Chapter 8. Toward a Sustainable and Resilient Future

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Executive Summary

Realizing adaptation potentials requires (a) **anticipation** of vulnerabilities and (b) **anticipatory actions** to reduce those vulnerabilities, rooted in risk management perspectives and development co-benefits.

It is unlikely that societies will be able to adapt to climate extremes associated with rapid and severe climate change without transformational changes. The risks associated with severe climate change may create **complex emergencies and new types of disasters**, potentially leading to risks and losses that threaten the sustainability of current patterns of activity.

Natural risks and climate change are some of the stresses that affect societies and economies. Managing these issues without taking into account other stresses (e.g., pressure on land availability, socio-economic trends, financial constraints) may lead to suboptimal strategies and **trade-offs**. In particular, in absence of multi-stress analyses, measures implemented to reduce one risk can **enhance other stresses**.

Managing the risks associated with **frequently occurring low-intensity events** is an effective **here and now** strategy to adapt development to climate change and will reduce the impact of future extremes. However, it is necessary to ensure that current risk reduction measures do not exacerbate current or future vulnerability.

Choices and outcomes for adaptive actions to climate extremes and extreme events are complicated by **multiple interacting processes**, competing prioritized **values** and **objectives**, and **different visions of development**.

A common key challenge to both disaster risk reduction and climate change adaptation is to strengthen **institutions** and **governance** arrangements (and create synergies across scales) and to increase access to information, technology, resources and capacity in countries and localities with the highest climate related risks and weak capacities to manage those risks.

A key challenge is to address and incorporate **uncertainty** into planning and implementing response. **Adaptive risk management** strategies are helpful in responding in the presence of uncertainty and complexity.

There is no single approach, framework or pathway to a sustainable and resilient future; a **diversity** of **responses** to extremes taken in the present can contribute to future resilience in situations of uncertainty.

Disasters can be considered both a **problem of development**, and a **problem for development**. Disaster risk reduction and climate change adaptation strategies must address both underlying problems of development, and emerging implications for development.

8.1. Introduction

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. Many of these challenges were discussed in the previous chapters of this report, including the scientific, conceptual, political and practical hurdles that must be acknowledged and overcome. It is clear from the assessment presented in these chapters that there are multiple perspectives on disaster risk reduction and climate change adaptation, and diverse interpretations of the problems and the solutions. Consequently, there are many entry-points for action, often involving tensions and trade-offs with multiple policy goals, particularly in relation to decision-making under uncertainty.

The complex interactions among changes in average climate conditions, changing occurrences of frequent, low-magnitude events and infrequent, high magnitude events pose challenges to sustainability and resilience, as they influence not only lives and livelihoods, but development trajectories. Changes in extreme events associated with climate change add additional risk and uncertainty to decision-making in the context of multiple stressors. However, for many population groups, regions, or sectors, there is no clear distinction between ongoing climate variability and changing extremes. Furthermore, extremes are translated into impacts by the underlying conditions of risk associated with the contexts in which they occur. Because climate change is only one of the many processes affecting people and places (and often not the most important), responses to multiple interacting stressors and risks require an understanding of these contexts, and of how people make choices. For example, choices can be associated with proximity to livelihood options, amenity values, cultural factors, risk perception, and so on. Looking at contexts and choices leads to a better understanding of how choices are constrained or facilitated by social, economic, political, technological and environmental conditions.

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. Both disaster risk reduction and climate change adaptation 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. Research on the resilience of social-ecological systems provides some lessons for addressing the gap between these objectives. Yet strengthening the links between disaster risk reduction, climate change adaptation and sustainable development will not be unproblematic, as there are different interpretations of development, different preferences, prioritized values and motivations, different visions for the future, and many trade-offs involved.

The changes in extreme event frequency and intensity associated with climate change can to some extent be managed as part of larger efforts to reduce anthropogenic climate change through reduction in greenhouse gas emissions. More importantly, however, the drivers of disaster risk can be addressed as a way not only to reduce the losses associated with climate extremes, but as a way of facilitating social and economic welfare and resilience. The challenges posed by climate extremes can provide additional impetus to address existing disaster risks, creating positive outcomes for humans and the environment. A growing literature suggests that a resilient and sustainable future is a choice that involves proactive measures including learning, innovation, transition, and transformation. Although such measures may be interpreted as wishful thinking, technological and managerial optimism, naive "green" rhetoric, or utopianism, there is a growing scientific and popular literature that discusses how climate change responses can lead to transformative social, economic, and environmental changes (Loorbach et al., 2008; Hedrén and Linnér, 2009).

While positive and optimistic outcomes are possible, they are far from inevitable. 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 (ISDR, 2009). Clearly 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. These choices will be made by different institutions and actors, and may open new debates about rights and responsibilities between governments, local authorities, the private sector, civil society, and individuals, at different scales.

There is a growing literature from the physical, social and humanistic sciences to support the conclusion that rapid and extreme climate change poses serious threats to society, which are likely to be felt through tipping points, complex emergencies and new types of disasters (Lenton et al., 2008, Rockström et al., 2009). While this chapter shows that a resilient and sustainable future is possible, these outcomes become increasingly less likely as the magnitude of climate change increases. Indeed, with more rapid climate change, adapting becomes more difficult and success in doing so becomes less likely (Dessai et al., 2009a; Dessai et al., 2009b; Hallegatte, 2009; Oswald Spring and Brauch, 2010). In addition, as shown by many of the case studies in Chapter 9, the consequences of non-adaptation or maladaptation increase with the pace and amplitude of climate change. It is clear that adaptation and disaster risk management can be improved, but that responses will be seriously challenged by relatively severe climate change and associated extremes. The chapter concludes by identifying and assessing synergies for action that address the tensions between different preferences and visions, which may be considered a prerequisite for responding to multiple and interacting challenges. Disaster risk reduction and climate change adaptation are both key aspects of development, development planning, and human development in general, and thus can be seen as cornerstones for a resilient and sustainable future.

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 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. This gains 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 technology can influence sustainable development.

8.2.1. Concepts of Adaptation, Disaster Risk Reduction, and Sustainable Development and How They are Related

Adaptation to climate change has been defined as adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate 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. It also involves changes in perceptions of climate risk (Weber, 2010). Adaptation actions may be anticipatory or reactive and may be undertaken by public or private actors. In practice, adaptation is more than a set of discrete measures specifically to address climate change, but an on-going process that encompasses responses to many factors and stresses (Tschakert and Dietrich, 2010). Actions to adapt to climate change are often difficult to distinguish from development actions, as in many cases adaptations yield development co-benefits (Agrawala, 2005; Klein et al., 2007; McGray et al., 2007; Hallegatte, 2008).

Disaster risk can be defined in many ways (see Chapter 1). In general, however, it is closely associated with the concepts of exposure, vulnerability, and hazards. All three of these concepts are interlinked, and vary and change over time. Consequently, disaster risk is not static, but rather a reflection of dynamic biogeophysical and socio-economic conditions. Taking risks is unavoidable and can be desirable if the benefits from the actions that create or increase risks yield other benefits that exceed the negative impact of risks. For instance, building in low-lying coastal zone can be considered beneficial in spite of the corresponding increase in risk, if the economic activity (e.g., ports and tourism) and the jobs it creates are highly valued by the population and the decision-makers (see for instance on the case of New Orleans, Lewis, 2003; Hallegatte, 2006; Levina et al., 2007). As a consequence, reducing risk as much as possible may not always be desirable, and analyses of the cost and benefits of risks are necessary to inform decision-makers.

Global increases in disaster risk since 1990 have been fundamentally driven by the increasing exposure of people and economic assets. The population exposed to major river basin flooding is estimated to have increased by 28% from 1990 to 2007 while the exposure of economic assets had increased by 98% (ISDR, 2009, P.52). Estimates also indicate that growing exposure will play a major role in shaping future risk to climate extremes (Economics of Climate Adaptation Group, 2009 : 40 -41). These increases in exposure are reflections of global patterns and trends of urban and economic development (Satterthwaite, 2007). For example, rates of urbanization generally correspond to increases in the percentage of GDP concentrated in the industry and service sectors. In some parts of the world, therefore, increases in disaster risk are associated with economically successful cities. For example, coastal cities in the export-led economies of Asia may have large populations exposed to hazards such as flooding, cyclones and storm surges (Nicholls et al., 2008). However, disaster risk is also growing in less successful cities. For example, in sub-Saharan Africa, some cities are experiencing increases in both vulnerability and exposure, particularly those with more than 70% of their population living in informal settlements, which are often in hazard prone areas and without risk-reducing infrastructure such as drainage (Dodman, Hardoy, Satterthwaite, 2008; Diagne and Ndiaye, 2009; Songsore, et. al. 2009).

While the disaster risks associated with low-recurrence extreme events capture the headlines, a significant proportion of damage is associated with frequently occurring, low-intensity, localized hazards (ISDR, 2009, P.67). This damage is particularly concentrated in low-income groups and contributes to increases in poverty, inequality and declining human development indicators (ISDR, 2009 : 78 – 84). Global models of disaster risk associated with weather-related hazards potentially influenced by climate change, show how risk is disproportionately concentrated in developing countries (ISDR, 2009). For example, in the case of tropical cyclones, relative mortality risk has been calculated as 200 times greater in low income countries than in OECD countries (ISDR 2009). In the case of relative economic loss, expressed as a proportion of exposed GDP, estimated losses in East Asia and the Pacific, Latin America and the Caribbean and South Asia are between 5 and 7 times greater than in OECD countries (ISDR 2009). Small-island states and others with small and vulnerable economies experiencing extreme trade limitations are particularly at risk (Corrales et. al. 2008). At the same time, increasingly global capital flows, as well as the increasing exposure of financial markets to risk (through the growth of insurance linked securities), increase the potential for impacts far beyond the areas where hazards occur. Ultimately, disaster risk is a global responsibility that all countries share.

Exposure of people, species and economic assets to hazards is a function of both physical geography and the social and economic context in which hazards occur. The social and economic context plays a major and increasing role as human populations increasingly settle in vulnerable areas (Pielke et al., 2008), and as globalization processes create new types of exposure (Leichenko and O'Brien, 2008; Stiglitz 2002, 2010). An increasing number of people are exposed to hazards as a result of ongoing development inequalities (for example, inadequate access to basic needs) and governance weaknesses (for example, insufficient land-use and building control) manifest through changes in the quality, density and distribution of basic needs and human rights as well as risk management-specific capacities (UNDP, 2004; ISDR, 2009). Rapid and uncontrolled urbanization may also increase exposure, especially in developing countries (Nicholls et al., 2008). Increases in exposure are due to important underlying factors, such as the growth of export-led economies in Asia that drives development in port cities vulnerable to storm surges, or the industrialization of developing countries that leads to rapid urbanization in land-scarce areas. Increases in exposure have contributed significantly to increases in vulnerability and disaster risk (Pielke et al., 2008; ISDR, 2009 and 2009 Swiss Re. report on Economics of Adaptation). For example, coastal cities in regions of tropical cyclone incidence have increased rapidly in both size and population over the past thirty years, exposing many more people to typhoons and storm surges (references).

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, P.14). In the climate change community (IPCC, 2007), vulnerability is a much more integrated concept, combining hazard, exposure, risk-management, and adaptive capacity (Fussel and Klein, 2006). Vulnerability can increase or decrease over time, as the result of both environmental and socioeconomic changes. In general, improvements in a country's development indicators have been associated with reduced vulnerability (Strobl and Schumacher, 2008). As countries develop, there is often a reduction in human mortality, yet an increase in economic loss and insurance claims (ISDR, 2009 and 2009 Swiss Re. report on Economics of Adaptation, Pielke met al. 2008; EM-DAT reports; etc.). However, some types of development may increase vulnerability, particularly if it leads to social marginalization for some groups, to a degradation of ecosystem services, or to uncontrolled urbanization (references). Vulnerability increases for many when development gains are unequally spread, particularly when large populations (often the majority of the urban population) live in unsafe dwellings or environments. Even where growth is more equitable, risk can be generated, for example when modern buildings are not constructed to prescribed safety standards.

Hazards consist of physical phenomena such as floods, landslides, cyclones, drought or wildfires that are potentially dangerous (to the exposed elements). 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 are 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 modify hazard patterns (Millenium Ecosystem Assessment, 2005; Nicholls et al., 2008). Indeed, most weather-related hazards now have an anthropogenic element (Lavell, 1999, Cardona, 1996).

