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

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Executive Summary

Local refers to a range of places, social groupings, experience, management, institutions, conditions and sets of knowledge that exist at a scale below the national level. Locales range from communities, villages, districts, suburbs, cities, metropolitan areas through to regions. Therefore they vary greatly in terms of disaster experience, nature of impact and responses, and stakeholders and decision-makers. Disasters are most acutely experienced at the local level and coping strategies to deal with disasters have been developed at this scale with varying degrees of effectiveness. Most adaptation to climate change effects on extreme events will take place at the local level. Some places have considerable experience with short-term climatic variability and this may provide the basis for longer-term adaptation to climate extremes. **Developing strategies for improving disaster risk management in the context of climate change will need to be tailored to local conditions and experiences by integrating local knowledge and supporting local empowerment and collective action.** [5.1, 5.3]

There are two key principles in disaster risk management applicable to climate change adaptation at the local level: **1) mainstreaming disaster risk management into policies and practices, addressing social welfare, quality of life, infrastructure, and livelihoods, and 2) incorporating a multi-hazards approach into planning and action.** [5.2, 5.4, 5.5.3]

There is a strong and complex link between local livelihood security and extreme and non-extreme natural hazard events. While localities with secure and sustainable livelihoods are likely to have better coping capacity for climate change and changing patterns of climatic vulnerability, climate sensitive events may also undermine local sustainability and thus increase vulnerability. **Building sustainable livelihoods is an important adaptation to climate change at the local level.** [5.4.1]

Local adaptation to climate change is not a finite set of actions, but an on-going process that includes learning, changing scenarios, and changing development pressures and opportunities. The localized expression of the type, frequency, and extremeness of climate-sensitive hazards will be set within these national and international contexts. **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 local enhancement of local collective actions, and the creation of subsidiary structures at national and international scales that complement such local actions.** [5.4, 5.5, 5.6]

The costs and non-economic losses of disasters at the local level are difficult to estimate. Similarly, the identification of climate change impacts at the local level is complicated. Accordingly, estimating the costs of disasters and adapting to changes in climate extremes is also difficult to estimate. **There is a need for further development of databases and tools to enable such costs and non-economic losses to be assessed from the bottom up perspective at the local level.** [5.4.2, 5.5.1, 5.6]

5.1. Introduction

5.1.1. Chapeau

The United Nations Framework Convention on Climate Change recognizes the management of the global climate system as a "common but differentiated responsibility." The assessment of the existing knowledge and practice about the way in which the common responsibility is shared in this special report is approached through the perspective of scale and the division into local, national, and global. Approaching the issue from the perspective of scale suggests two important considerations. What is the appropriate distribution of responsibility for the management of risks from climate extremes? Is the present local, national, international allocation working satisfactorily or are there options or choices that might improve upon existing management?

The pattern of responsibilities as assessed in this chapter and those that follow, Chapter 6 (national), and Chapter 7 (international), is complex. Local decisions are embedded in national governance structures, while international arrangements can affect national disaster risk management (Figure 5.1). These complex linkages between local, national, global have evolved over time as the nature and magnitude of the risks has changed; as the capabilities of the various levels of institutions and stakeholders have changed; and as the international architecture on climate change and disaster risk have evolved over the past two decades. There is a primary focus on risk management as a governmental function, especially at the national and international scales. The boundary between public (governmental) and private sector action and responsibility and similarly between government and the private citizen or household, and non-governmental or civil society organizations often is blurred, and this is equally considered in these chapters.

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

The division into separate chapters on local, national, and global recognizes both the bottom-up and the top-down strategies for managing risks and opportunities for climate change adaptation as well as the diversity of stakeholders engaged in the process. In the assessment of the science and practice for managing the risks from climate extremes as manifested at these different scales, local to global, it is possible to discern some guiding principles and assumptions (Box 5.1), which permeate each chapter and provide the continuity between them.

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Box 5-1. Principles of Shared Responsibility for Managing Risks from Climate Extremes

The following "Principles" provide the substantive content of Chapters 5, 6, and 7 (separately and as a group). They exemplify in varying ways the application of these ideas chiefly at local, national, and international scales and at the end of Chapter 7, how integration across scale is addressed.

1. *Subsidiarity*. The principle of subsidiarity is based on the ideas that the functions of government should be carried out at the lowest practical level. It ensures that government decisions are made as closely as possible to the people immediately affected. It strengthens accountability and reduces the dangers of making decisions in places remote from their point of application. In the case of risk management of climate extremes it is clear that major atmospheric events such as tropical cyclones, large floods and droughts can quickly overwhelm the capacity of local governments to cope, and in some instances even national governments. The principle of subsidiarity does not limit

or constrain the action of higher orders of government. It merely counsels against the unnecessary assumption of responsibilities at a higher level.

2. *Social Contract-Shared Responsibility*. When the management or coping capacity of lower levels of government such as communities, are exceeded then higher levels can be involved on the basis of a formal or informal social contract. Our common humanity leads people to care for each other especially in times of adversity. National governments come to the aid of communities and other sub-national entities. Nations cooperate and help each other when their individual capacities are stretched or exceeded. At the global level multilateral agreements are created to help in the identification, planning, and execution of models of mutual assistances, and in some cases the reallocation of responsibilities.

3. *Systemic Risks*. Often the impacts of climate extreme-related impacts potentially extend beyond localities and national boundaries. Regions including groups of several countries may be directly affected by tropical cyclones or droughts. Impacts of a less direct kind may extend well beyond the immediate locality or region affected. Relationships and connections involving the movement of goods (trade), people (displaced populations), and finance (capital flows and remittances), can extend to continents and indeed to the world as a whole.

4. *Economic efficiency*. Local to global risk management can be shown to be economically efficient. Greater aggregate benefits can be achieved through cooperation than when communities or countries are left to cope by themselves.

5. *Legal obligations*. Increasingly the allocation of roles and responsibilities among levels of government is codified into law. At the local and national level s this is often mandatory and provided for in legislation, regulations, ordinances. At the international level, “obligations” are sometimes termed “soft law”, where there is an agreement on expected behavior, but no penalties or sanctions are applied in the case of non-compliance.

6. *Reflexivity*. How actions at one level affect all others. These actions can both enhance or constrain coping and risk management. For example, actions taken at one level (e.g. local) can benefit coping and risk management at the national level. At the same time, national and international actions may constrain coping and risk management at the local level.

7. *Development*. Disasters are viewed from a developmental perspective, revealed by the deeply rooted patterns of vulnerability that have led to unsafe conditions. The impact of devastating floods and cyclones has set back generations of development investments in local and national economies, infrastructure, and human habitats. Instead of providing one-time relief after every event thereby creating a culture of dependence, development perspectives highlight opportunities for genuine social, economic, and physical development post-event.

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5.1.2. Definitions and Concepts Used

The impacts of disasters are most acutely felt at the local level. However, the word local has many connotations, and the definition of local influences the context for disaster risk management, the experience of disasters, and conditions, actions and adaptation to climate changes. 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. Local 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 where choices and actions for disaster risk management and adaptation to climate extremes are initially independent of national interventions. Local includes indigenous knowledge about disaster risk and grass roots actions to manage it. Local also includes functional or physical units such as watersheds, ecological zones, or economic regions and the private and public institutions that govern their use and management. Each of the differing connotations of local means 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 (Thomalla *et al*., 2006).

Locales can range from villages, districts, suburbs, cities, metropolitan areas, through to regions. They vary in their disaster experience, who and what is at risk, the potential geographical extent of the likely impact and responses, and in stakeholders and decision-makers. Localities and the people who live there 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 or the selection of drought resistant crops. 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 in fostering sustainable and disaster resilient places in the face of climate change and uncertainties. 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). However, such arrangements may constrain or impede local actions and ultimately limit the coping capacity and adaptation of local places.

5.1.3. Local Climate Extremes

Local communities routinely experience natural hazards many from climate-related events (see Chapter 3). Drought has affected localities from Africa to the Americas, to Australia and New Zealand. Tropical and extra-tropical windstorms are seasonal events for many regions. Flooding and windstorms (cyclones and hurricanes) are among the most prevalent, with the impacts measured in economic losses as well as human losses (IFRC, International Federation of Red Cross and Red Crescent Societies, 2010). However, local places routinely experience hazards that do not rise to the same level of impact as a disaster. These include snow and ice events; severe storms, flooding, and hail events. Heat waves and wildfires are more frequent events in the northern and southern hemispheres (Alcamo *et al*., 2007; Field *et al*., 2007). More intense rainfall has been observed and is projected for many parts of the world (see Chapter 3), possibly influencing flooding and mudslide occurrences in these areas. Localities affected by drought persist in Africa, India, and China. Coastal communities worldwide are experiencing more erosion due to stronger storms. What is now different is that some localities are experiencing certain types of hazards for the first time. 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. Research demonstrates that disaster experience influences proactive behaviors in preparing for and responding to subsequent events (see section 5.3.1).

