategies that are adopted to reduce climate change through greenhouse gas mitigation can affect biodiversity both positively and negatively, which in turn influences the capacity to adapt to climate extremes. For example, some bio-energy plantations replace sites with high biodiversity, introduce alien species and use damaging agrochemicals which in turn may reduce ecosystem resilience and hence their capacity to respond to extreme events. Large hydropower schemes can cause loss of terrestrial and aquatic biodiversity, inhibit fish migration and lead to mercury contamination (Montgomery *et al*., 2000), as well as change watershed sediment dynamics, leading to coastal areas sediment starvation which in turn could lead to coastal erosion and make coasts more vulnerable to sea level rise and storm surges (Silvestri and Kershaw, 2010).

The increasing international attention and support for efforts focused on Reducing Emissions from Deforestation and Degradation, maintaining/enhancing carbon stocks and promoting sustainable forest management (REDD+) is an example of where incentives for the protection and sustainable management of natural resources driven by mitigation concerns also has the potential of generating co-benefits for adaptation. By mediating run-off and reducing flood risk, protecting soil from water and wind erosion, providing climate regulation and providing migration corridors for species, ecosystem services supplied by forests can increase the resilience to some climatic changes. Locatelli and others (2010) recognize the conceptual linkages between mitigation and adaptation that forest conservation can provide. Primary forests tend to be more resilient to disturbance and environmental changes, such as climate change, than secondary forests and plantations (Thompson *et al*., 2009). However, forests are also vulnerable to climatic extremes, as recent experimental observations have shown (e.g. Nepstad *et al*., 2007) and modeling studies focused on examining the effects of global warming on forests ecosystems suggest (e.g., Vergara and Scholz, 2011). Hence, the role of forest ecosystems in climate change mitigation and adaptation will itself depend on the rate and magnitude of climate change and whether the crossing of ecological tipping points can be avoided.

### *8.5.3. Local, National, and International Winners and Losers*

While climate-related hazards cannot always be prevented, the scale of loss and its social and geographical distribution does differ significantly, determined by the characteristics of those at risk and overarching structures of governance including the legacy of preceding development paths on social institutions, economy and physical assets (Oliver-Smith, 1994). But disasters also generate winners. These may be organisations or individuals who benefit economically from reconstruction, but also response (West and Lenze, 1994; Hallegatte, 2008b), through the supplying materials, equipment, and services – often at a premium price generated by local scarcity and inflationary pressures (Benson and Clay, 2004) or a result of poorly managed tendering processes (Klein, 2007). Areas not impacted by disaster can also experience economic benefits, for example in the Caribbean where hurricanes have caused international tourist flows to be redirected (Pelling and Uitto, 2001). Political actors can also benefit by demonstrating strong leadership post-disaster, at times even when past political decisions have contributed to generating disaster risk (Olson and Gawronski, 2003; Le Billon and Waizenegger, 2007; Gaillard *et al*., 2008). The same can be said for climate change, with very unequal consequences in various regions of the world and various economic sectors and social categories (O'Brien *et al*., 2004; Adger *et al*., 2003; Tol *et al*., 2004). Less directly, those who have benefitted from policies and processes, such as expansion of commercial agriculture or logging, can also be described as winners. However, costs and benefits are often separated geographically and temporally, making any efforts at distributional equity challenging. For example, in the case of Hurricane Mitch, which killed more than 10,000 people and caused as much as $8.5 billion in damages, deforestation and rapid urban growth are often cited among the key causes of the disaster related losses (Pielke *et al*. 2003; Alves, 2002).

Analyses of winners and losers associated with climate change and discrete hazards need differentiation. While individual events can be assessed as a snapshot of winners and losers, climate change as an ongoing process has no final state. Over time, it may produce different distributions of winners and losers, for example as areas experience positive and then negative consequences of changes in temperature or precipitation. Whether or not a particular place produces winners or losers from an extreme event or a combination of climate extremes and other driving forces also depends on perceptions. These may be shaped by the recovery process, but are strongly influenced by prioritized values (Quarentelli, 1984, 1995; O'Brien, 2009; O'Brien and Wolf, 2010).

In considering winners and losers from climatic hazards and extreme events, it also vital to recognize that the understanding of winners and losers is highly subjective, and depends upon an individual, group or society's dominant paradigms and perspectives. While some regard winners and losers as a natural and inevitable outcome of ecological changes and/or economic development, others suggest that winners and losers are deliberately generated by unequal political and social conditions (O'Brien and Leichenko, 2003). Lurking behind discourses about winners and losers are issues of liability and compensation for losses: i.e., if a population or an area experiences severe losses due to an extreme event (at least partly) attributed to climate change, whose fault is it? Issues of equity, justice, and compensation are thus increasingly being raised (O'Brien *et al*., 2010b), and it seems likely that efforts to assign responsibility will emerge as an issue for both governments and courts (Farber, 2007).

### *8.5.4. Potential Implications for Human Security*

Changes in climate-related extreme events threaten human security, and both disaster risk reduction and climate change adaptation represent strategies that can improve human security while also avoiding disasters. Human security addresses the combined but related challenges of upholding human rights, meeting basic human needs, and reducing social and environmental vulnerability (UNDP, 1994; Brauch, 2009a; Fuentes and Brauch 2009; Sen, 2003; Bogardi and Brauch, 2005; Brauch 2005a, 2005b). It also emphasizes equity, ethics, and reflexivity in decision-making and a critical questioning and contestation of the drivers of climate change (O'Brien *et al*., 2010b) and local impacts (Pelling 2010). Human security is realized through the capacity of individuals and communities to respond to threats to their environmental, social, and human rights (GECHS, 1999; Barnett *et al*., 2010). A number of studies have assessed the relationship between climate change and human security, demonstrating that the linkages are often both complex and context-dependent (Barnett 2003; Barnett and Adger, 2007; Buhaug *et al*., 2008; O'Brien *et al*., 2010a). Among the most likely human security threats are impacts on health, food, water and soil (Oswald Spring, 2009a; Oswald Spring *et al*., 2011). Negative impacts of climate change on food security over the medium- and long-term are likely to create greater emergency food aid needs in the future (Cohen, 2007).

