Chapter 5. Managing the Risks from Climate Extremes at the Local Level

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Executive Summary

Disasters are most acutely experienced at the local level *(high agreement, robust evidence).* The reality of disasters in terms of loss of life and property occurs in local places and to local people. These localized impacts can then cascade to have national and international consequences. In this chapter, local refers to a range of places, social groupings, experience, management, institutions, conditions and sets of knowledge that exist at a sub-national scale. [5.1]

Developing strategies for disaster risk management in the context of climate change requires a range of approaches, informed by and customized to specific local circumstances *(high agreement, robust evidence).* These differences and the context (national to global, urban to rural) in which they are situated shape local vulnerability and local impacts. [5.1]

The impacts of climate extremes and weather events may threaten human security at the local level *(high agreement, medium evidence).* Vulnerability at the local level is attributed to social, political, and economic conditions and drivers including localized environmental degradation, and climate change. Addressing disaster risk and climate extremes at the local level requires attention to much wider issues relating to sustainable development. [5.1]

While structural measures provide some protection from disasters, they may also create a false sense of safety (*high agreement, robust evidence).* Such measures result in increased property development, heightened population density and more disaster exposure. Current regulations and design levels for structural measures may be inadequate under conditions of climate change. [5.3.2]

Sustainable land management is an effective disaster risk reduction tool *(high agreement, robust evidence).* Land management includes land use, zoning, conservation zones, buffer zones, or land acquisition. Often it is difficult for local jurisdictions to implement such measures as a result of political and economic pressures for development. However, such measures are often less disruptive to the environment and more sustainable at the local level than structural measures. [5.3.3]

Humanitarian relief is often required when other disaster risk reduction measures prove unsuccessful *(high agreement, robust evidence).* Such assistance is more effective when it takes local social, cultural and economic conditions into account, acknowledges local agency in disaster response, and recognizes that the initial assistance during and immediately after disasters is nearly always locally generated. [5.2.1]

The post-disaster recovery may provide a critical opportunity for reducing disaster risk under climate extremes and for improving adaptive capacity *(high agreement, robust evidence).* Typically, there is an emphasis on rapidly rebuilding houses, reconstructing infrastructure, and rehabilitating livelihoods at the local level. The urgency often overrides the need to avoid recovering in ways that recreate or even increase existing vulnerabilities. Including local actors benefits the recovery process. [5.2.3]

Disasters resulting from climate extremes influence population mobility and relocation affecting host and origin communities (*medium agreement, medium evidence*). Most people return and participate in the post-disaster recovery in their local areas. If disasters occur more frequently and/or with greater magnitude some local areas will become increasingly marginal as places to live or in which to maintain livelihoods. In such cases, migration becomes permanent and could introduce new pressures in areas of relocation. In extreme cases, such as atolls, entire communities it is possible that many residents will have to relocate. In other cases, migration is an adaptation to climate change, with remittances supporting community members who remain at home. [5.2.2]

Integration of local knowledge with external scientific and technical knowledge enhances knowledge transfer and improves local participation in disaster risk reduction and climate change adaptation (*high agreement, robust evidence).* Locals document in many different ways their experiences with the changing climate particularly extreme weather events, and this type of self-generated knowledge induces discussions of proactive adaptation strategies and can uncover existing capacity within the community. [5.4.4]

Effectively communicating risk involves multiple pathway exchanges between decision makers and local citizens *(high agreement, medium evidence).* Viewing risk communication as a social process allows for effective participatory approaches, relationship building and the production of visual, compelling and engaging information for use by local stakeholders. [5.3.1]

Inequalities influence local coping and adaptive capacity and pose disaster risk management and adaptation challenges *(high agreement, robust evidence).* These inequalities reflect differences in gender, age wealth, (class), ethnicity, health and disability. They may also be reflected in differences in access to livelihoods and entitlements. Understanding and increasing the awareness of coping mechanisms in the context of local-level livelihood is important to climate change adaptation planning and risk management. This signifies the need for the identification and accommodation of these differences to enhance opportunities arising from their incorporation into the adaptation planning and disaster response. [5.5.1]

Ecosystem management and restoration activities that focus on addressing the deteriorating environmental conditions are essential to protecting and sustaining people's livelihoods in the face of climate extremes *(high agreement, robust evidence).* Such activities include among others watershed rehabilitation, agro ecology and forest landscape restoration. Moreover, provision of better access and control of resources will improve people's livelihoods, and build long-term adaptive capacity. Such approaches have been recommended in the past, but have not been fore-grounded in capacity building to date. [5.3.3]

Local level institutions and self-organization are critical for social learning, innovations and action; all are essential elements for local risk management and adaptation *(high agreement, medium evidence).* Adaptive capacities are not created in a vacuum- local institutions provide the enabling environment for community-based adaptation planning and implementation. Local participation (CBOs, development committees) contribute to empowering the most vulnerable, and strengthening innovations. Addressing political and cultural issues at the local levels are fundamental to the development of any strategy aiming at sustained disaster risk management and adaptation. [5.4]

The rapid urbanization of the sub-national populations and the growth of megacities, especially in developing countries have led to the emergence of highly vulnerable urban communities, especially those in informal settlements presenting challenges to disaster management *(high agreement, robust evidence).* Addressing these critical vulnerabilities means consideration of the social, political, and economic driving forces, including rural to urban migration, changing livelihoods, and wealth inequalities as key inputs into decision-making. [5.5.1]

Effective local adaptation strategy requires addressing a number of factors that limit the ability of local people to undertake necessary measures to protect themselves against climate extremes and disasters *(high agreement, robust evidence).* Closing the information gap is critical to reducing vulnerability of natural-resource dependent communities. Maintaining the ability of a community to ensure equitable access and entitlement to key resources and assets is essential to building local adaptive capacity in a changing climate. Moreover, capacity-building and development of new skills for diversifying local livelihoods are key to flexibility in disaster reduction and improving the local adaptation and managing disasters. [5.5]

Comprehensive assessments of local disaster risk are lacking in many places *(high agreement, medium evidence).* As a foundation for management options, the methodology for locally-based vulnerability assessments (exposure and sensitivity) and potential costs needs more development and testing for applications to the local context. [5.6]

Insurance is a risk transfer mechanism used at the local level *(medium agreement, medium evidence).* Risk sharing (formal insurance, microinsurance, crop insurance) can be a tool for risk reduction and for recovering livelihoods after a disaster. Under certain conditions such tools can lead to disincentives for reducing disaster risk at the local level through the transfer of the risk spatially (to other places) or temporally (to the future). [5.6.3]

Community based adaptation is a process of participatory engagement and shows great promise as a management strategy for disaster risk and climate extremes (*medium agreement, medium evidence).* However, community based adaptation is constrained by the availability of disaster risk and climate information customized for local stakeholders. It is also constrained by the resources (human and financial capital) necessary to adequately implement the engagement process at the local level. [5.6]

Data on natural disasters and disaster risk reduction is particularly lacking at the local level and this constrains improving local resilience *(high agreement, medium evidence).* This is the case in all areas but especially so in developing countries. Local knowledge systems are often neglected in disaster risk management. There is considerable potential for adapting geographic information systems to include local level knowledge to support disaster management activities. [5.7]

Disaster loss estimates are inconsistent and highly dependent on the scale of the analysis, and result in wide variations among community, state, province, and sub-national regions (*high agreement, robust evidence*). Indirect losses are increasingly taken into account as significant factors in precipitating negative economic impact. Adaptation costs though hard to estimate can be reduced if climate change adaptation is integrated into existing disaster risk management and disaster risk management is in turn embedded in development strategies and decision-making. [5.5]

Mainstreaming disaster risk management into policies and practices provide key lessons that apply to climate change adaptation at the local level (*high agreement, medium evidence).* Addressing social welfare, quality of life, infrastructure, and livelihoods and incorporating a multi-hazards approach into planning and action for disasters in the short term, facilitates adaptation to climate extremes in the longer term. [5.4, 5.5, 5.6]

The main challenge for local adaptation to climate extremes is to apply a balanced portfolio of approaches as a one-size fits all strategy may prove limiting for some places and stakeholders *(high confidence, medium evidence).* Successful measures simultaneously address fundamental issues related to the enhancement of local collective actions, and the creation of approaches at national and international scales that complement, support, and legitimize such local actions. [5.4, 5.6]

5.1. Introduction: Why the Local is Important

Disasters occur first at the local level and affect local people. These localized impacts can then cascade to have national and international ramifications. As a result, and is noted in the Chapeau, the responsibility for managing

such risks requires the linkage of local, national, and global scales (Figure 5-1). Some disaster risk management options are bottom up strategies, designed by and for local places, while other management options are products of global negotiations (Chapter 7) that are then implemented through national institutions (Chapter 6) to local levels. Institutions, actors, governance, and geographic units of analysis are not uniform across these scales. Even within each scale there are differences. While some communities are able to cope with disaster risks, others have limited disaster resilience and capacity to cope with present disaster risk let alone adapt to climate variability and extremes. This is the topic of this chapter: to present evidence on where disasters are experienced, how disaster risks are managed at present, and the variability in coping mechanisms and capacity in the face of climate variability and change, all from the perspective of local places and local actors. The chapter explores three themes: how disaster risks are managed at present; how the impact of climate extremes threatens human security at the local level; and the role of scale and context in shaping variability in vulnerability, coping, adaptive capacity, and the management of disaster risks and climate extremes at the local level.

[INSERT FIGURE 5-1 HERE:
Figure 5-1: Linking local to global actors and responsibilities.]

The idea of local has many connotations. For the purposes of this report, local refers to a range of places, management structures, institutions, social groupings, conditions, and sets of experiences and knowledge that exist at a scale below the national level. As administrative units, local can range from villages, districts, suburbs, cities, metropolitan areas, through to regions, states, and provinces. The conception of local includes the set of institutions (public and private) that maintain and protect local people as well as those that have some administrative control over space and resources. In these places, choices and actions for disaster risk management and adaptation to climate extremes can be initially independent of national interventions. At the local level there is traditional knowledge about disaster risk and grass roots actions to manage it. Functional or physical units such as watersheds, ecological zones, or economic regions operate at the local level, including the private and public institutions that govern their use and management. Each of the differing connotations of local means that there are differing approaches and contents of disaster risk management practice, differing stakeholders and interest groups, and more significantly differing relations to the national and international levels (Adger *et al*., 2005). We recognize that states and provinces in many countries are large complex entities with similar powers as smaller nations. Where we discuss states and provinces and similar administrative structures in this chapter, we refer to them as sub-national for clarification purposes.

Local places vary in their disaster experience, who and what is at risk, the potential geographical extent of the potential impact and responses, and in stakeholders and decision-makers. Local places have considerable experience with short-term coping responses and adjustments to disaster risk (UNISDR, 2004), as well as with longer-term adjustments such as the establishment of local flood defenses, the selection of drought resistant crops, or seasonal or longer migration by one or more family members. For example, the use of remittances is a substantial source of post-disaster income and regularly used as a means for diversifying livelihoods to enhance resilience and to proactively cope with extremes (Adger *et al*., 2002).

Climate sensitive hazards such as flooding, tropical cyclones, drought, heat, and wildfires regularly affect many localities with frequent, yet low level, losses (UNISDR, 2009). Because of their frequent occurrence, localities have developed extensive reactive disaster risk management practices. However, disaster risk management also entails the day to day struggle to improve livelihoods, social services, and environmental services. Local response and long term adaptation to climate extremes will require disaster risk management that acknowledges the role of climate variability. This can mean a modification and expansion of local disaster risk management principles and experience through innovative organizational, institutional, and governmental measures at all jurisdictional levels (local, national, international). Institutionally-driven arrangements may constrain or impede local actions and ultimately limit the coping capacity and adaptation of local places.

Local communities routinely experience hazard impacts with many resulting from extreme weather and climate events (see Chapter 3). The significance of discussing these from the local perspective is that extreme weather and climate events will vary from place to place and not all places have the same experience with that particular initiating event. Research demonstrates that disaster experience influences proactive behaviors in preparing for and

responding to subsequent events (see section 5.4.1). In the context of climate change some localities could be experiencing certain types of hazards for the first time and not have the existing capacities for preparedness and response. For example, Hurricane Catarina, the first South Atlantic hurricane which made landfall as a category 1 storm just north of Porto Alegre, Brazil, in March 2004 (McTaggart-Cowan *et al.*, 2006), was the region's first local experience with a hurricane. However, there is low confidence in attribution of any long term increases in hurricane formation in this ocean region where tropical cyclones had not been previously recorded (Chapter 3, Table 3.2). Finally, not all of the extreme events become severe enough to cause a disaster of national or international magnitude, yet they will create ongoing problems for local disaster risk management.

The second theme of the chapter examines how climate extremes could threaten the human security of local populations. Because these risks often affect the basic functioning of society, it is increasingly recognized that climate change adaptation and disaster risk management should be integral components of development planning and implementation to increase sustainability (Thomalla *et al.*, 2006) (Box 5-1). In other words, both have to be mainstreamed into national development plans, poverty reduction strategies, sectoral policies, and other development tools and techniques (UNDP, 2007). For example, rural communities in many world regions face greater risks of livelihood loss resulting from flooding of low-lying coastal areas, water scarcity and drought, decline in agricultural yields and fisheries resources, and loss of biological resources (Osman-Elasha and Downing, 2007). In some African countries where recurrent floods are closely linked with El Niño-Southern Oscillation (ENSO) events (Ward *et al.*, 2010), the result is major economic and human loss seen in places such as Mozambique (Mirza, 2003; Obasi, 2005) and Somalia. For such communities, with less developed infrastructure and health services, the impacts of floods are often further exacerbated by health problems associated with water scarcity and quality, such as malnutrition, diarrhea, cholera and malaria (Kabat *et al.*, 2002).

_____ START BOX 5-1 HERE _____

Box 5-1. Climate Change and Violent Conflict

Linking climate change and violent conflict is controversial. The conceptual debate links climate change to resource scarcity (or those essential resources to support livelihoods), which in turn leads to human insecurity. At the local scale, there are two distinct outcomes: armed conflict or migration, with the latter potentially leading to increased conflict in the receiving locality (Barnett and Adger, 2007; Nordås and Gleditsch, 2007). For example, some research suggests that environmental stresses feed the tensions between localities as they compete for land to support their livelihoods (Barnett, 2003; Kates, 2000; Osman-Elasha and El Sanjak, 2009). Extreme events such as droughts and heat waves could increase these tensions in areas already facing situations of water scarcity and environmental degradation, giving rise to conflicts resulting in the dislocation of large numbers of refugees and people within and across borders. However, there is limited agreement and evidence to support the link between climate change and violent conflict, especially in Africa (Buhaug, 2010; Burke *et al.*, 2009). While the causal chain suggested in the literature (climate change increases the risk of violent conflict) has found currency within the policy community, it has not been adequately substantiated in the scientific literature (low agreement and limited evidence). Where empirical studies exist, they are methodologically flawed in a number of ways: not controlling for population size; focusing only on conflict cases not all migration instances; using aggregated, not disaggregated climate data at sub-national scales; and having inherent inconsistencies in the timeframes used (short-term variability in violent conflict; longer term variability in climate). More research on the local climate-conflict nexus is warranted in order to determine if a causal linkage exists.

_____ END BOX 5-1 HERE _____

In order to develop preparedness measures for disaster risk management and climate adaptation, the vast contextual differences of localities will have to be considered. They include differences in population characteristics that influence vulnerability, the settlement continuum from urban to rural, between administrative units, and within developing and developed countries. Given the wide disparities, it is clear that single solutions for disaster risk management are not possible. For example, there are differences between urban and rural communities in terms of disaster and climate change vulnerability and disaster risk and adaptation options. Given the rapid pace of urbanization and diffusion of communication and transportation networks into distant areas, the sharp distinction

between urban and rural is less visible in many areas. In its place is a continuum with local places exhibiting both rural and urban characteristics with a mix of vulnerabilities and jurisdictional issues that are neither totally urban nor rural (Aragon-Durand, 2007; McGregor *et al*., 2006).

Scalar considerations must also be emphasized in planning. Efforts to forge greater and more equitable capacity at the local scale have to be supported by policies at the national level to increase the ability of local institutions and communities to cope with present and future risks from climate-sensitive hazards. To effectively reduce vulnerabilities to hazards associated with climate change, coordination across different levels and sectors is required, in addition to the involvement of a broad range of stakeholders beginning at the local level (Davies, 2009; Devereux and Coll-Black, 2007; DFID, 2006; Tearfund., 2006; UNISDR, 2004). The larger global context within which a locality is situated affects outcomes. It is possible that the history of resource exploitation, globalization, and the processes of development as currently practiced, may be increasing, rather than reducing disaster vulnerability at the local level (see Chapter 2). Those choosing strategies for reducing disaster risk and adapting to climate change, especially in developing countries need to take these processes into account (UNISDR, 2009).

These contextual factors are critical to planning for climate extremes. They suggest the need for strengthening coordination between climate change adaptation and disaster risk management locally that will in turn improve the implementation of plans (Mitchell and van Aalst, 2008). Such coordination is also needed in order to avoid any negative impacts across different sectors or scales that could potentially result from fragmented adaptation and development plans. This is evident in the implementation of some of the adaptation strategies, such as large-scale agriculture, irrigation and hydroelectric development, which may benefit large groups or the national interests but may also harm local, indigenous and poor populations (Kates, 2000; Rojas Blanco, 2006). Some sources believe that it is essential that any new disaster risk reduction or climate change adaptation strategies must be built on strengthening local actors and enhancing their livelihoods (Osman-Elasha, 2006a). Moreover, a key aspect of planning for adaptation at local level is the identification of the differentiated social impacts of climate change based on gender, age, disability, ethnicity, geographical location, livelihood, and migrant status (Tanner and Mitchell, 2008). Emphasis needs to be given to identifying the adaptation measures that serve the most vulnerable groups, address their urgent needs, and increase their resilience. This often means using a more coordinated and integrated management approach with the involvement of diverse stakeholder groups (Sperling and Szekely, 2005), which may assist in avoiding maladaptation across sectors or scales and provide for win-win solutions.

5.2. How Local Places Currently Cope with Disaster Risk

Local people everywhere have developed skills, knowledge and management systems that enable them to interact with their environment. Often these interactions are beneficial and provide the livelihoods that people living in local places depend on. At the same time communities have developed ways of responding to disruptive environmental events. These coping mechanisms include measures that seek to modify the impacts of disruptive events, modify some of the attributes or environmental aspects of the events themselves, and/or actions to share or reduce the disaster risk burdens (Burton *et al*., 1993). By the same token some actions taken at local levels (e.g. deforestation and coral mining) may also increase disaster risks. It is important to acknowledge that while climate change may alter the magnitude and/or frequency of some climatic extremes (see Chapter 3), other environmental, social, political, or economic processes (many of them also global in scale) are affecting the abilities of communities to cope with disaster risks and climate-sensitive hazards (Adger and Brown, 2009; Wisner *et al*., 2004). Accordingly, disaster losses have increased significantly in recent decades (UNDP, 2004; UNISDR, 2004). These social, economic, and political processes are complex and deep seated and present major obstacles to reducing disaster risk, and may constrain efforts to reduce community vulnerabilities to extreme events under conditions of climate change. In section 5.2 we outline three common local-level coping strategies: emergency assistance and disaster relief, population movements, and recovery and reconstruction.

5.2.1. Emergency Assistance and Disaster Relief

Humanitarian assistance is often required when other measures to reduce disasters have been unsuccessful and plays a critical role in helping local people cope with the effects of disasters. Such relief often helps to offset distress and suffering at the local level and to assist in recovery and rehabilitation. Sometimes external relief is unnecessary or inappropriate because the local people affected by disasters often are not completely helpless or passive and are capable of helping themselves (Cuny, 1983; De Ville de Groyet, 2000). This view is sustained by commonplace definitions of disasters as situations where communities or even countries cannot cope without external assistance (Cuny, 1983; Quarantelli, 1998).

