Chapter 14. Adaptation Needs and Options

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14.2. Foundations of Adaptation

14.2.1. Understanding Adaptation

Given historical and current levels of emissions stemming from human activities, it is expected that the climate will continue to change (IPCC, 2007; Stott *et al*., 2010). These changes are predicted to be accompanied by greater variability in temperatures, precipitation, and extreme weather events that, in turn, will impact a wide range of critical functions and areas, including food production, water availability and quality, coastal and marine systems, disease vectors, and housing and building stability (IPCC, 2007; Fussel, 2009). Given that these changes will affect the functions and well-being of natural systems, human societies, and the built environment, it is essential for countries and subnational areas to be prepared by taking action to adapt (IPCC, 2007).

Climate adaptation is defined as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007: 869). While this definition is widely accepted, there is still a great deal of variability in views about the objectives of adaptation. As a result, our understanding of what constitutes successful adaptation span from maintaining present levels of risk, to reducing current risks, to minimizing the exposure of vulnerable populations (Doria, *et al*., 2009). Based on Delphi methodology, Doria, *et al*., (2009) were able to identify shared views of adaptation. Their findings suggest that success is regarded as any type of adjustment that reduces climate risks or vulnerability to climate impacts to previously determined levels and that promotes efforts to achieve economic, social, and environmental sustainability (Doria, *et al*., 2009).

14.2.1.1. Perspectives on Vulnerabilities

Most definitions of adaptation are rooted in the notion of reducing vulnerability or the potential to be harmed. According to AR4 (IPCC, 2007), vulnerability is the degree to which a system is "susceptible to, and unable to cope with, adverse effects of climate change." The concept of vulnerability traditionally is viewed as being comprised of three elements: exposure, sensitivity and adaptive capacity (IPCC, 2007). In other words, the stress faced by a system or individual, the extent to which the system will be affected, and the degree to which the system is able to cope with or respond to these stresses (Cutter, 1996; Cutter *et al*., 2003; O'Brien *et al*., 2005; Adger, 2006). From an adaptation standpoint, this concept is used to explicate contextual factors associated with exposure (Leichenko and

O'Brien, 2008). For instance, vulnerability at the national and sub-national levels is affected by geographic location, biophysical conditions, institutional and governance arrangements, and resource availability, including access to technology and economic stability. At the individual level it is shaped by personal characteristics such as gender and health as well as by social status and networks (Ionescu *et al.,* 2009). At the same time, vulnerability is used to identify and understand the ability of different systems and groups to cope with climate impacts (Leichenko and O'Brien, 2008).

Multiple sources of stress, some from climate impacts and some from other sources, combine to increase vulnerability. For instance, existing coastal erosion, deforestation and habitat fragmentation become even more serious problems when coupled with the projected impacts of climate change (Ayache *et al.*2009; Werner and Simmons, 2009; Sanchez-Arcilla *et al*., 2008). Multiple stressors also increase the risks to human populations. Africa, for instance, faces a critical convergence of deleterious multiple stressors, including the spread of HIV/AIDS, poverty, scarcity of basic resources and services, and armed conflict. In combination, these and other stressors are leading to greater vulnerability across the continent (Fields, 2005). As these examples suggest, multiple stressors can be additive or cumulative, resulting in impacts that are greater than any single stressor would produce.

14.2.1.1.1. Biophysical perspectives

Early views of the potential impacts of climate change and the opportunities for adaptation were dominated by a biophysical model of hazards and vulnerability to these hazards. Specifically, biophysical vulnerability was defined as a function of the frequency and severity of a given type of hazard (Brooks, 2003). This approach, which was largely derived from the hazard management perspectives advanced in the disaster risk management literature (Blakie *et al*., 1996), emphasises the magnitude of the biophysical threats arising from climate change to define vulnerability and the need for adaptive actions (Adger, 1999; Brooks, 2003; Brooks *et al*., 2005). The IPCC definitions and discussions have evolved from this strongly biophysical definition to an approach that combines biophysical and social perspectives of vulnerability. This has led to confusion around the different and sometimes incompatible definitions of vulnerability presented (Adger et al., 2004; Füssel and Klein, 2006). However, this refinement has led to a more operational concept of vulnerability, one that focuses on its underlying causes and on actions to reduce vulnerability without waiting for ongoing refinements in estimates of the size and location of climate hazards.