5.1.4. Basic Development and Human Security

Future changes in climate trends and patterns will alter the frequency and/or intensity of many severe climatic events (See chapter 3), especially at the local level. It is at the local level where ecosystems and communities are already facing multiple risks, where these climate sensitive hazards are first felt, and where human security is threatened. Rural communities in LDCs face greater risks of livelihood loss resulting from likely increased flooding of low-lying coastal areas, increased water scarcity, decline in agricultural yields and fisheries resources, and loss of biological resources (Osman-Elasha and Downing, 2007). For example, in some African countries where recurrent floods are closely linked with El Niño-Southern Oscillation (ENSO) events resulting in major economic and human losses such as Mozambique (Mirza, 2003; Obasi, 2005) and Somalia (Kabat *et al*., 2002). For such poor 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).

It is increasingly recognized that adaptation and disaster risk management should be integral components of development planning and implementation, to increase sustainability (Thomalla *et al.*, 2006). In other words, both should be mainstreamed into national development plans, poverty reduction strategies, sectoral policies and other development tools and techniques (UNDP, 2007). 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 (Tearfund., 2006). 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; UNISDR, 2004).

Linking climate change and 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, the latter which can also lead to increased conflict in the receiving locality (Barnett and Adger, 2007; Nordås and Gleditsch, 2007). For example 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 and result in dislocation of large numbers of refugees and internally displaced people (IDPs). However, there is mixed 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. Where such empirical studies exist, they are methodologically flawed in a number of ways: not controlling for population size; focusing only on conflict cases; 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 demonstrate the causal linkages.

5.1.5. Context

Differences in the effects of disasters among countries are usually demonstrated using data at the national scale (e.g., EM-Dat; IFRC), yet the differential effects are experienced at the local level, and many measures to reduce disaster risk are also applied at this scale. In this chapter we have addressed the issue of local disaster risk and disaster risk reduction using a variety of sources of information (see Box 5-2). However, given the wide differences between and within developing and developed countries it is clear that single solutions for risk reduction are unlikely. Moreover, it is possible that the a 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). Similarly, there are differences between urban and rural communities in terms of disaster and climate change vulnerability and disaster risk and adaptation options. For example, in many rural areas livelihoods have a strong subsistence component (i.e. the producer is the consumer) and climate impacts may have considerably more direct effects than upon some urban dwellers whose livelihoods may be less dependent upon climatic conditions. Conversely, the effects of heat waves are often more severe in urban than rural areas.

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Box 5-2. Capturing Local Knowledge: The Use of Grey Literature

Grey literature non-journal based sources of information, data, and analyses that have not gone through the traditional scientific peer review process that is the norm for refereed journal publications. According to the Sixth International Conferences on Grey Literature, it is “information produced on all levels of government, academics, business and industry in electronic or print formats not controlled by commercial publishing, i.e. where publishing is not the primary activity of the producing body” (www.greynet.org, accessed May 18 2010). Grey literature is formal, unpublished scientific and technical communication (Sondergaard *et al*., 2003) and includes reports (policy statements, technical reports, government documents, project reports, annual reports), working papers, conference proceedings and papers, theses and dissertations, brochures and pamphlets, audiovisual materials, and internet-based materials. The use of grey literature varies widely by scientific field. In economics, for example working paper series are quite common, but their impact (based on citations) is similar to low impact journals (Frandsen, 2009). Much disaster risk management literature, especially in, or relating to developing countries falls into this categories. Such literature includes key themes in disaster risk management such as those produced by the International Strategy for Disaster Reduction (ISDR), national level reports by governmental agencies, country reports, and project reports at various local levels. While the grey literature is not always peer reviewed in an academic sense, much of it is subjected to some form of review ranging from widespread consultation with peers outside the agency or entity to in house checking. IPCC assessment reports and other similar assessments produced by the World Bank or the International Strategy for Disaster Reduction (IRDR) represent special cases, undergoing a level of peer and public review far more extensive and rigorous than any journal publication.

Practitioner experience and local knowledge are key components in understanding disaster risk management and climate change adaptation at the local level. Utilizing the grey literature permits the understanding of the approach and the state-of-the-art of the real decision-making process, starting with the use of language and the identification of needs and solutions from the local perspective. Failure to include the grey literature in this assessment will result in a great majority of vulnerable communities being excluded from the IPCC process as their voices and experiences will not be heard, nor represented in the assessment.

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Strengthening coordination between climate change adaptation and disaster risk management locally will help improve the implementation— such as when, the appropriate level of coordination, and who should take the lead in the process (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 adaption 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 they may also harm local, indigenous and poor populations (Kates, 2000). It is therefore, essential that any new disaster reduction or climate change adaptation strategies must be built on strengthening local actors and enhancing their livelihoods (Osman-Elasha, 2006a). Moreover, key aspects 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 favor the most vulnerable groups, and to address their urgent needs using a more coordinated and integrated management approach with the involvement of different stakeholder groups, (Sperling and Szekely, 2005). This approach may assist in avoiding mal-adaptation across sectors or scales and provide for win-win solutions.

5.2. How Local Places Currently Cope with Disaster Risk

Localities 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 which 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). 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 are likely to constrain efforts to reduce community vulnerabilities to extreme events under conditions of climate change.

5.2.1. Structural Measures

Structural interventions to reduce the effects of extreme events often refer to engineering works to provide protection from flooding such as dykes, embankments, seawalls, river channel modification, flood gates, and reservoirs. However, they may 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). Most structural measures have a specific design life at the time of construction and thus can be viewed more as short-term solutions with short-term benefits, which may or may not be sustainable in the longer term or under changing conditions including climate. Furthermore, technical considerations should not preclude 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. One of the key reasons why local 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, S. V. R. K. *et al*., 2009) (see also section 5.3.6). In addition, national legislation can have important influences on the choice of disaster risk reduction strategies at the local level as can local and national institutional arrangements that often favor technocratic 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 trans-scalar lens (Adger *et al*., 2005). Examples are 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 bother 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).

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 results 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 are likely to 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 (Fearnside, 1995).

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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 very popular for flood-proofing in Asia. 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. It can also reduce the height of the structure making it less effective. 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 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 catastrophic disasters was increased and development intensified in armored areas only to be seriously devastated by events that exceed the engineering design level (Ericksen, 1986). While protection works often enable areas to be productively used and will continue to be needed for areas that are already densely settled, the so-called “levee effect”, often increases disaster risk rather than decreasing it (Montz and Tobin, 2008; Tobin, 1995). 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).

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 (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).

5.2.2. Emergency Assistance and Disaster Relief

Humanitarian assistance is often required when other measures to reduce disasters have been unsuccessful. Such relief often helps to offset distress and suffering at the local level and to assist in recovery and rehabilitation. Sometimes external relief is unsuitable or inappropriate because the local people affected by disasters 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). In some cases, relief serves to remove agency from disaster 'victims' so that 'ownership' of the event and control over the recovery phase is lost at the local level (Hillhorst, 2002).

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). 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 disaster relief process 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 (Morgan, 1994).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).

Much disaster assistance takes place at the local level through local charities, kinship networks and local governments. There is also a considerable amount of relief that tends to be organised at more of a national and international scale than local scale, although 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 (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 recent trend towards international humanitarian organisations working with local partners, although this can result in the imposition of external cultural values resulting in resentment or resistance (Hillhorst, 2002).

While relief is often a critically important strategy for coping, there are problems associated with it, although there have been improvements in recent years. Relief can undermine local coping capacities and reduce resilience and sustainability (Susman *et al.*, 1983; Waddell, 1989) and it may reinforce the status quo that was characterized by vulnerability (O'Keefe *et al.*, 1976). 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).

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 often overlooked by relief agencies. Fast onset and unusual disasters such as tsunamis generate much more public interest and contributions from governments, NGOs, and the public, sometimes referred to as the CNN factor (Schmid, 1998). Disasters that are overshadowed by other newsworthy or media events, such as coverage of the Olympic Games, 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 (who have more than a camera and satellite transmitter to transport and distribute) but who 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 (DRM) (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, and 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 often tied and is limited to materials from donor countries and most relief is subject to relatively strict criteria to reduce perceived levels of corruption. In both of these 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. 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.