It is important to realise that the first actors providing assistance during and after disasters are members of the affected community (De Ville de Groyet, 2000) who provide relief through local charities, kinship networks, or local governments. In isolated communities such as those in the outer islands of small-island developing states, external assistance may be subject to considerable delay and self-help is an essential element of response, especially in the period before assistance arrives. Typically, emergency assistance and disaster relief in developed countries comes in the form of assistance from national and state/provincial level governments to local communities. The provision of international relief is usually from members of the OECD to developing countries (Development Initiatives, 2009). The international provision of disaster relief to local places has become highly sophisticated and much broader in scope over the past two decades involving both development and humanitarian organizations, with the increasing recognition that external relief providers make use of local knowledge in planning their relief efforts (Darcy and Hofmann, 2003; Morgan, 1994; Méheux *et al*., 2010). The relief itself includes such things as assistance in post-disaster assessment, food provision, water and sanitation, medical assistance and health services, household goods, temporary shelter, transport, tools and equipment, security, logistics, communications and community services (Bynander *et al*., 2005; Cahill, 2007). Many of these activities are organised into clusters of specialists from multilateral organisations and non-governmental organisations, among others, coordinated by the United Nations.

While much of the relief tends to be organised at more of a national and international scale than local scale, the distribution and use of relief occur at the local level. From this perspective it is vital to understand what is locally appropriate in terms of the type of relief provided, and how it is distributed (Darcy and Hofmann, 2003; Kovác and Spens, 2007). Similarly, local resources and capacities should be utilised as much as possible (Beamon and Balcik, 2008). There has also been a trend towards international humanitarian organisations working with local partners, although on occasion this can result in the imposition of external cultural values resulting in resentment or resistance (Hillhorst, 2002).

Relief, nevertheless, is often a critically important strategy for coping. Relief organisations have built capacity based on experience in recent years, have become increasingly accountable, and are obliged to follow humanitarian principles. Despite these improvements, some problems remain. Relief cannot cover all losses most of which are borne locally. Relief can undermine local coping capacities and reduce resilience and sustainability (Susman *et al*., 1983; Waddell, 1989), reinforce the status quo that was characterized by vulnerability (O'Keefe *et al*., 1976), and in some cases, serve to remove independence or autonomy from disaster 'victims' so that ownership of the event and control over the recovery phase is lost at the local level (Hillhorst, 2002). Relief is often inequitably distributed and in some disasters there is insufficient relief. Corruption is also a factor in some disaster relief operations with local elites often benefiting more than others (Pelling and Dill, 2010). Humanitarian organizations are increasingly aware of these concerns and many are addressing them through coordination of activities, addressing gendered inequalities, and working in partnership with local organizations in disaster relief. There is also a growing recognition of the need for accountability in humanitarian work (The Humanitarian Accountability Partnership International, 2011).

Not all disasters engender the same response as local communities receive different levels of assistance. For example, those people most affected by a small event can suffer just as much as a globally publicised big event but are sometimes overlooked by relief agencies. Fast onset and unusual disasters such as tsunamis generate considerably more public interest and contributions from governments, NGOs, and the public, sometimes referred to as the CNN factor (Olsen *et al*., 2003). Disasters that are overshadowed by other newsworthy or media events, such as coverage of major sporting events, are often characterised by lower levels of relief support (Eisensee and Stromberg, 2007). Where there is widespread media coverage, NGOs and governments are often pressured to

respond quickly with the possibility of an oversupply of relief and personnel. This has worsened in recent times when reporters are 'parachuted' into disaster sites often in advance of relief teams but they have little understanding of the contextual factors that often underlie vulnerability to disasters (Silk, 2000). Such media coverage often perpetrates disaster myths such as the prevalence of looting, helplessness, and social collapse putting pressure on interveners to select military options for relief when humanitarian assistance would be more helpful (Tierney *et al.*, 2006).

Relief is politically more appealing than disaster risk management (Seck, 2007) and it often gains much greater political support and funding than measures that would help offset the need for it in the first place. Providing relief reflects well on politicians (both in donor and recipient countries) who are seen to be caring, taking action, and responding to public demand (Eisensee and Stromberg, 2007).

Major shares of the costs of disaster relief and recovery still fall on the governments of disaster affected countries. Bilateral relief is limited to materials from donor countries and most relief is subject to relatively strict criteria to reduce perceived levels of corruption. In both cases flexibility is heavily restricted. Relief can also produce local economic distortions such as causing shops to lose business as the market becomes flooded with relief supplies. These problems can be overcome by directly transferring cash to local people to buy building materials, seed and the like. Such programs have performed well where local supplies are available (Farrington and Slater, 2009). At the same time, there is the view that disaster relief can create a culture of dependency and expectation at the local level (Burby, 2006), where disaster relief becomes viewed as an entitlement program as local communities are not forced to bear the responsibility for their own locational choices, land use, and lack of mitigation practices.

5.2.2. Population Movements

A second coping strategy is population movements. Natural disasters are linked with population movements in a number of ways (Hunter, 2005; Perch-Nielson *et al.*, 2008; Warner *et al.*, 2010). Evacuations occur before, during and after some disaster events. Longer-term relocation of affected communities sometimes occurs. Relocations can be temporary or permanent. These different forms of population movements have variable social, psychological, health, and financial implications for the communities concerned. Population movements may also be differentiated on the basis of whether the mobility is voluntary or forced (displacement) and whether or not international borders are crossed. Most contemporary research views population mobility as a continuum from completely voluntary movements to completely forced migrations (Laczko and Aghazarm, 2009). The United Nations Office for the Coordination of Humanitarian Affairs and the Internal Displacement Monitoring Centre estimated that at least 36 million people were displaced by natural disasters in 2008. While these displaced people would come from and arrive at local origins and destinations there is little information on the local implications and time frames of the displacement (United Nations Office for the Coordination of Humanitarian Affairs and the Internal Displacement Monitoring Centre, 2009).

Where climate change increases the marginality of livelihoods and settlements beyond a sustainable level, communities may be forced to migrate or be displaced (McLeman and Smit, 2006). While migration typically has many causes, of which the environment (including climate) is just one factor, extremes often serve as precipitating events (Hugo, 1996). Furthermore, a number of researchers consider that climate related migration, other than forced displacement, may not necessarily be a problem and indeed may be a positive adaptive response with people who remain at the place of origin benefitting from remittances (Barnett and Webber, 2009; Tacoli, 2009). Nomadic pastoralists migrate as part of their livelihoods but often respond to disruptive events by modifying their patterns of mobility (Anderson *et al.*, 2010). Migration is highly gendered both in terms of drivers and impacts, which differ between men and women although it is not clear how these differences might be played out in the context of climate change (Hugo, 2010).

Global estimations provide little insight into the local implications of such large-scale migratory patterns. Migration will have local effects, not only for the communities generating the migrants, but those communities where they may settle. Barnett and Webber (2009) also note that the less voluntary the migration choice is, the more disruptive it will become. In the context of dam construction, for example Hwang *et al.* (2007) found that communities anticipating

forced migration experienced stress. Hwang *et al.* (2010) also found that forced migration directly led to increased levels of depression and the weakening of social safeguards in the relocation process. Much post-disaster relocation is temporary, which is also associated with psychological and social effects such as disruption of social networks and trauma (Neria *et al.*, 2009).

One outcome of climate change is that entire communities could be required to relocate and in some cases, such as those living in atoll countries, the relocation will be international. Such relocation can have significant social, cultural and psychological impacts (Campbell, 2010b). Community relocation schemes are those in which whole communities are relocated to a new non-exposed site. Perry and Lindell (1997) examined one such instance in Allenville, Arizona. They developed a set of five principles for achieving positive outcomes in relocation projects: 1) The community to be relocated should be organised; 2) All potential relocatees should be involved in the relocation decision-making process; 3) Citizens must understand the multi-organisational context in which the relocation is to be conducted; 4) Special attention should be given to the social and personal needs of the relocatees; and 5) Social networks need to be preserved. For many communities relocation is difficult, especially in those communities with communal land ownership. In the Pacific Islands, for example, relocation within one's own lands is least disruptive but leaving it completely is much more difficult, as is making land available for people who have been relocated (Campbell, 2010b).

5.2.3. Recovery and Reconstruction

Recovery and reconstruction include actions that seek to establish or re-establish the everyday life of the locality affected by disaster (Hewitt, 1997). Often reconstruction enables communities and businesses to return to the same conditions that existed prior to the disaster, and in so doing create the potential for further similar losses, thus reproducing the same exposure that resulted in disaster in the first place (Jha *et al.*, 2010). Recovery and reconstruction (especially housing rehabilitation and rebuilding) are among the more contentious elements of disaster response. One of the major issues surrounding recovery is the lack of clarity between recovery as a process and recovery as an outcome. The former emphasizes betterment processes where pre-existing vulnerability issues are addressed. The latter focuses on the material manifestation of recovery such as building houses or infrastructure. Often following large disasters top down programmes result in rebuilding houses but fail to provide homes (Petal *et al.*, 2008). Moreover, haste in reconstruction, while achieving short-term objectives, often results in unsustainable outcomes and increasing vulnerability (Ingram *et al.*, 2006). As seen in the aftermath of Hurricane Katrina, there are measureable local disparities in recovery, leading to questions of recovery for whom and recovery to what (Curtis *et al.*, 2010; Finch *et al.*, 2010; Stevenson *et al.*, 2010). There are a number of obstacles to effective and timely reconstruction including lack of labour, lack of capacity among local construction companies, material shortages, resolution of land tenure considerations, and insufficiency of funds (Keraminiyage *et al.*, 2008). While there is urgency to have people re-housed and livelihoods re-established, long-term benefits may be gained through carefully implemented reconstruction (Hallegatte and Dumas, 2009; Hallegatte, 2008) in order to achieve greater disaster resilience.

Most research on recovery and reconstruction has tended to focus on housing and the so-called lifelines of infrastructure: electricity, water supply and transport links. Less is published on the equally important, if indeed not more so, rehabilitation of livelihoods, and addressing the problems of power inequities that often include land and resource grabbing by the economic and politically powerful after disaster in both developed and developing countries. Agricultural rehabilitation (e.g. the provision of seeds, planting material, fertilisers, and stock, and the remediation of land) is particularly important where local livelihoods are directly affected such as in subsistence or semi-subsistence societies (Dorosh *et al.*, 2010). In addition some climate related disaster events, such as droughts do not always directly destroy the built environment infrastructure (like flooding or tropical cyclones) so the rehabilitation of livelihoods, in particular sustainable livelihoods, becomes an important aspect of disaster risk reduction and development (Nakagawa and Shaw, 2004).

As with relief, major problems can occur where planning and implementation of recovery and reconstruction is taken out of the hands of the local communities concerned. In addition, the use of inappropriate (culturally, socially or environmentally) materials and techniques may render rebuilt houses unsuitable for their occupants (Jha *et al.*,

2010). As Davidson *et al.* (2007) found, this is often the case and results in local community members having little involvement in decision making for the recovery process; instead they are used to provide labor. It is also important to acknowledge that post-disaster recovery often does not reach all community members and in many recovery programmes, the most vulnerable, those who have suffered the greatest losses, often do not recover from disasters, and endure long-term hardship (Wisner *et al.*, 2004). In this context, it is important to take into account the diversity of livelihoods in many local areas and to work with local residents and stakeholders to develop strategies that are potentially more resilient in the face of future events (Pomeroy *et al.*, 2006).

During the post-recovery phase, reconstruction requires weighing, prioritizing, and sequencing of policy programming, given the multiple, and sometimes competing agendas for most decision-makers and operational actors. Often there are opportunities for change in policy directions and agenda setting at local to national levels at this time (Birkland, 1997). The post-event lobbying for action and resources requires a balance between short-term needs and long term goals. The most significant is the pressure to quickly return to conditions prior to the event rather than incorporate longer term and more sustainable development policies (Christoplos, 2006; Kates *et al.*, 2006). How long such a window will stay open or precisely what factors will make it close under a given set of conditions is not well known even though 3-6 months has been recognized in specific cases (Kates *et al.*, 2006).

The most often used strategies for coping with present disaster risk at the local level are emergency assistance (including disaster relief), population movements, and recovery and reconstruction. As illustrated above, there is considerable variability among and between local places in how these actions are implemented and the impacts of their use.

5.3. Anticipating and Responding to Future Disaster Risk

This section examines how local places anticipate future risks and how they respond to them. In addition to enhanced communication, other approaches to anticipating and responding to future risks include structural interventions such as dykes or dams, natural resources planning and ecosystem protection, and storage and rationing of resources.

5.3.1. Communicating Risk

Effective communication is necessary across the full cycle of disaster management: reduction, preparedness, response, and recovery, especially at the local level where communications face particular constraints and possibilities. A burgeoning field of research explores the barriers to communicating the impacts of climate change to motivate constructive behaviors and policy choices (Frumkin and McMichael, 2008). Communicating the likelihood of extreme impacts of climate change also presents an important and difficult challenge (Moser and Dilling, 2007). Research on climate communications addresses how information can be designed, and the mechanisms and timing of its distribution.

5.3.1.1. Message Design

As used here, the term *risk communication* refers to intentional efforts on the part of one or more sources (e.g., international agencies, national governments, local government) to provide information about hazards and hazard adjustments through a variety of channels to different audience segments (e.g., the general public, specific at-risk communities). The characteristics of messages that have a significant impact on local adoption of adjustments involve information quality (specificity, consistency, and source certainty), information reinforcement (number of warnings and repetition) (Mileti and O'Brien, 1992; Mileti and Fitzpatrick, 1993; O'Brien and Mileti, 1992), and the ways in which information is designed. Messages targeted to specific audiences are more readily received (Maibach *et al.*, 2008) than those which are not. Targeting threats to future generations may generate more concern than overt actions to reduce contemporary climate change impacts (Maibach *et al.*, 2008). In addition, communication is will be more effective when the information regarding risk does not exceed the capacity for coping and therefore

galvanizes resilience (Fritze *et al*., 2008). Some research suggests that a focus on personal risk of specific damages of climate change can be a central element in motivating interest and behavior change (Leiserowitz, 2007). Risk messages vary in threat specificity, guidance specificity, repetition, consistency, certainty, clarity, accuracy, and sufficiency (Lindell and Perry, 2004; Mileti and Sorensen, 1990; Mileti and Peek, 2002).

Communications that include social, interpersonal, physical environmental, and policy factors can foster civic engagement and social change fundamental to reducing risk (Brulle, 2010). A participatory approach highlights the need for multiple pathways of communication that engenders credibility, trust, and cooperation (Frumkin and McMichael, 2008; National Research Council (NRC), 1989), which are especially important in high-stress situations such as those associated with climate extremes. For example, participatory video production is effective in communicating the extreme impacts of climate change (Baumhardt *et al*., 2009; Suarez *et al*., 2008). Participatory video involves a community or group in creating their own videos through story-boarding and production (Lunch and Lunch, 2006). Such projects are traditionally used in contexts, such as poor communities, where there are constraints to accessing accurate climate information (Patt and Gwata, 2002; Patt and Schröter, 2008). Engaging with community leaders or opinions leaders in accessing social networks through which to distribute information is another approach, traditionally used by health educators but also applicable to the translation of climate risks in a community context (Maibach *et al*., 2008). Another approach used in health communications that is relevant to climate education is the "community drama" in which community members engage in plays to communicate health risks (Middlekoop *et al*., 2006). These types of communication projects can motivate community action necessary to promote preparedness (Jacobs *et al*., 2009; Semenza, 2005).

Visualizing methods such as mapping, cartographic animations, and graphic representations are also used to engage with stakeholders who may be impacted by extreme events (McCall, 2008; Shaw *et al*., 2009b). Many programs are developing ways to use visualizations to help decision-makers adapt to a changing environment, suggesting that such tools can increase climate literacy (Niepold *et al*., 2008). Visualizations can be powerful tools, but issues of validity, subjectivity, and interpretation must be seriously considered in such work (Nicholson-Cole, 2004). These communications are most effective when they take local experiences or points of view and locally-relevant places into account (O'Neill and Ebi, 2009). Little evaluation has been done of visualization projects, therefore leaving a gap in understanding of how to most effectively communicate future risks of extreme events.

5.3.1.2. Modes and Timing of Risk Communication

The generation and receipt of risk information occurs through a diverse array of channels. They include: interpersonal contact with particular researchers; planning and conceptual foresight; outside consultation on the planning process; user-oriented transformation of information; and individual and organizational leadership (National Research Council (NRC), 2006). Researchers have long recognized a variety of informal information source vehicles including peers (friends, relatives, neighbors, and coworkers), and news media (Drabek, 1986). These sources systematically differ in terms of such characteristics as perceived expertise, trustworthiness, and protection responsibility (Lindell and Perry, 1992; Lindell and Whitney, 2000; Pulwarty, 2007). Risk area residents use information channels for different purposes: the internet, radio and television are useful for immediate updates; meetings are useful for clarifying questions; and newspapers and brochures are useful for retaining information that might be needed later. In addition, within community discussion on risks to livelihoods, such as during droughts, act as mechanisms for risk communication and response actions (Dekens, 2007).

Policies and actions affecting communications and advanced warning have a major impact on the adaptive capacity and resilience of livelihoods. The collection and transmittal of weather (and climate)-related information is often a governmental function and timely issuance remains a key weakness in climate information systems especially for communication passed on to communities from the national early warning units (UNISDR., 2006). There are other localized forms of communication that can be used rapidly, such as neighborhood watch systems (Lichterman, 2000). Some private communication methods, such as text messaging, Facebook and Twitter, may reach affected populations before government directives (Palen *et al*., 2007). However, some research shows that there has been too much reliance on one-way devices for communication (such as the radio), which were felt to be inadequate for agricultural applications (for example, farmers are not able to ask further questions regarding the information

provided) (Ziervogel, 2004). Within many rural communities, low bandwidth and poor computing infrastructure pose serious constraints to risk message receipt. Such gaps are evident in developed as well as lesser developed regions.

The degree of acceptability of information and trust in the providers, dictate the context of communicating disaster and climate information (see Box 5-2). Lindell and Perry (2004) summarized the available research as indicating message effects include pre-decisional processes (reception, attention, and comprehension). Several studies have identified the characteristics of pre-decisional practices that lead to effective communication over the long-term (Cutter, 2001; Fischhoff, 1992; Pulwarty, 2007). These include: 1) understanding of the goals, objectives, and constraints of communities in the target system; 2) mapping practical pathways to different outcomes carried out as joint problem definition and fact-finding strategies among research, extension and farmer communities; 3) bringing the delivery persons (e.g. extension personnel, research community etc.) to an understanding of what has to be done to translate current information into usable information; 4) interacting with actual and potential users to better understand informational needs, desired formats of information, and timeliness of delivery; 5) assessing impediments and opportunities to the flow of information including issues of credibility, legitimacy, compatibility (appropriate scale, content, match with existing practice) and acceptability; and 6) relying on existing stakeholders' networks and organizations to disseminate and assess climate information and forecasts.

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Box 5-2. Successful Communication of Local Risk-Based Climate Information

The following questions have been identified as shaping the successful communication of risk-based climate information (Ascher, 1978; Fischhoff, 1992; Pulwarty, 2003):

- What do people *know* and *believe* about the risks being posed?
- What is the *past experience*/outcomes of information use?
- Is the new information *relevant* for decisions in the particular community?
- Are the sources/providers of information *credible* to the intended user?
- Are practitioners (e.g. farmers) *receptive* to the information and to research?
- Is the information *accessible* to the decision maker?
- Is the information *compatible* with existing decision models e.g. for farming practice?
- Does the community (or individuals in the community) have the *capacity* to use information?