14.2.1.1.2. Social perspectives

From a social perspective, vulnerability varies as a consequence of the capacity of groups and individuals to cope with the impacts of climate change. Among the key factors associated with vulnerability are gender, age, health, social status, ethnicity, and class (Adger *et al*., 2009; Smit *et al*., 2001). For instance, the elderly and infirmed may not have the financial resources or social capital necessary to relocate or the physical capacity to evacuate when natural disasters strike. Those who are socially isolated may have difficulty adjusting to the changes taking place around them while those who do not speak the national language, such as immigrants and foreigners, may be unable to learn about impending issues. Ethnic minorities have a long history of unequal treatment in many parts of the world and these disparities often become acute in the aftermath of natural disasters.

Climate change is expected to have a significant impact on the poor as a consequence of their lack of financial resources, poor quality of shelter, exposure to the elements, and limited provision of basic services, (Moser and Satterthwaite, 2010; Huq *et al.,* 2007; Shikanga *et al*., 2009; Kovats and Akhtar, 2008; Revi, 2009; Tol *et al*., 2004). There are numerous instances where the poor have been able to adapt to changes. However, in addition to limited financial resources, the health and nutritional status of poor populations often is compromised. As a result, along with the sick and elderly, they are at increased risk from illness and death from climate-impacts such as increased pollution, higher indoor temperatures, exposure to toxins and pathogens from floods, and the emergence of new disease vectors (Kasperson and Kasperson, 2001). In a survey of recovery from shocks in Pakistan, Heltberg and Lund (2009) found that when faced with health and economic challenges, poor households often do not have sufficient coping mechanisms to rebuild their assets. This leaves them more prone to destitution and associated

problems of food insecurity and landlessness (Heltberg and Lund, 2009). A further consideration is that many poor, as well as indigenous, populations maintain subsistence lifestyles. Climate-induced changes in temperature, weather, and pollution will affect habitats and result in an inability to obtain or grow food supplies thereby posing challenges to their food security (Huq *et al.,* 2007; Ford *et al*., 2008; Gero *et al*., 2011).

14.2.1.1.3. Political perspectives

Political systems and politics are important in shaping and understanding national and sub-national vulnerability. Three critical issues in this regard are the nature of the regime in power, migration, and conflict. Different types of regimes rely on different types of policy instruments. While decentralized planning in democratic systems facilitate at least some levels of independent action, state-socialist and authoritarian systems rely on national level coordination. Drawing on case studies of water systems in the Middle East and North Africa, Sower *et al*. (2011) maintain that these largely centralized systems of planning, taxation, and revenue distribution render these governments more vulnerable since they are limited in their ability to adapt to climate change.

Normal politics and political behavior in democratic regimes also can contribute to vulnerability. According to Corfee-Morlot *et al*. (2011), while there are jurisdictional, institutional, economic, and technical issues that come into play, there also are a number of ongoing political issues that shape the relationships local governments have to managing climate risks. For instance, short term election cycles, when dealing with long term issues gives rise to limited incentives to make investments. Similarly, the proximity that local authorities typically have to interest groups can sway their decisions toward other issues while the drive to engage the public in planning and other activities can orient priorities in ways that do not support adaptation. Collectively, these situations can foster rather than address inherent vulnerabilities.

Climate change has the potential to increase stresses that can lead to organized conflict and therefore, can heighten vulnerability. While there are debates about whether climate change can directly lead to tensions, many assessments focus on changing climates without attending to concurrent conditions (e.g., Zhang *et al.,* 2006; Tol and Wagner, 2010). As examples such as Darfur suggest, climate change does not, in and of itself, result in conflict (Byers and Dragojlovic, 2004). It can, however, contribute to the emergence of conflict when there are other contextual and preexisting factors such as political and economic instability, social fragmentation and marginalization, migration, and maladaptation (Bahaug *et al*., 2010; Raleigh, 2010). According to Bahaug *et al*. (2010), these factors influence whether climate change will have adverse sociopolitical and economic effects and, in turn, determine whether they will increase the risk of armed conflict. While research suggests that climate change can increase the potential for conflict to emerge, it is important to acknowledge that countries engaged in conflict are among those with the lowest adaptive capacity given disruptions to basic services and agricultural production and therefore, are among the most vulnerable to climate impacts (Barnett, 2006).