Climate change magnifies present ongoing risk patterns, through changes in the frequency, severity and spatial distribution of weather-related hazards, as well as through increases in vulnerability due to changing climate means. Disaster risk reduction, by addressing existing risks and the underlying risk drivers, can be considered key to climate change adaptation. Promoting disaster risk reduction as a means for adaptation opens great scope for advancing practices in both fields. For example, disaster risk reduction promotes planning for multi-hazard contexts (including non-climate related issues such as economic underdevelopment, poverty, marginalization, etc.). Whereas climate change policy has tended to approach risk and its management from a top-down, global or at least national viewpoint (e.g., through reduction of greenhouse gas emissions), disaster risk reduction, including response and reconstruction and climate change adaptation are driven more by a bottom-up focus that emphasizes the contingency of geography and history in shaping risk and coping capacity (Schipper and Pelling, 2006; McBean and Ajibade, 2009; Pelling and Schipper, 2009).

Risk is linked to hazards, exposure and vulnerability, and disaster risk reduction can in principle address any combination of these three. For example, the hazard associated with tropical cyclones can be reduced by ecosystem measures such as conserving mangroves and by improving drainage; exposure can be reduced through zoning and land-use control; physical vulnerability can be reduced through improving building codes while early warning systems, disaster preparedness plans and education programs can reduce social vulnerability. Disaster risk reduction may be anticipatory (ensuring that new development does not increase risk) or corrective (reducing existing risk levels) (Lavell, 2009: 19). Given expected increases in the population of cities in hazard prone areas, anticipatory disaster risk reduction is clearly fundamental to reducing the risk to future climate extremes. At the same time, investments in corrective disaster risk reduction are required to address the huge accumulation of existing climate risks.

A significant proportion of risk in developing countries is concentrated in informal urban settlements. Currently it is estimated that more than 1 billion people live is such settlements and that the number is growing by about 25 million people a year (UN Habitat, 2009). Not all informal settlements are located in hazard prone areas, but often the most hazard prone areas in cities are occupied by informal settlements. In cities where detailed data is available, such as San Jose, Cali and Caracas (Bonilla, 2008; Jimenez, 2008), the increase in disaster loss is closely correlated with the expansion of informal settlements. Such areas are characterised by high levels of relative poverty and everyday risk, due to water stress, poor sanitation, dangerous living and working environments, pollution and other factors, with mortality rates for children under the age of five that may be 10 – 15 times higher than in cities in high income countries (Satterthwaite, Dodman, Hardoy, 2008).

Risk is a symptom of a generalised failure of development planning, but also governance. For example, with a few notable exceptions, most city governments in developing countries have not been able to provide land for the urban poor, meaning that they have to occupy land with the lowest value, often in hazard-prone areas (references). Secondly, most city governments have been unwilling or unable to provide the necessary infrastructure and services, including drainage (see Bhagat et al., 2006; Gupta, 2007; Ranger et al., 2010). Disaster risk management and adaptation in urban areas is thus fundamentally associated with the challenge of improving urban governance. Improvements in the provision of municipal services such as water, electricity, public health etc. do not *per se* reduce disaster risk. However it is unlikely that urban governments that are unable or unwilling to address the issue of access to land, infrastructure and services for poorer households will be able to address disaster risk.

In practice, particularly in the developing countries, disaster risk reduction has remained challenging and out of reach. A recent self-assessment in progress by 102 countries against the objectives of the Hyogo Framework of Action (ISDR, 2009:119-137) indicates that few developing countries have comprehensive, accurate and accessible risk assessments, which are a pre-requisite for both anticipatory and corrective disaster risk reduction. Above all, even when risk information is available, the institutional, legislative and political frameworks existing for disaster risk reduction do not facilitate the use of the information in development planning and decision making (Lavell and Franco, 1996; UNDP, 2008, ISDR, 2009:119-137). These frameworks are often centred in emergency response organizations that lack political authority. Implementation and enforcement mechanisms are often weak, particularly in countries where a large proportion of economic activity occurs in the informal sector. There is little or no integration between the frameworks developed for disaster reduction, climate change adaptation, and poverty reduction and development in general. As a result, disaster risk reduction is often limited to improvements in early warning, preparedness and response. While these actions can be decisive in reducing mortality risk, they do not address the underlying drivers of risk mentioned above, meaning that risk levels continue to rise unchecked. Likewise, there are limited examples of successful climate change adaptations in the literature (Fankhauser et al., 1999; Adger et al. 2007, Repetto, 2009), although attention to adaptation and its links to sustainable development is growing (Bizikova et al. 2010; Eriksen et al. submitted).

Sustainable development has become part of climate change policy discussions at the global level, particularly due to adoption of Agenda 21 and the various conventions resulting from the UNCED-1992 (Cohen et al., 1998, Yohe et al., 2007). It is an integrating concept that embraces economic, social and environmental issues (WCED, 1987; Grist, 2008). The generally accepted and most widespread definition 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). Hence sustainable development does not preclude the use of exhaustible natural resources, but requires that any use be appropriately managed or offset. Some argue that sustainable development cannot be achieved without significant economic growth in the developing countries, while others argue that any interpretations of development focusing on continued economic growth built on ever increasing rates of extraction and consumption of material goods directly contradicts notions of sustainability (Redclift, 1992; Goldemberg, et al., 1995; Robinson, 2004; Harvey, 2010). Questions of how sustainable economic growth is to be achieved, and the consequences for the spatial and temporal distribution of benefits and costs derived from resource use, consumption and impacts on increasingly fragile ecological systems, lie at the heart of challenges for moving towards sustainable development in a context of climate change.

The mainstream sustainable development discourse typically emphasizes inter-generational equity issues and focuses on both global and local environmental problems. Inter-species considerations are reduced to concerns for biodiversity depletion and ecosystem services (Lumley and Armstrong, 2004**;** Grist, 2008). Despite the centrality of sustainable development in climate change adaptation and disaster risk management policy and its function as an integrating concept, sustainable development inevitably draws attention to conflicting interpretations of 'development' (Redclift, 1992). Although it is clear that 'development' can be risk-reducing or risk-increasing (urbanization in coastal areas may increase disaster risk, while improved education, housing, and access to health may reduce disaster risk), it is important to recognize that the concept of development itself has been used in many ways. Although the dominant international discourse on development focuses on economic growth (Harvey, 2010), particularly through market-based policies, the concept of development has been used very differently by many scholars in the South (Amin, 1990, 1997; Stavenhagen, 2004; Furtado, 1965; Marini, 1973; Sen, 1992, 1999; Kameri-Mbote and Anyango Oduor, 2008; Huq et al., 1995; Huq and Asaduzzaman, 1999; Illich, 1976, 1976a; Freire, 1970, 1974, 1998, 1998a). Many scholars, for example, have examined the development of underdevelopment (Strahm and Oswald, 1990), including how 'development' in some regions has historically increased vulnerability to climate variability, as for example when local natural capital is extracted and economic capital accrues elsewhere, as in the case of droughts in India during the 19th century which were tied to British colonial extractive tendencies (Davis, 2001).

8.2.2. The Role of Values and Perceptions in Shaping Response

Planning for a future with heightened uncertainty when the stakes are high creates tensions among different visions of development. The disaster risk reduction community has used several points of view for resolving decisions in where to invest scare resources. These points of view include, for example, considerations of moral obligation and economic rationality (Sen, 2000). This inevitably draws attention to role of values, and in particular to how different ways of perceiving climate change and disaster risk lead to different prioritized solutions. 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 action, judgment, choice, attitude, evaluation, argument, exhortation, rationalization, and attribution of causality (Rokeach 1979). Recognizing and reconciling conflicting values increases the need for inclusiveness in decision-making and for finding ways to communicate across social and professional boundaries.

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 the 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 a sense of place, loss of identity, or loss of culture. This has long been observed within the disaster risk community (Hewitt, 1997; Mustafa, 2005) and in more recent work by climate change community (O'Brien, 2009; Adger et al., 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). 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; Adger et al. 2010; O'Brien and Wolf, 2010), and are significant when considering the interaction of climate change and disaster risk (Pelling, 2003).

The ethical considerations associated with disaster risk reduction and climate change adaptation are increasingly discussed in the literature (Gardiner 2010, references). Moral obligation to reduce avoidable risk and contain loss 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 meeting 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. 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 MDGs, 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 argues for investing in risk reduction where it is most cost-effective, and where calculated economic benefits are perceived to exceed costs. The calculated benefits of investing in risk reduction vary (e.g. from DFID), but are often considered significant (see Ghesquiere et al., 2006; World Bank 2010). There are, however, extreme difficulties to account for the complexity of disaster costs, i.e. of risk reduction investment benefits. 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, Cardona, and Barbat, 2010; ISDR, 2009, ISDR, 2002). At the same time, outcomes such as increased poverty and inequality (Fuente and Dercan, 2008), health effects (Murray et al., 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.

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 between social groups may hinder learning), or within nations (where indigenous groups may not be heard, and where social division and political power influence the development and adaptation agenda). In other words, these periods are frequently the times when those most affected are not consulted on their development visions and aspirations for the future. International social movements and humanitarian NGOs, government agencies and local relief organisations are all liable 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 national or economic interests. Political vulnerability has been recognised as a key factor in shaping disaster risk (Wilches-Chaux, 1993). Fundamentally, the current spatial distribution of disaster risk is a representation of underlying processes of unequal socio-territorial development (Maskrey, 1994). Both development planning as well as post-disaster recovery have tended to prioritise strategic economic sectors and infrastructure over local livelihoods and poor communities (Maskrey, 1989 and 1996). However, this represents a missed opportunity for building local capacity and including local visions for the future in planning the transition from reconstruction into development, which can undermine long-term sustainability (ProVention report; Christoplos 2006). This is true not only for disaster risk management, but also for adaptation, and for development in general.The distribution of power in society and who has the responsibility or right to shape the future through decision-making today is significant, as discussed below.

8.2.3. Planning for the Future

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. Although individual hazards and socio-political events can never be predicted, trends can be projected based on certain assumptions. 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 'story lines') rather than a single vision, in some cases enabling the definition of alternative trajectories of change that in early years can be compared with actual directions of change.

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). There is a strong tradition of predictive modeling in the environmental and economic fields, based on the quantitative and predictive orientation of dominant paradigms in the natural and social sciences, which has given rise to probablistic scenarios and forecasts of the future (Robinson, 2003). Scenario development in the social sciences is often done in several stages. As a first step, structural projections of key political 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 may produce quantitative and qualitative scenarios, covering socioeconomic changes, scientific and technological developments, and changes in political mindsets, worldviews and preferences. Important drivers of socio-economic changes (e.g., demography, population preferences, technologies) are highly uncertain, thus scenarios must consider a wide range of possible futures (Lempert and Collins 2007; WGBU 2008).

The challenge for disaster risk reduction and climate change adaptation is to produce regional and sub-national scenarios at longer timescales (see Gaffin et al., 2004; Theobald, 2005; van Vuuren et al., 2006; Bengtsson et al., 2006; Grübler at al., 2007; and a discussions on local scenarios in Hallegatte et al., 2008, and Van Vuuren et al., 2010; also cite the London case and some work in Paris and Phoenix, Calcutta, Mumbai, New Delhi, Lima, Dacca, Mexico City, Lagos, Cairo and Nairobi). Projections of the future are highly uncertain, because so many driving forces can change over time, especially in societies, institutions, and technologies. It is consequently difficult to base present-day decisions on future scenarios, hence choices must be made in the context of uncertainty. In particular, the situation of large uncertainty about how local climates will change makes it more difficult to analyze trade-offs and design adaptation strategies (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 regret strategies, flexibility and reversibility (e.g., Fankhauser et al., 1999; Goodess et al., 2007; Hallegatte, 2009).

With climate change, even more drastic choices may become necessary. In the many locations, for example, adapting to lower water availability may involve increased investments in water infrastructure to provide enough irrigation to maintain existing agriculture production, or a shift from current productions to less water consuming crops (see ONERC, 2009). The choices among different options depend on how the region sees itself in many 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 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).

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. There is no “optimal” way of adapting to climate change or to manage risks. For instance, focusing on and acting to protect against frequent events may lead to greater vulnerability to larger and rarer extreme events (e.g., Burby, 2006), and trade-offs between short-term and long-term objectives are always involved. *Add example*. However, in discussing trade offs between addressing short term and long term risks, there will be major differences between developed country contexts, where land use is planned and regulated and developing country contexts, where most risk prone development occurs in the informal sector, and therefore by definition is not regulated. In developed country contexts, it may be possible to regulate land-use such that risks to infrequent extreme events are not increased, although political expediency will often distort the regulatory process in a way that favors the short term.

In contrast to predictive scenarios, 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). 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, views the concept of sustainability not as a fixed outcome, but rather as “emergent properties of structured conversations about future options, consequences and tradeoffs, that combine expert understanding with the knowledge, values, and preferences of citizens and stakeholders” (Robinson 2003: 854).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. In any case, 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, 2008).