Among the most widely-discussed humanitarian and human security issues related to climate change are the possibilities of mass migration and/or violent conflict resulting from the biophysical or ecological disruptions associated with climate change (O'Brien *et al*., 2008). There are indications that migration conditions followed disasters in the distant past, as well as in current situations (see, e.g., Kinzig *et al*., 2006; Le Roy Ladurie, 1971; Peeples *et al*., 2006). Migration is a key coping mechanism for poor rural households, not only in extreme circumstance, for example, during a prolonged drought, as with the 20th Century U.S. Dustbowl period and Sahelian droughts (Harrington *et al*., 2009; Scheffran, 2011), but also as a means of diversifying and increasing income. Disasters linked to extreme events often lead to forced displacement of people, as well as provoking voluntary migration amongst the less poor.

The relationship between climate risk and displacement is a complex one and there are numerous factors that affect migration (UNDP, 2009). Nonetheless, recent research suggests that adverse environmental impacts associated with climate change have the potential to trigger displacement of an increased number of people (Kolmannskog, 2008; Feng *et al*., 2010). Studies suggest that most migration will take place internally within individual countries; that in most cases when hydro-climatic disasters occur in developing countries they will not lead to net out-migration because people tend to return to re-establish their lives after a disaster; and that long term environmental changes are likely to cause more permanent migration (Piguet, 2008;UNEP, 2009). The opportunities that population movement opens for risk reduction are seen in international remittance flows from richer to poorer countries. These are estimated to have exceeded US$318 billion in 2007 of which developing countries received US$240 billion (World Bank, 2008). More negatively, the social dislocation provoked by migration can lead to the breakdown of traditional rural institutions and associated coping mechanisms, for example, in the erosion of traditional community based water management committees in central and west Asia (Birkenholtz, 2008). Local coping and adaptive capacity can also be limited by increases in the number of female-headed households as men migrate (Oswald Spring, 1991; 2009a). The spectre of disappearing islands or widespread desertification that forces land abandonment will be stressful for migrants whose culture and sense of identity are affected (Montreaux and Barnett, 2008; Sánchez *et al*., 2010; Brauch and Oswald Spring, 2011).

Despite the opportunities for disaster response and reconstruction to enhance development, disaster response is often better at meeting basic needs than securing or extending human rights. Indeed, the political neutrality that underpins the humanitarian imperative makes any overt actions to promote human rights by humanitarian actors difficult. In this way disaster response and reconstruction can to only a partial extent claim to enhance human security (Pelling and Dill, 2009). Work at the boundaries between humanitarian and development actors, new partnerships, the involvement of government and meaningful local participation are all emerging as ways to resolve this challenge. One successful case has been the reconstruction process in Aceh, Indonesia following the India Ocean Tsunami, where collaboration between government and local political interests, facilitated by international humanitarian actions on the ground and through political level peace building efforts have increased political rights locally, contained armed conflict and provided an economic recovery plan (Gaillard *et al*., 2008).

Coping with the new and unprecedented threats to human society posed by climate change has raised questions about whether existing geopolitics and geostrategies have become obsolete (Dalby, 2009). The concepts, strategies, policies and measures of the geopolitical and strategic toolkits of the past as well as the short-term interests dominating responses to climate change have been increasingly questioned, while the potential for unprecedented disasters has led to a consideration of the security implications of climate change (UNSC, 2007; EU, 2008, 2008a; SIDS, 2009; UNGA, 2009; UNSG, 2009). Concerns range from increased needs for humanitarian assistance to concerns over environmental migration, emergent diseases for humans or in food chains, potentials for conflict between nations or localities over resources, and potential for political/governmental destabilization due to climate-related stresses in combination with other stresses, along with efforts to assign blame (Ahmed 2009; Brauch and Oswald Spring, 2011).

Adaptation planning that seeks long-term resilience is continually confronted by political instability directly after disasters (Drury and Olson, 1998; Olson, 2000; Pelling and Dill, 2009; UNDP, 2004). When disasters strike across national boundaries or within areas of conflict, they can provide a space for rapprochement, but effects are usually short lived unless the underlying political and social conditions are addressed (Kelman, 2003; Kelman and Koukis, 2000). New interest in disaster and climate change as a security concern has brought in lessons from security policy on planning for relatively low-probability/high-consequence futures. Although during times of stress, it is easy for polities to drift towards militarization and authoritarianism for managing disaster risk (Albala-Bertrand, 1993), there are alternatives, such as inclusive governance, which can meet the goals of sustainable development and human security over the long-term (Brauch, 2009a; Bauer, 2010; Olson and Gawronski, 2003; Pelling and Dill, 2003).

### *8.5.5. Implications for Achieving Relevant International Goals*

Addressing—or failing to address— disaster risk reduction and climate change adaptation can influences the success of international goals, particularly those linked to development. The AfDB and nine other development organizations (2003) highlighted in a qualitative assessment report that climate change may impact on progress towards Millennium Development Goals (MDGs) and in particular constrain progress beyond 2015, underlying the importance of managing climate risks within and across development sectors. DFID (2006) shows how each of the Millennium Development Goals is dependent on some aspect of disaster risk for success. Disaster impacts on the MDG targets are both direct and indirect. For example, MDG 1 (to eradicate extreme poverty and hunger) is impacted directly by damage to productive and reproductive assets of the poor and less poor (who may remain in poverty or slip into poverty as a result of disaster loss), and indirectly effected by negative macroeconomic impacts.