Rapid onset events, such as floods, as well as slow onset events including water shortages, famine, and desertification can serve as triggers for human migration, both within a given country as well as across borders. Based on case studies conducted in areas of Vietnam and Mozambique that are prone to rapid-onset flooding and in Egypt where they are facing slow-onset hazards of desertification as well as the potential of sea level rise, Warner *et al*.(2011) found patterns similar to those associated with conflict. Specifically, they suggest that economic and social factors are the major drivers of migration at the present time, but environmental forces associated with natural hazards contributed to the relocation process (Warner *et al*., 2011). Further, stresses such as poverty, high population growth and density, and low levels of economic development can exacerbate the situation even further since they are intertwined with access to resources and the ability to cope with stressors associated with climate change (Gemenne, 2011; Warner *et al.,* 2011).

14.2.1.1.4. Economic perspectives

In assessing vulnerability in relation to adaptation, economic and social elements are often combined in a socio-economic perspective (section 2.1.1.2). However, in some circumstances the emphasis is much more directly on the

economic component. This is particularly true in disaster risk assessment and similar analyses. Here the assessment typically uses the building blocks of probabilistic risk analysis to deliver for a particular scenario a quantitative estimate of the magnitudes of the hazard, exposure, vulnerability, and losses expressed in economic terms. Often the analysis is extended via randomized evaluations of the model to calculate the probability that a certain level of loss will be exceeded leading to a "loss exceedance curve", which then can be used to calculate other useful planning variables such average annual loss or probable maximum loss (Ghesquiere & Mahul, 2010; Anon 2010; eventual ref to SREX).

Recently there have been efforts to estimate the economic costs of adaptation both at global (see Chpt 17) and national level. One challenge has been to define and operationalize the concept of adaptation costs. The IPCC defines adaptation costs as the costs of planning, preparing for, facilitating, and implementing adaptation measures, including transaction costs (AR4 Glossary). But this is still difficult to operationalize. In a multi-country comparison the Economics of the Adaptation to Climate Change (World Bank, 2010) first established a baseline development path for each country with no climate change using standard economic forecasts and assuming that countries grow along reasonable development path. Then the calculations were repeated, sector by sector, assuming an appropriate level of adaptation. But there are many options as to that level. One option is to adapt completely, so that society is at least as well off as it was before climate change, but this may be prohibitively expensive. At the other extreme, countries could choose to do nothing, experiencing the full impact and losses from climate change. In the intermediate cases, countries invest in adaptation using the same criteria as for other development projects—until the marginal benefits of the adaptation measure exceed the costs. This method still had serious limitations. For example it was not able to deal with non-monetary losses such as those associated with ecosystems services, or costs of "soft adaptation options" such as institutional reform and strengthening. Moreover, another major lesson from the study was that it was unable "to translate the very rich, mostly qualitative information from field work into economic terms, so that the adaptation measures indicated by the local populations could be included in the economic analysis as explicit adaptation alternatives. This approach proved to be unworkable. Among the difficulties were (i) the level of effort required to obtain the necessary economic information, (ii) problem in scaling up very specific local and soft measures for incorporation in national models, and (iii) the high degree of overlap between what local communities saw as immediate development priorities and adaptation measures" (World Bank, 2010).

Another study (Economics of Climate Adaptation Working Group, 2011) also sought to estimate the potential climate change losses over coming decades (20 years), how much could be averted, with what measures, what investments would be needed, and where benefits outweigh losses. It provides a methodology and systematic presentation of the costs of adaptation actions against the losses avoided, to assist decision makers to visualize the range of adaptation options available.

14.2.1.2. Adaptive Capacity

All regions and all countries of the world are vulnerable to the impacts of climate change. Attending to these impacts requires that countries and sub-national bodies have sufficient capacity to adapt. Adaptive capacity refers to the ability to recover, adjust, or cope with the impacts of climate change (Smit and Pilifosova, 2001; Smit and Wandel, 2006; IPCC 2007; Nelson *et al.*, 2007; Jernek and Olsson, 2008). This can take place through advance preparation or through response at the time an event takes place (Smit *et al.*, 2001). Adaptive capacity is not limited to the ability to maintain an existing state, but reflects flexibility to transition to one that is more desirable (Engle and Lemos, 2009). What constitutes adaptive capacity varies in light of specific challenges and contexts (Adger *et al.*, 2007), but it is closely tied to the availability of tangible resources, including money, political power, and access to information and technology (Yohe and Tol, 2001; Smit and Wandel, 2006). While tangible resources are important, those associated with strong governance measures, such as institutions, networks, and civil and political rights, also contribute to the adaptive capacity of nations, regions, cities, and communities (Engle, 2011; Adger, 2006; Eakin and Lemos, 2006; Brooks *et al.*, 2004).