5.2.3. 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 popular approach to disaster risk management (Burby, 1998), although 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, it faces development pressures and real estate interests accompanied by property rights and the takings issue (Burby, 2000; Thomson, 2007; Titus *et al.*, 2009). 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. However, distance from people's coastal livelihoods and social disruptions led to the revision of buffers and resettlement policies (Ingram *et al*., 2006). In the U.S., coastal retreat measures were 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, 2007b).

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. Often systems of land tenure are very complex and flexible and contribute to vulnerability reduction as in the case of pastoralists in dryland environments where for example, sharing of land for grazing and of access to water are important drought responses (Anderson *et al*., 2010). 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, most successful efforts to bring about reductions in exposure have been those that have been locally led and that build on successful local initiatives, and in many cases are informal measures rather than those imposed by governments at the local level (Satterthwaite *et al*., 2007).

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 will. 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, 2010b; 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.

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 Asian 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 that includes 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, 2010a; Galloway, 2007; Opperman *et al*., 2009).

5.2.4. Surplus and Storage of Resources

Communities may take a range of approaches to cope with disaster induced shortages. These include production of surpluses and their storage. And if these fail, 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 (dioscorea spp.), swamp taro (cyrtosperma spp.) and sago (metroxylon spp.) 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, 2010). 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 at the local level is often instituted at the level of households, particularly poor ones without the ability to accumulate wealth or surpluses, in the face of disaster induced declines in livelihoods. 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.

Rationing may be seen as the initial response to food shortages at or near the onset of a famine. However, in many cases rationing is needed on a seasonal basis. This rationing is done at the level of households and communities. When the 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, the causes of famine 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 and welfare systems and NGO agencies respond to needs of those with livelihood deficits. However, other forms of rationing do exist particularly in response to drought events. Reductions in water use can be 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. Such events cause 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 (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 some 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. It should be noted that using fossil fuels to generate electricity as an alternative to hydro production may be considered a maladaptive option if carbon capture and storage and other technologies to reduce emissions are not adopted.

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).

5.2.5. Migration

Natural disasters are linked with population mobility in a number of ways (Hunter, 2005; Perch-Nielson *et al*., 2008; Warner *et al*., 2009). Evacuations occur before, during and after some disaster events. Longer-term relocation of affected communities sometimes occurs. Relocations can be both temporary (a few weeks to months), or longer, in which case they become permanent. These different forms of population movements have quite different implications for the communities concerned. They may also be differentiated on the basis of whether the mobility is voluntary or forced 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, 2009).

Where climate change increases the marginality of livelihoods and settlements beyond a sustainable level, communities may be forced to migrate (McLeman and Smit, 2006). This may be caused by changing mean conditions through changes in extreme events or a combination of both. Extremes often serve as precipitating events (Hugo, 1996). Brown (2008b) provides a range of estimates from an increase of five to ten per cent over current migration flows under a favourable projection upwards to a figure that may exceed 200 million under the worst case scenario. These efforts to quantify climate migration do not distinguish the climatic causes of migration which typically has many causative factors (Hugo, 1996). Many researchers have raised doubts about such a magnitude of migration and many consider that climate related migration 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). Nomadic pastoralists migrate as part of their livelihoods but often respond to disruptive events by modifying their patterns of mobility (Anderson *et al*., 2010).

Global estimations provide little insight into the likely 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)(Hwang *et al*., 2007) also found that forced migration directly led to increased levels of depression and the weakening of social safeguards in the relocation process.

One significant challenge for voluntary relocation particularly by property owners in countries without property insurance systems is that the investment connected to the affected property cannot be resold into the market. For some whose residential property loses value as a result of climate extremes and climate change, they may be unable to relocate and thus be forced to remain in place. Another outcome of climate change may be that entire communities may be required to relocate and in some cases, such as those living in atoll countries, the relocation may have to be international. It is likely that such relocation will 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) examine 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).

5.2.6. Recovery and Reconstruction

Recovery and reconstruction include actions that seek to establish '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). 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) to achieve greater disaster resilience.

Recovery and reconstruction (especially housing rehabilitation and rebuilding) are among the more contentious elements of disaster response. One of the major issues surrounding recovery in the scientific literature 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 large-scale top down programmes result in rebuilding houses but failing 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).

Most reporting on recovery and reconstruction has tended to focus on housing and the so-called lifelines of infrastructure: electricity, water supply and transport links. Equally important, if indeed not more so, is the rehabilitation of livelihoods, and the 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. 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 occur where planning and implementation of recovery and reconstruction is taken from the hands of the local communities concerned. Moreover, the use of inappropriate (culturally, socially or environmentally) materials and techniques may render rebuilt houses as unsuitable for their occupants (Jha *et al*., 2010). However, as Davidson *et al*. (2007) found, this is often the case and results in local community members having little involvement in decision making and being; 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).

Post-disaster rehabilitation provides a critical opportunity for reducing risk in the face of further events. In reconstructing livelihoods damaged or destroyed by disaster it is important to take into account the diversity of livelihoods in many local areas, to work with local residents and stakeholders to develop strategies and to work towards producing sustainable livelihoods that are likely to be more resilient in the face of future events (Pomeroy *et al*., 2006), especially at the local scale.

5.3. Local Risk Management in a Changing Climate

Community-based risk management has traditionally dealt with climate events without considering the long-term trajectories presented by a changing climate. This section provides examples of adaptations to disaster risk and how such proactive behaviors at the community level by local government and NGOs can 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.

5.3.1. Proactive Behaviors and Actions

Capacity investments necessarily involve decisions based on prior disaster experiences and future disaster expectations, including those related to emergency response and disaster recovery. Researchers have identified some of the physical and social characteristics that allow for the prior 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. Although loss of life from natural hazards has been declining, increases in property value have driven attendant increases in economic losses (Changnon *et al*., 2000; Pielke Jr. and Downton, 1999). Factors conditioning this outcome have been summed up by Burton *et al*. (Burton *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 with a fairly detailed understanding of planning and response needs. This knowledge appears to have been ignored at all levels of government including the local level (Kates *et al*., 2006). Burton *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.

5.3.1.1. Focusing Events for Local Action

Extreme events have been identified as offering "windows of opportunity" for including both disaster mitigation and long term risk management plans, such as for climate change adaptation, after particularly severe or visible events such as Hurricane Katrina or severe, sustained drought. In addition such a window can also create an opportunity for rebuilding or displacement programs that were decided upon a priori by the state or private sector. A policy window opens when the opportunity arises to change policy direction and is thus an important part of agenda setting (Anderson, 1994; Kingdon, 1984). Policy windows can be created by triggering or focusing events (Anderson, 1994; Birkland, 1997; Kingdon, 1984), such as disasters, as well as by changes in government and shifts in public opinion. Immediately following a disaster, the political climate may be conducive to much needed legal, economic and social change which can begin to reduce structural vulnerabilities, for example in such areas as mainstreaming gender issues, land reform, skills development, employment, housing and social solidarity. The assumptions behind the utility of policy windows are that: 1) new awareness of risks after a disaster leads to broad consensus; 2) development and humanitarian agencies are 'reminded' of disaster risks; and 3) enhanced political will and resources become available (Christoplos, 2006; Michaels *et al*., 2006). However, during the post-recovery phase, reconstruction requires weighing, prioritizing, and sequencing of policy programming, and there are multiple sometimes competing mainstreaming agendas for most decision-makers and operational actors to digest with attendant lobbying for resources for various actions. The most significant is the pressure to quickly return to conditions prior to the event rather than incorporate longer term 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 impacts and changes that some focusing events engender can only be defined retrospectively (Barton, 1969; Barton, 2005; Fritz, 1961; Turner, 1978). For example, a 30-year drought-induced famine ultimately becomes defined as a multiple disaster with impacts ranging from health and economy to food security. The cumulative effects of such a disaster are clearly seen only when changing historical conditions over decades have been collectively reconstructed to define them as acute. 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. A growing acknowledgement that aid cannot cover more than a small fraction of the costs of disasters is leading to new approaches, priorities and institutional configurations. The recognition 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 great catastrophes rarely last long enough to sustain the kind of efforts needed to reduce hazards and disaster risk.

Another pro-active action is the application of spatial hazard information by planners. However, use of such information is likely only if the information is clearly mapped, comes from an authoritative and in many cases a local source, and provides specific guidelines for action and ease of implementation, and the locality is provided with evidence that the approaches have worked in other places (Olshansky and Kartez, 1998). 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 (see 5.2.3). 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.

Short-term risk reduction strategies can actually produce greater vulnerability to future events as shown in diverse contexts such as ENSO-related impacts in Latin America, induced development below dams or levees in the U.S., and flooding in the UK (Berube and Katz, 2005; Bowden, 1981; Penning-Rowsell *et al.*, 2006; Pulwarty *et al.*, 2004). One important finding about locally-based protection works such as dams and levees is that they are commonly misperceived as providing complete protection, so they actually increase development—and thus vulnerability—in hazard-prone areas (Burby, 2006) (see 5.2.1). A more general statement of this proposition is found in the safe development paradox in which increased safety induces increased development leading to increased losses. 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.