It is also important to consider how the integration of disaster risk reduction considerations into development assistance frameworks (such as Common Country Assessments, United Nations Development Assistance Frameworks and Poverty Reduction Strategies) can influence climate change adaptation.

The UN-ISDR *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters* (HFA) recognizes the climate variability and change are important contributors to disaster risk and includes strong support for better linking disaster management and climate change adaptation efforts (Sperling and Szekely, 2005). The HFA priorities for action have proven foresightfull in including resilience explicitly as a component. Priority Three calls for ‘Knowledge, innovation and education to build a culture of safety and resilience at all levels’. This provides a strong justification for international actors to invest in resilience building and one that does not require the addition of new international agreements to start work.

More tangible examples of emerging visions for encouraging climate change adaptation and disaster risk reduction are still limited. Potential players include the global private sector (for instance, the World Business Council for Sustainable Development), major non-governmental organizations (for instance, the International Federation of Red Cross and Red Crescent Societies). Examples of subjects under discussion include relating the next set of Millennium Development Goals to climate change adaptation and risk management.

## 8.6. Options for Proactive, Long-Term Resilience to Future Climate Extremes

Considering the broad challenges described above, it is important to consider the fit of existing tools and the ways they are used, who uses them and how they interact and change-learn over time. Pursuing sustainable and resilient development pathways requires integrated and ambitious policy that is science-based and knowledge-driven, and that is capable of addressing issues of heterogeneity and scale. The latter issues are particularly vexing, as the consequences of, and responses to, climate extremes and disasters are local, but these responses need to be supported and enabled by actions at regional, national and global scales. This section first assesses the literature pertaining to tools and practices that can help address these issues, and then considers strategies to achieve transformational change. As the preceding sections in this chapter and other chapters in the report have argued, achieving a sustainable and resilient future requires a transformational change; and accomplishing such change will require a combination of adaptive management, learning, innovation, and leadership.

### *8.6.1. Approaches, Tools, and Integrating Practices*

Examples of past experience for integrating resilience into sustainable development that can enhance adaptation to climate extremes include experience of both specific decision-support tools and the governance and institutional contexts in which these tools and subsequent decisions are made. Tools include those that enable s information gathering, monitoring, analysis and assessment, develop projections of possible futures, simulate threats and explore implications for response. Approaches need to combine understandings of potential stresses from climate extremes, along with possible tipping points for affected social and physical systems, with monitoring systems for tracking changes and identifying emerging threats in time for adaptive responses. This is challenging and requires methodologies that can be open to both quantitative and qualitative data and its analysis including participatory deliberation (NRC, 2010). Scenarios, narrative storylines (Tschakert and Dietrich, 2010) and simulations (Nichols *et al*., 2007) can help to project and facilitate discussion of possible futures. Institutional innovation aimed at improving the availability of risk information to decision makers includes the creation of national or regional institutions to manage and distribute risk information (Von Hesse *et al*., 2008; Corfee-Morlot *et al*., 2011) which bring together previously fragmented efforts centred in national meteorological, geological, oceanographic and other agencies. New open source tools for comprehensive probabilistic risk assessment (GFDRR, nd) are beginning to offer ways of compiling information at different scales and from different institutions. A growing number of countries are also systematically recording disaster loss and impacts at the local level (DesInventar, 2010) and developing mechanisms to use such information to inform and guide public investment decisions (Comunidad Andina and GTZ, 2006; Comunidad Andina, 2009; Von Hesse *et al*., 2008) and for national planning. Unfortunately there is as yet only limited experience of the integrated deployment of such tools and institutional approaches, especially in ways that cross scales of risk management strategy development and decision-making. The following sections provide some more detail on current experience.

#### *8.6.2.1. Modelling Tools*

Various tools can be used to design environmental and climate policies. Among them, integrated environment-energy-economy models produce long-term projections taking into account demographic, technologic and economic trends (e.g., Edenhofer *et al*., 2006; Clark and Weyant, 2009). These models can be used to assess the consequences of various policies. However, most such models are at spatial and temporal scales that do not resolve specific climate extremes or disasters (Hallegatte *et al*., 2007). At smaller spatial scales, numerical models (e.g., input-output models, calculable general equilibrium models) can help to assess disaster consequences and, therefore, balance the cost of disaster risk reduction actions and their benefits (Gordon *et al*., 1998; Okuyama, 2004; Hallegatte, 2008b; Rose *et al*., 1997; Rose and Liao, 2005, 2007; Tsuchiya *et al*., 2007). In particular, they can compare the cost of dealing with disasters with the cost of preventing disasters. Since disasters have intangible consequences (e.g., loss of lives, ecosystem losses, cultural heritage losses, distributional consequences) that are difficult to measure in economic terms, the quantitative models are necessary but not sufficient to determine desirable policies and disaster risk reduction actions. Whether incorporated in models or used in other forms of analysis, cost-benefit analysis is useful to compare costs and benefits; but when intangibles play a large role and when no consensus can be reached on how to value these intangibles, other decision-making tools and approaches are needed. Multi criteria decision-making (Birkmann, 2006), robust decision-making (e.g., Lempert 2007; Lempert and Collins, 2007), transition management approaches (e.g. Loorbach, 2010; Kemp *et al*., 2007), and group-process analytic-deliberative approaches (Mercer *et al*., 2008) are examples of such alternative decision-making methodologies.