8.2.4. Technology Choices, Availability, and Access

Technologies can contribute to risk reduction and adaptation in a multitude of ways. Technology use can, of course, increase risks and add to adaptation challenges (references). For example, modern energy systems are dependent on physical structures that can be vulnerable to storm damage, as are centralized communication systems (Inderberg 2010). Lovins has 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). More often, however, technologies are considered to be a part of the solution rather than the problem (references). One focus of this kind of perspective is on physical infrastructure, including attention to ways to “harden” built infrastructures such as bridges or buildings or natural systems such as hillsides or river channels so 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: e.g., 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. Seasonal climate forecasts based on the results from numerical climate models have been developed in recent decades to provide users with information about the coming months, which can be used to prepare for floods and droughts (Stern and Easterling, 1999).

Attention to technology alternatives and their benefits, costs, potentials, and limitations 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 run, it is possible to consider potentials for new technology development, given identified needs. As one example, a seacoast region facing serious concerns about surface water scarcity due to climate change might consider potentials for lower-cost desalination technologies with green energy to meet some of their needs for fresh water some decades into the future (Wilbanks, 2010). Trade-offs are also often associated with technologies and infrastructure. For example, dams could mitigate drought and generate electricity, but displace large groups of people. If dams are not 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). But investments in technology infrastructures cast long shadows through time, because they tend to assume lifetimes of three of four decades or longer. If they are maladaptive rather than adaptive, the consequences for adaptability can be serious. For example, in the Mekong region, dykes, dams, drains and diversions established for flood protection often have unexpected side effects, particularly if they influence risk-taking behavior (Lebel et al. 2009).

Different countries and different social groups within countries have radically different opportunities for and constraints to choose and access technologies to address hazards, exposure and vulnerability, which is often a function of development conditions. Developed countries have been able to make major investments in physical measures to control identified hazards: the Thames barrier, which is designed to protect London against flooding, is an example of this kind of technology (Reeder et al., 2009). Due to high costs, few developing countries can afford such measures. However, regardless of costs, another issue relates to appropriateness and sustainability. While solutions based on high technology may be *implanted* in developing countries as part of bilateral and multilateral development assistance, they may not be appropriate to the surrounding social, cultural and economic context. Many such efforts fail due to apparently extra-technological reasons that are nonetheless are an integral part of the technological context. Examples include the failure of the national early warning system in Honduras during Hurricane Mitch (Villagran, 2010a), or post disaster housing projects with appropriate technology not adopted by the local population (references). This does not mean that all technologies applied in low-income countries must be home-grown and low-tech. The spread of cellular telephones in rural areas of Africa is a good example of rapid technological innovation. Nonetheless, technological innovations have to be able to insert themselves and thrive in the complexity of local societies if they are to be appropriated and sustainable.

When a disaster occurs, it has been suggested that destruction can foster a more rapid turn-over of capital, which could yield positive outcomes through the more rapid embodiment of new technologies. This effect, hereafter referred to as the “productivity effect”, has been mentioned for instance by Albala-Bertrand (1993), Stewart and Fitzgerald (2001), Okuyama (2004) and Benson and Clay (2004). Indeed, when a natural disaster damages productive capital (e.g., production plants, houses, bridges), the destroyed capital can be replaced using the most recent technologies, which have higher productivities. Capital losses can, therefore, be compensated by a higher productivity of the economy in the event aftermath, with associated welfare benefits that could compensate for the disaster direct consequences. This process, if present, could increase the pace of technical change and accelerate economic growth, and could therefore represent a positive consequence of disasters. However, this productivity effect is unlikely to be fully effective, for several reasons (Hallegatte and Dumas, 2008). First, when a disaster occurs, producers have to restore their production as soon as possible. This is especially true for small businesses, which cannot afford long production interruptions (see Kroll et al., 1991; Tierney, 1997), and in poor countries, where people have no mean of subsistence while production is interrupted. Replacing the destroyed capital by the most recent type of capital implies, in most cases, to adapt organizations and worker training, which takes time.

Producers have thus a strong incentive to replace the destroyed capital by the same capital, in order to restore production as quickly as possible, even at the price of a lower productivity. In extreme cases, reconstruction may be carried out with lower productivity, to facilitate reconstruction as fast as possible. Second, even when destruction is quite extensive, it is never complete. Some part of the capital can, in most cases, still be used, or repaired at lower costs than replacement cost. In such a situation, it may not be possible to save a part of the capital if the production system is reconstructed identical to what it was before the disaster. This technological "inheritance" acts as a major constraint to reconstruction based on the most recent technologies and needs, especially in the infrastructure sector. In addition, a larger proportion of productive assets in developed countries are fully insured, meaning that the producer at least has the opportunity to introduce new capital with increased productivity. More than 40% of direct disaster losses are insured in developed countries, compared to less than 10% in middle income countries and 5% in low income countries (Cummins and Muhul, 2009). In these latter, the inability to pay for new capital may lead to longer term decreases in productivity.

Add something here on disasters as an opportunity to integrate more appropriate technology into housing post-disaster. And a statement to acknowledge there is no research on the relationship between mitigation as a (re)design imperative and disaster safety in housing, critical infrastructure etc.

8.3. Synergies between Short-Term Coping and Long-Term Adaptation

When considering the linkages between disaster risk reduction, climate change adaptation and development, time-scales play an important role. Up until recently, disaster risk reduction efforts have fundamentally been reactive, dealing with response and reconstruction after disasters, and in the best of cases with emergency preparedness and early warning to mitigate losses when disasters happen. Progressively more attention is now being given by countries to move from an emergency management to a disaster risk reduction approach, which involves addressing exposure, vulnerability and hazards, which have 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). As described above, all these risk factors are dynamic and changing over time, meaning that risk levels are constantly changing. Climate change adds another level of uncertainty, raising the possibility of synergies and contradictions between actions focusing on the short-term and those required for long-term adjustment. While it is tempting to think of short-term strategies as 'coping' and long-term strategies as 'adaptation', both must be seen as processes influenced by cross-scale (spatial and temporal) interactions. This section reviews the literature regarding synergies and trade-offs. First, the implications of present day responses are assessed, particularly in relation to poverty traps. 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. However, the limits to these approaches are then assessed within the context of thresholds and tipping points associated with rapid climate change.

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. Positive implications can include resilience, capacity-building, broad social benefits from extensive participation in risk management/resilience planning, and the value of multi-hazard planning (references). Negative implications, which have received more research attention, 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 so-called "levee effect," where the adaptive solution to a current risk management problem builds confidence that the problem has been solved for the long term, blinding populations to the possibility that conditions may change, making the present adaptation inadequate (Burby, 2006; Burby et al., 2006).

The terms coping and adaptation reflect strategies for adjustments to changing climatic (environmental) conditions. In the case of a set of policy choices, both coping and adaptation denote forms of collective conduct that aim and indeed may achieve modifications in the ways in which society relates to nature and nature to society (Elsevier 2005). Coping actions are those which take place in trying to alleviate the impacts or 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 (Sperling et al. 2008). For example, communities in the Peruvian altiplano, who are exposed to multiple hazards, tend to sell livestock to cope with the immediate impact of a climatic shock. However, this depletes the asset base of a household. In particular, because in times of climatic shocks this is wide-spread response and animals are malnourished, prices for livestock tend to be lower than usual. If a household is forced to sell its entire livestock to cope with a climatic hazard and cannot replenish these assets or diversify income sources subsequently, it will become more vulnerable to future climatic shocks as it is more dependent on climate sensitive agricultural activities (Sperling et al. 2008). In developing countries, concern for 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, sanitation, education and health care, require more immediate attention (Klein et al 2005). Particularly, in poor rural contexts, short term coping, may be a trade-off which increases longer-term risks (ISDR, 2009, P.92). Adaptation, on the other hand, can take place before, during and after an event, but is often focused on minimizing potential risk to future losses (Oliver-Smith, 2007). Thus in post-disaster reconstruction one can find an opportunity for adaptation to building stock, while householders are still coping with damage to their livelihoods, and perhaps beginning to adapt to protect their remaining livelihood assets from vulnerability to future risk. Over the longer-term, adapting development to disaster and hazard mitigation options is based on expectations of the statistical characteristics of the hazard, and parameters such as return periods or flood frequencies.

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 major engineering solutions to water shortages threaten local livelihoods and undermine coping capacity. Interaction between coping and adaptation can also cross sectors, so that adaptation, if conceived for example as part of a settlement relocation scheme, can have severely detrimental impacts on short-term coping capacity and wellbeing when livelihoods and supporting social networks are disrupted. There is a large literature and much experience on this point from experience of slum relocation that is of direct relevance now to urban adaptation/coping (references).

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; Lopez, 2009; van den Berg, 2010). The process by which subsequent events generate 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 for instance Santos, 2007; Alderman et al., 2006).

These poverty traps at the micro level (i.e. the household level) could lead to macro-level poverty traps, in which entire regions could be affected. Such poverty traps could be explained by the amplifying feedback reproduced in Figure 8-1. Poor regions have a limited capacity to rebuild after disasters; if they are regularly affected by disasters, they do not have enough time to rebuild between two events, and they end up into a state of permanent reconstruction, with all resources devoted to repairs instead of addition of new infrastructure and equipments; this obstacle to capital accumulation and infrastructure development lead to a permanent disaster-related under-development. This effect has been discussed by Benson and Clay (2004), and investigated by Noy (2009) and Hochrainer (2009), and modeled by Hallegatte et al. (2007) and Hallegatte and Dumas (2008) with 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).

[INSERT FIGURE 8-1 HERE:
Figure 8-1: Amplifying feedback loop that illustrates how natural disasters could become responsible for macro-level poverty traps.]

Health, education, child development, household poverty traps and macro-level poverty traps means that short-term events can have long-lasting consequences. This can even be amplified by other long term mechanisms, such as changes in risk perception that reduces investments in the affected regions or reduced services that make qualified workers leave the regions (references). New Orleans following hurricane Betsy in 1965 provides an example of regional decline in population, even though the disaster may have been more of a trigger than the underlying cause of the decline (Colten, 2005). In conclusion, the consequences of a disaster can be much longer than what is considered the recovery and reconstruction period, and inability to cope over the short term with disaster can lead to long term consequence on development and growth.

There are 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, 2009, 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., forthcoming; Brauch and Oswald Spring, 2010). Past cases of island evacuation, for example in the case of Tristan da Cunha after a volcanic eruption in 1961, have shown the efforts to which islanders will go to preserve identity (reference). in this case isalanders preferred to return to Tristan da Cunha and face volcanic risk rather than live in an alien culture.

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: 166 – 170, 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). Others aim to factor disaster risk considerations into local land-use and development planning, for example.

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 in that component of future risk to climate extremes associated with increases in exposure, vulnerability and hazard. Addressing climate change itself, through the mitigation of greenhouse gases, is a longer term process, even if international agreements on emissions are reached and implemented. Fundamentally, therefore, the process of adapting to changing climate extremes, involves addressing existing risk patterns and the underlying drivers that will shape future risk.

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 because of a lack of technical know-how. The recent national self- assessments of progress towards achieving the HFA, indicated that some Least Developed Countries, for example, report lack the human, institutional, technical and financial capacities even to address emergency management concerns (ISDR, 2009, P.117). The development deficit in many developing country cities, 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, 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 in the future one. Doing so, however, would require very large amounts of funding (Satterthwaite et al., 2007), which are not always available. The World Bank, the UNDP and the UNFCCC estimated that the financial needs for adaptation will amount to between $9 and $166 billion per year, up to 2030. This is coherent 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: 184) Even though the methodologies that have been used are very questionable, the orders of magnitude are large enough to support the idea that funding will be a significant obstacle to adaptation in the future. Another obstacle is the technical know-how and access to technologies. 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 (references).

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 in the US by Birkland (2007).

Differences in mortality and economic loss risk between countries is as much explained by factors such as voice and acccountabilty and institutional quality as by GDP per capita (ISDR, 2009:.26 – 44) A change in the culture of public administration towards creative partnerships between national and local government 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. 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 Defense, 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; AfDB et al., 2003).

In addition to the barriers described above, there is also tendency for individuals to focus on the short-run and to ignore low probability events below their threshold level of concern that can have severe long-run consequences. Studies have identified a set of psychological and economic barriers as to how we make decisions under uncertainty (Kunreuther et al. forthcoming) Some of the most important elements are listed below:

Underestimation of the risk. Even when individuals are aware of the risks, they often underestimate the likelihood of the event occurring, often believing that a future disaster "cannot happen to me" (Smith and McCarty, 2006). This bias can be amplified by natural variability, which contributes to changes in event frequency over short and long periods of time (on hurricane activity and losses, see Pielke et al., 2008). It can also be exacerbated if experts disagree on the risk itself and/or the efficacy of measures to reduce its consequence. This is a particularly challenging problem in the case of estimating the future impacts of climate change and the ability of specific adaptation measures to reduce losses from floods, hurricanes and other disasters. Magat, Viscusi and Huber (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. Huber, Wider and

Huber (1997) showed that only 22 percent of subjects sought out probability information when evaluating risk managerial decisions.