Fostering adaptive capacity is regarded as a critical issue in preparing for climate change in all national and sub-national contexts. Because of their limited resources, developing countries, small island developing states, and poor

populations have limited adaptive capacity and therefore, are among the least able to cope with climate impacts (Adger *et al.*, 2003; Dow *et al.*, 2006). As a result, adaptive capacity is closely tied to the development path that is pursued by national and by sub-national bodies. In many instances, achieving widespread commitment means that adaptation should be integrated into ongoing economic and sustainable development efforts. Systematic planning and capacity-building are needed to reduce the risk of disasters and raise the resilience of communities to increasing extreme events such as droughts and floods. Assessing the impacts of and vulnerability to climate change and subsequently working out adaptation needs requires good quality information. Equally as important, and lacking at present, is the need for accurate socio-economic data. This data needs to come from across sectors and is an important complement to existing assessments, particularly given that poverty has been recognized as a major factor in vulnerability (UNCCC, 2007).

14.2.2. Mainstreaming Adaptation

Adaptation complements and has the potential to achieve co-benefits with many policy and planning arenas. As an alternative to pursuing isolated action, a mainstreaming approach focuses on linking adaptation to national and local goals and priorities. The rationale behind mainstreaming is that integrated interventions can have effects surpassing those of disaggregated, fragmented, or differentiated initiatives (Chuku, 2010). Mainstreaming emphasizes synergies between adaptation and ongoing activities of government ministries and departments as well as practical activities taking place at the community and household levels (Smit and Wandel, 2006; Agrawala, 2005; Willbanks and Kates, 2010). By developing an integrated plan of action, mainstreaming enhances the ability to streamline decision-making processes and accommodate an adaptation agenda without reinventing institutions and organizations (Smit and Wandel, 2006). It also can promote long-term sustainability of adaptation activities (Warner et al., 2011), and reduce future remedial costs (Agrawala and van Aalst, 2008), such as those that could emerge from maladaptation, poor decision-making tools, and mismatches in development trajectories. While adaptation offers complementarities and co-benefits with a variety of policy and planning arenas, this section focuses on linkages to and mainstreaming with climate change mitigation, development planning, and disaster management and hazard risk reduction.

14.2.2.1. Integrating with Mitigation

For many years, mitigation and adaptation have been viewed as relatively separate issues (Martens *et al.*, 2009), with mitigation seen more as a more pressing issue for developed countries and adaptation a priority for developing nations (Ayers and Huq, 2009). However, there is growing recognition that both are integral aspects of managing climate change (Willbanks *et al.*, 2003; Dowlatabadi, 2007; Klein, *et al.*, 2007; Swart and Raes, 2007; Venema and Rehman, 2007; Ayers and Huq, 2009; Larsen and Gunnarsson-Ostling, 2009). Mitigation priorities and adaptation measures are complementary and can offer co-benefits if they are addressed simultaneously (McEvoy *et al.*, 2006; Wilbanks and Sathaye, 2007; Klein *et al.*, 2007; Ayers and Huq, 2009; Laukkonen *et al.*, 2009; Neufeldt *et al.*, 2009; Preston *et al.*, 2011).

A variety of efforts around the world demonstrate the potential for integrating mitigation and adaptation. For example, Tokyo's urban greening policies promote the development of green roofs and urban gardens in order to address urban heat islands by acting as carbon sinks and urban flooding by reducing stormwater runoff and moderating building temperatures (Laukkonen *et al.*, 2009). Similarly, Hamin and Gurran (2009) note how the development of renewable energy resources in Cornwall UK and Aspen/Pitkin County, USA not only reduce greenhouse gas emissions, but reduce vulnerability to storm events and peak demand during periods of extreme temperature by generating power through smaller and more decentralized means (Hamin and Gurran, 2009). Despite complementarity, it is essential to consider the full range of alternatives and impacts as mitigation and adaptation measures also can be in conflict with each other. For instance, in the case of city center redevelopment in Byron Shire, Australia, mitigation policies recommended high density development to achieve energy efficiency while adaptation policies recommended more open spaces to buffer stormwater runoff and protect ecosystems and conserve biodiversity (Hamin and Gurran, 2009).