_____ END BOX 5-2 HERE _____

Much research has yet to be done regarding risk communication on climate change. There has been little systematic investigation, for example, on message effectiveness in prompting local action based on differing characteristics such as the precision of message dissemination, penetration into normal activities, message specificity, message distortion, rate of dissemination over time, receiver characteristics, sender requirements, and feedback (Lindell and Perry, 1992; National Research Council (NRC), 2006). Little research attention has been devoted to how information can be distributed within a family, although the existing research does show there are emotional, social, and structural barriers to such distribution (Norgaard, 2009).

5.3.1.3. Warnings and Warning Systems

The disaster research community has shown that warnings of impending hazards need to be complemented by information on the risks actually posed by the hazards as well as the potential strategies and pathways to mitigate the damage in the particular context in which they arise (Drabek, 1999; UNISDR., 2006). Local level early warnings based on traditional knowledge (e.g. water turning a different color, winds shifting) are frequently used. The use of radios, megaphones, and cell phones are also used at the local level to warn.

Effective early warning implies information interventions into an environment where vulnerability is assumed (Olson, 2000). This backdrop is reinforced through significant lessons that have been identified from the use of

seasonal climate forecasts over the past 15 years (Podestá *et al.*, 2002; Pulwarty, 2007) . It is now widely accepted that the existence of predictable climate variability and impacts are necessary but not sufficient to achieve effective use of climate information, including seasonal forecasts. The practical obstacles to using information about future conditions at the local scale are diverse. They include: limitations in modeling the climate system's complexities (e.g. projections having coarse spatial and temporal resolution; limited predictability of some relevant variables, and forecast skill characterization, see Chapter 3); procedural, institutional, and cognitive barriers in receiving or understanding climatic information; and the capacity and willingness of decision-makers to modify actions (Kasperson *et al.*, 1988; Marx *et al.*, 2007; Patt and Gwata, 2002; Roncoli *et al.*, 2001; Stern and Easterling, 1999). In addition functional, structural, and social factors inhibit joint problem identification and collaborative knowledge production between providers and users. These include divergent objectives, needs, scope, and priorities; different institutional settings and standards, as well as differing cultural values, understanding, and mistrust (Pulwarty *et al.*, 2004; Rayner *et al.*, 2005; Weichselgartner and Kasperson, 2010).

Significant advancements in warning systems in terms of improved monitoring, instrumentation, and data collection have occurred (Chapter 9.3.3.1), but the management of the information and its dissemination to at risk populations is still problematic (Sorensen, 2000). Researchers have identified several aspects of information communication, such as stakeholder awareness, key relationships, and language and terminology, which are socially contingent in addition to the nature of the predictions themselves. More is known about the effects of these message characteristics on warning recipients, than is known about the degree to which generators and providers of information including hazards researchers address them in their risk communication messages. For example, warnings may be activated (such as the tsunami early warning system), yet fail to reach potentially affected communities (Oloruntoba, 2005). Similarly, many communities do not have access to climate-sensitive hazard warning systems such as tone alert radio, emergency alert system, emergency phone numbers (reverse 911 in the US, but in other parts of the world you call 110, 112 or other numbers), and thus never hear the warning message, let alone act upon the information (Sorensen, 2000). On the other hand, Valdes (1997) demonstrated that flood warning systems based on community operation and participation in Costa Rica make a difference as to whether early warnings are acted upon to save lives and property. Implementing community early warning systems (such as the correlations of rain data and water levels among monitoring stations along the river) serve to encourage communities to become more proactive in their hazard mitigation approaches.

Part of the research gap regarding risk communication stems from the lack of projects that can be tested and shown to affect preparedness. On the most basic level, there is considerable understanding of the information needed for preparing for disasters, but less specific understanding of what information and trusted communication processes are necessary to generate local confidence and preparedness for climate change (Fischhoff, 2007). The very discussion of climate forecasts and projections within potentially impacted communities has served as a vehicle for democratizing the drought discourse in Ceará in Northeast Brazil (Finan and Nelson, 2001). Developing a seamless continuum across emergency responses, preparedness, and coping and adaptation requires insight into the demands that different types of disasters will place upon the local area and the need to perform basic emergency functions—pre-event assessments, proactive hazards mitigation, and incident management (Lindell and Perry, 1996). As noted in previous IPCC Reports (Solomon *et al.*, 2007), preparing for short-term disasters enhances the capacity to adapt to longer term climate change.

5.3.2. Structural Measures

Structural measures may be used to reduce the effects of climate related events such as floods, droughts, coastal erosion, and heat waves. Structural interventions to reduce the effects of extreme events often employ engineering works to provide protection from flooding such as dykes, embankments, seawalls, river channel modification, flood gates, and reservoirs. However, structural also include measures that strengthen buildings (during construction and retrofitting), those that enhance water collection in drought-prone areas (e.g. roof catchments, water tanks, wells), and those that reduce the effects of heat waves (e.g. insulation and cooling systems). Although many of these structural interventions can achieve success in reducing disaster impacts, they can also fail due to lack of maintenance, age, or due to extreme events that exceed the engineering design level (Doyle *et al.*, 2008; Galloway, 2007; Galloway *et al.*, 2009). In the event that the frequency and magnitude of extreme events increase as a result of

climate change new design levels may be necessary. Technical considerations should also include local social, cultural, and environmental considerations (Opperman *et al.*, 2009; WMO, 2003).

Implementing structural measures from planning through implementation that involve participatory approaches with local residents who are proactively involved often leads to increased local ownership and more sustainable outcomes. Such an example is a program of building, managing and maintaining cyclone shelters in Bangladesh (Zimmermann and Stössel, 2011). One of the key reasons why sub-national structural projects are often ineffective is that they are approved on the basis of technical information alone, rather than based on both technical information and local knowledge (ActionAid, 2005; Prabhakar *et al.*, 2009) (see also section 5.4.4). In addition, national legislation has important influences on the choice of disaster risk reduction strategies at the local level as can local and national institutional arrangements that often favor structural responses over other non-structural approaches (Burby, 2006; Galloway, 2009). Technological responses alone may also have unintended geomorphologic and social consequences including increasing flood hazard in downstream locations, increasing costs of long-term flood protection works or increasing coastal erosion in areas deprived of sediments by coastal protection works (Adger *et al.*, 2005; Hudson *et al.*, 2008) (Box 5-3).

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Box 5-3. Large Dams in Brazil: Scalar Challenges to Climate Adaptation

Effective climate adaptation requires consideration of cross-scale management concerns. Any project or impact that crosses jurisdictions from local to regional to national to transnational is best planned using a perspective that takes into account all levels of management(Adger *et al.*, 2005). The planned or built large dams in Amazonia, Brazil (McCormick, 2011) exemplify these issues. These dams are related to water management and would cross local, regional, and national boundaries. At the national level, these dams would provide large-scale energy needs and serve major urban centers and industrial sectors across the country. At the regional level, the large Amazonian dams could both generate energy and assist in drought management through storage of hydrological resources (Postel *et al.*, 1996). Because of the expansive range and impacts of large dams, their planning and management raises a variety of scalar concerns about climate adaptation. While on one level a dam may present benefits regionally and nationally, it may also cause serious environmental and social problems locally (McCormick, 2009). For example dams upstream may lead to erosion and inundation of deltas (Yang *et al.*, 2011).

While there are many environmental benefits of hydroelectric power and large-scale water management, the uncertainty of climate change could alter such benefits at local to global scales and influence the social and environmental ramifications of these projects. For example, the flooding caused by the construction of reservoirs could result in migration of locally affected communities, thereby increasing community fragmentation, poverty and ill health of humans and biota (Kingsford, 2000). This becomes a local and regional impact of dam construction that may increase vulnerability to climate change in many localities. Changing rainfall patterns that affect reservoir levels could impact the availability of energy generation at the national level (DeLucena *et al.*, 2009). Degradation of flora and fauna also result in additional greenhouse gas emissions at local to global scales (Fearnside, 1995).

_____END BOX 5-3 HERE_____

The method of protecting an entire area by building a dyke has been in use for thousands of years and is still being applied by communities in flood-prone countries. Embankments, dykes, levees and floodwalls are all designed to protect areas from flooding by confining the water to a river channel, thus protecting the areas immediately behind them. Building dykes is one of the most economical means of flood control (Asian Disaster Preparedness Centre, 2005). Dykes built by communities normally involve low technology and traditional knowledge (such as earth embankments). Sand bagging is also a very common form of flood-proofing. Generally, structures that are built of earth are highly susceptible to erosion leading to channel siltation and reduced water conveyance on the wet side and slope instability and failure on the dry side. Slopes can be stabilized by various methods, including turfing by planting vegetation such as Catkin grass and Vetiver grass in Bangladesh and Thailand, respectively. However there is a continuing debate in the region as to whether the grass strips prevent erosion, whether erosion is in fact the main problem instead of soil fertility, and whether farmers still need slope stabilization (Forsyth and Walker, 2008).

Decision-making for large scale structural measures is often based on cost-benefit analyses and technical approaches. In many cases, particularly in developed countries, structural measures are subsidized by national governments and local governments and communities are required to cover only partial costs. In New Zealand this led to a preponderance of structural measures despite planning legislation that enabled non-structural measures. As a result, the potential for major disasters was increased and development intensified in areas with structural measures only to be seriously devastated by events that exceed the engineering design level (Ericksen, 1986). Reduction of centralized subsidies in the mid-1980s and changes in legislation saw greater responsibility for the costs of disaster risk management falling on the communities affected and a move towards more integrated disaster risk reduction processes within New Zealand (Ericksen *et al*., 2000). Similar trends have been observed in relation to coastal protection where structural measures are often favored over non-structural options (Titus *et al*., 2009; Titus, 2011).

Building codes closely align with engineering and architectural structural approaches to disaster risk reduction (Kang *et al*., 2009; Petal *et al*., 2008). This is accompanied by the elevation of buildings and ground floor standards in the case of flooding (Aerts *et al*., 2009; Kang *et al*., 2009). Though building code regulations exist, non-adoption, especially in developing countries is problematic (Spence, 2004). Damages to the structure incur not only because of non-compliance with the codes, but also by a lack of inspections, the ownership status of the structure, and the political context and mechanisms of local governance (May and Burby, 1998). Insurance arrangements can provide incentives to local governments and households to implement building codes (Botzen *et al*., 2009).

Short-term risk reduction strategies can actually produce greater vulnerability to future events as shown in diverse contexts such as ENSO-related impacts in parts of Latin America, induced development below dams or levees in the U.S., and flooding in the UK (Berube and Katz, 2005; Bowden *et al*., 1981; Penning-Rowsell *et al*., 2006; Pulwarty *et al*., 2004). While locally-based protection works often enable areas to be productively used and will continue to be needed for areas that are already densely settled, they are commonly misperceived as providing complete protection, and actually increase development—and thus vulnerability—in hazard prone areas, resulting in the so-called "levee effect" (Montz and Tobin, 2008; Tobin, 1995). A more general statement of this proposition is found in the safe development paradox in which increased safety measures such as dams or levees induce increased development, which in turn leads to increased exposure and ultimately losses (Burby, 2006). The conflicting policy goals of rapid recovery, safety, betterment, and equity and their relative strengths and weaknesses largely reflect experience with large disasters in other places and times. The actual decisions and rebuilding undertaken to date clearly demonstrate the rush by government at all levels and the residents themselves to rebuild the familiar or increase risks in new locations through displacement (Kates *et al*., 2006). Similarly, in drought prone areas provision of assured water supplies encourages the development of intensive agricultural systems – and for that matter, domestic water use habits – that are poorly suited to the inherent variability of supply and will be even more so in areas projected to become increasingly arid in a changing climate (Chapter 3).

5.3.3. Land Use and Ecosystem Protection

Changes in land use not only contribute to global climate change but they are equally reflective of adaptation to the varying signals of economic, policy, and environmental change (Lambin *et al*., 2001). Local land use planning embedded in zoning, local comprehensive plans, and retreat and relocation policies is a useful approach to disaster risk management to keep people and property away from locations exposed to risk (Burby, 1998). However, some countries and rural areas may not have formal land use regulations that restrict development or settlement. As land use management regulates the movement of people and industries in hazard-prone zones, such policies face strong opposition from development pressures, real estate interests accompanied by property rights, and local resistance against land acquisition (Burby, 2000; Thomson, 2007). Buffer zones, setback lines in coastal zones, and inundation zones based on flood and sea-level rise projections can result in controversies and lack of enforcement that bring temporary resettlement, land speculation, and creation of new vulnerabilities (Ingram *et al*., 2006; Jha *et al*., 2010). The government of Sri Lanka, for example, created buffer zones after the Indian Ocean tsunami of 2004, and relocated people to safer locations. Distance from people's coastal livelihoods and social disruptions led to the revision of buffers and new resettlement (Ingram *et al*., 2006). In the U.S., coastal retreat measures are difficult to implement as coastal property carries high value and wealthy property owners can exert political pressure to build

along the coast (Ruppert, 2008). Shorefront property owners and realtors especially oppose setback regulations because they consider the regulation to deter growth (NOAA, 2007).

Land use planning and the application of spatial hazard information is another avenue for disaster risk management, especially hazard mitigation. Berke and Beatley (1992) examined a range of hazard mitigation measures and ranked them according to effectiveness and ease of enforcement. The most effective measures include land acquisition, density reduction, clustering of development, building codes for new construction, and mandatory retrofit of existing structures. The high cost land acquisition programs can make them unattractive to small communities. There has been limited systematic scientific characterization of the ways in which different hazard agents vary in their threats and characteristics and, thus, requiring different pre-impact interventions and post-impact responses by households, businesses, and community hazard management organizations. However, Burby *et al.* (1997) have found evidence for some communities that previous occurrence of a disaster did not have a strong effect on the number of hazard mitigation techniques subsequently employed.

Formal approaches to land use planning as a means of disaster risk management are often less appropriate for many rural areas in developing countries where traditional practices and land tenure systems operate. Systems of land tenure often are very complex and flexible and can contribute to vulnerability reduction. In the case of pastoralists in dryland environments, sharing of land for grazing and of access to water are important drought responses (Anderson *et al.*, 2010). This is not always the case and some land tenure systems marginalize certain groups and increase their vulnerability (Clot and Carter, 2009; Robledo *et al.*, 2011). There are also restrictions on land use planning in regards to slums and squatter settlements. Poverty and the lack of infrastructure and services increase the vulnerability of urban poor to adverse impacts from disasters and national governments and international agencies have had little success in reversing such trends. As a result, successful efforts to reduce hazard exposure have been locally led, built upon successful initiatives, and composed of informal measures rather than those imposed by governments at the local level (Satterthwaite *et al.*, 2007; Zimmermann and Stössel, 2011).

Land acquisition is another means of protecting property and people by relocating them away from hazardous areas (Olshansky and Kartez, 1998). Many jurisdictions have the power of eminent domain to purchase property but this is rarely used as a form of disaster risk management (Godschalk *et al.*, 2000) or climate change adaptation. Voluntary acquisition of land, for example, requires local authorities to purchase exposed properties, which in turn enables households to obtain less risky real estate elsewhere without suffering large economic losses in the process (Handmer, 1987), but this is rarely used in developing countries because of lack of resources and political support. Given the rapid population growth in coastal areas and in flood plains in many parts of the world, and the large number and high value of exposed properties in coastal zones in developed countries such as the United States and Australia this buy out strategy is cost-prohibitive and thus, rarely used (Anning and Dominey-Howes, 2009). Similarly, voluntary acquisition schemes for developing countries are equally fraught with problems as people have strong ties to the land, and land is held communally in places like the Pacific Islands where community identity cannot be separated from the land to which its members belong (Campbell, 2010b). Land use planning alone, therefore, may not be successful as a singular strategy but when coupled with related policies such as tax incentives or disincentives, insurance, and drainage and sewage systems it could be effective (Cheong, 2011b; Yohe *et al.*, 1995). However, if sea level rise adversely affects local coastal areas some form of relocation may become necessary in all exposed jurisdictions. In the United States, some state and local governments have adopted rolling easement policies, which allow construction in vulnerable areas subject to the requirement that the structures will be removed if and when the landward edge of a wetland or beach encroaches (Titus, 2011).

Ecosystem conservation offers long-term protection from climate extremes. The mitigation of soil erosion, landslides, waves, and storm surges are some of the ecosystem services to protect people and infrastructure from extreme events and disasters (Sudmeier-Rieux *et al.*, 2006). The 2004 Indian Ocean tsunami attests to the utility of mangroves, coral reefs, and sand dunes in alleviating the influx of large waves to the shore (Das and Vincent, 2009). The use of dune management districts to protect property along developed shorelines has achieved success in many places along the U.S. eastern shore and elsewhere (Nordstrom, 2000; Nordstrom, 2008). Carbon sequestration is another benefit of ecosystem-based adaptation based on sustainable watershed and community forest management (McCall, 2010). While the extent of their protective ecosystem functions is still debated (Gedan *et al.*, 2011), the merits of the ecosystem services in general are proven, and development of quantified models of the services is well

under way (Barbier *et al*., 2008; Nelson *et al*., 2009). These nonstructural measures are considered to be less intrusive and more sustainable, and when integrated with engineering responses provide mechanisms for adapting to disasters and climate extremes (Cheong, 2011a; Galloway, 2007; Opperman *et al*., 2009).

5.3.4. Storage and Rationing of Resources

Communities may take a range of approaches to cope with disaster induced shortages of resources including producing surpluses and storing them. If the surpluses are not available, rationing of food may occur. Many localities produce food surpluses which enable them to manage during periods of seasonal or disaster initiated disruptions to their food supplies although such practices were more prevalent in pre-capitalist societies. In Pacific Island communities, for example, food crops such as taro and breadfruit were often stored for periods up to and exceeding a year by fermentation in leaf-lined pits. Yams could be stored for several years in dry locations, and most communities maintained famine foods such as wild yams, swamp taro and sago, which were only harvested during times of food shortage (Campbell, 2006). The provision of disaster relief among, other factors, has seen these practices decline (Campbell, 2010a). In Mali, women store part of their harvest as a hedge against drought (Intercooperation, 2008). Stockpiling and prepositioning of emergency response equipment, materials, foods and pharmaceuticals and medical equipment is also an important form of disaster preparedness at the local level, especially for many indigenous communities.

Rationing may be seen as the initial response to food shortages at or near the onset of a food crisis. However, in many cases rationing is needed on a seasonal basis. Rationing at the local level is often self-rationing instituted at the level of households, particularly poor ones without the ability to accumulate wealth or surpluses. Often, rationing initially occurs among women and children (Hyder *et al*., 2005; Ramachandran, 2006). Most rationing takes place in response to food shortages and is for most poor communities, the first response to the disruption of livelihoods (Baro and Deubel, 2006; Barrett, 2002; Devereux and Sabates-Wheeler, 2004; Walker, 1989). In many cases increases in food prices force those with insufficient incomes to ration as well.

When the food shortage becomes too severe, households may reduce future security by eating seeds or selling livestock, followed by severe illness, migration, starvation and death if the shortages persist. While climate change may alter the frequency and severity of droughts (see Chapter 3.5.1), the causes of food crises are multi-factoral and often lie in social, economic and political processes in addition to climatic variability (Bohle *et al*., 1994; Corbett, 1988; Sen, 1981; Wisner *et al*., 2004).