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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. One frequently hears the following comment: "I live from pay-day to pay-day. I cannot afford the high costs of these measures" (Kunreuther et al. 1978: 113). Such a budget constraint may extend to higher income individuals if they set up separate mental accounts for different expenditures (Thaler, 1999).

Difficulties in Making Tradeoffs: Individuals are also not skilled in making tradeoffs 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. There is a natural tendency to postpone taking actions that require investments in time and money. The most salient is the observed tendency for individuals to defer ambiguous choices; the less certain one is about a correct course of positive action, the more likely one is to choose inaction (Tversky and Shafir 1992). Trope and Lieberman (2003) offer a wide array of evidence showing that when making choices for the distant future we tend to focus on the abstract benefits of options, whereas when making immediate choices we tend to focus on concrete costs.

Samaritan's Dilemma. People who expect public sector relief following a disaster will refuse to invest in risk-reduction measures because they feel that others (the Good Samaritans) will rescue them. Kunreuther et al. (1978) found that most homeowners in earthquake- and hurricane-prone areas did not expect to receive aid from the federal government following a disaster. Burby et al. (1991) found that local governments that received disaster relief undertook more efforts to reduce losses from future disasters than those that did not.

The Politician's Dilemma. An elected official who saddles its constituency with additional taxes for risk reduction measures that have long-term benefits may lose the next election. This NIMTOF (Not in My Term of Office) attitude often leads to inaction because the costs of undertaking protective measures are counted against one while the reduction in uncertain future losses benefits are not considered by the electorate as justifying these measures. The uninsured victims in Alaska were financially better off after the earthquake than their insured counterparts (Dacy and Kunreuther 1968). The difficulty in enforcing disaster risk reduction measures has been characterized as the *politician's dilemma* (Michel-Kerjan, 2008).

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These biases and heuristics that are exhibited by key stakeholders have led to economic development of floodplains and coastal areas subject to hurricanes, and building structures on barrier islands that are rapidly eroding. 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 and businesses are reluctant to invest in adaptation measures for reducing the impacts of climate change because they cannot justify the high upfront costs associated with these measures: there is a tendency to consider the expected benefits from adaptation over the next several years rather than over the expected life of the structure. Myopic behavior can be costly to individuals at risk and to society. There is a need to develop long-term strategies that also provide short-run returns for coping with climate change and its consequences.

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, in order to inform risk analysis and risk management strategies. A common example is the increase in population and asset at risk from hurricanes in Florida in the last decades. Most of the population increase took place during a period (the 70's and 80's) with exceptionally low levels of hurricane losses (Pielke et al., 2008), and economic actors may have forgotten the normal level of hurricane risks in this region. This change made Florida excessively vulnerable in periods of normal activity. In the future, climate change will increase the uncertainty on climate and extreme statistics, increasing the risk of such maladaptation. For instance, in many regions climate models do not agree, even on the sign of future precipitation changes. These uncertainties make it difficult to implement optimal risk-management strategies, especially because many of such strategies require a large anticipation. For instance, building the Thames barrier to protect the London vicinity against storm surges took more than 30 years, between when construction was decided and when the barrier was fully operational: managing natural risks requires anticipating how natural hazards will change over the next decades, but uncertainty on climate change is a significant obstacle to such anticipation (Reeder et al., 2009)

8.3.3. Promoting Resilience to Connect Short- and Long-Term Goals

The previous section highlighted the importance of linking short-term and long-term goals as a means of using disaster risk reduction to advance climate change adaptation. 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. However, understandings and interpretations of resilience vary widely. It has developed as a fusion of ideas from several bodies of literature: ecosystem stability (e.g., Gunderson, 2008), engineering robust infrastructures (e.g., Tierney and Bruneau, 2007), disaster risk reduction (e.g., Cutter et al., 2008), vulnerabilities to hazards (Moser, 2008) 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. In this context resilience is understood as the capacity of a system to absorb recurrent disturbances not only to retain its essential structures, processes and feedbacks but to recover to an enhanced state (Wilbanks and Kates, 2010). Originating in ecological science and closely linked to Holling's concept of the adaptive cycle (Holling, 1973; Gunderson, 2000), resilience is now used in interdisciplinary analysis of the interactions of people and nature, applied to the notion of a linked social ecological system (Berkes and Folke, 1998).

Resilience 'thinking' (Walker and Salt, 2006) may thus provide a useful framework to understand the interactions between climate change and other changes, and in reconciling and evaluating trade-offs between short-term and longer-term goals in devising response strategies. Emerging resilience theory contrasts with the conventional engineering systems emphasis on capacity to absorb external shocks. New resilience theory 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). This approach emphasizes the need to manage for change and to see change as an intrinsic part of any system, social or otherwise. 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; the degree to which the system can build capacity to learn and adapt.

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). Berkes (2007) provides a helpful summary of how resilience can inform understanding of uncertainty and vulnerability in the context of hazards. He points to three key contributions: first in providing a holistic framework to evaluate hazards in coupled human-environment systems; secondly, in putting emphasis on the ability to deal with hazard or disturbance; and thirdly, in helping to explore options to dealing with uncertainty and future changes.

Resilience thinking highlights that change and uncertainty are key features of social ecological systems; it tells us to 'expect the unexpected'. Emerging from systems ecology it is predicated on non-equilibrium – or more precisely multiple-equilibria - views of how ecosystems respond to change. The definition of resilience as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker et al., 2004) itself reveals tensions between changing and staying the same – of persistence versus stability. Indeed, as Gallopin (2006) comments, when the concept of resilience is unlinked from the notion of multi-stability, it becomes very difficult to distinguish it from structural stability. According to the social ecological systems perspective however, resilience processes rely on flexibility and adaptive capacity for change rather than stability or equilibrium with return to the exact same steady state. Gundersson (2000) defines resilience as the property that mediates transition among multiple steady states or stability domains.

In ecosystems, increases in variety/novelty are associated with the greater probability of sudden transitions to new states, known as 'regime shifts' (Walker and Salt, 2006). Social-ecological systems have to deal with both gradual and abrupt changes (Folke, 2006), and in a vulnerable system, even small disturbances may initiate impressive social consequences (Adger, 2006). 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 science and policy. 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 bad: Folke (2006: 253) emphasizes the capacity for renewal, re-organization and development, in a resilient social ecological systems, whereby 'disturbance has the potential to create opportunity for doing new things, for innovation and for development.' The possibilities for positive change are highlighted. Resilience thinking concerns how to persist through continuous development in the face of change and how to innovate and transform 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. This highlights not only adaptations to current conditions and in the short term, but 'how to achieve transformations toward more sustainable development pathways is one of the great challenges for humanity in the decades to come' (Folke, 2006: 263). Walker et al. (2004) distinguish adaptation and transformation where 'adaptability is referred to as the capacity of people in a social-ecological system to build resilience through collective action whereas transformability is the capacity of people to create a fundamentally new social-ecological system when ecological, political, social or economic conditions make the existing system untenable'. This has relevance for distinguishing between short-term and long-term responses to climate change.

Ideas about adaptive governance have recently emerged from the social ecological resilience literature. Folke (2006: 254) claims that 'the resilience perspective shifts policies from those that aspire to control change in systems assumed to be stable, to managing the capacity of social-ecological systems to cope with, adapt to, and shape change… managing for resilience enhances the likelihood of sustaining desirable pathways for development in changing environments where the future is unpredictable and surprise is likely'. Folke (2006: 262) claims that 'Adaptive governance is a major extension of conventional resource management and it consists of at least four essential parts; understanding ecosystem dynamics; developing management practices that combines different ecological knowledge system to interpret and respond to ecosystem feedback and continuously learn; building adaptive capacity to deal with uncertainty and surprise including external drivers; and supporting flexible institutions and social networks in multi-level governance systems'.

Resilience thinking is not without its critiques (references). The shortcoming often highlighted can be summarized as three dimensions: first, that in adopting a systems approach and framework to understanding the relationship between society, environment and change, it under-emphasizes the role of human agency in change and responses to change. Secondly, and following this, it depoliticizes the governance of change and the different interests, and winners and losers in different (resilience-based) strategies to address change. Thirdly, when resilience is applied in a literal sense – as it is now in widespread areas of policy globally – it tends to promote stability rather than flexibility; it can be used to maintain the *status quo* and thus to serve particular interests and not to support adaptive management, social learning or inclusive decision-making.

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. Pielke et al. (2007) have highlighted that locating adaptation policy in a narrow risk framework through concentrating only on what are identifiable anthropogenic risks, in their words, 'creates bizarre distortions in public policy' (p.597) because vulnerabilities are created through multiple stresses. 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, 2007:412). 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.

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 run, the investments to 'hold-the-line' may have diminished capital resources for other adaptations and hence reduced adaptive capacity to future sea level rise. Thus dealing with specific risks without full accounting of the nature of system resilience leads to responses that can potentially undermine long term resilience.

8.3.4. Thresholds and Tipping Points as Limits to Responses

The concept of resilience focuses on how systems respond to disturbances, including the social and ecological impacts of extreme climate events (see chapter 4). Recent literature has brought forward the possibility that climate change may lead not only to changes in the frequency and magnitude of extreme events, but also to large-scale, system-level changes, or 'tipping points' that could alter climatic and socio-economic conditions over large geographical areas (Lenton et al, 2008; Hallegatte et al., 2010). Examples of 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). Examples of socio-economic tipping points are profitability limits in economic activities that play a large role in a regional economy, like some crops production in agricultural regions (e.g., Schlenker and Roberts, 2006), or snow tourism in some mountainous regions (OECD report on the Alps). In the climate domain, these tipping points could significantly alter the frequency, magnitude and distribution of hydrometeorological hazards (e.g., paper by Hall on extreme sea level rise). In the socio-economic domain, they can lead to decreased resilience in the face of disasters (Hallegatte et al., 2010). Most of the scientific literature, as well as the political debate, has focused on the outcomes related to the long-term trends in climate and socio-economic variables, paying little attention to the consequences of tipping points.

Disasters are threshold-breaching events, and may provide a useful context to explore responses to tipping points. Many developing countries are already inadequately equipped to deal with current climate variability. The frequent occurrence of climate related disasters underscores this existing adaptation deficit (e.g. Burton and van Aalst, 2004). Multi-hazard environments, such as the Peruvian altiplano, may experience adverse years within the current natural climate variability, where coping capacities of communities are overwhelmed and migration of may be the only choice for some households (e.g. Sperling et al., 2008). Disasters may lead to non-local impacts, e.g., when the impacts from one disaster triggers others, as when hurricanes trigger landslides; or flooding causes the release of toxic chemicals (references) or when different hazards produce concatenated impacts over time . For example the droughts and fires during the 1997/1998 ENSO event in Central America increased landslide and flood hazard during Hurricane Mitch in 1998 (Villagrán, 2010a). Critical social thresholds may be crossed as disaster impacts spread across society. For the poor with few economic or physical assets and little protection, threats to 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, or 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. Because climate change takes systems beyond their historical experience, tipping points may lie beyond stress levels that have ever been observed and analyzed. In some cases, possible future conditions can be simulated experimentally or observed in other places, but in many cases the only research alternative is modeling, which presents a higher level of uncertainty.

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 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 wider 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.

One of the challenges in considering possible impact thresholds is that they are enmeshed in multiple causation. Tipping points are seldom a function of climate change alone; in most cases, they reflect a convergence of multiple sources of stress. For instance, a forest ecosystem is more likely to see catastrophic effects from climate change if it is already under stress from regional air pollution, land use, and other driving forces. Indeed, ecologists point out that human modification and simplification of ecosystem services has reduced the capacity of ecosystems to self-regulate, thus increasing the potential for abrupt ecological changes associated with moderate climate change (Peterson 2009).

For impact thresholds, the generalization supported by the most research is that 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). The most direct significance of thresholds is that such non-linear change may lie beyond the capacity of adaptation to avoid serious disruptions and pain. Examples include the disappearance of Arctic sea ice, effects of climate change on traditional livelihoods of indigenous cultures in Arctic areas, 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; African agriculture), thresholds are likely to be closer and to be met earlier. Increased natural hazards, for instance, would lead to larger reduction in economic activity in places where reconstruction capacity is limited for financial or technical reasons (Hallegatte et al., 2007).

Responses to potential thresholds or tipping points range from efforts to establish monitoring systems to provide early warning of an impending system collapse, so that avoidance strategies can be considered and response strategies can be prepared, to advocacy of geo-engineering to avoid such tipping points through human interference with causes of climate change (references). Protecting all coastlines against sea level rise is probably undesirable and economically and physically unfeasible. As a consequence, choices will have to be made between human settlements that will be protected from sea level rise and human settlements that will have to be abandoned. This choice will have to be carried out through a political process, using all information that can be provided by climate scientists and sea level change projections, by coastal managers, and by socio-economic analysis. However, losses will be lower when and where abandonment is anticipated and communicated well in advance, to make it possible for all actors to manage the transition as smoothly as possible. Worst-case scenarios are those in which an area is first claimed to be protected against sea level rise and storm surges, attracting population and investments, but where protection is eventually revealed as impossible for financial, technical, or political reasons.