Also necessary are indicators to measure the successes and failures of policies. For example, climate change adaptation policies often target the enhancement of adaptive capacity. The effects and outcomes of policies are often measured using classical economic indicators like GDP. The limits of such indicators are well known, and have been summarized in several recent reports (e.g., CMEPSP, 2009; OECD, 2009). To measure progress toward resilient and sustainable future, one needs to include additional components, including measures of stocks, other capital types (natural capital, human capital, social capital), distribution issues, welfare factors (health, education, etc.). Many alternatives indicators have been proposed in the literature, but no consensus exists. Examples of these alternatives indicators include: the Human Development Index, the Genuine Progress Indicator, the Index of Sustainable

Economic Welfare, the Ecological Footprint, the normalized GDP (Jones, 2010; Costanza *et al*., 2004; Lawn, 2003; Costanza, 2000).

#### *8.6.1.2. Institutional Approaches*

Amongst the most successful disaster risk reduction and adaptation project are those that have facilitated the development of partnerships between local leaders and framing governmental or other extra-local stakeholders. This allows local strength and priorities to surface in risk management while acknowledging also that communities (including local government) have limited resource and strategic scope and alone can not always address the underlying drivers of risk. Local programmes are now increasingly moving from a focus on strengthening preparedness and response to reducing local hazard levels (for example, through slope stabilization, flood control measures, improvements in drainage etc.) and to reducing vulnerability (ISDR, 2009; Lavell, 2009; Reyos, 2010). Most of the cases where sustainable local processes have emerged are where national governments have decentralized both responsibilities and resources to the local level, and where local governments have become more accountable to their citizens as for example in cities in Colombia such as Manizales (Velásquez, 1998; Velásquez, 2005). In Bangladesh and Cuba successes in disaster preparedness and response leading to drastic reduction in mortality due to tropical cyclones, built on solid local organization, have relied on sustained support from the national level (Ahmed *et al*., 1999; Bern *et al.,* 1993; Chowdhury, 2002; Elsner *et al*., 2008; Haque and Blair, 1992; Karim and Mimura, 2008; Knutson *et al*., 2010; Kossin *et al*., 2007; World Bank, 2010a). A growing number of examples now exist of community driven approaches that are supported by local and national governments as well as by international agencies, through mechanisms such as social funds and others (Bhattamishra and Barrett, 2008).

Risk transfer instruments, such as insurance, reinsurance, insurance pools, catastrophe bonds, micro insurance and other mechanisms, shift economic risk from one party to another and thus provide compensation in exchange for a payment, often a premium (ex post effect) (see 5.5.2.2, 6.3.3.3 and 7.4.5.1). Many obstacles to such schemes still exist particularly in low income and many middle income countries: including the absence of comprehensive risk assessments and required data, legal frameworks and the necessary infrastructure and probably more experience is required to determine the contexts in which they can be effective (Cummins and Mahul, 2008; Mahul and Stutley, 2010; Linnerooth-Bayer and Mechler, 2007). In addition, ex ante, these mechanisms can also help to anticipate and reduce (economic) risk as they reduce volatility and increase economic resilience at the household, national and regional levels (Linnerooth-Bayer, Mechler and Pflug, 2005). As one example, with such insurance, drought exposed farmers in Malawi have been able to access improved seeds for higher yielding and higher risk crops thus helping them to make a leap ahead in terms of generating higher incomes and the adoption of higher return technologies (Hazell and Hess, 2010; World Bank, 2005).

Risk reduction and adaptation can also be addressed through the enhancement of generic adaptive capacity alongside hazard-specific response strategies (IFRC, 2010). This capacity includes access to information, the skills and resources needed to reflect upon and apply new knowledge, and institutions to support inclusive decisions-making. These are cornerstones of both sustainability and resilience. While uncertainty may make it difficult for decision-makers to commit funds for hazard-specific risk reduction actions, these barriers do not exist to prevent investment in generic foundations of resilient and sustainable societies (Pelling, 2010). Importantly, from such foundations local actors may be able to make better-informed choices on how to manage risk in their own lives, certainly over the short/medium terms. For instance, federations formed by slum dwellers have become active in identifying and acting on disaster risk within their settlements and seeking partnerships with local governments to make this more effective and larger scale (IFRC, 2010).

### ***8.6.2. Transformational Strategies and Actions for Achieving Multiple Objectives***

The question of how to achieve transformations toward more sustainable and resilient development pathways is a key challenge for humanity in the decades ahead (Folke, 2006). Transformation can be defined as a fundamental qualitative change, or a change in composition or structure that is often associated with changes in perspectives or initial conditions. It involves a change in paradigm, including shifts in perception and meaning, changes in underlying norms and values, reconfiguration of social networks and patterns of interaction, changes in power structures, and the introduction of new institutional arrangements and regulatory frameworks (Folke *et al*., 2010; Smith and Stirling, 2010; Pahl-Wostl, 2009; Folke *et al*., 2009). Successful transformational strategies promote organisational arrangements that are capable of evolving over time as risk landscapes change.