Food rationing is unusual in developed countries where most communities are not based on subsistence production. Welfare systems and NGO agencies respond to needs of those with livelihood deficits in these countries. However, other forms of rationing do exist particularly in response to drought events. Reductions in water use are achieved through a number of measures including: metering, rationing (fixed amounts, proportional reductions, or voluntary reductions), pressure reduction, leakage reduction, conservation devices, education, plumbing codes, market mechanisms (e.g. transferable quotas, tariffs, pricing) and water-use restrictions (Froukh, 2001; Lund and Reed, 1995).

Electricity supplies may also be disrupted by disaster events resulting in partial or total blackouts. While a number of countries have national electrical grids, decisions on responses to shortages are often made at local levels causing considerable disruption to other services, domestic customers, and to businesses. Rose *et al*. (2007) show that many American businesses can be quite resilient in such circumstances adapting a variety of strategies including conserving energy, using alternative forms of energy, using alternative forms of generation, rescheduling activities to a future date or focussing on the low or no energy elements of the business operation. Rose and Liao (2005) had similar findings for water supply disruption. Electricity storage (in advance) and rationing may also be required when low precipitation reduces hydroelectricity production, a possible scenario in some places under climate projections (Boyd and Ibarrarán, 2009; Vörösmarty *et al*., 2000). In some cases there may be competition among a range of sectors including industry, agriculture, electricity production and domestic water supply (Vörösmarty *et al*., 2000) that may have to be addressed through rationing and other measures such as those listed above. Clear rules outlining which consumers have priority in using water or electricity is important.

Other elements that may be rationed as a result of natural hazards or disasters include prioritization of medical and health services where disasters may simultaneously cause large a spike in numbers requiring medical assistance and a reduction in medical facilities, equipment, pharmaceuticals and personnel. This may require classifying patients and giving precedence to those with the greatest need and the highest likelihood of a positive outcome. This approach seeks to achieve the best results for the largest number of people (Alexander, 2002; Iserson and Moskop, 2007).

Responding to future disaster risk will entail multiple approaches at the local level. Starting with risk communication and warning information, the following dominate the range of adjustments local areas presently undertake in responding to future risks: structural measures, land use planning, ecosystem protection, and storage and rationing of resources.

5.4. Building Capacity at the Local Level for Risk Management in a Changing Climate

Local risk management has traditionally dealt with extreme events without considering the climate change context. This section provides examples of adaptations to disaster risk and how such proactive behaviors at the community level by local government and NGOs provide guidance for reducing the longer term impacts of climate change. Although reacting to extreme events and their impacts is important, it is crucial to focus on building the resilience of communities, cities and sectors in order to ameliorate the impacts of extreme events now and into the future.

5.4.1. Proactive Behaviors and Protective Actions

Researchers have identified some of the physical and social characteristics that allow for the adoption of effective partnerships and implementation practices during events (Birkland, 1997; Pulwarty and Melis, 2001). These include the occurrence of previous strong focusing events (such as catastrophic extreme events) that generate significant public interest and the personal attention of key leaders, a social basis for cooperation including close inter-jurisdictional partnerships, and the existence of a supported collaborative framework between research and management.

Factors conditioning this outcome have been summed up by (White *et al.*, 2001) as “knowing better and losing even more”. In this context knowing better indicates the accumulation of readily available knowledge on drivers of impacts and effective risk management practices. For instance researchers have understood the consequences of a major hurricane hitting New Orleans prior to Hurricane Katrina with fairly detailed understanding of planning and response needs. This knowledge appears to have been ignored at all levels of government including the local level after Hurricane Katrina (Kates *et al*., 2006). White *et al*. (2001) offer four explanations for why such conditions exist from an information standpoint: 1) knowledge continues to be flawed by areas of ignorance; 2) knowledge is available but not used effectively; 3) knowledge is used effectively but takes a long time to have an impact; and 4) knowledge is used effectively in some respects but is overwhelmed by increases in vulnerability and in population, wealth, and poverty. Another possibility is that some individuals or communities choose to take the risk. For example, there is some evidence that the value of living near the coast, especially in developed countries pays back the cost of the structure in a few years due to increases in housing values (Kunreuther *et al*., 2009), so the risk is worth taking by the individual and the community. Finally, knowledge is often discounted.

Individuals can make choices to reduce their risk but social relations, context, and certain structural features of the society in which they live and work mediate these choices and their effects. The recognition that dealing with risk and insecurity is a central part of how poor people develop their livelihood strategies is giving rise to prioritizing disaster mitigation and preparedness as important components of many poverty alleviation agendas (Cuny, 1983; Olshansky and Kartez, 1998; UNISDR, 2009). A number of long-standing challenges remain as the larger and looser coalitions of interests that sometimes emerge after disasters rarely last long enough to sustain the kind of efforts needed to reduce present disaster risk, let alone climate extremes in a climate change context.

At the household level and community level, individuals often engage in protective actions to minimize the impact of extreme events on themselves, their families, and their friends and neighbors. In some cases individuals ignore the warning messages and choose to stay in places of risk. The range and choice of actions are often event specific and time dependent, but they are also constrained by location, adequate infrastructure, socioeconomic characteristics, access to disaster risk information and risk perception (Tierney *et al*., 2001). For example, evacuation is used when there is sufficient warning to temporarily relocate out of harm's way such as for tropical storms, flooding, and wildfires. Collective evacuations are not always possible given the location, population size, transportation networks, and the rapid onset of the event. At the same time, individual evacuation may be constrained by a host of factors ranging from access to transportation, monetary resources, health impairment, job responsibilities, gender, and the reluctance to leave home. There is a consistent body of literature on hurricane evacuations in the U.S., for example that finds 1) individuals tend to evacuate as family units, but they often use more than one private vehicle to do so; 2) social influences (neighbors, family, friends) are key to individual and households evacuation decision-making; if neighbors are leaving then the individual is more inclined to evacuate and vice versa; 3) risk perception, especially the personalization of risk by individuals is a more significant factor in prompting evacuation than prior adverse experience with hurricanes; 4) pets and concerns about property safety reduce household willingness to evacuate, and 5) social and demographic factors (age, presence of children, elderly, or pets in households, gender, income, disability, and race or ethnicity) either constrain or motivate evacuation depending on the particular context (Adeola, 2009; Bateman and Edwards, 2002; Dash and Gladwin, 2007; Dow and Cutter, 1998; Dow and Cutter, 2000; Dow and Cutter, 2002; Edmonds and Cutter, 2008; Lindell *et al*., 2005; McGuire *et al*., 2007; Perry and Lindell, 1991; Sorensen *et al*., 2004; Sorensen and Sorensen, 2007; Van Willigen *et al*., 2002; Whitehead *et al*., 2000). Culture also plays an important role in evacuation decision making (Clot and Carter, 2009). For example, recent studies in Bangladesh have shown that there are high rates of non-evacuation despite improvements in warning systems and the construction of shelters. While there are a variety of reasons for this, gender issues (e.g. shelters were dominated by males, shelters didn't have separate spaces for males and females) have a major influence upon females not evacuating (Paul and Dutt, 2010a; Paul *et al*., 2010b).

A different protective action, shelter-in-place occurs when there is little time to act in response to an extreme event or when leaving the community would place individuals more at risk (Sorensen *et al*., 2004). Seeking higher ground or moving to higher floors in residential structures to get out of rising waters is one example. Another is the movement into interior spaces within buildings to seek refuge from strong winds. In the case of wildfires, shelter in place becomes a back-up strategy when evacuation routes are restricted because of the fire and include protecting the structure with garden hoses or finding a safe area such as a water body (lake or backyard swimming pool) as temporary shelter (Cova *et al*., 2009). In Australia, the shelter in place action is slightly different. Here the local community engagement with wildfire risks has two options: stay and defend or leave early policy. In this context, the decisions to remain are based on social networks, prior experience with wildfires, gender (males will remain to protect and guard property), and involvement with the local fire brigade (McGee and Russell, 2003). The study also found that rural residents were more self-reliant and prepared to defend then suburban residents (McGee and Russell, 2003).

The social organization of societies dictates the flexibility in the choice of protective actions—some are engaged in voluntarily (such as in the U.S., Australia, and Europe), while other protective actions for individuals or households are coordinated by centralized authorities such as Cuba and China. Planning for disasters is a way of life for Cuba, where everyone is taught at an early age to mobilize quickly in the case of a natural disaster (Bermejo, 2006; Sims and Vogelmann, 2002). The organization of civil defense committees at block, neighborhood, and community levels working in conjunction with centralized governmental authority makes the Cuban experience unique (Bermejo, 2006; Sims and Vogelmann, 2002). Recent experience with hurricanes affecting Cuba suggests that such efforts are successful because there has been little loss of life.

In many traditional or pre-capitalist societies it appears that mechanisms existed, which protected community members from periodic shocks such as natural hazards. These mechanisms, sometimes referred to as the *moral economy*, were underpinned by reciprocity and limiting exploitation so that everyone had basic security. The mechanisms are often linked to kinship networks, and serve to redistribute resources to reduce the impacts on those who had sustained severe losses identified in Southeast Asia (Scott, 1976), Western Africa(Watts, 1983), and the Pacific Islands(Paulson, 1993). The moral economy incorporated social, cultural, political and religious

arrangements, which ensured that all community members had a minimal level of subsistence (see Box 5-4). For example, traditional political systems in the semiarid Limpopo Basin, in northern South Africa enabled chiefs to reallocate surpluses during bad years but this practice has declined under contemporary systems where surpluses are sold (Dube and Sekhwela, 2008). In Northern Kenya social security networks existed among some groups of nomadic pastoralists that enabled food and livestock stock to be redistributed following drought events but these are also breaking down with the monetization of the local economy among other factors (Oba, 2001).

_____ START BOX 5-4 HERE _____

Box 5-4. Collective Behavior and the Moral Economy at Work

A variety of socio-political networks, that were used to offset disaster losses, existed throughout the Pacific region prior to colonization (Paulson, 1993; Sahlins, 1962). One example of such a system is the *Suqe*, or graded society, which existed in northern Vanuatu, a small island nation in the South West Pacific Ocean. In the *Suqe* 'big men' achieved the highest status by accumulating surpluses of valued goods such as shell money, specially woven mats and pigs. Men increased their grade within the system by making payments of these goods to men of higher rank. In accumulating the items men would also accumulate obligations to those they had borrowed from. Accordingly networks and alliances emerged among the islands of northern Vanuatu. When tropical cyclones destroyed crops, the obligations could be called in and assistance given from members of the networks who lived in islands that escaped damage (Campbell, 1990). A number of processes associated with colonialism (changes to the socio-political order), the introduction of the cash economy (the replacement of shell money) and religious conversion which resulted in the banning of the *Suqe),* as well as the provision of post-disaster relief has caused a number of elements of the moral economy to fall into disuse (Campbell, 2006).

_____ END BOX 5-4 HERE _____

Although the concept of moral economy is generally associated with pre-capitalist societies and those in transition to capitalism (in the past) significant features of moral economy, such as reciprocity, barter, crop sharing and other forms of cooperation among families and communities or community based management of agricultural lands, waters or woods are still part of the social reality of developing countries that cannot be considered anymore as pre-capitalist. Many studies show that moral economy based social relationships are still present such as traditional institutions regulating access, use and on-going redistribution of community owned land (Hughes, 2001; Rist *et al.*, 2003; Rist, 2000; Sundar and Jeffery, 1999; Trawick, 2001). The revitalization, enhancement, and innovation of such moral economy based knowledge, technologies and forms of cooperation and interfamily organization represents an important and still existing source of fostering collective action that serves as an enabling condition for preventing and coping with hazards related to natural resource management. While aspects of the traditional moral economy have declined in many societies, informal networks remain important in disaster risk reduction (see Section 5.4.3).

The notion of the moral economy does not recognize the inequalities in some of the social systems that enabled such practices to be sustained (e.g. gender-based power relationships) and tended to perhaps provide an unrealistic notion of a less risky past. In addition, kinship based sharing networks may foster freeloading among some members (diFalco and Bulte, 2009). Nevertheless, a reduction in traditional coping mechanisms including the moral economy is reflected in growing disaster losses and increasing dependency on relief (Campbell, 2006).

Collective action to prepare for or respond to disaster risk and extreme climate impacts can also be driven by localized organizations and social movements. Many such groups represent networks or first-responders for climate-sensitive disasters. However, there are many constraints that these movements face in building effective coalitions including the need to connect with other movement organizations and frame the problem in an accessible way (McCormick, 2010). One means of mobilizing collective responses at the local level is through participatory approaches to disaster risk reduction such as Community Based Disaster Reduction (CBDR) or Community based Disaster Preparedness (CBDP) (see 5.6.2). Such approaches build on local needs and priorities, knowledge and social structures and are increasingly being used in relation to climate change adaptation (Reid *et al.*, 2009).

5.4.2. Empowerment for Local Decision Making

A critical factor in community based disaster risk reduction is that community members are empowered to take control of the processes involved. Marginalization (Adger and Kelly, 1999; Mustafa, 1998; Polack, 2008) and disempowerment (Hewitt, 1997) are critical factors in creating vulnerability and efforts to reduce these characteristics play an important role in building resilient communities. In this chapter, *empowerment* refers to giving community members control over their lives with support from outside (Sagala *et al*., 2009). This requires external facilitators to respect community structures, traditional and local knowledge systems, to assist but not take a dominating role, to share knowledge and to learn from community members (Petal *et al*., 2008). A key element in empowering communities is building trust between the community and the external facilitators (Sagala *et al*., 2009). In the Philippines, for example, Allen (2006) found that many aspects of community disaster preparedness such as building on local institutions and structures, building local capacity to act independently, and building confidence through achieving project outcomes were already present. She also found that where agencies focused on the physical hazard as the cause of disasters and neglected the underlying causes of the social vulnerability within these small specific projects, the result was disempowerment. It is also important to note that communities have choices from a range of disaster management options (Mercer *et al*., 2008). Empowerment in community based disaster risk management may also be applied to groups within communities whose voice may otherwise not be heard or who are in greater positions of vulnerability (Wisner *et al*., 2004). These include women (Bari, 1998; Clifton and Gell, 2001; Polack, 2008; Wiest *et al*., 1994) and disabled people (Wisner, 2002).

Another key element of empowerment is ownership of or responsibility for disaster management (Buvinić *et al*., 1999). This applies to all aspects of the disaster, from the ownership of a disaster itself so that the community has control of relief and reconstruction, to a local project to improve preparedness. Empowerment and ownership ensure that local needs are met, that community cohesion is sustained and a greater chance of success of the disaster management process. Empowerment and ownership of the disaster impacts may be particularly important in achieving useful (for the locality) post-disaster assessments (Pelling, 2007). It is important for external actors to identify those voices who speak for the local constituencies. Also, accountability and governance of disaster and climate management issues is growing in importance.

5.4.3. Social Drivers

Similar to empowerment is the role of localized social norms, social capital, and social networks as these also shape behaviors and actions before, during, and after extreme events. Each of these factors operates on their own and in some cases also intersects with the others. As vulnerability to disasters and climate change is socially-constructed (Chapter 2.4, 2.5.2), the breakdown of collective action often leads to increased vulnerability. Norms regarding gender also play a role in determining outcomes. For example, women were more prone to drowning than men during the Asian tsunami because they were less able to swim and because they were attempting to save their children (Rofi *et al*., 2006) (Chapter 2 section 2.5.8).

Social norms are rules and patterns of behavior that reflect expectations of a particular social group (Horne, 2001). Norms structure many different kinds of action regarding climate change (Pettenger, 2007). Norms are embedded in formal institutional responses, as well as informal groups that encounter disasters (Raschky, 2008). Norms of reciprocity, trust, and associations that bridge social divisions are a central part of social cohesion that fosters community capacity (Kawachi and Berkman, 2000). A number of types of groups drive norms and, consequently, vulnerability, including religious, neighborhood, cultural, and familial groups (Breknert and Malone 2005). In the occurrence of extreme events, affected groups interact with one another in an attempt to develop a set of norms appropriate to the situation, otherwise known as emergent norm theory of collective behavior (National Research Council (NRC), 2006). This is true of those first affected at the local level whose norms and related social capital affect capacity for response (Dolan and Walker, 2004).

Social capital is a multifaceted concept that captures a variety of social engagements within the community that bonds people and generates a positive collective value. It is also an important element in disaster preparedness,

coping, and response. It is suggested as an important element in the face of climate extremes because community social resources such as networks, social obligations, trust, and shared expectations create social capital to prevent, prepare, and cope with disasters (Dynes, 2006). In climate change adaptation, scholars and policymakers increasingly promote social capital as a long-term adaptation strategy (Adger, 2003; Pelling and High, 2005). Although often positive, social capital can have some negative outcomes. Internal social networks are oftentimes self-referential and insular (Dale and Newman, 2010; Portes and Landolt, 1996). This results in a closed society that lacks innovation and diversity essential elements for climate change adaptation. Disaster itself is overwhelming, and can lead to the erosion of social capital and the demise of the community (Ritchie and Gill, 2007). This invites external engagement beyond local-level treatment of the disaster and extreme events (Brondizio *et al*., 2009; Cheong, 2010). The inflow of external aids, expertise, and the emergence of new groups to cope with disaster are indicative of the necessity of bridging and linking social capital beyond local boundaries.

Social capital is embedded in social networks (Lin, 2001), or the social structure composed of individuals and organizations through multiple types of dependency, such as kinship, financial exchange, or prestige (Wellman and Berkowitz, 1988). Social networks provide a diversity of functions, such as facilitating sharing of expertise and resources across stakeholders (Crabbé and Robin, 2006). Networks can function to promote messages within communities through preventive advocacy, or the engagement of advocates in promoting preventive behavior (Weibel, 1988). Information about health risks has often been effectively distributed through a social network structure using opinion leaders as a guide (Valente and Davis, 1999; Valente *et al*., 2003), and has promising application for changing behavior regarding climate adaptation (Maibach *et al*., 2008). Such opinion leaders may span a range of types, from formally-elected officials, celebrities and well-known leaders, to local community members who are well-embedded in local social networks. It is important to note that more potential has been shown in influencing behavior through community-level interventions than through individual-level directives at the population level (Kawachi and Berkman, 2000). Local and international networks can support the development of policies and practices that result in greater preparedness (Tompkins, 2005). Local resilience in the face of climate change can be fostered by strong social networks that support effective responses (Ford *et al*., 2006). For example, networks facilitate the transmission of information about risks (Berkes and Jolly, 2001). Therefore, communities with stronger social networks appear to be better prepared for extreme climate impacts because of access to information and social support (Buckland and Rahman, 1999).

At the same time, it is important to note that social networks may not always be sufficient to foster effective adaptation to extreme events. Some social networks actually discourage people from moving away from a high risk zones, such as has been the case in storms and floods when residents have not wanted to leave risk zones (Eisenman *et al*., 2007). The impacts of climate change itself may also change the structure and utility of social networks. As people migrate away from climate and other risks or are pulled toward alternative locations for social or ecological resources, those left behind can experience fragmented or weakened social networks. The utilization of social networks can also be prevented by the status of particular social groups, such as illegal and legal settlers or immigrants (Wisner *et al*., 2004). Other social and environmental contextual factors must be considered when conceptualizing the role of social networks in managing extreme events. For example, strong social networks have facilitated adaptability in Inuit communities, but are being undermined by the dissolution of traditional ways of life (Ford *et al*., 2006).