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

Responses to climate change, and climate policies, include adaptation as well as mitigation. In many instance, adaptation and mitigation will act on the same levers, such as land-use plans to reduce transport related energy-consumption and limit exposure to floods, or building norms 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 possibilities of possible win-win strategies that address both objectives simultaneously (IPCC, 2007, Wilbanks and Sathaye, 2007; Wilbanks, 2010; Hallegatte, 2009; Yohe and Leichenko 2010). This section explores the interactions between adaptation and mitigation on the one hand, with disaster risk management on the other. Although there is not much literature on these topics together, there is a growing literature on interactions among multiple processes, which influence disaster risk reduction, climate change adaptation and mitigation of greenhouse gas emissions.

8.4.1. Adaptation, Mitigation, and Disaster Management Interactions

In an increasingly urbanised world, global sustainability in the context of a changing climate will depend on achieving sustainable cities: cities where the resilience of communities and households is greater than the risks they face. 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 (on the link between urban form and energy consumption due to transport, see Newman and Kenworthy 1989; Bento et al., 2005; Handy, Cao and Mokhtarian, 2005; Grazi, van den Bergh and van Ommeren, 2008; Brownstone and Golob, 2009; on the link between urban form and residential energy use, see Ewing and Rong, 2008; and on both issues, see 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 Group, 2010; UN-HABITAT, 2009).

Mitigation actions relating to climate change are important but often less visible in rural areas, and the links to disaster management are less obvious. One common shift evident in many rural areas is the growth in wind-generation of electricity. This has the potential to reduce at least some of the power-related greenhouse gas emissions around the globe, and also represents a stable income source for many farmers. In addition, there is at least one example of recovery to a disaster involving extensive actions to 'green' a small community in the United States. 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 Green Building Council 'Leadership in Energy and Environmental Design' (LEED) Platinum standards (Harrington, 2010). Unfortunately, these actions have slowed rebuilding of the town, leading to loss in social capital while attempting to create a model 'green' community.

The extent to which future adaptation will be required is dependent on the extent and rapidity with which mitigation actions may be taken (references). Consequently, mitigation may be seen to be directly connected to disaster risk reduction and adaptation needs and actions.

8.4.2. Interactions among Responses

Changes in the underlying development drivers (such as urbanisation) will contribute more to future increases in risk than climate change itself (Nicholls et al., 2008; ECA Working Group. 2009). It has not been possible to estimate the contribution of climate change to increases in disaster risk, compared to other drivers of vulnerability, such as environmental degradation, the deficit in infrastructure provision (particularly drainage), and urban growth. Improved reporting of disaster loss may also be a contributing factor (reference). While a great deal of focus has been placed on the potentially catastrophic impacts of climate change outcomes such as sea-level risk on urban areas (World Bank, 2010; Nicholls et al., 2008; Hallegatte et al., 2010) probably the most immediate and generalised outcome will be a further increase in the number and impact of localised recurrent disasters in poor areas. Adaptation, therefore, has to address those underlying drivers of existing vulnerability, which are influenced by multiple, interacting stressors, and magnified by climate change.

Urbanization is a process that can compound environmental problems. More than half of the world's population was living in cities and towns (UN Habitat, 2009). Most of the growth in urban areas is in developing countries, with the world urban population in 2000 of 1.9 billion projected to more than double to nearly 4 billion by 2030 (including a growth of the urban proportion in Africa and Asia from 39% to 54-55% in this period). 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 (references). As cities grow they also modify their surrounding environment, and consequently generate a significant proportion of the hazard to which they are 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. 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 (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 decision-making must itself take into account multiple stresses and constraints, making it more difficult to determine an optimal approach, as trade-offs have always to be made. For instance, more parks in a city reduce urban heat island and limit heat wave vulnerability, but, if not carefully planned, they may also reduce land availability and increase rents, with negative consequence on housing accessibility by the poorest households (Oke 1987; Rosenfeld et al. 1998; Stone and Rodgers 2001; Stone 2005; Pizarro, Blakely, and Dee 2006; McEvoy, Lindley, and Handley 2006; Hamin and Gurran 2009). In addition to climate change aspects, urban planning also determines spatial and social inequalities, access to jobs, leisure and amenities, and city attractiveness to professionals and businesses (World Bank Group 2008; UN-HABITAT 2009).

Metropolitan areas depend on rural areas for provision of ecosystem services, including food production, natural resources, regulation of Earth system operations, and cultural connections with the environment. Although they provide for the needs of the world's urban majority, rural areas face considerable pressure as they cope with demographic changes, infrastructure shortcomings, rising energy prices, globalization, climate variation and change, and decisions and controls that often are external to the area. Beyond self-interest reasons for the urban majority to support improvements to disaster management and adaptation to risk and environmental change in rural areas, as well as mitigation of climate change and hazards, there are moral and ethical reasons to improve the lot of those in more isolated and potentially precarious positions might be identified.

Rural livelihoods are being transformed by a) corporatisation, globalisation, and changes in scale of farming (and other livelihood) operations; b) greater need for non-farm income in more industrial regions, where production on "family" size farms no longer generates the income needed to maintain expected living conditions without supplemental activities and income; c) increased opportunities for non-farm earnings in less industrialized regions, as previously remote areas become more integrated in national and global markets; d) 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); e) remittances resulting from migration (either within or across national boundaries); and f) opportunities for income from the global illicit drug industry (Chouvy and Laniel, 2007; Mansfield, n.d.). 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), and diversification has been used to cope with livelihood stresses and shocks or disasters (Ellis, 1998; Marschke and Berkes, 2006).

The notion of multiple stressors thus draws attention to the importance of addressing the underlying drivers of risk as a means of both disaster risk management and adaptation, and the importance of critically assessing responses so that they do not create new vulnerabilities and risks.

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

The previous sections of this chapter have assessed some of the ways that both disaster risk reduction and climate change adaptation influence, and are influenced by, development processes. Differences in perspectives, approaches, values, interests, and objectives (including trade-offs and tensions between short-term and long-term goals), reveal some of the challenges for building resilient and sustainable development pathways. Yet it is clear that if these challenges are not addressed, then climate-related extremes may create situations with widespread economic, social, and environmental consequences for ecosystems and humans. This section assesses some of the implications of such hazards, considered in relation to access to renewable and non-renewable resources, and to the use of environmental services for human consumption and production. Issues related to capacity and equity are discussed, including the idea that there will be winners and losers, and the implications for human security and the achievement of other international goals.

8.5.1. Capacities and Resources: Availability and Limitations

Hazards affect economic, social and cultural capital in diverse ways (Sen 2000). The capacity to manage risks and adapt to changes are unevenly distributed within and across nations, regions, communities and households (references). The literature on how these capacities contribute to disaster risk reduction and climate change adaptation emphasizes the role of economic, financial, social, cultural, institutional, and natural capital (references). Economic and financial capital can help in coping with the extreme outcomes of hazards and help to avoid disasters. Economic capital (which controls economic resources such as cash, assets) is closely linked to social capital, which is based on group memberships, relations, networks, social stratification and support that create power relations (Bourdieu and Passeron, 1977). Both capitals are interrelated with cultural capital, where forms of knowledge, skills, education and belongings have created social stratification that are reinforcing social differentiation, thus creating social vulnerability (Bourdieu, 1983). Furthermore, institutional capital (rule of law, fiscal resources, long-term planning and trained people) offers these countries the means for the prevention and mitigation of hazard impacts, and for resilience-building supported by the mass media and training in disaster risk reduction (references). Poor countries have limited economic, institutional and social assets that constrain their technological means. Within these countries, the livelihoods and wellbeing of higher social classes and castes are less affected by climate-related hazards relative to others.

Communities are seldom homogenous, and more typically consist of different social groups. These social groups are frequently stratified as the result of socio-cultural and economic factors, and thus have unequal access to resources. As a result, it is often those who have access to power and capital who have greater access to resources such as land, as compared to less endowed social groups. In some areas of the world, large parcels of arable land are owned by wealthy individuals who are often absentee land owners, blocking access to such land, water, and other resources needed by smallholder farmers (Ifejika Speranza, 2006). Poor people throughout the world are therefore severely affected when their access to resources is restricted. This is attributed to the fact that poor people generally depend more on ecosystem services and products for their livelihoods than wealthy people. The means by which a poor family gains an income and meets its basic needs are often met by multiple livelihood activities. For example, exploiting common property resources such as fish, grazing land or forests can provide income, food, medicine, tools, fuel, fodder, construction materials and so on. As a result of this dependency, any impact that climate change and natural disasters have on natural systems threatens the livelihoods, food intake and health of poor people (Smith & Troni, 2004; Reid, 2004).

Some demographic groups, such as children, 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 factors that contribute to the vulnerability of people over 60 years of age to climate change are similar to factors that make them vulnerable to other types of hazards: deterioration of health, personal lifestyles, loneliness, poverty, or inadequate health and social structures are all elements that can contribute to vulnerability (OECD, 2006). The context in which people are aging will also influence future vulnerability to climate change. This context includes changing health conditions, as well as issues of social exclusion; welfare programme reforms and their impact on the elderly income; developments in the health and social care system; and finally, the evolution of family structures (references).

_____ 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

Children's relative vulnerability to extreme events has been a key feature of the literature, with estimates that 66.5 million children affected annually by disasters (Penrose and Takaki, 2006). Research on post-disaster vulnerabilities focuses on psychosocial impacts on children and the short and long term physical health implications of disaster (Bunyavanich et al, 2003; Balaban, 2006; Bartlett 2008; del Ninno and Lindberg, 2005; Norris et al. 2002; Waterson, 2006). This characterises their vulnerability in part due to their less developed physical and mental state 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; Sanchez et al 2009; 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 and schooling, 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

There is increasing acknowledgement that 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 DRR or adaptation supported through child-centred programmes. 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; in Back *et al,* 2009; and in 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). The implication of these studies is that greater resources should be channelled towards children's agency, including enhanced efforts to incorporate children's perspectives, knowledge, and potential for action into regular community-driven development programmes (Tanner et al, 2009).

_____ END BOX 8-1 HERE _____

Traditional knowledge and cultural and biological diversity may reduce the risks of future hazard impacts, but their role is often ignored in preventive disaster risk management, and in reconstruction processes (references). In contrast, the role of culture, including traditional knowledge, has been increasingly recognized in the climate change literature (Heyd and Brooks 2009). For example, the small size of plots that smallholder farmers own is exacerbated by cultural practices, whereby land is sub-divided among the younger generation based on the traditional notion of providing land resources to sons to enable them to farm. This tradition further reduces land available for agriculture and the units that individual farmers can access. Under conditions of low input and manual agriculture, the small plots are just big enough for the farmers to be able to work them manually. But also dominance of patriarchal systems of land inheritance that hinders access to land by women, who constitute the larger proportion of African agricultural labour (Verma, 2001; Eriksen et al., 2005; Ifejika Speranza, 2006a).

Studies also show that 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 finding has to do with unequal access to resources by females in many countries. Females have been found to have less access to resources such as land, property and public services (Agarwal, 1991; Nemarundwe, 2003; Njuki et al., 2008; Thomas-Slayter et al., 1995).

8.5.2. Sustainability of Ecosystem Services in the Context of DRR and CCA

Ecosystems can act as natural barriers against climate-related extremes. However, their presence alone cannot be used as a disaster reduction strategy. Ecosystem health, resilience and level of intervention can affect how a natural system responds to the forces of nature, and hence be considered part of disaster risk reduction strategies. The event itself, the geomorphology of the area, and the geography and location of the system in respect to the source of the event are also crucial factors influencing how each ecosystem can respond to the forces of nature (Lacambra *et al* 2010). 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. There is evidence that the likelihood of regime shifts may increase when, among other changes, the magnitude, frequency, and duration of disturbance regimes is altered (Folke et al. 2004).

The use of ecosystem approaches to adaptation include the conservation of water resources, wetlands for both hydrological sustainability and human water supply; forest conservation for carbon sink and alternative source of energy such as the use of biofuels to reduce carbon emission (IIED 2006); coastal defences; and avalanche protection (Silvestri and Kershaw, 2010). Any change in the constituents of an ecosystem can change the ecosystems dynamics and interact with other systems, altering their resilience as described by Holling (1973), leading sometimes to unexpected results (Gordon et al. 2008; Peterson 2009), including the elimination of the ecosystem and the services they provide.