5.3.1.2. Individual and Collective Behavior

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, and access to disaster risk information (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 which finds that 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 likely 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; and 4) 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 (Adeloa, 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. 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 (for example 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 then include protecting the structure 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 there is local community engagement with wildfire risks with stay and defend or leave early (SDLE) 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 than 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 imposed by state authorities such as Cuba and China. Planning for natural 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 which are sometimes referred to as the *moral economy*, were underpinned by reciprocity, often linked to kinship networks, and served to redistribute resources to reduce the impacts on those who had sustained severe losses and were identified by Scott (1976) in Southeast Asia, Watts (1983) in Western Africa and Paulson (1993) in the Pacific Islands. 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 enabled chief's 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

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 conversion to Christianity (missionaries banned 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). A variety of socio-political networks, that were used to offset disaster losses, existed throughout the Pacific region prior to colonization (Paulson, 1993; Paulson, 1993; Sahlins, 1962).

_____ 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 dealing 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 5.3.5).

There is some controversy over the significance of the notion of moral economy with some writers claiming that it oversimplified intra- and inter-community linkages in pre-capitalist settings. In doing so it does not recognize the inequalities in some of the social systems that enabled such practices to be sustained 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 5.3.2). 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).

5.3.2. Anticipating Risk

In order to anticipate the risks and uncertainties associated with climate change there are a number of emerging approaches at the local level. One set of responses focuses on integrating information about changing climate risks into disaster planning and scenario assessments of the future. Another set of responses engages the effected community through community-based adaptation (CBA), where they help to define solutions for managing risks whilst considering climate change.

Contextualizing disaster response within a climate change continuum requires information and knowledge about both slow and fast onset events (Ensor and Berger, 2009) . Weather information is critical for responding to flashfloods and cyclones, seasonal climate information can help to respond to drought and above normal rainfall predictions and longer-term decadal forecasts can help to understand shifts in the seasons. Although early warning systems that draw on weather information have been used to manage disasters, there has not been much experience in using seasonal climate forecast information to prepare for extreme events although there is experience on using seasonal forecasts as a means for dealing with annual variability that is expected to shift with climate change (Hellmuth *et al.*, 2007; Patt *et al.*, 2009). A response by the IFRC in the West/Central Africa Zone (WCAZ) shows how they issued the first emergency appeal based on a seasonal forecast of expected intense rainfall and pre-positioned relief items, developed flood contingency plans and launched pre-emergency funding requests (IFRC, International Federation of Red Cross and Red Crescent Societies, 2009; Suarez, 2009). Setting up plans in advance enabled communication systems to be strengthened before the extreme event struck, so that when it did information was passed from national headquarters to regional focal points, to the districts, to community leaders and on to communities (IFRC, International Federation of Red Cross and Red Crescent Societies, 2009). Whether or not such programs resulted in the delivery of relief faster is unknown.

In order to strengthen the integration of climate information at the local level, better systems are necessary. A systematic restructuring is needed in order for the humanitarian community to absorb and act on climate information that is currently available (Suarez, 2009). Part of the challenge is in translating output from climate change scenarios and seasonal climate forecasts, including figures, tables and technical statements, into decisions on whether humanitarian organizations should act or not. Communication strategies are needed to ensure that climate information about impending threats can be synthesized and translated into decisions and actions (Suarez, 2009).

The second response to strengthening community-based disaster risk management in a climate change context has been to focus on community-based adaptation (CBA), where the community is involved in deciding 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 (Allen, 2006). 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 climate 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 (Van Aalst *et al.*, 2008) and storylines about possible future climate change impacts (Ebi, 2008; Patiño and Gauthier, 2009b), although these tools often require input from participants external to the community with long-term climate information (Van Aalst *et al.*, 2008).

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 (Allen, 2006) and may conflict with the principle of keeping CBA simple (Van Aalst *et al.*, 2008). 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 CBA illustrate some of the processes involved. In northern Bangladesh, a Practical Action 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 have 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, the City Repair project engaged 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 simultaneously increased a sense of ownership in the improvements (Ebi, 2008). In the Philippines, the CBDP approach enabled a deeper understanding of local-specific vulnerability than previous disaster management contexts, which is critical because of the diverse impacts of climate change as compared to isolated disaster events (Allen, 2006) . However, 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 5-5). 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 (Douglas *et al.*, 2009). Existing activities were uncoordinated although some collective action was undertaken to clear drainage channels. However, residents felt that much could be done to adapt to frequent flooding including increasing awareness of roles and responsibilities in averting floods, improving the drainage system, garbage and solid waste disposal as well as 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).

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Box 5-5. Case Study – Small-Scale Farmers Adapting to Climate Change (Northern Cape, South Africa): Taking Collective Action to Improve Livelihoods Strategies

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. Adaptive capacity has been built by recognizing local conditions, integrating local knowledge with scientific climate information and driven by a positive vision of affected communities and how they can build sustained resilience in the face of environmental, economic and social change.

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5.3.3. Communicating Risk

Both anticipating and responding to risk entails communications among and between localities, public officials, and experts. However, communicating the likelihood of extreme impacts of climate change presents an important and difficult challenge (Moser and Dilling, 2007). Effective communication is necessary across the full cycle of disaster management: reduction, preparedness, response, recovery. 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). Research has shown that when delivering messages, those targeted to specific audiences are more likely to be effective (Maibach *et al.*, 2008). In addition, communication is likely to 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 has suggested 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). In addition, indicating threats to future generations may generate more concern than mentioning other climate change impacts (Maibach *et al*., 2008).

5.3.3.1. Risk Information and Messaging

The generation and receipt of risk information occurs through a diverse array of channels. Policies and actions affecting communications and advanced warning have a major impact on the adaptive capacity and resilience of livelihoods with for example, access to reliable and low cost telecommunications services are central factors influencing the ability of local populations to diversify their income strategies. The collection and transmittal of weather (and climate)-related information is often a governmental function while communications systems such as cell phone networks tend to be private. Examples of risk information generation and diffusion efforts within disasters research and response communities include: interpersonal contact with particular researchers; planning and conceptual foresight (Red Cross/Red Crescent brochures); outside consultation on the planning process (FEMA); user-oriented transformation of information; and individual and organizational leadership (NRC, 2006) (see Box 5-6 for additional sources of risk information).

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Box 5-6. Selected Sources of Risk Information

There are many sources of risk, vulnerability, and warning information. Among them are the Asia Disaster Preparedness Centre, Natural Hazards Research and Applications Information Center, at the University of Colorado, South Carolina Hazards and Vulnerability Research Institute, Caribbean Disaster Emergency Management Agency, Latin America Vulnerability Project, National Early Warning Units, in Southern Africa, National Weather Service (NWS) Warning Program and the NOAA/Columbia University International Research Institute for Climate and Society. More generally the space in which problem definition, information needs assessments, and knowledge co-production is usually takes the form of:

- Workshops and meetings (shared scenario construction including agro-climatic decision calendars
- Presentations and briefings (incl. locally organized events, e.g. hearings)
- One-on-one technical assistance and training
- Coordination with other ongoing projects
- Web site development and maintenance
- Courses on climate impacts and adaptation (see below)
- Media (local and mass media and information telenovelas etc.)

(Perarnaud *et al*., 2004; Pulwarty, 2007; Van Aalst *et al*., 2008)

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The characteristics of messages within risk communications that have a significant impact on local adoption of adjustments involve information quality (specificity, consistency, and source certainty) and information reinforcement (number of warnings) (Mileti and O'Brien, 1992; Mileti and Fitzpatrick, 1993; O'Brien and Mileti, 1992). 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). Researchers have long recognized a variety of information source vehicles including peers (friends, relatives, neighbors, and coworkers), news media, and/or authorities (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).

Risk messages also 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). The need to understand the usability of scientific information, especially at the local level, has received much attention from a communications perspective but little from an organizational perspective. 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; NRC, 2006). Receiver characteristics include previous hazard experience, preexisting beliefs about the hazard and protective actions, and personality traits. In addition, demographic characteristics—such as gender, age, education, income, ethnicity, marital status, and family size play strong roles. 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). Within several countries (Lesotho, Mozambique and Swaziland) it was found that timely issuance remains a key weakness in climate information systems especially for communication passed on to communities from the national early warning units. There was also 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.