Transformational change cannot be realized without understanding how and why change occurs, or does not occur. Traditional approaches to managing change successfully in businesses and organizations focus on defined steps to improve management of the problems at hand (Harvard Business School Essentials, 2003). Kotter (1996), for example, identifies an eight-step process for leading change: 1) create a sense of urgency; 2) pull together the guiding team; 3) develop the change vision and strategy; 4) communicate for understanding and buy in; 5) empower others to act; 6) produce short-term wins; 7) don't let up; and 8) create a new culture. Kotter (1996) also identifies eight errors that are often made when leading change, including, for example, allowing too much complacency, failing to create a sufficiently powerful guiding coalition, and underestimating the power of a sound vision (Kotter, 1995). It is also important to recognize that many change initiatives create uncertainty and disequilibria, and are considered disruptive or disorienting (Heifetz *et al.*, 2009). Consequently, fundamental change is often resisted by the people that it affects the most (Kotter, 1996, Kegan and Lahey, 2009). Helping people, groups and organizations to manage the resulting disequilibria is seen as essential to successful transformation.

Many of the recent approaches to change and transformation focus on learning organizations, and the importance of changing mindsets or mental models (Senge, 1990; Scharmer, 2009; Heifetz *et al*., 2009). The "transformational change" literature distinguishes between technical problems that can be addressed through management based on existing organizational structures and cultural norms, and adaptive challenges that require a change in mindsets, including changes in assumptions, beliefs, priorities, and loyalties (Kegan and Lahey, 2009, Heifetz *et al*., 2009). Treating disaster risk reduction and climate change adaptation as technical problems may focus attention on improving technologies, reforming institutions, or managing displaced populations, whereas viewing them as an adaptive challenge shifts attention towards gaps between values and behaviors (e.g., values that promote human security vs. policies or behaviors that undermine health and livelihoods), beliefs (e.g., a belief that disasters are inevitable or that adaptation will occur autonomously) and competing commitments (e.g., a commitment to maintaining aid dependency or preserving of social hierarchies). Although most problems have both technical and adaptive elements, treating an adaptive challenge only as a technical problem often results in failure (Heifetz *et al*., 2009).

Transformative changes that move society towards the path of openness and adaptability depend not only on changes in mindsets, but also on changes in systems and structures. Case studies of social-ecological systems suggest that there are three phases involved in systems transformations. The first phase includes being prepared for, or preparing the system, for change. The second phase calls for navigating the transition by making use of a sudden crisis as an opportunity for change, whether the crisis is real or perceived. The third phase involves building resilience of the new system (Olsson *et al*., 2004, Chapin *et al*., 2010). Traditional management approaches emphasize the reduction of uncertainties, with the expectation that this will lead to systems that can be predicted and controlled. However, in the case of climate change, it is likely that significant uncertainties about future projections of climate variables and the statistics of climate extremes will remain. Consequently, there is a need for management approaches that are adaptive, and robust in the presence of large and irreducible uncertainties.

Both changes in management paradigms and the development of innovative methods are required to do justice to the complexity of social-ecological systems, which are 'complex adaptive systems' (Pahl-Wostl, 2007). The nature of transformative change can be captured by the concept of triple-loop learning (Argyris and Schön, 1978; Peschl, 2007). These three types of learning differentiate respectively among learning that improves efficiency, learning that reframes the goals that set conditions for practice, and learning that questions deep, underlying principles from which goals and behaviour are derived and legitimated (Pelling *et al*., 2007; Birkmann *et al*., 2008; Pahl-Wostl, 2009). Societal transformations can be described as multi-level and multi-loop processes, where triple loop learning allows for reexamining the underlying ideology and value systems. The example of flood management, which has been subjected to a global paradigm shift over the past decades, is used to illustrate the typical kinds of questions posed in the successive stages of learning (see Figure 8-1).

[INSERT FIGURE 8-1 HERE:
Figure 8-1: Sequence of learning loops in the concept of triple-loop learning applied to flood management (modified from Pahl-Wostl, 2009).]

Changes in systems and structures may call for new ways of thinking about social contracts, which describe the balance of rights and responsibilities between different parties. Social contracts that are suitable for technical problems can be limiting and insufficient for addressing adaptive challenges (Heifetz, 2010). Pelling and Dill (2009) describe the ways that current social contracts are tested when disasters occur, and how disasters may open up a space for social transformation, or catalyse transformative pathways building on pre-disaster trajectories. O'Brien *et al*. (2009) consider how resilience thinking can contribute to new debates about social contracts in a changing climate, drawing attention to trade-offs among social groups and ecosystems, and to the rights of and responsibilities towards distant others and future generations.

### *8.6.3. Facilitating Transformational Change*

Adaptation that is transformative marks a shift from risk management's preference for finite projects with linear trajectories and readily identifiable, discrete strategies and outcomes (Schipper, 2007), towards an approach that includes adaptive management, learning, innovation and leadership, among other elements. These aspects of adjustment are increasingly seen as being embedded in ongoing socio-cultural and institutional learning processes. This can be observed in the many adaptation projects that emphasize learning about risks, evaluating response options, experimenting with and rectifying options, exchanging information, and making trade-offs based on public values using reversible and adjustable strategies (Leary *et al.*, 2008; McGray *et al.*, 2007; Hallegatte, 2009; Hallegatte *et al.*, 2011c).

#### *8.6.3.1. Adaptive Management*

In general terms, adaptive management can be defined as a structured process for improving management policies and practices by systemic learning from the outcomes of implemented strategies, and by taking into account changes in external factors in a proactive manner (Pahl-Wostl, 2007; Pahl-Wostl *et al*., 2007). Principles of adaptive management can contribute to a more process-oriented approach to disaster risk management, and have already shown some success in promoting sustainable natural resource management under conditions of uncertainty (Medema *et al*., 2008). Adaptive management is often associated with 'adaptive' organizations that are not locked into rigid agendas and practices, such that they can consider new information, new challenges, and new ways of operating (Berkhout *et al*., 2006; Pelling *et al*., 2007). Organizations that can monitor environmental, economic and social conditions and changes, respond to shifting policies and leadership changes, and take advantage of opportunities for innovative interventions are a key to resilience, especially with respect to conceivable but long-term and/or relatively low-probability events. Those social systems that appear most adept at adapting are able to integrate formal organizational roles with cross-cutting informal social spaces for learning, experimentation, communication and for trust based and speedy disaster response (Pelling *et al*., 2009).