5.4.4. Integrating Local Knowledge

Local and traditional knowledge is increasingly valued as important information to include when preparing for disasters (McAdoo *et al*., 2009; Shaw *et al*., 2009a). It is embedded in local culture and social interactions and transmitted orally over generations (Berkes, 2008). Place-based memory of vulnerable areas, know-how for responding to recurrent extreme events, and detection of abnormal environmental conditions manifest the power of local knowledge. Because local knowledge is often tacit and invisible to outsiders, community participation in disaster management is essential to tap this information as it can offer alternative perspectives and approaches to problem-solving (Battista and Baas, 2004; Turner and Clifton, 2009).

Within a climate change context, indigenous people as well as long-term residents often conserved their resources *in situ*, provide important information about changing environmental conditions as well as actively adapting to the changes (Macchi *et al*., 2008; Salick and Byg, 2007; Salick and Ross, 2009; Turner and Clifton, 2009). Research is emerging in helping to document changes that local people are experiencing (Ensor and Berger, 2009; Salick and Ross, 2009). Although this evidence might be similar to scientific observations from external researchers, the fact that local communities are observing it is initiating discussions about existing and potential adaptation to climate changes from within the community.

The following example is illustrative. In six villages in eastern Tibet, near Mt. Khawa Karpo, local documentation of warmer temperatures, less snow, and glacial retreat across areas were consistent, whereas other observations were more varied, including those for river levels and landslide incidences(Byg and Salick, 2009) . In Gitga'at (Coast Tsimshian) Nation of Hartley Bay, British Columbia, indigenous people observe the decline of some species but also new appearances of others, anomalies in weather patterns, and declining health of forests and grasslands that have affected their ability to harvest food(Turner and Clifton, 2009) . The Alaska Native Tribal Health Consortium generated *Climate Change & Health Impact Assessment Reports* from observations, data, and traditional ecological knowledge (ANTHC (Alaska Native Tribal Health Consortium), 2011). Other than knowledge from indigenous groups, local knowledge associated with contemporary societies and cities exist though more research is needed in this area (Hordijk and Baud, 2011).

Integration of local knowledge with external scientific, global, and technical knowledge is an important dimension of climate change adaptation and disaster management. Experiences in environmental management and integrated assessment suggest mechanisms for such knowledge transfers from the bottom up and from the top down (Burton *et al*., 2007; Prabhakar *et al*., 2009). For example, communities set up trusted intermediaries to transfer and communicate external knowledge such as technology-based early warning systems and innovative and sustainable farming techniques that incorporate the local knowledge system (Bamdad, 2005; Kristjanson *et al*., 2009). Another example is the re-engineering of local practices to adapt to climate change as shown in the conversion of traditional dry-climate adobe construction to more stabilized earth construction built to withstand regular rainfall. The utilization of participatory methods to draw in the perspectives of local stakeholders for subsequent input into hazards vulnerability assessments or climate change modeling or scenario development is well documented. Stakeholder interactions and related workshops using participatory or mediated modeling elicit discussions of model assumptions, local impacts, consistencies of observed and modeled patterns, and adaptation strategies (Cabrera *et al*., 2008; Langsdale *et al*., 2009).

Obstacles to utilizing local knowledge as part of adaptation strategies exist. Climate-induced biodiversity change threatens historical coping strategies of indigenous people as they depend on the variety of wild plants, crops and their environments particularly in times of disaster(Turner and Clifton, 2009). In dry land areas such as in Namibia and Botswana one of the indigenous strategies best adapted to frequent droughts is livestock herding, including nomadic pastoralism (Ericksen *et al*., 2008). Decreased access to water sources through fencing and privitization has inhibited this robust strategy. Also in Botswana, it has been suggested that government policies have weakened traditional institutions and practices, as they have not adequately engaged with local community institutions and therefore the mechanisms for redistributing resources have not been strengthened sufficiently (Dube and Sekhwela, 2008).

5.4.5. Local Government and Non-Government Initiatives and Practices

Governance structures are pivotal to addressing disaster risk and informing responses as they help shape efficiency, effectiveness, equity, and legitimacy (Adger *et al*., 2003; UNISDR, 2009). Some places centralize climate change management practices at the national level (see Chapter 6). This may be due to the ways in which many climate extremes affect environmental systems that cross political boundaries resulting in discordance if solely locally managed (Cash and Moser, 2000) but could also be based on old practices of operations. In other places, actions are more decentralized, emerging at the local level and tailored to local contexts (Bizikova *et al*., 2008). If multiple levels of planning are to be implemented, mechanisms for facilitation and guidance on the local level are needed in order that fairness is guaranteed during the implementation of national policies at the local scale (Thomas and

Twyman, 2005). Local governments play an important role as they are responsible for providing infrastructure, preparing and responding to disasters, developing and enforcing planning, and connecting national government programs with local communities (Huq *et al*., 2007; UNISDR, 2009). The quality and provision of these services have an impact on disaster and climate risk (Tanner *et al*., 2009). Effective localized planning, for example, can minimize both the causes and consequences of climate change (Bulkeley, 2006).

Though local government–led climate adaptation policies and initiatives are less pronounced than climate change mitigation measures, a growing number of cities and sub-national entities are developing adaptation plans, but few have implemented their strategies (Birkmann *et al*., 2010; Heinrichs *et al*., 2009). The Greater London Authority (2010), for example, has prepared a Public Consultation Draft of their climate change adaptation strategy for London. The focus of this is on the changing risk of flood, drought and heat waves through the century and actions for managing them. Some of the actions include improvement in managing surface water flood risk, an urban greening program to buffer the impacts from floods and hot weather, and retro-fitting homes to improve the water and energy efficiency. ICLEI, a non-profit network of more than 1200 local government members across the globe provides web-based information (www.iclei.org) in support of local sustainability efforts using customized tools and case studies on assessing climate resilience and climate change adaptation.

Some assessments of urban adaptations exist. For example, adaptation efforts in eight cities (Bogotá, Cape Town, Delhi, Pearl River Delta, Pune, Santiago, Sao Paulo and Singapore) tend to support existing disaster management strategies (Heinrichs *et al*., 2009). Another study comparing both formal adaptation plans and less formal adaptation studies in nine cities including Boston, Cape Town, Halifax, Ho Chi Minh City, London, New York, Rotterdam, Singapore, and Toronto demonstrates that the focus is mostly on risk reduction and the protection of citizens and infrastructure, with Rotterdam seeing adaptation as opportunity for transformation (Birkmann *et al*., 2010). These nine cities have focused more on expected biophysical impacts than on socio-economic impacts and have not had a strong focus on vulnerability and the associated susceptibility or coping capacity. Despite the intention that city adaptation responses aim at an integrated approach, they tend to have sectoral responses, with limited integration of local voices. There is a good understanding of the impacts, but the implementation of policy and outcomes on the ground are harder to see (Bulkeley, 2006; Burch and Robinson, 2007).

In these adaptation strategies, the size of the local government is important, and it varies depending on the population and location. Primate and large cities exert more independence, whereas smaller municipalities depend more on higher levels of the government units, and often form associations to pool their resources (Lundqvist and Borgstede, 2008). In the latter case, state mandated programs and state-generated grants are the main incentives to formulate mitigation policies (Aall *et al*., 2007) and can be applicable to adaptation policies. Lack of resources and capabilities has lead to outsourcing of local adaptation plans, and can generate insensitive and unrefined local solutions and more reliance on technological fixes (Crabbé and Robin, 2006).

The history and process of decentralization are significant in the capacity of the local government to formulate and implement adaptation policies. Aligning local climate adaptation policies with the state/provincial and national/federal units is a significant challenge for local governments (Roberts, 2008; van Aalst *et al*., 2008). The case of decentralization in climate change adaptation is relatively new, and we can draw some lessons from decentralized natural resource management and crisis management. One of the problems of decentralization has been the complexity and uniqueness of each locality that policy planners often failed to take into account because of the lack of understanding and consultation with the local community, and this could result in recentralizing the entire process in some instances (Geiser and Rist, 2009; Ribot *et al*., 2006). Some remedies include working with local institutions, ensuring appropriate transfer of various rights and access, and providing sufficient time for the process (Ribot, 2003). The crisis management literature also points out that there has been a lack of coordination and integration between central and local governments (Schneider, 2008; Waugh and Streib, 2006). Moynihan (2009) suggests a networked collaboration as a solution and posits that even a hierarchical disaster management structure such as the incident command system in the U.S. operates on the network principles of negotiation, trust, and reciprocity.

Although government actors play a key role, it is evident that partnerships between public, civic, and private actors are crucial in addressing climate hazards-related adaptation (Agrawal, 2010). While international agencies, the

private sector, and NGOs play a norm-setting agenda at provincial, state, and national levels, community-based organizations (CBOs) often have greater capacity to mobilize at the local scale (Milbert, 2006). NGO and CBO networks play a critical role in capturing the realities of local livelihoods, facilitating sharing information, and identifying the role of local institutions that lead to strengthened local capacity (Bull-Kamanga *et al*., 2003). Strong city-wide initiatives are often based on strategic alliances, and local community organizations are essential to operationalizing city planning (Hasan, 2007). This can be seen in the case of New York City Panel on Climate Change that acted as a scientific advisory group to both the Mayor Bloomberg's Office of Long-term Planning and Sustainability and the New York City Climate Change Adaptation Task Force, a stakeholder group of approximately 40 public agencies and private-sector organizations that manage the critical infrastructure of the region (Rosenzweig *et al*., 2011). The Panel and stakeholders separated functions between scientists (knowledge provision) and stakeholders (planning and action) and communicated climate change uncertainties with the coordination by the Mayor's office (Rosenzweig *et al*., 2011).

Many non-government actors charged with managing climate risks use community risk assessment tools to engage communities in risk reduction efforts and influence planning at district and sub-national levels (Twigg, 2007; van Aalst, 2006). NGO engagement in risk management activities ranges from demonstration projects, training and awareness-raising, legal assistance, alliance building, small-scale infrastructure, socio-economic projects, and mainstreaming and advocacy work (Luna, 2001; Shaw, 2006). Bridging citizen-government gaps is a recognised role of civil society organisations and NGOs often act as social catalysts or social capital, an essential for risk management in cities (Wisner, 2003). Conversely, the potential benefits of social capital are not always maximised due to mistrust, poor communications or lack of functioning either within municipalities or non-government agencies. This has major implications for risk reduction (Wisner, 2003) and participation of the most vulnerable in non-government initiatives at municipal or sub-national level is not guaranteed (Tanner *et al*., 2009).

This section highlighted mechanisms for building capacity for local adaptation to climate extremes ranging from empowerment for decision making to utilization of social networks. A balanced portfolio of approaches that capture local knowledge, proactive behaviors, and governmental and non-governmental initiatives and practices will prove most successful in managing the risk of climate extremes at the local level.

5.5. Challenges and Opportunities

As illustrated earlier in the chapter, disaster risk management actions increase the coping capacity of local places to disasters in the short term and benefit a community's resilience in the long term. Differences in coping, risk management, and adaptation along with the costs of managing disaster risk at the local level present challenges and opportunities for adaptation to climate extremes. They not only influence human security, but the scale and context of the differences highlight opportunities for proactive actions for risk reduction and climate change adaptation, but also identify constraints to such actions.

5.5.1. Differences in Coping and Risk Management

There are significant differences among localities and population groups in the ability to prepare for, respond to, recover from and adapt to disasters and climate extremes. During the last century, social science researchers have examined those factors that influence coping responses by households and local entities through post-disaster field investigations as well as pre-disaster assessments (Mileti, 1999; National Research Council (NRC), 2006). Among the most significant individual characteristics are gender, age, wealth, ethnicity, livelihoods, entitlements, health, and settlements. However, it is not only these characteristics operating individually, but also their synergistic effects that give rise to variability in coping and managing risks at the local level.

5.5.1.1. Gender, Age, and Wealth

The literature suggests that at the local level gender makes a difference in vulnerability (Chapter 2.4) and in the differential mortality from disasters (Neumayer and Plümper, 2007). The evidence is robust with high agreement. In disasters, women tend to have different coping strategies and constraints on actions than men (Fothergill, 1996; Morrow and Enarson, 1996; Peacock *et al*., 1997). These are due to the socialized gender factors such as social position (class), marital status, education, wealth, and caregiver roles, as well as physical differences in stature and endurance. At the local level for example, women's lack of mobility, access to resources, lack of power and legal protection, and social isolation found in many places across the globe tend to augment disaster risk, and vulnerability (League of Red Cross and Red Crescent Societies, 1991; Mutton and Haque, 2004; Schroeder, 1987; UNIFEM, 2011). Relief and recovery operations are often insensitive to gender issues (Hamilton and Halvorson, 2007), and so the provision of such supplies and services also influences the differential capacities to cope (Ariyabandu, 2006; Enarson, 2000; Fulu, 2007; Wachtendorf *et al*., 2006), especially at the local level. However, the active participation of women has been shown to increase the effectiveness of prevention, disaster relief, recovery and reconstruction thereby improving disaster management (Enarson and Morrow, 1997; Enarson and Morrow, 1998; Enarson, 2010; Fothergill, 1999; Fothergill, 2004; Hamilton and Halvorson, 2007) (see Box 5-5).

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Box 5-5. The Role of Women in Proactive Behavior

Women's involvement in running shelters and processing food was crucial to the recovery of families and communities after Hurricane Mitch hit Honduras. A third of the shelters were run by women, and this figure rose to 42% in the capital. The municipality of La Masica in Honduras, with a mostly rural population of 24,336 people, stands out in the aftermath of Mitch because, unlike other municipalities in the northern Atlanta Department, it reported no mortality. Some attributed this outcome to a process of community emergency preparedness that began about six months prior to the disaster. Gender lectures were given and, consequently, the community decided that men and women should participate equally in all hazard management activities. When Mitch struck, the municipality was prepared and vacated the area promptly, thus avoiding deaths. Women participated actively in all relief operations. They went on rescue missions, rehabilitated local infrastructure (such as schools), and along with men, distributed food. They also took over from men who had abandoned the task of continuous monitoring of the early warning system. This case study illustrates the more general finding that the active incorporation of women into disaster preparedness and response activities helps to insure success in reducing the impacts of disasters (Buvinić *et al*., 1999; Cupples, 2007; Enarson, 2009).

_____END BOX 5-5 HERE_____

Age acts as an important factor in coping with disaster risk (Cherry, 2009). Older people are more prone to ill-health, isolation, disabilities, and immobility (Dershem and Gzirishvili, 1999; Ngo, 2001), which negatively influence their coping capacities in response to extreme events (see 9.3.1.1). In North America, for example, retired people often choose to live in hazardous locations such as Florida or Baja California because of warmer weather and lifestyles, which in turn increases their potential exposure to climate-sensitive hazards. Often because of hearing loss, mental capabilities, or mobility, older persons are less able to receive warning messages, take protective actions, and are more reluctant to evacuate (Hewitt, 1997; O'Brien and Mileti, 1992). However, older people have more experience and wisdom with accumulated know-how on specific disasters/extreme events as well as the enhanced ability to transfer their coping strategies arising from life experiences.

Children have their own knowledge of hazards, hazardous places, and vulnerability that is often different than adults (Gaillard and Pangilinan, 2010; Plush, 2009). Research has shown significant diminishment of coping skills (and increases in post-traumatic stress disorder and other psychosocial effects) among younger children following Hurricane Katrina (Barrett *et al*., 2008; Weems and Overstreet, 2008). In addition to physical impacts and safety (Lauten and Lietz, 2008; Weissbecker *et al*., 2008), research also suggests that emotional distress caused by fear of separation from the family, and increased workloads following disasters affects coping responses of children (Babugura, 2008; Ensor, 2008). However, the research also suggests that children are quite resilient and can adapt to

environmental changes thereby enhancing the adaptive capacity of households and communities (Bartlett, 2008; Manyena *et al*., 2008; Mitchell *et al*., 2008; Pfefferbaum *et al*., 2008; Ronan *et al*., 2008; Williams *et al*., 2008).

Wealth, especially at the local level affects the ability of a households or localities to prepare for, respond to, and rebound from disaster events (Cutter *et al*., 2003; Masozera *et al*., 2007). Wealthier places have a greater potential for large monetary losses, but at the same time, they have the resources (insurance, income, political cache) to cope with the impacts and recover from extreme events, and they are less socially vulnerable. In Asia, for example, wealth shifted construction practices from wood to masonry, which made many of the cities more vulnerable and less able to cope with disaster risk (Bankoff, 2007), especially in seismic regions. Poorer localities and populations often live in cheaper hazard-prone locations, and face challenges not only in responding to the event, but also recovering from it. Poverty also enhances disaster risk (Carter *et al*., 2007). In some instances, it is neither the poor nor the rich that face recovery challenges, but rather localities that are in-between such as those not wealthy enough to cope with the disaster risk on their own, but not poor enough to receive full federal or international assistance.

In some localities, it is not just wealth or poverty that influence coping strategies and disaster risk management, but rather the interaction between wealth, power, and status, that through time and across space has led to a complicated system of social stratification (Heinz Center, 2002). One of the best examples of this is the human experience with Hurricane Katrina (see Box 5-6).

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Box 5-6. Race, Class, Age, and Gender: Hurricane Katrina Recovery and Reconstruction

The intersection of race, class, age, and gender influenced differential decision making; the uneven distribution of vulnerability and exposure; and variable access to post-event aid, recovery and reconstruction in New Orleans before, during, and after Hurricane Katrina (Elliott and Pais, 2006; Hartman and Squires, 2006; Tierney, 2006). Evacuation can protect people from injury and death, but there are inequalities in who can evacuate and when, with the elderly, poor, and minority residents least able to leave without assistance (Cutter and Smith, 2009). Extended evacuations (or temporary displacements lasting weeks to months) produce negative effects. Prolonged periods of evacuation can result in a number of physical and mental health problems (Curtis *et al*., 2007; Mills *et al*., 2007). Furthermore, separation from family and community members and not knowing when a return home will be possible also adds to stress among evacuees (Curtis *et al*., 2007). DeSalvo *et al*.(2007) found that long periods of displacement were among the key causes of post traumatic stress disorder in a study of New Orleans workers. These temporary displacements can also lead to permanent outmigration by specific social groups as shown by the depopulation of New Orleans five years after Hurricane Katrina (Myers *et al*., 2008). In terms of longer term recovery, New Orleans is progressing, however large losses in population, housing, and employment suggest a pattern of only partial recovery for the city with significant differences in the location and the timing at the neighbourhood or community level (Finch *et al*., 2010).

_____ END BOX 5-6 HERE _____

5.5.1.2. Livelihoods and Entitlements

Adaptive capacity is influenced to a large extent by the institutional rules and behavioural norms that govern individual responses to hazards (Dulal *et al*., 2010). It is also socially differentiated along the lines of age, ethnicity, class, religion, and gender (Adger *et al*., 2007). Local institutions regulate the access to adaptation resources, those that ensure equitable opportunities for access to resources promote adaptive capacity within communities and other local entities (Jones *et al*., 2010) . Institutions, as purveyors of the rules of the game (North, 1990), mediate the socially differential command over livelihood assets, thus determining protection or loss of entitlements.

Livelihood is the generic term for all the capabilities, assets, and activities required for a means of living. Livelihood influences how families and communities cope with and recover from stresses and shocks (Carney, 1998). Another definition of livelihoods gives more emphasis to access to assets and activities that is influenced by social relations

(gender, class, kin, and belief systems) and institutions (Ellis, 2000). Understanding how natural resource-dependent people cope with climate change in the context of wider livelihood influences is critical to formulating valid adaptation frameworks.