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 et al, 2010, 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. As biodiversity is lost, options for change are diminished and human society becomes more vulnerable (IIED 2004). For example, at a watershed level, forests on higher lands prevent soil erosion and flashfloods in lower areas (Oswald Spring et al., 2010). Mangrove forests, for example, are a highly effective natural flood control mechanism which will become increasingly important with sea level rise, and are already used as a coastal defence against extreme climatic and non-climatic events, mostly in Asia (Adger et al., 2009). Conservation of biodiversity and maintenance of ecosystem integrity may be a key objective towards improving the adaptive capacity of such groups to cope with climate change; both have been directly related to ecosystem resilience, which in turn is related to the capacity of ecosystems to respond to disturbances (Peterson *et al*., 1997; Elmqvist *et al.,* 2003).

In some cases, 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 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).

Ecosystem-based approaches to adaptive management can reduce disaster risk and contribute to climate change adaptation (references). For example, integrated watershed management can conserve watershed biodiversity in addition to increasing water retention and availability in times of drought; decreasing the chance of flash floods and maintaining vegetation as a carbon sink (Silvestri and Kershaw, 2010). Reducing deforestation maintains and protects biodiversity, soils, water, and many other ecosystem services that are normally not taken into account such as pollination, local climate regulation, biomass production among others, but may result in a short-term loss of economic welfare for some stakeholders, which contributes to vulnerability. Although ecosystem-based approaches can contribute to climate change adaptation; such strategies require research and understanding of local level ecological and social processes, including ecosystem dynamics and the interactions with human communities (Walker and Salt, 2006). The thresholds at which ecosystems can both act as barriers against climate-originated disturbances and adapt to climate change remain still unknown (references).

8.5.3. Local, National, and International Winners and Losers

While climate-related hazards cannot always be prevented, the number of victims (deaths, affected people) and the economic damages have differed significantly in the past due to different degrees of social vulnerability. In many hazard-affected countries, the degree of social vulnerability is influenced by multiple discriminations based on class, caste, race, ethnicity, religion, gender and age (Aryabandu and Fonseka 2009; Oswald Spring, 2008). Disasters often draw attention to the losers – those whose lives, livelihoods, and/or system viability are adversely affected by climate-related extremes. However, there are also winners associated (at least indirectly) with disasters, including suppliers of materials, equipment, and services during an emergency response period and during the reconstruction (West and Lenze, 1994; Hallegatte, 2008), or other areas or systems that gain competitive advantage (e.g., areas that appear more attractive as investment targets or tourism destinations because they are considered less vulnerable).

Analyses of winners and losers of climate-related hazard impacts requires a distinction between the analysis of the “final state”, which can be considered more desirable than the initial situation (e.g., a warming in cold world regions), and the analysis of the transition toward that final state. Sometimes, the fact that the final state is viewed as more desirable than the initial one does not imply that the transition between the two states will not be difficult, for instance because it requires high investments and economic reconversion (Hallegatte et al., 2010).

Analyses of winners and losers of climate-related hazard impacts require a distinction between linear projections of global climate change and non-linear thresholds that may trigger tipping points of ecological and social systems. While some countries may experience initial benefits from an increase in temperature and precipitation (e.g. in

Canada, Northern Europe, Russia), they may also be negatively affected by sea level rise and the projected increase in the number and intensity of hazards. However, some of these same countries may be losers of an abrupt climate change due to changes in the Gulf Stream – one of several possible tipping points that may exist (Lenton et al., 2008). Whether or not a particular place/area is a winner or loser from an extreme event or a combination of climate extremes and other driving forces also depends on external (and internal) perceptions that are shaped by the recovery process, as well as by subjective factors such as values (O'Brien, 2009; O'Brien and Wolf, 2010).

Places that respond by using a renewal process to make themselves better can convert losses to wins, which is one aim of community resilience (references). Moreover while climate change associated trends in warming or precipitation may yield benefits, extremes embedded within these trends may be less positive making planning for climate change more problematic. Further uncertainty for possible winners comes from balancing any benefits from direct local impacts with exposure to indirect global consequences of climate change (which could be beneficial or detrimental to local business and costs of living), through for example volatility in global food or other resource markets.

Every risk management strategy is associated with winners and losers at every scale, from local to international. In most cases, the contrasts are most dramatic at relatively local scales where the impacts, real or potential, are much more salient and the choices represent a larger share of a local economy, ecology, or society (references). Climate variability has been documented to cause costly impacts for OECD countries that have a relatively high coping capacity, as the impacts of the heatwave in Europe, of Hurricane Katrina in the United States and the repeated forest fires in South Europe, the United States and in Australia have in recent years demonstrated (references). Lurking behind discourses about winners and losers is the issue of liability for losses: i.e., if a population or an area experience severe losses due to an extreme event (at least partly) attributed to climate change, whose fault is it? At some point during the next half-century, it seems likely that this kind of effort to assign blame will emerge as an issue for both governments and courts. Issues of equity, justice, and compensation are thus increasingly being raised (O'Brien et al., 2010).

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 for both improving human security and avoiding disasters. Human security can be understood as freedom from fear, freedom from want, freedom to live in dignity, and freedom from hazard impacts (UNDP, 1994; Sen, 2003; Annan, 2005; Bogardi and Brauch, 2005; Brauch 2005, 2005a). Human security can also be thought of as the capacity of individuals and communities to respond to threats to their environmental, social, and human rights (GECHS, 1999; Barnett et al., 2010). Human security addresses the combined but related challenges of upholding human rights, meeting basic human needs, reducing social and environmental vulnerability (UNDP, 1994; Brauch, 2009a; Fuentes and Brauch 2009).

The physical effects of climate change (e.g., temperature increases, sea level rise, precipitation changes and extreme weather events) will have multiple societal consequences which under certain conditions pose dangers to human security. Among the most likely human security threats are impacts on health, food, water and soil (Oswald Spring, 2009a; Oswald Spring et al., 2010). A number of studies have assessed the relationship between climate change and 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., 2010). For example, 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 surrounding climate change are the possibilities of mass migration and/or violent conflict as the result of biophysical or ecological disruptions associated with climate change. Migration and conflict are emerging as key security concerns among national governments and international institutions, are both issues are intricately related to the existing vulnerability context that disaster risk reduction and climate change adaptation are targeting.

In the poorest rural areas, many people are only just coping and surviving even in normal years due an absence of assets and reserves, and human development conditions characterised by high levels of malnutrition, high rates of infant mortality, lack of high levels of education and insufficient medical care. Approximately 75% of the people living below the World Bank defined international poverty line of US$1.25 dollars per day live and work in rural areas (with 268 million in sub-Saharan Africa, 223 million in East Asia and the Pacific and 394 million in East Asia alone) (World Bank, 2009). When affected by a hazard impact, or simply ongoing stress, coping often fails. This may lead to sometimes dramatic declines in human development indicators (possibly low at the outset) and, in extreme cases, large scale migration and increased mortality (Sánchez et al., forthcoming). There are indications that such conditions followed stresses in the distant past, as well as in current situations (see, e.g., Kinzig et al., 2006; Le Roy Ladurie, 1971; Peeples, Barton and Schmich, 2006). Yet, when affected by a hazard impact, coping often fails, leading to a sometimes dramatic decline in already low human development indicators and in extreme cases large scale migration or even mortality. For example, Rodriguez-Oreggia et al. (2009) focus municipalities in Mexico that are affected by disasters see an increase in poverty by 1.5 to 3.6 percentage point.

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 (Scheffran, 2010) but also as a means of diversifying and increasing income. Disasters linked to extreme events often lead to displaced people, refugees, relocated communities and temporary or permanent migration. The relationship between climate risk and displacement is a complex one and there are numerous factors that affect migration. Nonetheless, recent research suggest that adverse environmental impacts associated with climate change have the potential to trigger displacement of an increased number of people (Kolmannskog, 2008). Studies further 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). Worldwide remittance flows are estimated to have exceeded US$318 billion in 2007 of which developing countries received US$240 billion (World Bank, 2008). On the negative side, migration to cities and urbanisation may lead to the breakdown of traditional rural households and coping mechanisms; rapid increases in the number of female headed households as men migrate (Oswald Spring, 1991, 2009); the ways in which towns and cities often displace their environmental burdens and risks to rural hinterlands, etc. (García, 2004).

During times of stress, it is easy for polities to drift towards militarization which promises clear leadership, and authoritarianism can offer limited success in managing disaster risk (Albala-Bertrand, 1993). Institutions in society that are responsible for national and international security are beginning to discover climate change as a potential threat. For example, the first federal government agency in Germany to publicly recognize climate change as a threat to national well-being was the Federal Ministry on the Environment, Nature Conservation and Nuclear Safety (BMU, 2002). The UN Security Council first debated climate change on 17 April 2007. Later the UN General Assembly adopted a Resolution on Climate Change and International Security on 11th June 2009 (A/RES/63/281), requesting the UN Secretary General to submit a Report, which was released on 11th September 2009 (UN/SG, 2009). Concerns range from possible needs for humanitarian assistance to possible causes of environmental migration, emergent disease for humans or in food chains, potentials for conflict between nations or localities over increasingly scarce resources, and potentials for political/governmental destabilization due to climate-related stresses in combination with other stresses, along with efforts to assign blame (Brauch and Oswald Spring, 2010).

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 limited 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 societies 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). Adaptation planning that seeks long-term stability is continually confronted by political vulnerability 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 also 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).

The growing interest of the security policy and research communities in climate change vulnerability and security issues is having a powerful effect on climate science, which has historically concerned itself almost entirely with high-probability climate futures. The security communities, by contrast, are responsible for contingency planning for relatively low-probability/high-consequence possible futures, and they are bringing this perspective into climate science. Examples of benefits from this new fusion of interests include the *valuation* of low-probability/high consequence contingencies as an issue related to *budget allocations* for addressing such contingencies (references). It also draws attention to alternatives that can promote human security. Inclusive governance, for example, is an alternative that 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 influence other international goals. Numerous potential international goals can be discussed, including 1) the Millennium Development Goals; 2) the Habitat Agenda Goals and Principles; and 3) international environmental agreements (Convention on Biodiversity). It is also important to 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, together with the protection and recovery of ecosystems) can influence climate change adaptation (ISDR, Hyogo Framework for Action 2005-2015).

The shift towards a more preventive approach, that focused on reducing vulnerabilities to disasters, was already evident when the UN General Assembly declared 1990 to 1999 the International Decade for Natural Disaster Reduction (IDNDR). An outcome of this was that the World Conference on Natural Disaster Reduction in Yokohama, 1994, conceived the Yokohama Strategy and Plan of Action for a Safer World, which stressed the responsibility of countries to protect its people and assets from the impact of natural disasters. While this represented a shift from a mainly reactive approach towards a more comprehensive approach (Sperling and Szekely, 2005), it was only at the World Conference on Disaster Risk Reduction (WCDR) in Kobe, 2005, that climate change was explicitly recognized as an integral concern for disaster risk management. The *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters* (HFA) recognizes the climate variability and change as important contributors to patterns of disaster risk and includes strong support for better linking disaster management and climate change adaptation efforts (Sperling and Szekely, 2005).

There is a debate on whether disasters are currently a problem *of* development, or a problem *for* development; in other words, the relationship between disasters and economic growth and development is not clear (references). Regardless of the current debate, climate change is likely to influence the conclusion, showing that both perspectives are valid. Disaster response is related to development issues, especially at local level, where authorities are often not prepared for preventive behavior. Further more hydro-meteorological events occur in developing countries. All disasters have an effect on the GDP of the affected regions and therefore countries in the South are higher threatened by. There are direct impacts from disasters and indirect ones, which are often bigger and remain for longer time. For example, hurricanes and landslides destroy transportation and communication systems and tourist infrastructure avoiding activities after the disaster, sometimes for several months or yearsw. These indirect damages could be bigger than the direct ones, increasing economic crisis and unemployment (see Wilma, Mitch, etc.).

Arguments for addressing disaster risk and climate change not only through targeted risk management but as a core aspect of development planning draw on a range of arguments. The Risk Society thesis by Ulrick Beck (1992) and linked discussion on late-modernity by Antony Giddens (2009) amongst others both champion enhanced communication between science and policy and more inclusive governance for the linkages between development and risk to be more clearly understood and acted upon. In civil society disquiet about the excesses of consumption have fed into global environmental and climate change movements. In the development community and private sector the quality rather than quantity of exchange relations is coming under increased scrutiny. Many critiques seek to frame climate change responses not as a loss of value or utility, but as a way of enriching life while also reducing risk (references).

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

Building a sustainable and resilient future will require an integrated and ambitious policy response 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 actual impacts of climate change and disasters are local, and most aspects of resilience need local action and institutions but very often the responses also need to be implemented through actions at regional, national and global scales. Policy approaches that can resolve conflicts and exploit synergies between multiple objectives related to sustainable development, disaster risk reduction and climate change adaptation are likely to be most effective. This section therefore first reviews the literature pertaining to policy options, then considers actions and responses for achieving multiple objectives, which typically include trade-offs in decision-making. The importance of learning, innovation, transitions, and transformations are then considered in relation to disaster risk reduction and climate change adaptation. Finally, the role of actors and agency are discussed.