Adaptive management is a challenge for those organisations that perceive reputational risk from experimentation and the knowledge that some local experiments are likely to fail (Fernandez-Gimenez *et al*., 2008). Where this approach works best, outcomes have gone beyond specific management goals to include trust-building among stakeholders—a resource that is fundamental to any policy environment facing an uncertain future, which also has benefits for quality of life and market competitiveness (Pelling, 2010). It requires revisiting the relationship between the state and local actors concerning facilitation of innovation, particularly when experiments go wrong. Investing in experimentation and innovation necessarily requires some tolerance for projects that may not be productive, or at least not in the short term or under existing risk conditions. However, it is exactly the existence of this diversity of outcomes that makes societies fit to adapt once risk conditions change, particularly in unexpected and non-linear directions.

*8.6.3.2. Learning*

This dynamic notion of adaptation promotes learning as an iterative process in order to build resilience and enhance adaptive capacity now, rather than targeting adaptation in the distant future. Social and collective learning includes support for joint problem solving, power sharing, and iterative reflection (Berkes, 2009). The need to take into account the arrival of new information in the design of response strategies have been mentioned also for mitigation policies (Ha Duong *et al*., 1997; Ambrosi *et al*., 2003). Adaptive management is an incremental and iterative learning-by-doing process, whereby participants make sense of system changes, engage in actions, and finally reflect on changes and actions. Lessons from learning theories, including experiential learning (Kolb, 1984) and transformative learning (Mezirow, 1995), stress the importance of learning-by-doing in concrete learning cycles, problem-solving actions, and the re-interpretation of meanings and values associated with learning activities.

Learning as a key component for living with uncertainty and extreme events is nurtured by building the right kind of social/institutional space for learning and experimentation that allows for competing worldviews, knowledge systems, and values, and facilitates innovative and creative adaptation (Thomas and Twyman, 2005; Armitage *et al.*, 2008; Moser, 2009; Pettengell, 2010). It is equally important to acknowledge that abrupt and surprising changes may surpass existing skills and memory (Batterbury, 2008). Adaptation projects have demonstrated that fostering adaptive capacity and managing uncertainty on the go by adjusting as new information, techniques, or conditions emerge, especially among populations exposed to multiple risks and stressors, is more effective than more narrowly designed planning approaches that target a given impact and are dependent on particular future climate information (Pettengell, 2010; McGray *et al.*, 2007). In the humanitarian sector, institutionalized processes of learning have contributed to leadership innovation (see Box 8-2).

_____ START BOX 8-2 HERE _____

**Box 8-2. Institutionalized Learning in the Humanitarian Sector**

An important attribute of the humanitarian sector is its readiness to learn. Learning unfolds at multiple levels, including sector wide reviews of performance, practice (e.g., ALNAP). Learning is also structured around the internal needs of organisations (e.g., Red Cross) or the outcomes of individual events (e.g., DEC reviews of humanitarian practice including the Indian Ocean Tsunami). All have different methodologies, target audiences and frames of reference, but they all have led to practical and procedural changes. Less well-developed is active experimentation in the field of practice, with a view of proactive learning. This is difficult in the humanitarian sector where stakes are high and rapid action has typically made it difficult to implement learning-while-doing experiments. Where experimentation may be more observable, for example in disaster prevention and risk reduction or reconstruction activities, there are significant gaps in documentation and impartial impact assessment that has slowed down the transferring of learning outcomes between organizations. Competition between agencies within the humanitarian and development sectors partly explain why there is more learning based on the sharing of experience inside organizations than across sectors. But the increasing scale and diversity of risk associated with climate change, and compounded by other development trends such as growing global inequality and urbanization, puts more pressure on donors to promote cross-sector communication of productive innovations and of the experimentation such innovation builds upon.

_____ END BOX 8-2 HERE _____

Action research and learning provides a powerful complement to resilience thinking, as it focuses explicitly on iterative or cyclical learning through reflection of success and failures in experimental action, transfer of knowledge between learning cycles, and the next learning loop that will lead to new types of action (Ramos, 2006; List, 2006). In this process, critical reflection is paramount; it also constitutes the key pillar of double loop learning, the questioning of what works and why that is fundamental to shifts in reasoning and behavior (Kolb and Fry, 1975; Argyyris and Schön, 1978; Keen *et al.*, 2005). Allowing time for reflection in this iterative learning process is important because it provides the necessary space to develop and test theories and strategies under ever changing conditions. It is through such learning processes that empowered agency can emerge and potentially be scaled up into everyday spaces to trigger transformation (Kesby, 2005).

### *8.6.3.3. Innovation*

The transformation of society towards sustainability and resilience involves both social innovations and technological innovations, incremental as well as radical. In some cases, small adjustments in practices or technologies may represent useful steps towards sustainability, while in other cases there is a strong need for more radical transformations. Some of the literature on innovation focuses on ensuring economic competitiveness for firms in an increasingly globalized economy (Fløysand and Jakobsen, 2010), and some concentrates on the relationship between environment on the one hand and the competitiveness of firms on the other (Mol and Sonnenfield, 2000). In addition, there is a body of social science literature on innovation that has emerged during the last 15 years, motivated by the need for transforming society as a whole in more sustainable directions. Recent literature has brought out new ideas and frameworks for understanding and managing technology and innovation-driven transitions, such as the Multi Level Perspective (MLP) (Rip and Kemp, 1998; Geels, 2002; Geels and Schot, 2007; Markard and Truffer, 2008). Combining insights from evolutionary theory and sociology of technology, the MLP conceptualizes major transformative change as the product of inter-related processes occurring at the three levels of niches, regimes and landscape. The model emphasizes the incremental nature of innovation in socio-technical regimes. Transitions, i.e. shifts from one stable socio-technical regime to another—occur when regimes are destabilized through landscape pressures, which provide breakthrough opportunities for niche-innovations.