Local people's livelihoods and their access and control of resources can be affected by events largely beyond their control such as climatic extremes (e.g. floods, droughts) conflict, or agricultural problems such as pests and disease and economic shocks that can largely impact their livelihoods (Chambers and Conway, 1992; Jones *et al*., 2010). For poor communities living on fragile and degraded lands such as steep hillsides, dry lands and floodplains, climate extremes present additional threats to their livelihoods that could be lost completely if exposed to repeated disastrous events within short intervals leaving insufficient time for recovery. Actions aiming at improving local adaptive capacity focus more on addressing the deteriorating environmental conditions. A central element in their adaptation strategies involve ecosystem management and restoration activities such as watershed rehabilitation, agroecology and forest landscape restoration, (Ellis, 2000; Ellis and Allison, 2004; Osman-Elasha, 2006b)**.** As some suggest (Spanger-Siegfried *et al*., 2005) these types of interventions often protect and enhance natural resources at the local scale and address immediate development priorities, but can also improve local capacities to adapt to future climate change. The buffering capacities of local people's livelihoods and their institutions are critical for their adaptation to extreme climate stress. They often rest on the ability of communities to generate potentials for self-organization and for social learning and innovations (Adger *et al*., 2006).

A number of studies indicated that sustainable strategies for disaster reduction help improve livelihoods (UNISDR, 2004); while social capital and community networks support adaptation and disaster risk reduction by diminishing the need for emergency relief in times of drought and/or crop failure (Devereux and Coll-Black, 2007) (see 5.2.1). A research study in South Asia suggests that adaptive capacity and livelihood resilience depend on social capital at the household level (i.e. education and other factors that enable individuals to function within a wider economy), the presence or absence of local enabling institutions (local cooperatives, banks, self-help groups), and the larger physical and social infrastructure that enables goods, information, services and people to flow. Interventions to catalyze effective adaptation are important at all these multiple levels (Moench and and Dixit, 2004). Diversification within and beyond agriculture is a widely recognized strategy for reducing risk and increasing well-being in many developing countries (Ellis, 2000; Ellis and Allison, 2004).

Entitlements are assets of the individuals and household. Assets are broadly defined and include not only physical assets such as land, but also human capital such as education and training. At the local scale assets include institutional assets such as technical assistance or credit; social capital such as mutual assistance networks; public assets such as basic infrastructure like water and sanitation, and environmental assets such as access to resources and ownership of them (Leach *et al*., 1999). The link between disaster risk, access to resources, and adaptation has been widely documented in the literature (Adger, 2000; Brooks, 2003; Sen, 1981). Extreme climate events generally lead to entitlement decline in terms of the rights and opportunities that local people have to access and command the livelihood resources that enable them to deal with and adapt to climate stress.

Assessment of livelihoods provides the explanation as to the differences in responses based on the understanding of endowments, entitlements and capabilities, within the organizational structure and power relations of individuals, households, communities, and other local entities (Scoones, 1998). Access to assets and entitlements is an important element in improving the ability of localities to lessen their vulnerability and to cope with and respond to disasters and environmental change. In some instances, this may not be true. For example, if a disaster affects a household asset, but the household is still paying off its debt regarding the initial cost of the asset and assuming that the asset is not protected or insured against hazards, the asset loss coupled with the need to pay off the loan renders the household more vulnerable, not less (Twigg, 2001). Entitlement protection thus requires adaptive types of institutions and patterns of behaviour (Meehl *et al*., 2007), with a focus on local people's agency within specific configurations of power relations. The challenge is therefore, to empower the most vulnerable to pursue livelihood options that strengthen their entitlements and protect what they themselves consider the social sources of adaptation and resilience in the face of extreme climate stress. Better management of disaster risk also maximizes use of available resources for adapting to climate change (Kryspin-Watson *et al*., 2006).

5.5.1.3. Health and Disability

The changes in extreme events and impacts to climate change influence the morbidity and mortality of many populations now, and even more so in the future (Campbell-Lendrum *et al.*, 2003). The extreme impacts of climate change (see Chapters 3.1.1 and 4.4.6) directly or indirectly affect the health of many populations and these will be felt first at the local level. Heat waves lead to heatstroke and cardiovascular disease, while shifts in air pollution concentrations such as ozone that often increase with higher temperatures cause morbidity of other diseases (Bernard *et al.*, 2001). Heat waves differentially affect populations based on their ethnicity, gender, age (Díaz *et al.*, 2002), and medical and socioeconomic status (O'Neill and Ebi, 2009), consequently raising concerns about health inequalities (see Chapter 9.3.1.1), especially at the local scale. Health inequalities are of concern in extreme impacts of climate change more generally, as those with the least resources often have the least ability to adapt making the poor and disenfranchised most vulnerable to climate-related illnesses (McMichael *et al.*, 2008). For extreme events, pre-existing health conditions that characterize vulnerable populations can exacerbate the impact of disaster events since these populations are more susceptible to additional injuries from disaster impacts (Brauer, 1999; Brown, 1999; Parati *et al.*, 2001). Chronic health conditions/disabilities can also lead to subsequent communicable diseases and illnesses in the short term, to lasting chronic illnesses, and to longer term mental health conditions (Bourque *et al.*, 2006; Few and Matthies, 2006; Shoaf and Rottmann, 2000).

A range of vector-borne illnesses has been linked to climate, including malaria, dengue, Hantavirus, Bluetongue, Ross River Virus, and cholera (Patz *et al.*, 2005). Cholera, for example, has season variability that may be directly affected by climate change (Koelle *et al.*, 2004). Vector-borne illnesses have been projected to increase in geographic reach and severity as temperatures increase (McMichael *et al.*, 2006), but these changes depend on a variety of human interventions like deforestation and land use. The areas of habitation by mosquitoes and other vectors are moving to areas previously free from such vectors of transmission (Lafferty, 2009). Pools of standing water that are breeding grounds for mosquitoes promise to expand, therefore increasing illness exposure (Depradine and Lovell, 2004; Meehl *et al.*, 2007). At the same time, some literature shows that illnesses like malaria are less prone to increase than originally thought (Gething *et al.*, 2010). Much of the nuance of this literature is due to the location-specific nature of these outcomes. Therefore, vector-control programs will be best suited to the local characteristics of changing risks. Some programs, like those geared toward surveillance, need common characteristics to support national programs and also need to be coordinated across scales from local to national and between local places. In addition, there are a variety of social factors that have the potential to influence disease rates that are most suitably managed at the sub-national level or urban scale. For instance, certain types of population growth or change may increase risk and affect disease rates (Patz *et al.*, 2005). Increased population and related land use changes can also increase disease rates. Vector control programs generally implemented at the local level also have the potential to influence health outcomes (Tanser *et al.*, 2003). Infectious disease patterns also have the potential to change dramatically, necessitating improved prevention on the part of local providers who have knowledge of local environmental change (Parkinson and Butler, 2005).

There is concern regarding the mental health impacts of storms and floods that lead to destruction of livelihoods and displacement, especially for vulnerable populations (Balaban, 2006). In some hurricanes, the mental health of residents in affected communities is extremely negatively impacted over an extended period of time (Weisler *et al.*, 2006). Policy responses to the event were insufficient to manage these impacts, and provide a lesson for future events where greater mental health services may be necessary (Lambrew and Shalala, 2006). Managing public health and disability is important in the response to disasters (Shoaf and Rottmann, 2000).

Human health is at risk of many extreme events liked to climate change. While resources from scales above the local are often necessary, the direction and application of those resources by local actors who know how to best apply them could make significant differences in human morbidity and mortality linked to climate extremes.

5.5.1.4. Human Settlements

Settlement patterns are another factor that influences disaster risk management and coping with extremes. Human settlements differ in their physical and governance structures, population growth patterns, as well as in the types,

drivers, impacts, and responses to disasters. As noted earlier (see section 5.5.1.2) rural livelihoods and poverty are drivers of disaster risk, but not the only ones. Poverty, resource scarcity, access to resources, as well as inaccessibility constrains disaster risk management. When these are coupled with climate variability, conflict, and health issues they reduce the coping capacity of rural places (UNISDR, 2009). At the other extreme are the concentrated settlements of towns and cities where the disaster risks are magnified because of population densities, poor living conditions including overcrowded and substandard housing, lack of sanitation and clean water, and health impairments from pollution and lack of adequate medical care (Bull-Kamanga *et al*., 2003; De Sherbinin *et al*., 2007). Strengthening local capacity in terms of housing, infrastructure, and disaster preparedness is one mechanism shown to improve urban resilience and the adaptive capacity of cities to climate-sensitive hazards (Pelling, 2003). It is also instructive to note how communities with differing capacities address similar problems (Walker and Sydneysmith, 2008).

One important locality receiving considerable research and policy attention are megacities (see 9.3.2.1) due to the density of infrastructure, the population at risk, the growing number and location of informal settlements, complex governance, and disaster risk management(Mitchell, 1999). Given the rapid rate of growth in the largest of these world's cities and the increasing urbanization, the disaster risks will increase in the next decade placing more people in harm's way with billions of dollars in infrastructure located in highly exposed areas (Kraas *et al*., 2005; Munich Re Group, 2004; Wenzel *et al*., 2007).

For many regions, the ability to limit urban exposure has already been achieved through building codes, land management, and disaster risk mitigation, yet losses keep increasing. For disaster reduction to become more effective, megacities will need to address their societal vulnerability and the driving forces that produce it (rural to urban migration, livelihood pattern changes, wealth inequities, informal settlements) (Wisner and Uitto, 2009). Many megacities are seriously compromised in their ability to prepare for and respond to present disasters, let alone adapt to future ones influenced by climate change (Fuchs, 2009; Heinrichs *et al*., 2009; Prasad *et al*., 2009).

However, it is not only the megacities that pose challenges, but the overall growth in urban populations. Currently more than half of the global population lives in urban areas with an increasing population exposed to multiple risk factors (UNFPA, 2009). Risk is increasing in urban agglomerations of different size due to unplanned urbanization and accelerated migration from rural areas or smaller cities (UN-HABITAT, 2007). The 2009 Global Assessment Report on Disaster Risk Reduction (UNISDR, 2009) lists unplanned urbanization and poor urban governance as two main underlying factors accelerating disaster risk. It highlighted that the increase in global urban growth of informal settlements in hazard prone areas reached 900 millions in informal settlements, increasing by 25 million per year (UNISDR, 2009). Urban hazards exacerbate disaster risk by the lack of investment in infrastructure as well as poor environmental management, thus limiting the adaptive capacity of these areas.

5.5.2. Costs of Managing Disaster Risk and Risk from Climate Extremes

5.5.2.1. Costs of Impacts, Costs of Post-Event Responses

It is extremely difficult to assess the total cost of a large disaster, such as Hurricane Katrina, especially at the local scale since most economic data are only available at the national scale. Direct losses consist of direct market losses and direct non-market losses (intangible losses). The latter include health impacts, loss of lives, natural asset damages and ecosystem losses, and damages to historical and cultural assets. Indirect losses (also labelled higher-order losses (Rose, 2004) or hidden costs (Heinz Center, 1999) include all losses that are not provoked by the disaster itself, but by its consequences. Measuring indirect losses is important as it evaluates the overall economic impact of the disaster on society. Another difficulty with the measurement of economic losses at the local level has to do with the boundary delineation for local analyses. For example, local losses can be compensated from various inflows of goods, workers, capital, and governmental or foreign aid from outside the affected (Eisensee and Stromberg, 2007). Local disasters also provide ripple effects and influence world markets, for instance, oil prices in the case of Hurricane Katrina due to the temporary shutdown of oil rigs. It s important to consider trade-offs at different spatial scales especially when estimating indirect losses at the local level. Disaster loss estimates are,

therefore, highly dependent on the scale of the analysis, and result in wide variations among community, state, province, and sub-national regions.

Despite the difficulties in assessing local economic impact, several studies exist. For example, Strobl (2008) provided an econometric analysis of the impact of the hurricane landfall on county-level economic growth in the U.S. This analysis showed that a county struck by at least one hurricane over a year led to a decline in economic growth on average by 0.79% and an increase by 0.22% the following year. The economic impact of the 1993 Mississippi flooding in the U.S. showed significant spatial variability within the affected regions. In particular, states with a strong dependence on the agricultural sector had a disproportionate loss of wealth compared to states that had a more diversified economy (Hewings and Mahidhara, 1996). Noy and Vu (2010) investigated the impact of disasters on economic growth in Vietnam at the provincial level, and found that fatal disasters decreased economic production while costly disasters increased short-term growth. Rodriguez-Oreggia *et al.* (2010) focused on poverty and the World Bank's Human Development Index at the municipality level in Mexico, and demonstrated that municipalities affected by disasters saw an increase in poverty by 1.5% to 3.6%. Studies also found that regional indirect losses increase nonlinearly with direct losses (Hallegatte, 2008), and can be compensated by importing the means for reconstruction (workers, equipment, finance) from outside the affected area.

The U.S. Bureau of Labour Statistics (2006) also provided a detailed analysis of the labour market consequences of Hurricane Katrina within Louisiana and found a marked economic and employment loss for the Louisiana businesses, high unemployment rates immediately after the disaster, and continued unemployment into 2006 for returning evacuees. At the household level, Smith and McCarty (2006) show that households are more often forced to move outside the affected area by infrastructure problems than by structural damages to their home.

Modelling approaches are also used to assess disaster indirect losses at sub-national levels. These approaches include input-output (IO) models (Haimes *et al.*, 2005; Hallegatte, 2008; Okuyama, 2004) and Computable General Equilibrium (CGE) models (Rose *et al.*, 1997; Rose and Liao, 2005; Tsuchiya *et al.*, 2007). Most of the published analyses are carried out in developed countries. In the U.S., West and Lenze (1994), for example, discuss the merits of combining different impact models to triangulate, obtaining better primary data to reduce uncertainty, and developing tools for estimating the impact of Hurricane Andrew on Florida using reconstruction scenarios. The lack of research on disaster loss estimates in developing countries creates problems of under-reported of economic losses or overestimation of disaster losses depending on political or other interests. This is a big research gap.

5.5.2.2. Adaptation and Risk Management – Present and Future

Studies on the costs of local disaster risk management are scarce, fragmented, and conducted mostly in rural areas. One study estimated the benefit/cost ratio of disaster management and preparedness programs in villages of Bihar and Andra Pradesh, India to be 3.76 and 13.38, respectively (Venton and Venton, 2004), suggesting higher benefits than costs. Research undertaken by the Institute for Social and Environmental Transition (ISET) on a number of cases in India, Nepal and Pakistan demonstrated that benefits exceed the costs for local interventions (Dixit *et al.*, 2008; Moench and Risk to Resilience Study Team., 2008). For example they note that return rates are particularly robust for lower-cost interventions (e.g. raising house plinths and fodder storage units, community based early warning, establishing community grain or seed banks, and local maintenance of key drainage points), when compared to embankment infrastructure strategies that require capital investment (Moench and Risk to Resilience Study Team., 2008). The studies demonstrated a sharp difference in the effectiveness of the two approaches, concluding that the embankments historically have not had an economically satisfactory performance in that study area. In contrast, the benefit/cost ratio for the local level strategies indicated economic efficiency over time and for all climate change scenarios (Dixit *et al.*, 2008). In developed countries, there are cost differences in adaptation strategies between urban and rural areas. For example, in Japan disaster damage is several hundred times more costly in urban than in rural areas, necessitating different disaster risk management strategies depending on the benefit to cost analysis (Kazama *et al.*, 2009).

Though disaster risk management and adaptation policies are closely linked, few integrated cost analyses of risk management and adaptation are available at the local level. One example draws from recent studies of the cost of

city-scale adaptation. Rosenzweig *et al.* (2011; 2007) developed a sophisticated analytical response to a projected fall in water availability in New York. This frames adaptation assessment within a step-wise decision analysis by identifying and quantifying impact risks before identifying adaptation options that are then screened, evaluated and finally implemented. Another series of studies used simplified catastrophe risk assessment to calculate the direct costs of storm surges under scenarios of sea level rise coupled with an economic input-output (IO) model for Copenhagen and Mumbai (Hallegatte *et al.*, 2011; Hallegatte *et al.*, 2008a; Hallegatte *et al.*, 2008b; Ranger *et al.*, 2011). The output is an assessment of the direct and indirect economic impacts of storm surge under climate change including production, job losses, reconstruction time, and the benefits of investment in upgraded coastal defences. Results show that the consideration of adaptation is an important element in the economic assessment of extreme disaster risks related to climate change (Hallegatte *et al.*, 2011). Ranger et al. (2011) show that by improving the drainage system in Mumbai, losses associated with a 1-in-100 year flood event could be reduced by as much as 70%. This means that the annual losses could be reduced in absolute terms compared with the current level, even with climate change. Full insurance coverage of flooding could also cut the indirect cost by half. These analyses highlight the fact adaptation to extreme events and climate change can focus on reducing the direct losses (e.g., through the upgrade of coastal defences) or indirect losses by making the economy more robust, utilizing insurance schemes, or enacting public policies to support small businesses after the disaster.

5.5.2.3. Consistency and Reliability of Cost and Loss Estimations at Local Level

There are inconsistencies in disaster-related economic loss data at all levels—local, national, global—which ultimately influences the accuracy of such estimates (Downton and Pielke Jr., 2005; Guha-Sapir and Below, 2002; Pielke Jr. *et al.*, 2008). The reliability of disaster economic loss estimates is especially problematic at the local level. First, the spatial coverage and resolution of databases are global in coverage, but are only available at the national level with no consistent sub-national data. Second thresholds for inclusion, where only large economically significant disasters are included, bias the data toward singular events with large losses, rather than multiple, smaller events with fewer losses. Third what gets counted varies between databases (e.g. insured vs. uninsured losses; direct vs. indirect) (Gall *et al.*, 2009). Moreover, disaster loss estimates have various purposes (e.g., assessment of foreign aid needs; cost-benefit analysis of protection investments) (World Bank, 2010). Depending on the purpose, spatial and conceptual gaps exist depending on the inclusion of loss-only data or a combination of loss and gain estimates as well as the calculation of non-market losses.

Similarly, there is some ambiguity on impact and adaptation costs that affect local-level economic analyses. The lack of consensus on physical impacts of climate change and adaptive capacity (see Chapter 4.6) is one issue. Another is the discount rate (Heal, 1997; Nordhaus, 2007; Stern, 2007; Tol, 2003; Weitzman, 2007) and the evaluation of non-market costs, especially the value of biodiversity or cultural heritage (Pearce, 1994), the latter contributing some uncertainty on local impact and adaptation costs. Finally, the possibility of low-probability high-consequence climate change is not fully included in most analysis (Lonsdale *et al.*, 2008; Nicholls *et al.*, 2008; Stern, 2007; Weitzman, 2007).

5.5.3. Limits to Local Adaptation

Local adaptation is set within larger spatial and temporal scales (Adger *et al.*, 2005), which influence the range of actors involved and the types of potential barriers to the adaptation process (Moser and Ekstrom, 2010) (see Chapter 6.3; Chapter 7.6). At the local scale, limits and barriers to local adaptation generally fall into three interconnected categories: ecological and physical; human informational related to knowledge, technology, economics, and finances; and psychological, behavioral, and socio-cultural barriers (Adger *et al.*, 2010; ICIMOD, 2009). The social and cultural limits to adaptation are not well researched, with little attention within the climate change literature devoted to this thus far.

The lack of access to information by local people has restricted improvements in knowledge, understanding, and skills—needed elements in helping localities undertake improved measures to protect themselves against disasters and climate change impacts (Agrawal *et al.*, 2008). The information gap is particularly evident in many developing

countries with limited capacity to collect, analyze and use scientific data on mortality and demographic trends, as well as evolving environmental conditions (Carraro *et al*., 2003; IDRC, 2002; National Research Council (NRC), 2007). Based on Fischer *et al*. (2002) closing the information gap is critical to reducing climate change related threats to rural livelihoods and food security in Africa.