5.3.3.2. Local Communication Channels

The degree of acceptability of information and trust in the providers, dictate the context of communicating disaster and climate information (see Box 5-7). 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 including revisiting potential usefulness for past events experienced; 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 5-7. 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 already know and believe about the risks being posed?
What has been 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?

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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; NRC, 1989), which are especially important in high-stress situations such as extreme impacts of climate change. 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 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). 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.*, 2009a). 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.

5.3.3.3. Warnings and Warning Systems

The disaster research and emergency management communities have shown that warnings of impending hazards need to be complemented by information on the risks actually posed by the hazards and likely strategies and pathways to mitigate the damage in the particular context in which they arise. Effective “early warning” implies information interventions into an environment in which much about 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, ranging from 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), to 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 (see Box 5-8), 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, reverse 911, 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.

Part of the research gap regarding communication stems from the lack of communication 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, incident management (Lindell and Perry, 1996). As noted in previous IPCC Reports (IPCC, 2007a), preparing for short-term disasters enhances the capacity to adapt to longer term climate change.

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Box 5-8. The Famine Early Warning Systems Network (FEWS NET)

The Famine Early Warning Systems Network (FEWS NET) is a USAID-funded activity that collaborates with international, regional and national partners to provide timely and rigorous early warning and vulnerability information on emerging and evolving food security issues(Brown, 2008a). FEWS NET professionals in the Africa, Central America, Haiti, Afghanistan and the United States monitor and analyze relevant data and information in terms of its impacts on livelihoods and markets to identify potential threats to food security. Once these issues are identified, FEWS NET uses a suite of communications and decision support products to help decision-makers act to mitigate food insecurity. These products include monthly food security updates for 25 countries, regular food security outlooks, and alerts, as well as briefings and support to contingency and response planning efforts. More in-depth studies in areas such as livelihoods and markets provide additional information to support analysis as well as program and policy development.

FEWS NET focuses its efforts on strengthening early warning and food security networks through a suite of communications and decision support products (see www.fews.net/ml/en/products). Climate monitoring and forecasting are especially important given the large number of rural people dependent on subsistence agriculture and pastoralism. Because conventional climate station networks are sparse, remote sensing and modeling methods have been developed to supplement conventional climate analysis. FEWS NET employs a livelihoods framework to geographically characterize vulnerability and interpret hazards. By assembling information on how households access food and income, routine monitoring of rainfall, vegetation, crops, and market prices is made more meaningful. Key food security questions are more readily answered, such as: Which population groups are facing food insecurity, and for how long? What are the best ways to mitigate adverse trends or shocks to their livelihood systems?

Early warning triggers the contingency planning process. FEWS Early Warning and Response engages in a series of steps depending on the phase of intervention (before during, after etc.):
1. *Pre-season Vulnerability Assessment and Profiles of At-Risk Groups*. FEWS analysis conducted prior to the growing season to identify populations likely to be hit hard in the case of a drought or other shock.
2. *Seasonal Monitoring*. Reading and reporting of satellite imagery on rainfall and crop growth and cereal price data produced by a number of different groups and collated by FEWS.
3. *Special Alerts and Warning*. Briefings, cables, and emails to USAID by FEWS to inform of potential food emergencies.
4. *Contingency Planning including scenario development*. Intra-USAID mission efforts undertaken during poor production years monitor food security situation and determine appropriate responses. The contingency planning

group, which includes the FEWS Report, uses a number of monitoring instruments.
5. *Response plan development and implementation*. Based on a needs assessment, response objectives and programs to meet those objectives need to be defined. Arrangements and procedures to implement these programs also need to be defined, as do the material, human resources and financial resources required. If a good contingency plan has been developed, this can be adapted, based on assessment results, and become a response plan.
6. *Aid Intervention Evaluation*. Selective assessments are conducted with FEWS involvement, to (i) understand targeting methods used by NGOs; (ii) gain insight into nature of vulnerability; and (iii) observe community status after intervention.

Monitoring and evaluation of response, impact and changes in needs is an ongoing process, before, during, and after. While regular monitoring of progress should identify problems and ways to improve interventions during the response, afterward a more detailed evaluation needs to be undertaken. The lessons learned should be identified and incorporated into future contingency plans and response mechanisms, thus providing the necessary feed-back loop for disaster risk communication.

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5.3.4. 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. 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, disempowerment may result. 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 the issue (Buvinić *et al*., 1999). This applies to all aspects of disaster management, 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.

5.3.5. 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 both operates on their own and in some cases also intersects with the others. As vulnerability to disasters and climate change is socially-constructed (see Chapter 2), the breakdown of collective action often leads to increased vulnerability. For example, coastal Northern Vietnam's institutional breakdown due to its economic transition has led to greater vulnerability to climate extremes (Adger and Kelly, 1999). Norms regarding gender also play a role in determining outcomes. For example, women were more likely to drown than men during the Asian tsunami because they were less able to swim (Rofi *et al*., 2006).

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). 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 (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 engagement within the community that bonds people and generates a positive collective value. 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). While 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 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, 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). Therefore, communities with stronger social networks are more likely to be 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 can also function to discourage effective adaptation to extreme events. External support, such as financial resources, may actually create inequalities amongst community members resulting in contention and weakened social networks (Ford *et al*., 2006). The impacts of climate change itself may also change the structure and utility of social networks. As people migrate away from climate risks, 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).

5.3.6. 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, who are long-term residents who have 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 indigenous people (people living with local and traditional cultures) 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 these changes from within the community (Byg and Salick, 2009). In six villages in eastern Tibet, near Mt. Khawa Karpo, documentation of changes experienced by local indigenous groups were consistent across areas, such as warmer temperatures, less snow, and glacial retreat, 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 are noticing 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).

Local knowledge is also an important anchor for communities in the integration of local knowledge with external scientific, global, and technical knowledge. Further, 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, S. V. R. K. *et al.*, 2009). For example, communities set up trusted intermediaries to transfer and communicate external knowledge such as technology –based early warning systems 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 (see Section 5.3.3).

Obstacles to utilizing local knowledge 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 dryland 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).

5.3.7. 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), resulting in poorer countries with weaker governance experiencing concentrated global disaster risk (UNISDR, 2009). In some places, climate change management practices have been centralized at the national level. This may be, in part, 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 many places, actions emerging at the local level are context-specific 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 procedural justice is guaranteed during the implementation of national policies at the local scale (Thomas and Twyman, 2005). In this light, 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 are developing adaptation plans, though few have implemented their strategies (Birkmann *et al.*, 2010; Heinrichs *et al.*, 2009). The Greater London Authority (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.

An assessment of the current state of progress on adaptation in eight cities (Bogotá, Cape Town, Delhi, Pearl River Delta, Pune, Santiago, Sao Paulo and Singapore) suggests that adaptation 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 suggests 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. Unfortunately with many of these cases, 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, 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 technological fixes (Crabbé, 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, 2009). 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), 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 (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 dysfunctionalities 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).

5.4. Challenges and Opportunities

There are two key principles in disaster risk reduction that are applicable to climate change adaptation: 1) mainstreaming disaster risk management into normal policies addressing social welfare, quality of life, infrastructure, and livelihoods; and 2) incorporating a multi-hazards approach into planning and action. Differences in coping and adaptation along with the costs of managing disaster risk at the local level present challenges and opportunities for adaptation to climate extremes.

5.4.1. 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; 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.

5.4.1.1. Gender

The literature suggests that at the local level gender makes a difference in vulnerability (Chapter 2), and also in the differential mortality from disasters (Neumayer and Plümper, 2007). 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 and social isolation found in many places across the globe tend to augment disaster risk, and vulnerability(Clot and Carter, 2009; League of Red Cross and Red Crescent Societies, 1991; Mutton and Haque, 2004; Schroeder, 1987). 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 (Enarson and Morrow, 1997). Based on the literature, opportunities arise in disaster risk management for the incorporation of gender-sensitive needs into disaster planning and response through the inclusion of women's indigenous knowledge as well as the promotion of literacy, provision of avenues for women's active engagement in the recovery process, and the assurance of access to physical and psychological resources, and legal protections (Hamilton and Halvorson, 2007)(see Box 5-9).

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Box 5-9. 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. This outcome can be directly attributed 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. The experience shows that preparedness is an important step in saving lives. The incorporation of women from the start, on an equal footing with men, contributed to the success in saving lives (Enarson and Morrow, 1997)**.**

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5.4.1.2. Age

Age acts as an important factor in coping with disaster risk (Cherry, 2009). 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. At the same time, 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 Heat Case Study in Chapter 9). Often because of hearing loss, mental capabilities, or mobility, older persons are less likely 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.