14.2.2.2. Integrating with Development

Developing countries are striving to improve the quality of life for their populations by taking actions reduce poverty and provide an adequate standard of living. However, climate variability and increases in natural hazards have the potential to undermine these goals (UNEP, 2011; Dupont, 2008; Kuwali, 2008). For instance, increased precipitation will result in increases in flooding and exposure to toxins and diseases in areas that lack appropriate drainage and sanitation services. Alternatively, droughts may emerge as increases in temperature lead to increasing rates of glacial melt or as regions experience reductions in precipitation. In these situations, the poor may have difficulty obtaining access to water, as supplies become scarce (Kovats and Akhtar, 2008). Mainstreaming adaptation into national and regional development policies offers a means to address vulnerability to climate change while still maintaining progress in achieving economic and human development goals (Chuku, 2010). In fact, for many nations, the relationship between adaptation and development is so pressing that a wide variety of existing development issues are being reframed in the context of climate adaptation (Lemos *et al*., 2007).

Sustainable development is a distinct and holistic approach to development that seeks to balance economic, ecological and social issues. Climate change and sustainable development often are considered to be two separate agendas. However, they too have the potential to be complementary and mutually reinforcing. This complementarity derives from the fact that climate adaptation initiatives can reduce vulnerability while promoting economic, ecological, and social goals and objectives associated with development (Eriksen and O'Brien, 2007; Ayers and Huq, 2009; Ayers and Dodman, 2010). At the same time, the promotion of issues such as food security, environmental quality, and health and sanitation associated with development, can be made more sustainable and equitable over the long term by accounting for projected climate impacts (Mooney *et al*., 2009).

The term sustainable adaptation has been advanced to emphasize the potential co-benefits that can be derived when development and climate adaptation are seen as complementary (O'Brien and Leichenko, 2007). Despite the potential for synergies to exist, adaptation efforts do not always attend to the environmental, social, and economic consequences of action. For example, in some situations adaptation has inadvertently reinforced traditional gender roles (Carr, 2008) and inequalities (Eriksen and Lind, 2009). In addition, according to Turner, et al (2010), adaptations such as building dams, migrating from water stressed to less developed areas, and exploiting natural resources in times of stress will have negative impacts on biodiversity conservation. By linking adaptation and sustainability, there will be greater sensitivity to equity, environment, and economic issues such as livelihoods when seeking to advance climate adaptation.

The relationship between economic development and adaptation tends to be articulated somewhat differently in developed and developing countries. In developed countries, adaptation plans and strategies often focus more on infrastructure, particularly in relationship to transportation and utilities (Ford et al., 2011), and rely on large-scale, complex, and capital intensive engineering and technological solutions (Sovacool, 2011). Developing countries, on the other hand, tend to be more concerned with integrating adaptation strategies with poverty and vulnerability reduction (Eriksen and O'Brien, 2007; Mertz *et al*., 2009; Hertel and Rosch, 2010), including those that promote basic service provision and delivery (Satterthwaite *et al*., 2007; Bauer and Scholz, 2010), food and water security (Nath and Behera, 2011), and education and health care (Smit and Wandel, 2006; Eriksen and O'Brien, 2007; Brauch, 2008; Perch-Nielsen *et al.,* 2007; Halsnaes and Traerup, 2009; Scott and Becken, 2010). Given this North-South difference, while adaptation planning must ensure that development plans are robust against climate hazards and disasters in all socioeconomic and development contexts, this nexus is especially critical in the most vulnerable countries and least developed locations (ADB and IFPRI, 2009)

14.2.2.3. Integrating with Disaster Risk Reduction

Climate adaptation and disaster risk reduction (DRR) share the common goals of reducing vulnerability of areas and populations to the impacts of extreme events while creating sustainable strategies that limit risks from hazards (Solecki *et al*. 2011; Schipper, 2009). Given that both fields seek to reduce vulnerabilities and build capacity (Solecki *et al.,* 2011), integrating adaptation and DRR offers a number of co-benefits. For instance, DRR can become more robust by considering climate change projections and assessments when planning measures to reduce

impacts. Further, many rural and subsistence communities are aware of climate change, but do not distinguish between climate impacts and events and stressors that affect their lives and livelihoods. Integrating adaptation and DRR, will ensure that the climate predictions and scenarios are considered when planning for disasters and extreme events (Mercer, 2010).

Given the synergies between adaptation and DRR, some cities and communities have begun to explore the linkages between these two areas. However, integration remains limited, particularly at the national level. Drawing on reviews of plans, as well as expert interviews conducted in Germany, the United Kingdom, and Fiji, Birkmann and Teichman (2010) found that despite having national adaptation plans that noted the importance of linking adaptation and DRR, little action was taken at the national level to establish working relationships.