Lack of capacities and skills, particularly by women also has been identified as a limiting factor for effective local adaptation actions (Osman-Elasha *et al*., 2006). For example, localities in areas prone to climate extremes such as frequent drought have developed certain coping responses that assist them in surviving harsh conditions. Over time, such coping responses proved inadequate due to the magnitude of the problem (Ziervogel *et al*., 2006). For example, in Mali one initiative involves empowering women and giving them the skills to diversify their livelihoods, thus linking environmental management, disaster risk reduction, and the position of women as key resource managers (United Nations, 2008).

In terms of financial microfinance services typically do not reach the poorest and most vulnerable groups at local levels who have urgent and immediate needs to be addressed (Amin *et al*., 2001; Helms, 2006). The ability of a community to ensure equitable access and entitlement to key resources and assets is a key factor in building local adaptive capacity.

In developed countries, household decisions regarding disaster risk reduction, and adaptation, are often guided by factors other than cost. For example, Kunreuther *et al*. (2009) found that most individuals underestimate the risk and do not make cost-benefit trade-offs in their decisions to purchase hazard insurance and/or have adequate coverage. They also found empirical evidence to suggest that the hazard insurance purchase decision was driven not only by the need to protect assets, but also to reduce anxiety, satisfy mortgage requirements, and social norms (p. 120). For other types of disaster mitigation activities, households do not voluntarily invest in cost-effective mitigation because of underestimating the risk, taking a short-term rather than long-term view, and not learning from previous experience (p. 247). However, they found social norms significant: if homeowners in the neighborhood installed hurricane shutters, most would follow suit; the same was true of purchasing insurance (Kunreuther *et al*., 2009). For municipal governments, adoption of building codes in hurricane prone areas reduces damages by $108 a square meter for homes built from 1996-2004 in Florida (Kunreuther *et al*., 2009). However, enforcement of building codes by municipalities is highly variable and becomes a limiting factor in disaster risk management and adaptation.

Local-level adaptation actions, in many cases are portrayed as reactive and short term, unlike the higher-level national or regional plans which are considered anticipatory and involve formulation of policies and programs (Bohle, 2001; Burton *et al*., 2003). Poverty, increased urbanization, and extreme climate events limit the capacity to initiate planned livelihoods adaptations at the local scale. If extreme events happen more frequently or with greater intensity or magnitude some locations may be uninhabitable for lengthy and repeated periods rendering sustainable development impossible. In such a situation, not all places will be able to adapt without considerable disruption and costs (economic, social, cultural and psychological). In some cases forced migration may be the only alternative (Brown, 2008).

As the above paragraphs show, the main challenge for local adaptation to climate extremes is to find a good balance of measures that simultaneously address fundamental issues related to the enhancement of local collective actions, and the creation of subsidiary structures at national and international scales that complement such local actions. This means that the localized expression of the type, frequency, and extremeness of climate-sensitive hazards will be set within these national and international contexts.

5.5.4. Advancing Social and Environmental Justice

One of the key issues in examining outcomes of local strategies for disaster risk management and climate change adaptation is the principle of fairness and equity. There is a burgeoning research literature on the climate justice looking at the differential impacts of adaptation policies (Adger *et al*., 2006; Kasperson and Kasperson, 2001) at local, national, and global scales. The primary considerations at the local level are the differential impacts of policies on communities, subpopulations, and regions from present management actions (or inactions) (Thomas and

Twyman, 2005). There is also concern regarding the impact of present management (or inactions) in transferring the vulnerability of disaster risk from one local place to another (spatial inequity) or from one generation to another (intergenerational equity) (Cooper and McKenna, 2008). There is less research on the mechanisms or practical actions needed for advancing social and environmental justice at the local scale, independent of the larger issues of accountability and governance at all scales. This is an important gap in the literature.

5.6. Management Strategies

5.6.1. Basics of Planning in a Changing Climate

Prior to the development and implementation of management strategies and adaptation alternatives, local entities need baseline assessments on disaster risk and the potential impacts of climate extremes. The assessment of local disaster risk includes three distinct elements: 1) exposure hazard assessment, or the identification of hazards and their potential magnitudes/severities as they relate to specific local places (see below); 2) vulnerability assessments that identify the sensitivity of the population to such exposures and the capacity of the population to cope with and recover from them (see below and Chapter 2.6.2; Chapter 4.4); and 3) damage assessments that determine direct and indirect losses from particular events (either *ex -post* in real events or *ex-ante* through modeling of hypothetical events) (already described in 5.5.2; see Chapter 4.6.1). Each of these plays a part in understanding the hazard vulnerability of a particular locale or characterizing not only who is at risk but also the driving forces behind the differences in disaster vulnerabilities in local places.

There are numerous examples of exposure and vulnerability assessment methodologies and metrics (Birkmann, 2006) (see Chapter 2). Of particular note are those studies focused on assessing the sub-national exposure to coastal hazards (Gornitz *et al*., 1994; Hammar-Klose and Thieler, 2001), drought (Alcamo *et al*., 2008; Kallis, 2008; Wilhelmi and Wiilhite, 2002), or multiple hazards such as FEMA's multi-hazard assessment for the United States (FEMA, 1997).

Vulnerability assessments highlight the interactive nature of disaster risk exposure and societal vulnerability. While many of them are qualitatively-based (Bankoff *et al*., 2004; Birkmann, 2006), there is an emergent literature on quantitative metrics in the form of vulnerability indices. The most prevalent vulnerability indices, however, are national in scale (Cardona, 2007; SOPAC and UNEP, 2005) and compare countries to one another, not places at sub-national geographies. The exceptions are the empirically-based Social Vulnerability Index (or SoVI^{TM}) (Cutter *et al*., 2003) and extensions of it (Fekete, 2009).

Vulnerability assessments are normally hazard specific and many have focused on climate-sensitive threats such extreme storms in Revere, Massachusetts (Clark *et al*., 1998), sea level rise in Cape May, New Jersey (Wu *et al*., 2002) or flooding in Germany (Fekete, 2009) and the U.S. (Burton and Cutter, 2008; Zahran *et al*., 2008). Research focused on multi-hazard impact assessments range from locally-based county level assessments for all hazards (Cutter *et al*., 2000) to sub-national studies such as those involving all hazards for Barbados and St. Vincent (Boruff and Cutter, 2007) to those involving a smaller subset of climate-related threats (Alcamo *et al*., 2008; Brenkert and Malone, 2005; O'Brien *et al*., 2004). The intersection of local exposure to climate-sensitive hazards and social vulnerability was recently assessed for the northeast (Cox *et al*., 2007) and southern region of the U.S. (Oxfam, 2009).

However, the full integration of hazard exposure and social vulnerability into a comprehensive vulnerability assessment for the local area or region of concern is often lacking for many places. Part of this is a function of the bifurcation of the science inputs (e.g. natural scientists provide most of the relevant data and models for exposure assessments while social scientists provide the inputs for the populations at risk). It also relates to the difficulties of working across disciplinary or knowledge boundaries.

The development of methodologies and metrics for climate adaptation assessments are emerging and mostly derivative of the methodologies employed in vulnerability assessments noted above. For example, some are extensions or modifications of community vulnerability assessment (CRA) methodologies and employ community

participatory approaches such as those used by World Vision (Greene, n.d.), Red Cross (van Aalst *et al.*, 2008) and others. Still others begin with livelihood or risk assessment frameworks and use a wide range of techniques including multi-criteria decision analyses (Eakin and Bojorquez-Tapia, 2008); index construction (Vescovi *et al.*, 2009); segmentation and regional to global comparisons (Torresan *et al.*, 2008), and scenarios (Wilby *et al.*, 2009).

5.6.2. Community-Based Adaptation

Community-based adaptation (CBA) empowers communities to decide how they want to prepare for climate risks and coordinate community action to achieve adaptation to climate change (Ebi, 2008). Part of this entails community risk assessment (CRA) for climate change adaptation that assesses the hazards, vulnerabilities and capacities of the community(van Aalst *et al.*, 2008) , which has also been called community based disaster preparedness (CBDP) among other names. The intention is to foster active participation in collecting information that is rooted in the communities and enables affected people to participate in their own assessment of risk and identify responses than can enhance resilience by strengthening social-institutional measures including social relations (Allen, 2006; Patiño and Gauthier, 2009b). In assessing short and long term risks, the needs of vulnerable groups are often excluded(Douglas *et al.*, 2009) . The tools for engaging vulnerable groups in the process include transect walks and risk maps that capture the climate related hazards and risks and storylines about possible future climate change impacts (Ebi, 2008; Patiño and Gauthier, 2009b; van Aalst *et al.*, 2008), although these tools often require input from participants external to the community who have long-term climate information.

The challenges in using community-based adaptation approaches include the challenge of scaling up information (Burton *et al.*, 2007), the fact that it is resource-intensive (van Aalst *et al.*, 2008) and recognizing that disempowerment occurs when local stories are distorted or not valued sufficiently (Allen, 2006). The integration of climate change information increases this challenge as it introduces an additional layer of uncertainty and may conflict with the principle of keeping CBA simple. There is little evidence that secondary data on climate change has been used in CBA, partly because of the challenge of limited access to downscaled climate change scenarios relevant at the local level (Ziervogel and Zermoglio, 2009) and because of the uncertainty of projections.

Examples of community-based approaches illustrate some of the processes involved. In northern Bangladesh, a flooding adaptation project helped to establish early warning committees within villages that linked to organizations outside the community, with which they did not usually interact and that had historically blocked collective action and resource distribution (Ensor and Berger, 2009) . Through this revised governance structure the building of small roads, digging culverts, and planting trees to alleviate flood impacts was facilitated. In Portland, Oregon, another project involved a range of actors to reduce the impact of urban heat islands through engaging neighborhoods and linking them to experts to install green roofs, urban vegetation, and fountains that led to an increased a sense of ownership in the improvements (Ebi, 2008). In the Philippines, the community-based approach enabled a deeper understanding of locally-specific vulnerability than in previous disaster management contexts (Allen, 2006). While individually important, these community-based approaches should be viewed as part of a wider system that recognizes the drivers at multiple scales, including the municipalities and national levels.

CBA responses provide increased participation and recognition of the local context, which is important when adapting to climate change (see Box 5-7). The need for coordinated collective action was seen in Kampala, where land cover change and changing climate is increasing the frequency and severity of urban flooding and existing response activities are uncoordinated and consist of clearing drainage channels (Douglas *et al.*, 2009). However, residents felt more could be done to adapt to frequent flooding including increasing awareness of roles and responsibilities in averting floods, improving the drainage system, improving garbage and solid waste disposal, strengthening the building inspection unit, and enforcing bylaws on the construction of houses and sanitation facilities. Similarly, in Accra, residents felt that municipal laws on planning and urban design need to be enforced suggesting that strong links are needed between community responses and municipal responses (Douglas *et al.*, 2009).

_____ START BOX 5-7 HERE _____

Box 5-7. Taking Collective Action to Improve Livelihoods Strategies:
Small-Scale Farmers Adapting to Climate Change in Northern Cape, South Africa

The Northern Cape Province, South Africa, is a harsh landscape, with frequent and severe droughts and extreme conditions for the people, animals and plants living there. This has long had a negative impact on small-scale rooibos farmers living in some of the more marginal production areas. Rooibos is an indigenous crop that is well adapted to the prevailing hot, dry summer conditions, but is sensitive to prolonged drought. Rooibos tea has become well-accepted on world markets, but this success has brought little improvement to marginalized small-scale producers.

In 2001 a small group of farmers decided to take collaborative action to improve their livelihoods and founded the Heiveld Co-operative Ltd. Initially established as a trading co-operative to help the farmers produce and market their tea jointly, it subsequently became apparent that the local organization was also an important vehicle for social change in the wider community(Oettlé *et al.*, 2004). The Heiveld became a repository and source of local and scientific knowledge related to sustainable rooibos production. Following a severe drought (2003-2005) and a perceived increase in weather variability, the Heiveld farmers decided to monitor the local climate and to discuss seasonal forecasts and possible strategies in quarterly climate change preparedness workshops. These workshops are facilitated in collaboration with two local NGOs (Indigo and EMG). They are also supported by scientists to address farmers' questions in a participatory action research approach – to ensure that local knowledge and scientific input can be combined to increase the resilience of local livelihoods. The Heiveld Co-operative has been an important organizational vehicle for this learning process, strongly supported by their long term partners, with the focus on supporting the development of possible adaptation strategies through a joint learning approach to respond to and prepare for climate variability and change.

The extension of social, participatory, and organizational learning to climate change adaptation illustrated in this case study emphasizes the significance of identifiable climate change signals, informal networks, and boundary organizations to enhance the preparation of people and organizations to the changing climate (Berkhout *et al.*, 2006; Pelling *et al.*, 2008). Participatory learning is especially emphasized (Berkhout, 2002; Shaw *et al.*, 2009b; Shaw *et al.*, 2009a). Focusing on what can be learnt from managing current climate risk is a good starting point particularly for poor and marginalized communities (Someshwar, 2008).

_____ END BOX 5-7 HERE _____

5.6.3. Risk Sharing and Transfer at the Local Level

Risk transfer and risk sharing are pre-disaster financing arrangements that shift economic risk from one party to another and are more fully discussed in Chapter 2, Chapter 7.4.4, and Chapter 9.3.3.3. Informal risk sharing practices are common and important for post-disaster relief and reconstruction. In the absence of more formal mechanisms like insurance, those incurring losses may employ diverse non-insurance financial coping strategies, such as relying on the solidarity of international aid, remittances, selling and pawning fungible assets and borrowing from moneylenders. Traditional livestock loans are one example (Oba, 2001). At-risk individuals in low-income countries rely extensively on reciprocal exchange, kinship ties, and community self-help. For example, women in high-risk areas often engage in innovative ways to access post-disaster capital by joining informal risk-hedging schemes, becoming clients of multiple micro-finance institutions, or maintaining reciprocal social relationships. Combined analysis of multiple surveys suggests that about 40% of households in low- and lower-middle income countries are involved in private transfers in a given year as recipients or donors (Davies and Leavy, 2007).

Households in disaster-prone slum areas in El Salvador spend an average of 9.2 percent of their yearly income on risk management, including financing emergency relief and recovery (Wamsler, 2007). A particularly important informal risk sharing mechanism is remittances, or transfers of money from foreign workers to their home countries (discussed further in section 7.4.4). Household saving can be accesses from a bank, but they can also be in the form

of stockpiles of food, grains, seeds and fungible assets. Small savings institutions, however, can be directly impacted by catastrophes, which can result in insufficient liquidity to handle a run on their accounts, as occurred during the 1998 floods in Bangladesh (Kull, 2006). Lacking sufficient savings, many disaster victims take out loans to cover their post-disaster expenses. The interest rate (18-60%) charged on formal micro-credit, while relatively high, generally is far below the rate (120-300%) charged by local moneylenders (Linnerooth-Bayer and Mechler, 2009).

Insurance, including microinsurance, is the most common formal risk transfer mechanism at the local level. An insurance contract spreads stochastic losses geographically and temporally, and can assure timely liquidity for the recovery and reconstruction process. As such, it is an effective disaster risk reduction tool especially when combined with other risk management measures. For example, in most industrialized countries, insurance is utilized in combination with early warning systems, risk information, disaster preparation and disaster mitigation. Where insurance is applied without adequate risk reduction, it can be a disincentive for adaptation, as individuals may rely on insurance to manage their risks and are left overly exposed to impacts (Rao and Hess, 2009) (see 5.4.1). Furthermore, insurance can provide the necessary financial security to take on productive but risky investments (Höppe and Gurenko, 2006). Examples include a pilot project in Malawi where microinsurance is bundled with loans that enable farmers to access agricultural inputs that increase their productivity (Hess and Syroka, 2005), and a project in Mongolia that protects herders' livestock from extreme winter weather to reduce livestock losses (Skees *et al.*, 2008).

Microinsurance is a financial arrangement to protect low-income people against specific perils in exchange for regular premium payments (Churchill, 2006; Churchill, 2007). Several pilot projects have yielded promising outcomes, yet experience is too short to judge if microinsurance schemes are viable in the long run for local places. Many of the ongoing microinsurance initiatives are index-based: a relatively new approach whereby the insurance contract is not against the loss itself, but against an event that causes loss, such as insufficient rainfall during critical stages of plant growth (Turvey, 2001). Weather index insurance is largely at a pilot stage, with several projects operating around the globe, including in Mongolia, Kenya, Malawi, Rwanda and Tanzania (Hellmuth *et al.*, 2009). Index insurance for agriculture is more developed in India, where the Agricultural Insurance Company of India (AIC) has extended coverage against inadequate rainfall to 700,000 farmers (Hellmuth *et al.*, 2009).

Index-based contracts as an alternative to traditional crop insurance have the advantages of greatly limiting transaction costs (from reduced claims handling) and in improving emergency response (Chantarat *et al.*, 2007). A disadvantage is their potential of a mismatch between yield and payout, a critical issue given the current lack of density of meteorological stations in vulnerable regions— a challenge remote sensing may help address (Skees and Barnett, 2006). Participants' understanding of how insurance operates, as well as their trust in the product and the stakeholders involved may also be a problem for scaling up index insurance pilots, although simulation games and other innovative communication approaches are yielding promising results (Patt *et al.*, 2009). Affordability can also be a problem. Disasters can affect whole communities or regions (co-variant risks), and because of this insurers must be prepared for meeting large claims all at once, with the cost of requisite backup capital potentially raising the premium far above the client's expected losses—or budget. While valuable in reducing the long-term effects on poverty and development, insurance instruments, particularly if left entirely to the market, are not appropriate in all contexts (Linnerooth-Bayer *et al.*, 2010).

The insurance industry itself is vulnerable to climate change. The continuing exit of private insurers in some market areas is seen with the increasingly catastrophic local losses in the U.S. (Lecomte and Gahagan, 1998), UK (Priest *et al.*, 2005) and Germany (Botzen and van den Bergh, 2008; Thieken *et al.*, 2006), which in turn reduces disaster management options at the sub-national scale. Climate change could be particularly problematic for this sector at the local scale (Vellinga *et al.*, 2001) including the probable maximum loss and pressures from regulators responding to changing prices and coverage (Kunreuther *et al.*, 2009).

One response to rising levels and volatility of risk has been to increase insurance and reinsurance capacity through new alternative risk transfer instruments, such as index-linked securities (including catastrophe bonds and weather derivitives) (Vellinga *et al.*, 2001). These tools could play an increasingly important role in a new era of elevated catastrophe risks (Kunreuther *et al.*, 2009). Another approach is to reduce risks through societal adaptation (Herweijer *et al.*, 2009), and through risk communication and financial incentives from insurers (Ward *et al.*, 2008).

For example, Lloyds of London (2008) demonstrated that in exposed coastal regions, increases in average annual losses and extreme losses due to sea level rise in 2030 could be offset through investing in property-level resilience to flooding or sea walls. Similarly, RMS (2009) shows that wind-related losses in Florida could be significantly reduced through strengthening buildings.

Risk transfer is broader than shifting the economic burden from one party to another. It also entails the transfer of risks from one generation (intergenerational equity) to the next. Risk transfer also has a spatial element in shifting the risk burdens from one geographic location to another. Both of these larger transfer mechanisms are significant for disaster risk management and climate change adaptation at the local scale, but more research is required to assess the localized effects. The broader issues of spatial and intergenerational equity are considered in Chapter 8.

5.6.4. A Transformative Framework for Management Strategies

Management strategies need to consider adaptation as a process rather than measures and actions for a particular event or time-period. Experience in planning and implementing adaptation to climate change as well as disaster response reveals that socio-institutional processes are important in bringing together a set of inter-twined elements (Tschakert and Dietrich, 2010) (see Chapter 8). O'Brien *et al*. (2011) suggest an adaptation continuum (see Figure 5-2), where the goal is to move towards partnerships that enable social transformations and increased resilience.