At the other end of the age spectrum are children (Peek, 2008). Children have their own knowledge of hazards, hazardous places, and vulnerability that is often different than adults (Gaillard and Pangilinan, M. L. C. J. D., 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).

5.4.1.3. Wealth

The level of wealth 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. 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). 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 5-10).

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Box 5-10. Case Study – Hurricane Katrina Recovery and Reconstruction

The intersection of race, class, age, and gender influenced differential decision making and perception of hazards; an uneven distribution of vulnerability and exposure resulting in disproportionate disaster losses; diverse types of hazard preparedness and disaster mitigation; and variable access to post-event aid, recovery and reconstruction (Elliott and Pais, 2006; Elliott and Pais, 2006; Hartman and Squires, 2006; Tierney, 2006).

Evacuation can protect people from injury and death, but extended evacuations (or temporary displacements lasting weeks to months) can have 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 with estimates suggesting a time frame that is likely to take 8-11 years (Kates et al. 2006). 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).

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5.4.1.4. Livelihoods

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 (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 with short intervals not sufficient for recovery. Actions aiming at improving their adaptive capacity focus more on addressing the deteriorating environmental conditions that undermine livelihoods and capacity to cope. 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**.** These types of interventions protect and enhance natural resources at the local scale and address immediate development priorities, but also improve local capacities to adapt to future climate change (Spanger-Siegfried *et al*., 2005).

A number of studies indicated that sustainable strategies for disaster reduction help improve livelihoods (UNISDR, 2004); while social capital, such as community networks support adaptation and disaster risk reduction by reducing the need for emergency relief in times of drought and/or crop failure (Devereux and Coll-Black, 2007) (see 5.2.2). 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 which contributes to spreading risk is a widely recognized strategy for reducing risk and increasing well-being in many developing countries (Ellis, 2000; Ellis and Allison, 2004).

5.4.1.5. Entitlements

Entitlements are based on the 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; and public assets such as basic infrastructure like water and sanitation. The link between disaster risk, access to resources, and adaptation has been widely documented in the literature (Adger, 2000; Brooks, 2003). 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.

Declining access to resources and ownership can affect environmental entitlements (Leach *et al*., 1999), food entitlements (Sen, 1981) and, more generally, all the material, social, political and cultural resources that are the basic building blocks of any coping and adaptation options towards disaster risk and climate stress. The buffering capacities of local people's livelihoods and their institutions are critical for their adaptation to extreme climate stress. More specifically, adaptive capacities rest on the ability of communities to generate potentials for self-organization, for social learning and innovations (Adger *et al*., 2006), with a focus on social actors, their practices and their agency that allow for resilient transformations (Bohle *et al*., 2009).

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 key to improving the ability of localities to lessen their vulnerability and to cope with and respond to disasters and environmental change. However, in some cases this may not be true, for example, if a disaster affects a household asset, but they 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 (Twigg, 2001). Entitlement protection thus requires adaptive types of institutions and patterns of behaviour (Bohle *et al*., 2009), 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.

Adaptive capacity is also 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, and it has been suggested that institutions which ensure equitable opportunities for access to resources are likely to 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. These rules are constantly made and remade through local people's social practices, but they are also contested and struggled over (Bohle *et al*., 2009). Better management of disaster risk also maximizes use of available resources for adapting to climate change (Kryspin-Watson *et al*., 2006).

5.4.1.6. Health and Disability

Initial estimates of the global impacts of climate change suggest nearly 160,000 annual human deaths are caused by vector borne diseases, food insecurity, heat waves, and other problems (Campbell-Lendrum *et al*., 2003). However, this is likely an underestimate since it based on modeling and not actual observations. The extreme impacts of climate change (Chapters 3 and 4) are likely to directly or indirectly affect the health of many populations. Heat waves lead to heatstroke, while cardiopulmonary problems and respiratory illness are linked to shifts in air pollution concentrations such as ozone that often increase with higher temperatures (Bernard *et al*., 2001). Heat waves differentially affect populations based on their race, 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). Health inequalities are of concern in extreme impacts of climate change more generally, as those with the least resources 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). Pre-event 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).

Other illnesses linked to climate change affect localities and are best managed at that scale. 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). Vector-borne illnesses have been projected to increase in geographic reach and severity as temperatures increase (McMichael *et al*., 2006). As seasons lengthen, mosquitoes and other vectors begin to inhabit areas previously free from such vectors of transmission. Pools of standing water which are breeding grounds for mosquitoes promise to expand, therefore increasing illness exposure (Depradine and Lovell, 2004). At the same time, some literature shows that climate change will dry mosquito habitat, therefore reducing illness rates (Mouchet *et al*.). 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. 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). Vector control programs generally implemented at the local level also have the potential to influence outcomes (Tanser *et al*., 2003). Infectious disease patterns also have the potential to change dramatically, necessitating improved prevention on the part of local providers that have specific knowledge of localized environmental change (Parkinson and Butler, 2005). Cholera, for example, has seasonal variation that may be directly affected by climate change (Koelle *et al*., 2004).

There is concern regarding the mental health impacts of acute climate events, such as 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).

5.4.1.7. 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 5.4.1.4) rural livelihoods and poverty are the drivers of disaster risk, Poverty, resource scarcity, access to resources, as well as inaccessibility constrains disaster risk management and when coupled with climate variability, conflict, and health issues further compounds 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 among others issues (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).

One important locality receiving considerable research and policy attention are megacities due to the density of infrastructure, the population at risk, the growing number and location of informal settlements, and the complexity of governance and disaster risk management. 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 untold billions of dollars in infrastructure located in highly exposed areas (Kraas *et al.*, 2005; Munich Re Group, 2004; Wenzel *et al.*, 2007). The complex and dynamic interaction between social, economic, political, and environmental processes insures that when a disaster strikes one of these megacities or mega-regions, there will be catastrophic losses of lives, property, and economic wealth resulting in major humanitarian crises (Mitchell, 1999).

For many regions, the ability to limit 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. It is likely that increased urbanization could limit not only the adaptive capacity of urban areas, but rural areas as well.

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

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

It is extremely difficult to assess the total cost of a large scale event, such as Hurricane Katrina, especially at the local scale. Total losses can be separated into direct and indirect losses (see Chapter 4). Direct losses can be separated into direct market losses and direct non-market losses (intangible losses). They 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 as important as it evaluates the overall economic impact of the disaster on society. At the local scale, the assessment of indirect losses is difficult because of the limited availability of economic data at this level. Most economic data (e.g., input-output table, income data) are available at the national scale, and direct loss estimates are generally aggregated at the national scale. In addition, the intricate linkages of the affected area and the world can complicate the assessment as well as the difficulty of establishing the boundary of local analyses. For example, local losses can be compensated from various inflows of goods, workers, and capital from outside the area to assist with reconstruction, along with governmental or foreign aid (Eisensee and Stromberg, 2007). At the same time, local disasters can provide ripple effects and influence world markets, such as Hurricane Katrina's impact on the world oil market, when most of the Gulf of Mexico oil rigs were shut down for weeks. Trade-offs in business loss and gain at different spatial scales, thus, need to be considered in accounting for indirect losses at the local level. Disaster loss estimates are, therefore, highly dependent on the scale of the analysis, and results can be very different between community-scale and subregional-scale analyses.

Despite the difficulties noted above, many local 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 saw its economic growth reduced on average by 0.79%, and increased 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; 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.* (2009) 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 reconstruction means (workers, equipment, finance) from outside the affected regions.

Using firm-level surveys at the local scale, Kroll *et al*. (1991), Tierney (1997), and Boarnet (1998) investigate the consequences of lifeline and transportation interruption of firm activity and survival for the Loma Prieta earthquake in 1989 and the Northridge earthquake in 1994. They found that the local consequences of infrastructure-related indirect impacts are often larger than the direct impact on firms, and this result is likely to be valid for large-scale climate-related disasters. West and Lenze (1994) summarize the impact of Hurricane Andrew on Florida, including local job market consequences. The U.S. Bureau of Labor Statistics (2006) also provides a detailed analysis of the large labor market consequences of Hurricane Katrina within Louisiana. Using household survey in three counties and 16 cities after the 2004 hurricane landfalls in Florida, 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. There is a clear lack of research on disaster estimates in developing countries, and it is a big gap in need of further research.

5.4.2.2. 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 cost/benefit 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). Research undertaken by the Institute for Social and Environmental Transition (ISET) on a number of cases in India, Nepal and Pakistan also consistently demonstrated positive benefit to cost ratios and notes that return rates are particularly robust for lower-cost, local level interventions (including such actions as 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 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, often necessitating different disaster risk management strategies depending on cost-benefit 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 and colleagues (Rosenzweig *et al.*, 2011; Rosenzweig *et al.*, 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. Hallegatte *et al.* (2008a), Hallegatte *et al.* (2008b), and Ranger *et al.* (2010) use a 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. 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.*, 2010).