8.6.1. Review/Assessment of Bridging Practices, Tools, and Approaches

There are a number of potential practices, tools and approaches for addressing disaster risk, climate change adaptation and poverty reduction. Policy frameworks provide the basis for responding to extreme events. As discussed in Chapter 7, the Hyogo Framework for Action (HFA) was adopted by 168 countries in 2005, and provides a technical and political agreement on the areas that needs to be addressed to reduce disaster risk. The HFA presents five priorities for action: 1) ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation; 2) identify, assess and monitor disaster risks and enhance early warning; 3) use knowledge, innovation and education to build a culture of safety and resilience at all levels; 4) reduce the underlying risk factors; and 5) strengthen disaster preparedness for effective response at all levels.

Practices, tools, and approaches for improving risk management related to climate extremes are related to such needs as information-gathering and monitoring, information analysis and assessment, projections of possible futures, and exercises to simulate threats and explore implications of responses. For example, one need is to combine understandings of potential stresses from climate extremes, along with possible tipping points for affected systems, with monitoring systems for tracking changes and identifying emerging threats in time for adaptive responses, where possible. Another need is for approaches to analysis and assessment that include both quantitative analysis and qualitative integrative deliberation (references). Possible futures need to be projected and discussed with the help of scenarios and narrative story lines (Tschakert and Dietrich, 2010). In many cases, it is also very helpful to use simulations of possible extremes and associated disruptive impacts to engage stakeholders and responders in situations that help them understand both threats and effective responses (Nichols et al., 2007).

Progress is being made to improve the availability of risk information to decision makers. This includes efforts to create national institutions to manage risk information (Von Hesse, Kamiche and de la Torre, 2008) 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 also beginning to offer ways of compiling information at different scales and from different institutions to generate a vision of risk that can allow decisions to be made. A growing number of countries are also systematically recording disaster loss and impacts at the local level, enabling estimations of the extent, cost and frequency of climate related disaster events (DesInventar, 2010).

Other countries are developing mechanisms to use such information to inform and guide public investment decisions (Comunidad Andina and GTZ, 2006; Comunidad Andina, 2009; Von Hesse and Kamiche and de la Torre, 2008) and for national planning. Major investments in infrastructure (including ports, airports, transportation systems, energy generation and water supply systems, irrigation systems, etc.) typically have a planned life of 50 – 150 years and provide a spatial structure for other public and private investments in business, housing, social and local infrastructure. In other words, such investments will have a critical bearing on long-term risk patterns in the future. Ensuring that such investments take into account likely patterns of future climate hazard is therefore key to a sustainable future.

While it is impossible to *correct* major concentrations of existing risk, through retrofitting or relocation, national public investment systems informed by comprehensive risk assessments can be a means to *anticipate* future risk by guiding new investment to areas with lower hazard levels, particularly taking into account climate change outcomes such as sea-level rise, declining freshwater availability and increased flooding and drought. Opportunities also arise when existing or obsolete infrastructure is replaced or upgraded or when it is rebuilt following damage or destruction in a disaster. Clearly, as described early in this chapter, this raises trade-offs between a long-term reduction in losses and short term economic gains (Satterthwaite et. al, 2009b).

Urban planning is one of the adaptation strategies that can reduce disaster risk, but it takes time to produce significant effects. Using urban planning to adapt to climate change requires an unprecedented anticipation of future climate change, taking into account how climate will change over many decades and the uncertainty on this information. This requires moving from short-term perspectives (25 or 30 years) to up to 100-yr perspectives. This change implies new challenges, and new methodologies will have to be developed. For instance, climate change risk analysis requires local urban scenarios, which are particularly difficult to design as they depend on innumerable parameters (see Section 8.2.3). 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. 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 (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. These are extreme examples of low-income settlement transformation that is occurring worldwide through processes of gentrification or large-scale renewal. While vulnerability is not resolved through such transfers of land from the poor to middle and high-income land use there is potential for building mitigation into urban design through integrated land-use planning and climate smart building design. There are also a growing number of large-scale 'slum' /informal settlement upgrading programmes that are improving housing and living conditions for low-income households (Boonyabancha 2005, Satterthwaite 2010). These improving housing conditions and install or upgrade infrastructure and services – and as such reduce disaster risk. These also have the potential to build greater resilience to many likely impacts of climate change.

Other innovative experiences are also emerging in the area of land-use planning and urban governance, which can also play a key role in *anticipating* future risk and hence address one of the key underlying risk drivers outlined above. Conventional approaches to land-use planning have generally failed to provide land for low-income urban dwellers, with a consequence, already mentioned above that over 1 billion urban dwellers live in informal settlements, often in hazard prone locations and with a number increasing by 25 million per year. Again, as mentioned above, planning and building regulations and standards are often an obstacle to providing safe land for the urban poor, given that inappropriate standards, waiting lists, cut-off dates and other mechanisms are used to exclude poor households. However, processes where organizations representing low-income urban households have been able to negotiate with urban governments, have shown that it is possible to identify and finance land-acquisition for the urban poor in safer locations, as well as support the development of housing and infrastructure (ISDR, 2009, 154 – 156; Satterthwaite, 2009a).

The most successful programmes are those that – while community- or locally based – have developed broader partnerships with governments and other supra-local stakeholders (see Box 8-2). Many of the underlying risk drivers cannot be addressed by community organizations on their own and some are also beyond the capacities of local governments. Partnerships with national agencies permit scaling-up of initiatives to go beyond individual communities and localities to address problems that affect wider areas, such as watersheds and coastlines. They enable the investment of resources that are unavailable locally and increase continuity and sustainability as initiatives move from stand-alone projects and programmes to longer-term processes. Many of these more successful initiatives would appear to have been catalysed by decentralisation processes, in which more competent and better resourced local governments are able to play a more active role in addressing disaster risk. 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 success in disaster preparedness and response, leading to a real and drastic reduction in mortality due to tropical cyclones, builds on solid local organization, but in both cases it has received sustained support from the national level (references).

_____ START BOX 8-2 HERE _____

Box 8-2. Strengthening Local Capacities Reduces Catastrophic Disaster Risk

In the municipality of La Masica, Honduras, a local level early warning system was developed in 1997, with support from the Organisation of American States (OAS), GTZ and the Network for Social Studies on Disaster Prevention in Latin America (LA RED) to assist the population to reduce their risks to local flooding in a small-river basin. When a catastrophic hazard event occurred in 1998 (Hurricane Mitch) the municipality was as exposed as others on the north coast of Honduras. However, the local early warning system was activated and an evacuation from flood prone areas occurred that meant that no deaths occurred. Similar areas, where no local capacity building had taken place, experienced major mortality.(Global Water Platform, nd)). In the tsunami affected coastline of Tamil Nadu, India, communities where capacities in basic disaster management had been strengthened suffered substantially lower mortality than in communities where capacity development had not taken place (Government of India and UNDP, 2009).

_____ END BOX 8-2 HERE _____

While many approaches to risk reduction may be place- and hazard-specific, supporting more effective, better resourced and more accountable local governments thas the benefit of building generic adaptive capacity alongside hazard-specific response strategies (IFRC 2010). The uncertainty brought by climate change reinforces this message. Most fundamentally, 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 the generic foundations of resilient and sustainable societies. 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).

While such mechanisms are important to *anticipate* future risk, there are huge accumulations of existing climate risk that are continuing to grow. Again, a wide range of experiences show that it is possible to at least partially address or *correct* this existing risk. Local level and community based disaster risk management 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 (strengthening and protecting existing buildings and local infrastructure; adopting new production systems in rural areas etc.); increasing resilience through instruments such as micro-insurance and finance or protecting or restoring critical regulatory ecosystem services (ISDR, 2009, P166-170; Lavell, 2009, Reyos 2010). Because they are locally based and often locally controlled, such programmes and processes tend to respond better to local conditions and needs, are more cost effective because they can access local knowledge and resources and build local ownership and most importantly build awareness and capacities. 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). However, most such experiences are still isolated, local and short term in character.

Various tools are used to design environmental and climate policies. Among them environment-energy-economy models produce long term scenarios taking into account demographic, technologic and economic trends. These scenarios can be used to assess consequences of various policies.These tools have limits and it is particularly difficult to model structural economic changes, as these models have been developed to represent marginal changes around reference scenarios. Introducing disasters within these models leads to specific issues, due to time and spatial scale inconsistency: these models have been developed to represent long term evolutions, while disasters are short term events; these models represent large region (supranational), while disaster consequences are highly heterogeneous and affect disproportionally small communities and subnational regions. However, at smaller spatial scales, models can help assess disaster consequences and, therefore, balance the cost of disaster risk reduction actions and their benefits. In particular, they can compare the cost of dealing with disasters with the cost of preventing disasters. Since disaster have intangible consequences (e.g., loss of lives, ecosystem losses, cultural heritage losses, distributional consequences) that are difficult to measure in economic terms, these models are necessary but to sufficient to decide about desirable policies and disaster risk reduction actions. Cost-benefit analysis is useful to compare costs and benefits. However, when intangibles play a large role and when no consensus can be reached on how to value these intangibles, other decision-making methods can be used. Multicriteria decision-making and robust decision-making are examples of such alternative decision-making methodologies.

Risk transfer schemes, such as insurance, reinsurance, catastrophe pools and bonds, parametric and micro insurance and other mechanisms, do not anticipate or reduce risk *per se* but can increase resilience at the national, local and household level. Many obstacles to such schemes still exist particularly in low income and many middle income countries: including the absence of comprehensive risk assessments, 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).

This capital of local initiatives to address risk to climate extremes is key to a sustainable future. Its effectiveness has been demonstrated in various cities in Latin America (IFRC 2010). But to unlock this potential for all urban areas requires a radical change in the culture of public administration and investment in most nations. While local communities can address certain issues with their own resources, the installation or upgrading of infrastructure, for example, requires investments and planning at the level of local, city or national governments. Correcting risk, therefore will only be possible in the context of a new culture of partnership between civil society, local and national governments and with major investments to reduce the development deficit in high risk urban and rural areas. While the investments required are potentially huge, working in a way that empowers local communities can lead to a radical reduction in costs. Above all, it can lead to a fundamental change in the dynamics of the political relationships between those at risk and those who control the resources required to address risk that holds the key to a more sustainable future.

8.6.2. Policies and Actions for Achieving Multiple Objectives

Managing the risks associated with climate extremes requires national, political commitment at the highest level and the transformation of the existing disjointed frameworks and mechanisms to address into a coherent overarching policy framework of the *state*. Unless such a policy framework is adopted, is backed by appropriate political authority, legislation and resources, it is difficult to see how existing mechanisms, organized around emergency management or environment offices in governments will be able to address multiple challenges. Policies and actions to achieve multiple objectives include stakeholder participation, participatory governance (IRGC, 2009, 2009a), capacity-building, and adaptive organizations.

The central issue is usually potentials to increase the likelihood of effective action by both increasing potential payoffs and broadening constituency support for a policy strategy and implementation approach by assuring that it benefits multiple agendas: e.g., resilience to *future* climate change extremes, reduced stresses on *existing* systems, prospects for economic and social development, and prospects for both economic and environmental sustainability. One of the ways to work toward the "bundling" of multiple objectives is to broaden participation in strategy development and action planning, both to identify multiple objectives and to encourage attention to mutual co-benefits. Although practices and traditions for such stakeholder participation differ across cultures, there is a considerable knowledge base reflecting both research and practice to use as a starting point (e.g., NRC, 2008). A second approach is to emphasize capacity-building of several kinds: capacities of multiple groups to identify and assess pathways for achieving objectives, capacities of local expertise to represent and communicate the existing knowledge, and capacities of decision-makers to incorporate knowledge and diverse views into coherent strategies for action (references). A third approach is to promote the development of adaptive organizations: organizations that are not so locked into rigid agendas and practices that they cannot consider new information, new challenges, and new ways of operating (Berkhout et al., 2006). Organizations that can monitor environmental, economic and social conditions and changes, respond to shifting winds of policy 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 contingencies. Characteristics of adaptive organizations are relatively well-known (e.g., references), but examples of developing and sustaining such organizations are more difficult to find.