[INSERT FIGURE 5-2 HERE:
Figure 5-2: Learning and transformation. Throughout the adaptation process, learning is expected to increase along with institutional change leading to the potential for paradigmatic transformation—the community moves away from an impact-focus perspective to a resilience-centric one where there is an expectation of risk and where good governance and key partnerships are the norm. Source: Adapted from O'Brien *et al*., 2011.]

A key component of the disaster risk management and adaptation process is the ability to learn (Armitage *et al*., 2008; Lonsdale *et al*., 2008; Pahl-Wostl *et al*., 2007). This focus on learning partly derives from the fields of social-ecological resilience and sustainability science (Berkes, 2009; Kristjanson *et al*., 2009). As scenarios combine quantitative indicators of climate, demographic, biophysical, and economic change as well as qualitative storylines of socio-cultural changes at the local level, the participation of local stakeholders is essential to generate values and understandings of climate extremes.

Adaptation is a process rather than an end-point and requires a focus on the institutions and policies that enable or hinder this process (Inderberg and Eikeland, 2009) as well as the acknowledgement that there are often competing stakeholder goals (Ziervogel and Ericksen, 2010). Fostering better adaptive capacity for disaster and climate risk will help to accelerate future adaptation (Inderberg and Eikeland, 2009; Moser, 2009; Patt, 2009). However, there are barriers including lack of coordination between actors, the complexity of the policy field (Mukheibir and Ziervogel, 2007; Winsvold *et al*., 2009), and limited human capacity to implement policies (Ziervogel *et al*., 2010). Lastly, individual, sector, and institutional perceptions of risk and adaptive capacity can determine whether adaptation responses are initiated or not (Grothmann and Patt, 2005).

5.7. Information, Data, and Research Gaps at the Local Level

The causal processes by which disasters produce systemic effects over time and across space is reasonably well-known (Cutter, 1996; Kreps, 1985; Lindell and Prater, 2003; National Research Council (NRC), 2006). Yet, local emergency management communities have by and large paid little attention to the links between climate change and natural hazards (Bullock *et al*., 2009). As a result, state and local disaster mitigation plans, even when required by law, usually fail to include climate change, sea level rise, or climate extreme events in hazard assessments or do so in entirely deterministic ways.

Decisions about development, hazard mitigation, and emergency preparedness in the context of climate change give rise to critical questions about social and economic adaptation, and the information and data to support it, especially

at the local scale (Cutter, 2001; Mileti and Peek, 2002; Mileti, 1999). For example: How do cumulative impacts of smaller events over time compare to single high impact events for localities? Do increased levels of hazard mitigation and disaster preparedness increase local risk taking by individuals and social systems? How do short-term adjustments or coping strategies enable or constrain long-term vulnerabilities in localities? What are the tradeoffs among decision acceptability versus decision quality, especially within local contexts (Comfort *et al.*, 1999; Travis, 2010)?

For many of these questions, sufficient empirical information is lacking, especially at the sub-national scale (see also section 5.4.2.3). Two recent all-hazards studies for the U.S. found from 1970-2004, climate-sensitive hazards accounted for the majority of recorded fatalities from natural hazards (Borden and Cutter, 2008; Thacker *et al.*, 2008). Yet, these are the only databases for monitoring mortality from natural hazards at the local level and suffer from lack of consistency and completeness.

The hurricane recovery process includes ample evidence of how efforts to ensure that the rush to return to normal have also led to depletion of natural resources and increased risk. How decisions regarding the right to migrate (even temporarily), the right to organize and the right of access to information are made will, as a result, have major implications for the ability of different groups to adapt successfully to floods, droughts, and storms. The idea of linking place-based recovery, preparedness, and resilience to adaptation is intuitively appealing. However, the constituency that supports improved disaster risk management has historically proven too small to bring about many of the changes that have been recommended by researchers, especially those that focus on strengthening the social fabric to decrease vulnerability. Behind the specific questions of the transparency of risk, are broader questions about the public sphere. What public goods will be provided by governments at all levels (and how will they be funded), what public goods will be provided by private or organizations in civil society, what will be provided by market actors, and what will not? How will these influence local-level disaster risk management, especially to climate-sensitive hazards (Mitchell, 1988; Mitchell, 1999; Thomalla *et al.*, 2006; van Aalst *et al.*, 2008)?

While there has been increasing focus on the processes by which knowledge has been produced, less time has been spent examining the capacity of local communities to critically assess knowledge claims made by others for their reliability and relevance to those communities (Fischhoff, 2007; Pulwarty, 2007). There is the need to move beyond the integration of physical and societal impacts to focus on practice and evaluation. How are impediments to the flow of information created? Is a focus on communication adequate to ensure effective response? How are these nodes defined among differentially vulnerable groups e.g. based on economic class, race, or gender? However, there is little research on the extent to which local jurisdictions have adopted policy options and practice and the ways in which it is being implemented. Most of the studies to date have addressed factors that lead to policy adoption and not necessarily successful implementation.

Beyond infrastructure and retrofitting concerns, successful adaptation strategies integrate urban planning, water management, early warning systems and preparedness. One widely-acknowledged goal is to address, directly, the problem of an inadequate fit between what the research community knows about the physical and social dimensions of uncertain environmental hazards and what society chooses to do with that knowledge. An even larger challenge is to consider how different systems of knowledge about the physical environment, and competing systems of action can be brought together in pursuit of diverse goals that humans wish to pursue (Mitchell, 2003). Several sources (Bullock *et al.*, 2009; Comfort *et al.*, 1999; McKinsey Group, 2009) have identified key research and data requirements for addressing these challenges, including designing and developing:

1) Multi-way information exchange systems-effective adaptation will always be locally-driven. Communities need reliable measurements and assessment tools, integrated information about risks that those tools reveal, and best approaches to minimize those risks. The research goal is to improve the assessment and transparency of risk in a geographic place-based approach for vulnerable regions. Improving the collection and quality control of locally-based data on economic losses, disaster and adaptation costs, and human losses (fatalities) will ensure improved empirically-based baseline assessments.
2) Maps of the decision processes for disaster mitigation, preparedness, response and recovery and guidance for using such decision support tools are needed. Hazard maps developed through collaboration between researchers and affected communities are the simplest and often most powerful form of risk information. They capture the likelihood and impact of a peril and are important for informing many aspects of disaster

risk management including disaster risk reduction, risk-based pooling of resources, and risk transfer. Such devices would identify: specific segments of threatened social systems that could suffer disproportionate disaster impacts; critical actors at each jurisdictional level; their risk assumptions; their different types of information needs; and the design of an information infrastructure that would support their decisions at critical entry points (Comfort, 1993).

3) People who face hazards often need assistance to manage their own environments over the long term and develop systematic actions to improve resilience in vulnerable localities. Research is needed on how local governments and institutions can support, provide incentives, and legitimize successful approaches to increasing capacity and action.
4) Methodologies, indicators, and measurement of progress in reducing vulnerability and enhancing community capacity at the local level are under-researched at present. Locally-based risk management, cost-effectiveness methodologies and analyses, quantification of societal impacts of catastrophic events at local to national scales, and research on implementation and evaluation of risk management and mitigation programs are needed. Similarly, there is a critical need for the assessment and coordination of multi-jurisdictional and multi-sectoral efforts to help avoid the unintended consequences of actions and interventions especially at the local scale.
5) Underserved people require to access to the social and economic security that comes from sharing risk, through financial risk transfer mechanisms such as insurance. There is a paucity of studies at the local level to assess the efficacy of alternative risk reduction, risk-based resource pooling and transfer methods, analysis of benefits and costs to various stakeholder groups, analysis of complementary roles of mitigation and insurance, and analysis of safeguards against insurance industry insolvency.

Interdisciplinary collaboration is clearly needed to prioritize and address research needs described above. Situating the scientific understanding of hazards, disaster risk, and climate change adaptation within a broader discourse about different forms of knowledge will increase the likelihood of public actions that are better grounded in scientific knowledge and customized for the local context.

5.8. Summary

This chapter presented evidence on how climate extremes affect local places: how local places current cope with disasters such as emergency assistance and disaster relief and how they anticipate and plan for future disaster risk using improved communication, structures such as dams and levees, land use management and ecosystem protection, and storage of resources. The role of scale and context shapes the variability in building adaptive capacity at the local level. Differences in coping and risk management also are scale dependent and context-specific and could affect or limit adaptations to climate extremes at the local level. Lastly, climate extremes threaten human security at the local level. Localized vulnerability attributed to social, economic, environmental, and climate change drivers at a variety of scales, heighten the impacts of climate extremes on local places. While some places have considerable experience with disasters and some inherent capacity to cope with climate extremes, others do not. These differences in coping and management necessitate a range of approaches for disaster risk management and climate change adaptation necessitating attention to the broader set of national and international contexts relating to social welfare, quality of life, and sustainable livelihoods.

Frequently Asked Questions

FAQ 5.1: Why is the local context important in climate change adaptation and disaster risk management?

In the context of this report, the local refers to a range of places (community, city, province, region, state), management structures, institutions, social groupings, conditions, and sets of experiences and knowledge that exist at a scale below the national level. It also includes the set of institutions (public and private) that maintain and protect social relations as well as those that have some administrative control over space and resources. The definition of the local influences the context for disaster risk management, the experience of disasters, and conditions, actions and adaptation to climate changes. Local is important because locals respond and experience

disasters at first hand, they retain local and traditional knowledge valuable for disaster reduction and adaptation plans, and lastly they implement adaptation plans.

FAQ 5.2: What lessons have been learned on effective disaster management and climate change adaptation at the local scales?

In fostering sustainable and disaster resilient areas, local response to climate extremes will require disaster risk management that acknowledges the role of climate variability and change and the associated uncertainties and that will contribute to the long term adaptation. In order to anticipate the risks and uncertainties associated with climate change there are a number of emerging approaches and responses at the local level. One set of responses focus on integrating information about changing climate risks into disaster planning and scenario assessments of the future. Setting up plans in advance, for example, enabled communication systems to be strengthened before the extreme event struck. Another is community-based adaptation (CBA), which helps to define solutions for managing risks whilst considering climate change. CBA responses provide increased participation by locals and recognition of the local context and the access to adaptation resources and promote adaptive capacity within communities. A critical factor in community based actions is that community members are empowered to take control of the processes involved. Scaling up community-based approaches pose a challenge as well as integrating climate information and other interventions such as ecosystem management and restoration, watershed rehabilitation, agroecology and forest landscape restoration. These types of interventions protect and enhance natural resources at the local scale, improve local capacities to adapt to future climate and may also address immediate development needs.

FAQ 5.3: What are the limits to adaptation at local level?

Traditionally local risk management strategies focused only on short term climatic events without considering the long-term trajectories presented by a changing climate. Although reacting to climate extreme events and their impacts is important, it is more crucial now to focus on building the resilience of communities, cities, and sectors in order to ameliorate the impacts of future climatic changes. The range and choice of actions that can be taken at the levels of individual or households are often event-specific and time dependent. They are also constrained by location, adequate infrastructure, socioeconomic characteristics, and access to disaster risk information. For example, the increased urban vulnerability, due to urbanization and rising population exacerbates disaster risk by the lack of investment in infrastructure as well as poor environmental management, and can have spillover effects to rural areas.

The obstacles to information transfer and communications are diverse, ranging from limitations in modeling the climate system to procedural, institutional, and cognitive barriers in receiving or understanding climatic information and advance warnings and the capacity and willingness of decision-makers to modify action. Within many rural communities, low bandwidth and poor computing infrastructure pose serious constraints to risk message receipt. Such gaps are evident in developed as well as lesser developed regions. Constraints exist in locally-organized collective action because of the difficulties of building effective coalitions with other organizations and framing the problem accessible to the local population.

FAQ 5.4: Is it possible to estimate the cost of risk management and adaptation at local scale?

Studies on the costs of local disaster risk management are scarce, fragmented, and conducted mostly in rural areas. Most economic data (e.g., input-output table, income data) are available at the national scale. Moreover; there is a clear lack of research on disaster estimates in developing countries, which presents a big gap in need of further research. In developed countries, there are cost differences in adaptation strategies between urban and rural areas. The reliability of disaster economic loss estimates is especially problematic at the local level due to factors associated with the global nature of spatial coverage and resolution. In addition there is some ambiguity on impact and adaptation costs that affect local-level economic analyses, such as the lack of consensus on physical impacts of

climate change and adaptive capacity and on the evaluation of non-market costs (e.g. biodiversity or cultural heritage) which creates some uncertainty on local impact and adaptation costs.

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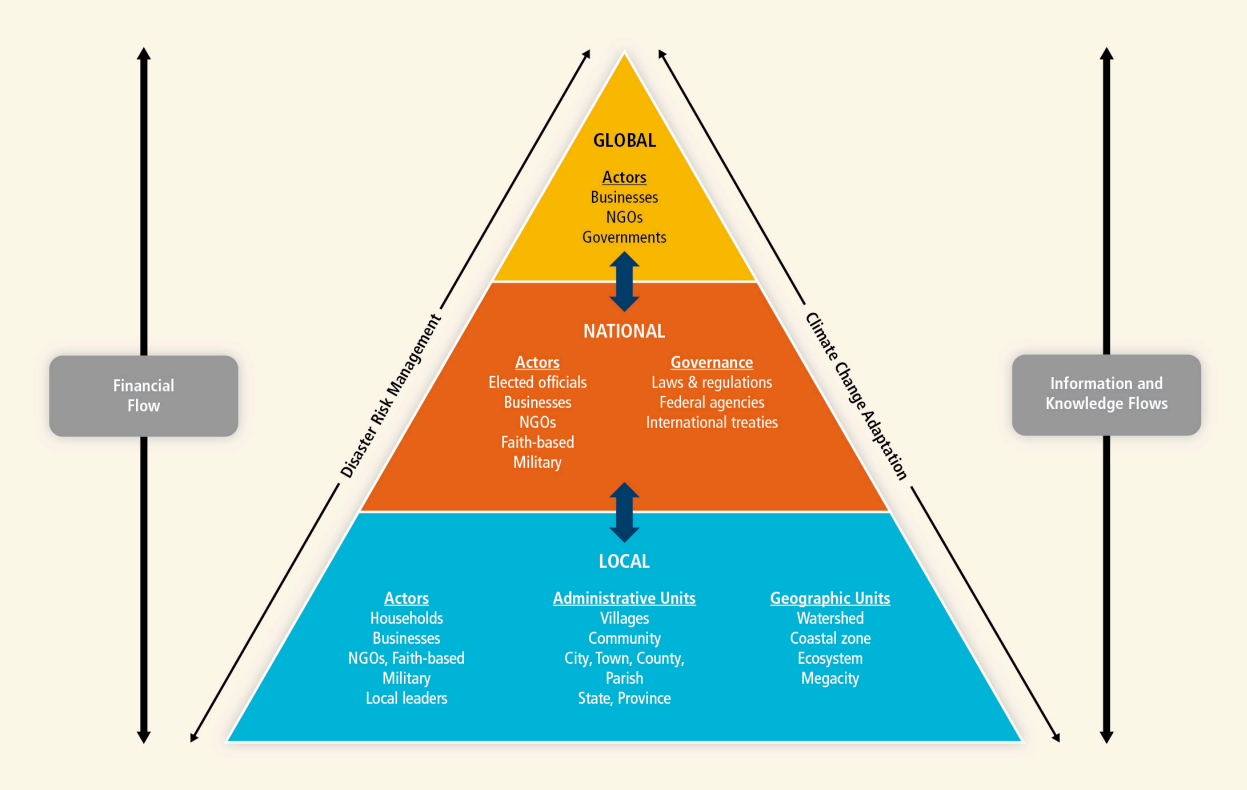

Figure 5-1: Linking local to global actors and responsibilities.

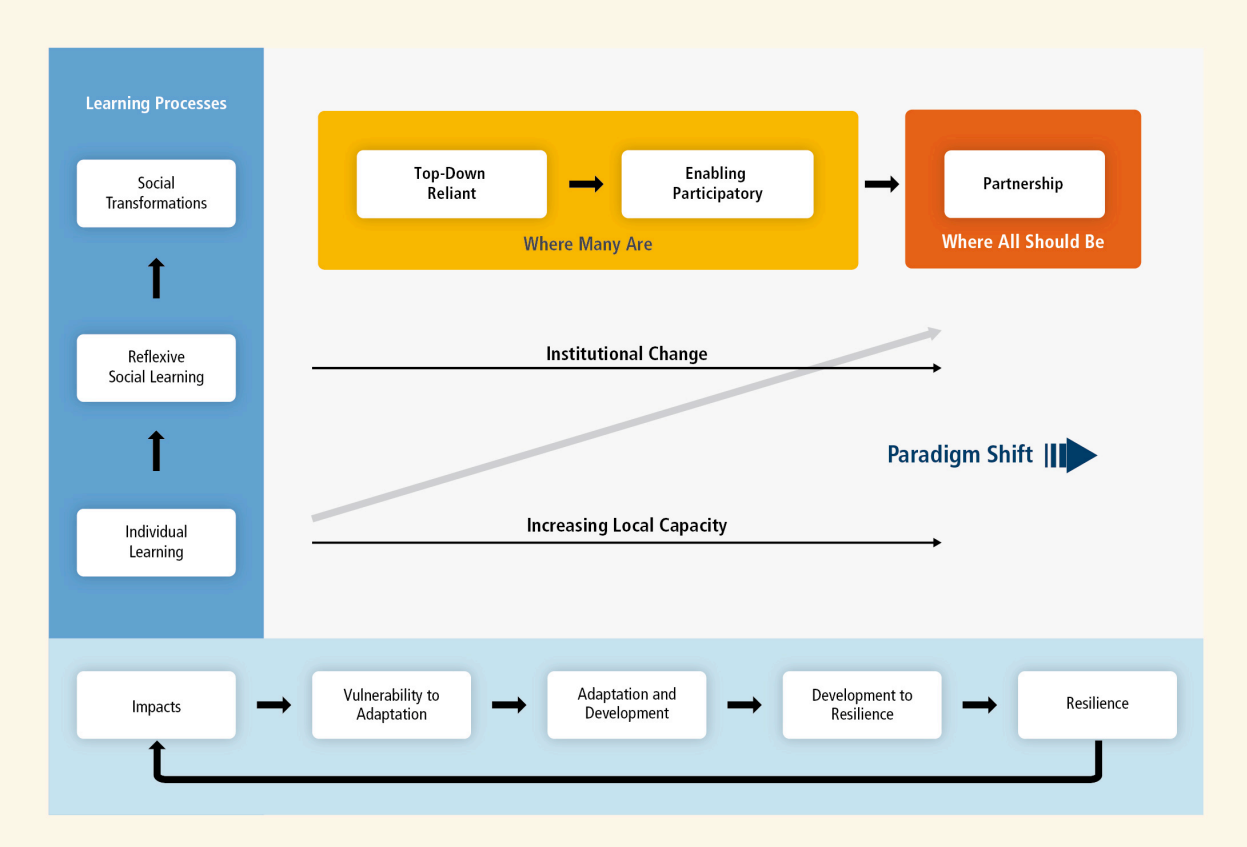

Figure 5-2: Learning and transformation. Throughout the adaptation process, learning is expected to increase along with institutional change leading to the potential for paradigmatic transformation—the community moves away from an impact-focus perspective to a resilience-centric one where there is an expectation of risk and where good governance and key partnerships are the norm. Source: Adapted from O'Brien *et al.*, 2011.

[Initial attempt to bring graphic to specification; illustration to undergo revision to conform to SREX style guide.]