Ranger et al. (2010) evaluated the risk of heavy rainfall in Mumbai, and concluded that total direct and indirect losses associated with a 1-in-100 year event could rise by 200% (i.e. triple) in the 2070's compared with current estimate of $690 to $1890 million that includes indirect losses of $100 to $400 million. They also note that a combined adaptation and risk management approach could significantly reduce future losses. Estimates suggest, for instance, 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 public policies to support small businesses after the disaster.

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

There are inconsistencies in present disaster risk 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 due to: 1) the spatial coverage and resolution of databases that are global in coverage, but only at the national level with no consistent sub-national data; 2) thresholds for inclusion where only large economically-significant disasters are included, thus biasing the data toward singular events with large losses, rather than multiple, smaller events with fewer losses; and 3) what gets counted varies between databases (e.g. insured vs. uninsured losses; direct vs. indirect)(Gall *et al.*, 2009). Moreover, disaster loss estimates are carried out for various purposes (e.g., assessment of foreign aid needs; cost-benefit analysis of protection investments) (IBRD and WB, 2010). Depending on the purpose, the spatial boundaries of the analysis are different (investigating losses only, or taking into account gains) and the conceptual boundaries are different (including or not non-market losses). Comparing disaster loss data requires taking into account of these differences in boundaries and purposes.

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); on the discount rate (Heal, 1997; Nordhaus, 2007; Stern, 2007; Tol, 2003; Weitzman, 2007); and on the evaluation of non-market costs, especially the value of biodiversity or cultural heritage (Pearce, 1994) create 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).

5.4.3. Limits to Adaptation

Limits and barriers to local adaptation are generally grouped into three interconnected categories: ecological and physical; human informational limitations 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, 2007). Based on Fischer *et al.* (2001) 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). Reducing community's vulnerabilities particularly women's through capacity-building and instilling new skills and knowledge proved an effective approach for improving the local adaptive capacity. A successful initiative in Mali 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). Another example is teaching women to swim, especially in tsunami-prone coastal areas.

In terms of financial limitations and despite the potential contribution of microfinance to vulnerability reduction among the world's poor, certain risks have been identified that should be considered from the perspective of adaptation to climate change. For example microfinance services typically do not reach the poorest and most vulnerable groups at local levels who have urgent and immediate needs to be addressed (Helms, 2006). The ability of a community to ensure equitable access and entitlement to key resources and assets should be seen as key to 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 and Michel-Kerjan (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 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 $10 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 climatic shocks limit the capacity to initiate planned livelihoods adaptations at the local scale. If extreme events happen more frequently and/or with greater intensity/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) and in some cases forced migration may be the only alternative (Brown, 2008b).

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 local 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.

5.4.4. 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. This is an important gap in the literature.

5.5. Management Strategies

5.5.1. Methods, Models, Assessment Tools

Prior to the development and implementation of management strategies and adaptation alternatives, local entities need baseline assessments on disaster risk and the likely 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; 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; 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). 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 qualitative assessments (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 in Georgetown County, South Carolina (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 is also related 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.). 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).

5.5.2. 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. These arrangements, which include informal instruments that "share" risk (e.g. remittances) and formal market instruments that "transfer" risks for a price (e.g., insurance), can be an essential part of an overall adaptation strategy. They do not explicitly reduce overall risk or direct losses, and in the case of insurance clients can expect to pay more than their expected loss; yet, by smoothing consumption, financial instruments protect against catastrophic losses and by supplying timely capital for recovery, they reduce long-term indirect disaster impacts. They also provide the security necessary for productive investments, thus promoting development and helping the most vulnerable escape disaster-related poverty traps (Barnett *et al*., 2008). At the same time, poorly designed instruments can lead to disincentives for reducing disaster risks (moral hazard), and public and international interventions can crowd out private sector operations and investments. These drawbacks should be viewed in relation to the alternative of international post-disaster aid, which, in theory, reduces incentives for and expenditures on ex-ante prevention (Linnerooth-Bayer *et al*., 2005).

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 money lenders. At-risk individuals in low-income countries rely extensively on reciprocal exchange, kinship ties and community self help. For example, often women in high risk areas 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 indicates 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 7.4.5.2). 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 18-60% interest rate charged on formal micro-credit, although relatively high, is generally far below the 120-300% often charged by local moneylenders (Linnerooth-Bayer and Mechler, 2009). Such "loan sharking" is most common after disasters when demand is high.

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). 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 (Skees *et al.*, 2008).

Formal insurance is utilized extensively in the industrialized countries, where it covers around 40 percent of disaster losses (Höppe and Gurenko, 2006) to residents and businesses. However, coverage is heterogeneous across countries and lines of business (Vellinga *et al.*, 2001). This results from differential levels of exposure, regulatory and economic conditions and market characteristics, all of which affect local communities. In many industrialized countries, the public sector plays some role in insuring risks, either by taking a slice of the risk, for example providing a backstop or 'insurer of last resort' for the most extreme catastrophe risks, or by covering lines that are uninsurable at an affordable rate by the private market (Vellinga *et al.*, 2001). The U.S., for example, has a federally-backed National Flood Insurance Program (NFIP) although it continues to run at a deficit.

Typically insurance coverage expands with economic growth. Penetration is currently growing rapidly in the emerging economies (+15% per year between 1998 and 2008) outstripping that in the developed world (Swiss Re, 2009). In 2008, total premiums from emerging economies stood at just over $0.5 trillion USD. Insurance has a much lower penetration in developing countries; here it covers only around 3 percent of disaster losses (Höppe and Gurenko, 2006) and mainly the commercial and industrial sectors and higher income groups. The penetration of agricultural insurance in developing countries is low despite its economic importance, with premiums accounting for only 0.01 percent of GDP. This results from a lack of affordability and distribution channels, but also socio-cultural factors (e.g. many poorer societies utilize informal social safety nets). New types of insurance are being designed to service these lower income groups; for example, micro-insurance.

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 haul 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). In India, a weather insurance program grew from covering just 1,100 farmers in 2004 to insuring over 700,000 farmers by 2008. 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 eliminating moral hazard (as there are no incentives to negligent behavior because claims are independent of the farmers' practices). 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 that 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: because disasters can affect whole communities or regions (co-variant risks), 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. Eighty-seven percent of insured losses events between 1985 and 1999 were weather-related (Munich Re Group, 2000). Research by the Association of British Insurers (Association of British Insurers (ABI), 2005) concluded that an increase of just 6 per cent in wind speeds could increase average annual insured local property losses in the United States from hurricanes from US$5.5 billion to around US$9.5 billion. The continuing exit of private insurances 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). Climate change could be particularly problematic in communities, which begin to see new types of risks for which they are unprepared. Vellinga *et al.* 2001 (Vellinga *et al.*, 2001) overview a number of dimensions of insurer vulnerability that could be impacted by climate change, 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) (Vellinga *et al.*, 2001). Kunreuther and Michel-Kerjan (Kunreuther *et al.*, 2009) and others suggest that these tools could play an increasingly important role in a new era of elevated catastrophe risks. Another approach is to reduce risks through societal adaptation (Herweijer *et al.*, 2009). For example, Lloyds of London (2008) demonstrates that in exposed coastal regions communities increase 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. Given the clear benefits of adaptation for insurance, Ward et al. (2008) describes a number of ways in which insurers themselves can help to promote adaptation through risk communication and financial incentives.

5.5.3. Adaptation as a Process

Experience in planning and implementing adaptation to climate change as well as disaster response reveals that socio-institutional processes are critical in bringing together a set of inter-twined elements (Downing and Dyszynski, In press; Tschakert and Dietrich, In press)). 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. Throughout the 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.

[INSERT FIGURE 5-2 HERE:
Figure 5-2: Dimensions of the adaptation continuum (O'Brien *et al.*, 2009).]

A key component of the 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). The extension of social, participatory, and organizational learning to climate change adaptation has emphasized 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)(Berkhout, 2002; Shaw *et al.*, 2009b; Shaw *et al.*, 2009a; 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). 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.

If adaptation is a process rather than an end-point it requires a focus on the institutions and policies that enable or hinder this process (Inderberg and Eikeland, 2009) and 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. These include lack of coordination between actors, and the complexity of the policy field hampering innovative approaches (Mukheibir and Ziervogel, 2007; Winsvold *et al.*, 2009). Limited human capacity to implement policies can also hamper adaptation (Ziervogel *et al.*, 2010), although individuals' perceptions of risk and adaptive capacity can determine whether adaptation responses are initiated or not (Grothmann and Patt, 2005).