In this field of research there is a strong focus on systems innovation and transformation of socio-technical systems, with the potential of facilitating transitions from established systems for transport, energy supply, agriculture, housing, etc., to alternative, sustainable systems (Hoogma *et al*., 2002; Raven, 2010).Though not directly dependent on changes in technology, technological and social innovations are often closely interrelated, not the least in that they involve changes in social practices, institutions, cultural values, knowledge systems, and technologies (Rohracher, 2008). A central, basic insight established within this research is that social and technological change is an interactive process of co-development between technology and society (Kemp, 1994, Hoogma *et al*., 2002; Rohracher, 2008). Through history, new socio-technical systems have emerged and replaced old ones in so-called technological revolutions, and an important characteristic of such transitions are the interactions and conflicts between new, emerging systems and established and dominating socio-technical regimes, with strong actors defending business as usual (Kemp, 1994; Perez, 2002).

_____ START BOX 8-3 HERE _____

**Box 8-3. Innovation and Transformation in Water Management**

The impacts of climate change are predominantly linked to the water system, in particular through increased exposure to floods and droughts (Lehner *et al*., 2006; Smith and Barchiesi, 2009). Considering water as a key structuring element or guiding principle for landscape management and landuse planning requires technology, integrated systems thinking, and the art of thinking in terms of attractiveness and mutual influence, or even mutual consent, between different authorities, experts, interest groups, and the public. One of the most pronounced changes can be observed in the Netherlands where the government has requested a radical rethink of water management in general and flood management in particular. The resulting policy stream, initiated through the ‘Room for the River’ (*Ruimte voor de Rivier*) policy, has strongly influenced other areas of government policy. Greater emphasis is now given to the integration of water management and spatial planning with the regulating services provided by landscapes with natural flooding regimes being highly valued. This requires a revision of land use practices and reflects a gradual movement towards integrated landscape planning whereby water is recognized as a natural, structural element. The societal debate about the plans to build in deep-lying polders and other hydrologically unfavorable spots, and new ideas on floating cities indicate a considerable social engagement of both public and private parties with the issue of sustainable landscapes and water management. However, although such innovative ideas have been adopted in policy, they take time to implement, as there is considerable social resistance.

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### *8.6.3.4. Leadership*

Leadership can be critical for disaster risk reduction and climate change adaptation, particularly in initiating processes and sustaining them over time (Moser and Ekstrom, 2010). Change processes are shaped both by the action of individual champions (as well as by those resisting change) and their interactions with organisations, institutional structures and systems. Leadership can be a driver of change, providing direction and motivating others to follow, thus the promotion of leaders by institutions is considered an important component of adaptive capacity (Gupta *et al*., 2010).

Leaders who facilitate transformation have the capacity to understand and communicate a wide set of technical, social and political perspectives related to a particular issue or problem. They are also able to reframe meanings, overcome contradictions, synthesize information, and create new alliances that transform knowledge into action (Folke *et al*., 2009). Leadership also involves diagnosing the kinds of losses that people are likely to experience with transformation, such as the loss of status, wealth, security, loyalty, or competency, not to mention loved ones (Heifetz, 2010). Leaders helps individuals and groups to take action to mobilize "adaptive work" in their communities, such that they and others can thrive in a changing world by managing risk and creating alternative development pathways – or engaging and directing people during times of choice and change (Heifetz, 2010).

## 8.7. Synergies between Disaster Risk Reduction and Climate Change Adaptation for a Resilient and Sustainable Future

Drawing on the discussions presented in this chapter, it becomes clear that there are many potential synergies between disaster risk reduction and climate change adaptation that can contribute to a resilient and sustainable future. There is, however, no single approach, framework or pathway to a sustainable and resilient future; a diversity of responses to extremes taken in the present and under varying social and environmental conditions can contribute to future resilience in situations of uncertainty. Nonethless, there are some important factors that can contribute to risk reduction and sustainability. Four critical factors identified by Tompkins et al. (2008) that have been discussed in this chapter include 1) flexible, learning-based, responsive governance; 2) committed, reform-minded and politically active actors; 3) disaster risk reduction integrated into other social and economic policy processes; and 4) a long-term commitment to managing risk. Creating space and recognizing a diversity of voices often means reframing what counts as knowledge, engaging with uncertainties, nourishing the capacity for narrative imagination, and articulating agency and strategic adaptive responses in the face of already experienced changes and to anticipate and prepare for future disturbances and shocks (Tschakert and Dietrich, 2010).