The principles of adaptive management have shown some success in promoting sustainable natural resource management under conditions of increased uncertainty that are to be expected with climate change (Medema et al, 2008). These principles include intentional procedural or technical experimentation and observation in real-time to compare the responsiveness of alternative management strategies to emerging risks. The underlying concept is to promote organisational arrangements that are capable of evolving over time as risk landscapes change. This has huge potential application for managing disaster risk under climate change and can build on solid foundations of reflexivity that already exist in the humanitarian sector. A methodological framework for facilitating anticipatory learning processes to manage for resilience is presented by Tschakert and Dietrich (2010). This research emphasizes the conceptual similarities and overlaps between resilience approaches and action research/learning approaches, and considers the implications for climate change adaptation (see Table 8-1). Evidence suggests that many of the challenges of adaptive management are common to other risk management and development approaches that seek to incorporate or be led by community actors. Such challenges are most well studied in international development contexts (eg Mungai et al., 2004) and often revolve around the distribution of power between local and management actors worked out through the division of labour and responsibilities, and control of information and decision-making rights (Pelling, 2007).

[INSERT TABLE 8-1 HERE:
Table 8-1: Conceptual similarities and overlaps between the resilience framework and participatory action research/learning (AR/AL), implications for learning, and examples for climate change adaptation. Source: Tschakert and Dietrich, 2010.]

Learning in the humanitarian sector takes place through a range of initiatives, some is sector-wide (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 have 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-doping experiments. More generally adaptive management is a challenge for those organisations that perceive reputational risk from experimentation in the knowledge that some local experiments will be seen to fail (Fernandez-Gimenez et al., 2008). Where this approach works best outcomes have gone beyond specific management goals to build trust between stakeholders a resource that is fundamental to any policy environment facing an uncertain future.

8.6.3. Tradeoffs in Decisionmaking

Decision-making related to both disaster risk reduction and climate change adaptation involves political, economic, social and cultural tradeoffs, which are related to differences in values, interests, and goals for the future, and mediated through power relations. The ethical implications of these tradeoffs 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; Dalb,y 2009; Brauch, 2009).

Tradeoffs 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 most benefits usually to the private investors.. 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 againstthe 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) (references).

Another example of trade offs linked to climate change and development is the future need for additional protection in historical city centres and touristic areas. When considering additional protection (e.g., dikes and seawalls) in historical centres, the building costs of protection will not be the only component to take into account. Aesthetic impacts of protections and consequences on city attractiveness will be central in decision-making (references). If, for example, buildings have to be modified in Paris to make them better able to cope with the high temperatures that are expected by the end of the 21st century, the city will have to be deeply modified. Today, very strict rules are in place to maintain the traditional architecture and urbanism of Paris, and adaptation targets will conflict with cultural heritage protection. Because of difficulties to attribute values to cultural assets, cost-benefit analyses based on economic assessments of costs and benefits is not the best tool to approach these type of problems. Multi-criteria decision-making tools have been developed to help make these trade-offs (references). Because these trade-offs imply political, ethical, and philosophical aspects, participatory approaches can be useful (references).

During disaster reconstruction it is important to balance speed with sustainability, and strong leadership with participatory approaches may result in a longer timeframe to reach decisions, but the decisions may better reflect local values as well as integrate scientific and wider strategic concerns (references). Yet 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 (references). When successful, participatory reconstruction planning has been shown to build local capacity and leadership, bind communities and provide a 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 (references). To manage trade-offs and conflicts is an open, efficient, and transparent way, institutional and legal arrangements are extremely important. (Add examples (e.g., the Netherlands) and various existing legal schemes.

8.6.4. Addressing Multiple Scales

Different geographic scales of action tend to have different potentials and different limitations. Local scales offer potentials for bottom-up actions that assure participation, flexibility, and innovativeness, while large 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 climate 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? In many cases, the experience to date suggests that initiatives undertaken at relatively large scales – at least in government – often discourage local agency by bogging down relatively localized (sectoral as well as geographic) action in bureaucratic requirements as a condition for access to financial and other resources. Top-down sustainability initiatives are often preoccupied with *input* accountability, 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 NAS, 2005).

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. One study, for example, concludes that what local agency needs in order to initiate significant actions for greenhouse gas emission reduction are several conditions: 1) growing evidence of impacts on that locality of climate change; 2) policy interventions that directly or indirectly associate emission reductions with incentives and assistance for local innovation; and 3) technology alternatives appropriate to local conditions (AAG, 2003). Meanwhile, actions at local scales can undermine larger-scale initiatives through political opposition or downright obstruction, by passive resistance such as a denial of useful information, and/or by local redirections.

The challenge is to find ways to combine the strengths of both scales rather than having them work against each other (Wilbanks, 2007). Consider, for example, certain strengths offered by both internal and external assets for relatively local-scale climate change adaptation initiatives. Internally from a local perspective, factors of importance include wealth (or the lack of it), a capacity for collective social action (or the lack of it), economic diversification (or the lack of it), and local leadership (or the lack of it). Externally, factors of importance include linkages that expand the range of alternatives for the locality: financial and human resources, commodities, information; structures that enable adaptive responses such as market an non-market incentives and mechanisms for coordination; risk-sharing approaches such as insurance; and portfolios of locally-appropriate technologies.

For the development of proactive strategies, policies and measures on climate change adaptation and disaster risk reduction call for close cooperation between the scientific and the political communities. But the translation of new scientific and technological knowledge into binding policy decisions is time-consuming. To obtain the political support it is necessary to declare them as security issues of utmost importance that require extraordinary measures (Waever 2008; 2008a). This needs a horizontal coordination between international organizations, national ministries and local stakeholders, as well as both bottom-up and top-down approaches with close vertical cooperation across different levels.

8.6.5. Role of Actors and Agency

The challenge of addressing disaster risk reduction and climate change adaptation in a manner that promotes resilience and sustainability requires more than a haphazard approach. It calls for changes at all levels – by governments, civil society, individuals, and the private sector. These changes may potentially include new ways of thinking about social contracts, which describe the rights and responsibilities between these different parties. 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. The concept of resilience, which emphasizes the dynamics, linkages, and complexity of coupled social-ecological systems, can contribute to new ways of thinking about rights and responsibilities between states and citizens in the context of climate change, including new approaches to social contracts (O'Brien et al., 2009). In particular, lessons from research on resilience points to the importance of including a wider group of stakeholders interacting across different levels to address the dynamics and complexity of climate change. Facilitating cross-scale interactions as described above may call for coalition building or deliberative democracy. In any case, the hierarchical structures that have traditionally governed social contracts may no longer be effective, and new types of arrangements may be needed to reach the goals of resilience and sustainability (O'Brien et al., 2009). Pelling (2010) suggests that the potential for climate-related disasters opens for new understandings of identity and social organization that may present alternatives to established social contracts.

Means of improving connections between science and decision-making where decisions have a significant scientific component has been a topic of interest for many decades , including research attention as well as experiments in practice. For example, a recent report by the U.S. National Research Council on *Informing Decisions in a Changing Climate* (NRC, 2009) concluded that effective decision support involves six principles: begin with user needs, give priority to process over product, link information producers and users, build connections across disciplines and organizations, seek institutional stability, and design processes for learning. Particularly important was a finding that promoting science for decision-making requires iterative interaction between information providers and information users, not just one-way science communication.

A particular challenge in fields such as climate change is the treatment of uncertainties about what may lie ahead (references). On the one hand, communicating uncertainties to decision-makers about climate change extremes can have the effect of discouraging actions that might require resources or cause political controversy. On the other hand, failing to communicate uncertainties would be scientifically questionable. The fact is that decision-makers from individuals to national leaders make decisions constantly in the face of uncertainty, and in most cases they distrust messages from science that appear to claim certainty. Communicating uncertainties without impeding actions is an important aspect of science for society. Current knowledge indicates that the treatment of uncertainty in communications between science and decision-making needs more iterative interaction than is usually the case. It also needs to recognize that decision-makers differ greatly in their time horizons and their ways of coping with risks, and approaches for communicating uncertainty should be sensitive to different decision-making contexts.

Disaster risk reduction and sustainability policies have large policy implication (e.g., on inequalities). As a consequence, science alone cannot decide which policies are desirable, and political processes are necessary. These processes have to include scientific information and political choices. Different approaches have been implemented to include these two aspects, like working groups involving experts, stakeholders, and decision-makers. Examples can be provided on climate change management.

8.7. Synergies between Disaster Risk Reduction and Climate Change Adaptation

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 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, Lemos and Boyd (2008, p. 736) 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.

However, there are 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 in rural areas (CRED, year?). 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).

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 risks, transparency of values, and active engagement of civil society. Committing to such a learning process is, as Tschakert and Dietrich (2010) argue, preferable to alternatives because "Learning by shock is neither an empowering nor an ethically defensible pathway."

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Table 8-1. Conceptual similarities and overlaps between the resilience framework and participatory action research/learning (AR/AL), implications for learning, and examples for climate change adaptation. Source: Tschakert and Dietrich, 2010.

Resilience Framework	Action Research/ Learning (AR/AL)	Implications for Learning		Examples for Climate Change Adaptation
Complex adaptive cycles	Loop learning and spirals of steps	Iterative, cross-level/cross-scale information exchange	→	Learning about and practicing adaptation as an action-reflection process
Windows of opportunities	Nodes of reflection	Opening for unexpected connections, innovation, and transformation	→	Possibility for adjustment in agriculture or diversification out of agriculture
Memory	Experiential grounding	Knowledge base for envisioning the future	→	Lessons learned from past droughts and floods to facilitate foresight
Re-organization	Insightful questioning for action	Challenging assumptions and worldviews	→	Understanding of local and global drivers of climatic changes
Experimentation	Testing theories through action/practice	Flexible, incremental learning-by-doing, learning from mistakes	→	Local monitoring of climate and other changes and testing adaptation options
Back-loop learning	Co-production of knowledge and multiple voices	Arena for creative knowledge generation	→	Local and scientific climate knowledge and re-abstraction of external information
Self-organization	Spontaneous cooperation and bounded instability	Participant-led problem solving and action	→	Agricultural innovation through farmer–extension agent collaboration
Revolting	Challenging of power imbalances	Empowerment, new dynamics across scales	→	Shift from vulnerable people as passive victims of climate change to active agents who shape change
Small disturbances and surprises	Management probes	Out-of-the box thinking, innovative learning	→	Introduction of extreme climate events into scenario building to explore adaptation options exceeding current response repertoire
Navigating transitions	Rehearsing for reality	Learning spaces for transformation	→	Several alternative plans for managing climate uncertainties

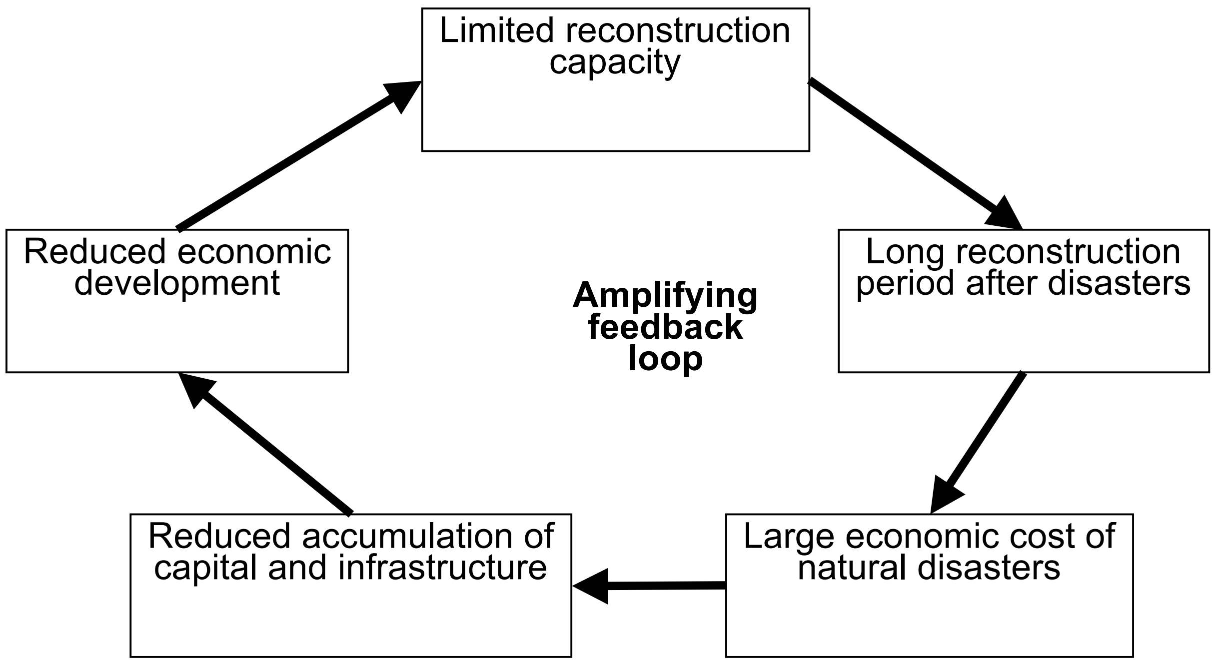

Figure 8-1: Amplifying feedback loop that illustrates how natural disasters could become responsible for macro-level poverty traps.