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

The causal processes by which disasters produce systemic effects in chronological and social time is reasonably well-known and has been outlined by Kreps and others (Cutter, 1996; Kreps, 1985; Lindell and Prater, 2003; 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 mitigation plans, even when required by law, usually fail to include climate change, sea level rise, or extreme precipitation 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. A case in point is the lack of sub-national data on the local pattern of losses for disasters (see also section 5.4.2.3). There are few consistent databases for monitoring mortality from natural hazards at the local level (Borden and Cutter, 2008; Thacker *et al.*, 2008). However, two recent all-hazards studies for the U.S. found from 1970-2004, climate-sensitive hazards (severe weather in the summer and winter, and heat) accounted for the majority of recorded fatalities from natural hazards. Geographically, fatalities were greatest in the coastal counties bordering the Gulf of Mexico and South Atlantic (the U.S. hurricane coast), in rural counties, and in the American South (Borden and Cutter, 2008).

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 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, 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) Develop maps of the decision processes for disaster mitigation, preparedness, response and recovery and guidance for using such decision support tools. 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.

Previous studies have identified community hazard vulnerability, community resources, and especially, strategies and structures that emergency managers and other hazards professionals can adopt at low cost. The knowledge to construct regional geographic information systems that provide the information base for indices is already available

(Maskrey, 1989; National Academy of Public Administration (NAPA), 1998). Most studies had to rely on limited samples and need further work to replicate and extend their findings. Interdisciplinary collaboration is clearly needed to prioritize and address research tasks for bridging knowledge gaps in our understanding. These gaps include: analyses of vulnerability that integrate into their assessment the extent to which knowledge is framed, co-produced and utilized; factors that promote the adoption of more effective community level hazard mitigation measures and assessments of the effectiveness of hazard mitigation programs; development and local calibration of better models to guide long-term protective action decision making in emergencies; understanding impacts, response and recovery for near-catastrophic and catastrophic disaster events at the local level; research and support for risk-pooling mechanisms for small-scale production units; and understanding the role and benefits of ecosystems services in providing buffers for uncertain risks.

The experiences of extreme events and sequences of events considered in this chapter validate the notion of socially constructed disasters. Disaster risk management and climate change adaptation strategies must address the underlying practices that contribute to vulnerability. One goal is to be clearer about existing conditions and projected changes in support systems and services e.g. weakening of bridges, levees and other structures due to long exposure to water of changing quality and other corrosives, or the decline of upstream watershed conditions that affect the livelihoods of downstream communities. These actions will situate the scientific understanding of hazard within a broader discourse about different forms of knowledge, and increase the likelihood of public actions that are better grounded in scientific knowledge and customized for the local context.

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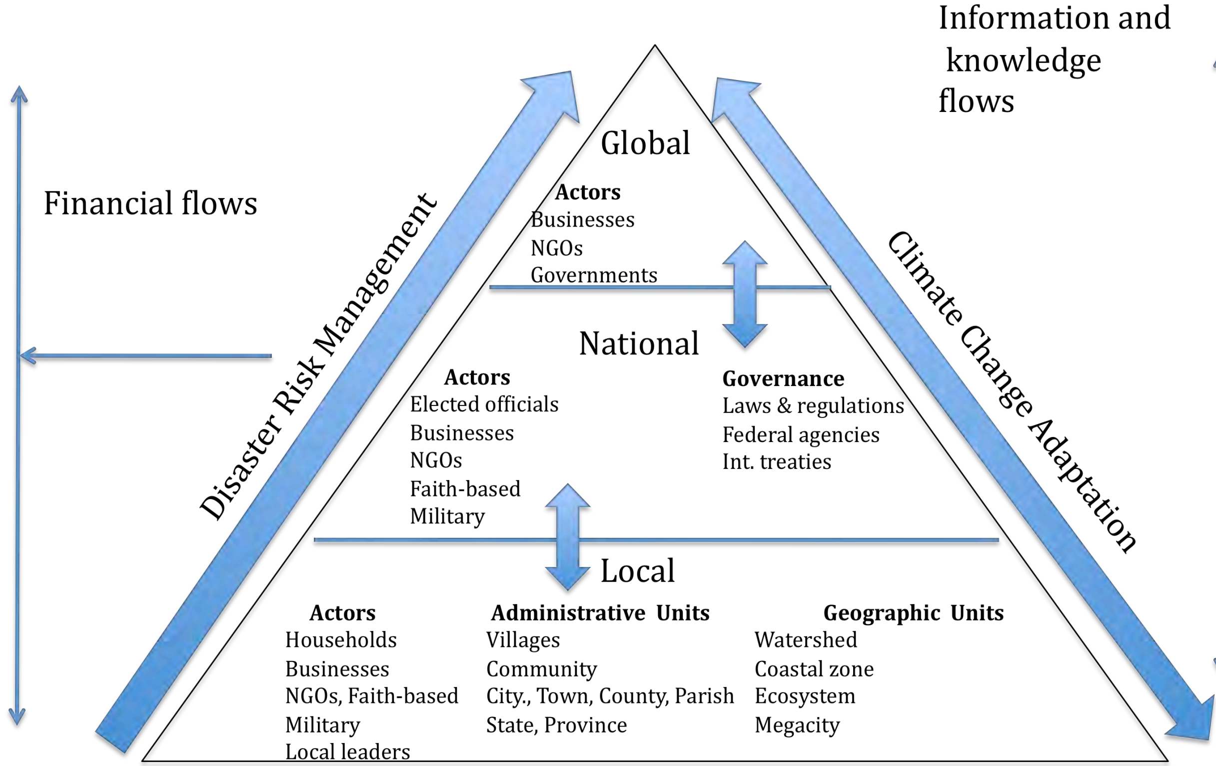

Figure 5-1 Linking local to global actors and responsibilities

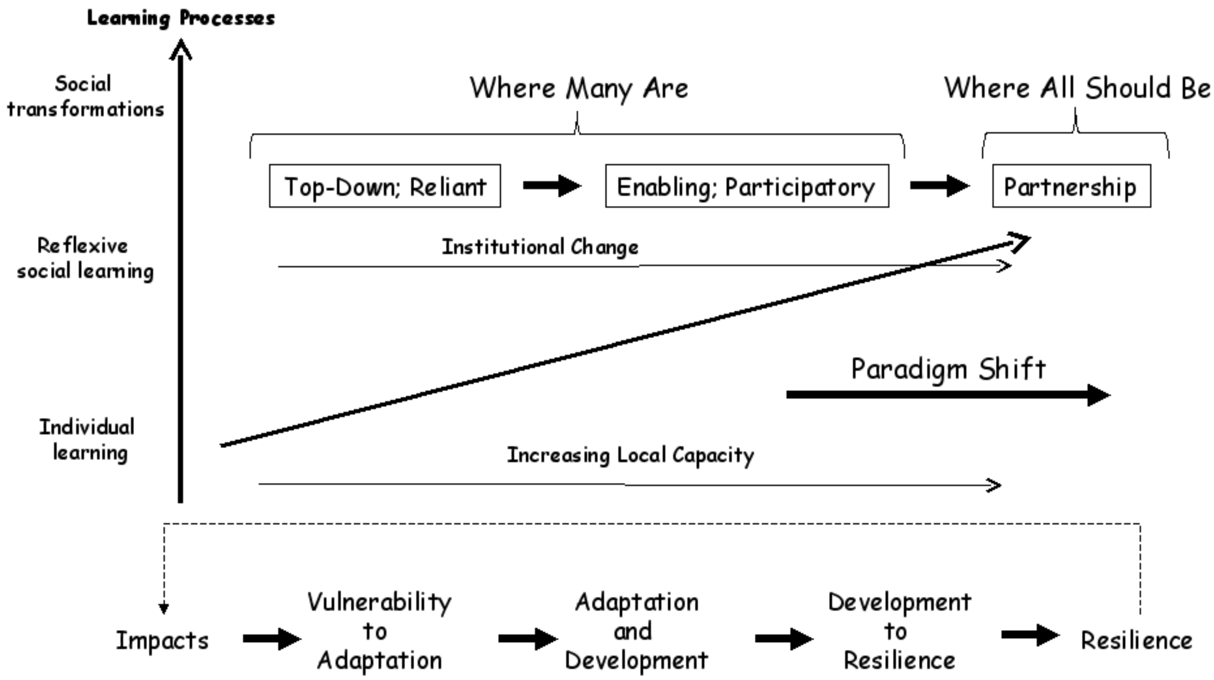

Figure 5-2: Dimensions of the adaptation continuum (O'Brien et al. 2009).