Lessons learned in climate change adaptation and disaster risk reduction illustrate that managing uncertainty through adaptive management, anticipatory learning and innovation can lead to more flexible, dynamic, and efficient information flows, adaption plans, and transformational action. Engaging with possible and desirable futures and options for decision-making fosters knowledge generation that is essential for adaptive risk management as well as iterative change processes. Zooming in on uncertain elements and their likely impacts (e.g. changes in direction of rainfall and variability) and identifying factors that currently limit adaptive capacity (e.g. marginalization, lack of access to resources) allows for more robust decision-making that also integrates local contexts (asset portfolios, spreading and managing risks) with the climate context (current trends, likely futures, and uncertainties) to identify the most feasible, appropriate, and equitable response strategies, policies, and external interventions (Pettengell, 2010). Challenges remain with respect to anticipating low probability/high impacts events and potentially catastrophic tipping points. This is either because they represent futures too undesirable to imagine, especially under circumstances where exposure and vulnerability are high and adaptive capacity low, or because they are perceived as inconsistencies or logically impossible (Volkery and Ribiero, 2009). Moreover, anticipating vulnerabilities as well as feasible and fair actions may also reveal limits of adaptation and risk management, and thus the potential need for transformation. Yet, decisions about when and where to facilitate transformative change and to whose benefit are inherently normative and cannot be approached without understanding related ethical and governance dimensions.

There are, however, many gaps and barriers to realizing synergies that can and should be addressed to foster a resilient and sustainable future. For example, overcoming the current disconnect between local risk management practices and national institutional and legal frameworks, policy and planning can be considered key to reconciling short- term and long-term goals for vulnerability reduction. Reducing vulnerability has, in fact, been identified in many studies as perhaps the most important prerequisite for a resilient and sustainable future. In fact, some research has concluded that disaster risk reduction must be combined with structural reforms that address the underlying causes of vulnerability and the structural inequalities that create and sustain poverty, constrain access to resources, and threaten long-term sustainability (Lemos *et al*., 2007; Pelling, 2010). Globally, disaster mortality levels drop when countries' development indicators improve, particularly in rural areas (ISDR, 2009). There have been major documented reductions in drought, flood and cyclone mortality (IFRC, 2010). These are due to a combination of improved development conditions (for example, flood mortality drops dramatically when transport infrastructure to permit evacuation exists and when health services are available), disaster preparedness, and early warning and response (which are also characteristic of improved development conditions).

Disasters often require urgent action and represent a time when everyday processes for decision-making are disrupted. Often, the most vulnerable to hazards are left out of decision-making processes (Mercer *et al*., 2008; Pelling, 2003, 2007; Cutter, 2006), whether it is within households (where the knowledge of women, children or the elderly may not be recognised), within communities (where divisions among social groups may hinder learning), or within nations (where marginalized groups may not be heard, and where social division and political power influence the development and adaptation agenda). These periods are frequently the times when those most affected are not consulted on their development visions and aspirations for the future. Instead, international social movements and humanitarian NGOs, government agencies and local relief organisations are likely to impose their own values and visions, often with the best of intentions. It is also important to recognize the potential for some people or groups to prevent sustainable decisions by employing their veto power or lobbying against reforms or regulations based on short-term political or economic interests. The distribution of power in society and who has the responsibility or right to shape the future through decision-making today is thus significant.

Actions to reduce disaster risk and responses to climate change invariably involve trade-offs with other societal goals, and conflicts related to different values and visions for the future. Innovative and successful solutions that combine multiple perspectives, differing worldviews, and contrasting ways of organizing social relations has been described by Vermeij *et al*. (2006) as "clumsy solutions." Such solutions, they argue, depend on institutions in which all perspectives are heard and responded to, and where the quality of interactions among competing viewpoints foster creative alternatives. Drawing on the development ethics literature, St. Clair (2010) notes that when conflict and broad-based debate is forged, alternatives flourish and many potential spaces for action can be created, tapping into people's innovation and capacity to cope, adapt and build resilience. Pelling (2010) stresses the importance of social learning for transitional or transformational adaptation, and points out that it requires a high level of trust, a willingness to take experiment and accept the possibility of failure in processes of learning and innovation, transparency of values, and active engagement of civil society. Committing to such a learning process is, as Tschakert and Dietrich (2010, p. 17) argue, preferable to alternatives because "Learning by shock is neither an empowering nor an ethically defensible pathway."

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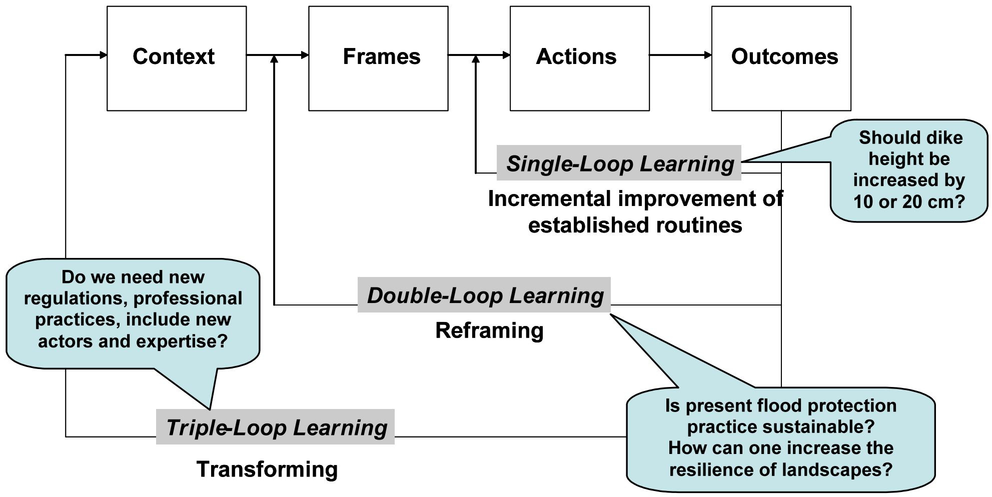


Figure 8-1: Sequence of learning loops in the concept of triple-loop learning applied to flood management (modified from Pahl-Wostl, 2009).