Climate change is one of many stressors that governments and communities must address (Willbanks and Kates, 2010; Mercer, 2010). At the same time, adaptation is increasingly recognized as being linked to the development paths of both developed and developing countries (Agrawala, 2005; Stern, 2006; Nelson *et al*., 2007; Agrawala and van Aalst, 2008; Ayers and Dodman, 2010; Willbanks and Kates, 2010). Since DRR has a long history of being associated with development, more comprehensive efforts are being called for in order to bridge adaptation, disaster management, and economic and social development needs (Willbanks and Kates, 2010). By adopting a broader perspective, countries, states, and communities can address multiple stressors and multiple vulnerabilities while building adaptive capacity (Willbanks and Kates, 2010; Solecki *et al.,* 2011).

14.2.2.4. Integrating with National and Local Planning

Countries have pursued different approaches to integrating adaptation priorities with existing planning processes. Some have chosen to produce stand-alone climate adaptation plans and strategies. These include Finland's National Strategy for Adaptation to Climate Change (Marttila et al., 2005), Germany's Strategy for Adaptation to Climate Change (BMU, 2008), and Burkina Faso's submission to the National Adaptation Programmes of Action (Kalame *et al*., 2011). Although these stand-alone plans are administered through one central ministry or department, they explicitly address integrating adaptation into areas and sectors such as agriculture, water resources, land use, and transportation (Biesbroek *et al*., 2011; Kalame *et al*., 2010). In addition, some countries have begun to integrate adaptation into their sector plans. For example, Australia's National Agriculture and Climate Change Action Plan seeks to promote the development of a sustainable, competitive, and profitable agricultural sector while also recognizing the need to pursue adaptation strategies and build resilience (DAFF, 2006). Despite these examples, incidences of successfully mainstreamed adaptation into national planning lag behind those at local and sub-national levels (Ford *et al.,* 2011).

Local governments are responsible for ensuring the safety, security, and well-being of their residents through efforts including the provision of infrastructure and basic services, preparedness for emergency response, and protection of environment quality and biodiversity. Of particular importance at the local level is addressing adaptation in the context of land use planning. Adaptation can be integrated into these and other activities as well as into local policies and plans (Dodman and Satterthwaite, 2008; Corfee-Morlot, 2011; Measham *et al.,* 2011) and then be implemented using existing institutional structures and processes (Wheeler, 2008; Kithiia and Dowling, 2010). Many local governments are making strides in advancing an adaptation agenda (Rosenzweig, *et al.,* 2010), but mainstreaming is proving to be a challenge in many locations. In order for local governments to integrate adaptation with their policies, plans, and ongoing activities, there must be adequate political support, capacity, and resources (Dodman and Satterthwaite, 2008; Seto et al., 2010; Amundsen et al., 2010; Corfee-Morlot, 2011), along with reliable local climate information (Dessai et al., 2005; Amundsen et al., 2010; Measham et al., 2011).

14.2.3. Issues and Challenges in Adapting

Adaptation is important for reducing and managing the risks associated with a changing climate. While adaptation has the potential to be mainstreamed with planning and implementation across a variety of fields, there are numerous challenges that need to be addressed in order for efforts to be successful. As discussed in the sections that

follow, among the challenges that must be overcome are scaling up, institutional mismatches, capacity and resource limitations, and the availability of data and models that support action.

14.2.3.1. Scaling Up

An ongoing challenge that nations, regions, cities and communities face is moving from ideas to action. Scaling-up in the context of climate adaptation refers to transitioning from isolated projects and activities to comprehensive initiatives. Top-down and bottom-up approaches to adaptation both have the potential to be scaled-up. The former approach can take advantage of intergovernmental coordination both within and across levels of government and the potential to bring adaptation to existing and new policies. In contrast, the latter can advance projects from one-off activities to programmatic modes of action, both within a community as well as across communities and regions, as well as through engaging diverse stakeholders in adaptation (Urwin and Jordan, 2008).

Despite the potential to transform from small-scale to widespread initiatives, scaling adaptation often requires integration with other activities. Most models of adaptation require separate plans or dedicated planning measures. A deficiency that is common to these approaches is that they separate adaptation planning and action from the ongoing work of governmental and nongovernmental actors. However, often it is not feasible for national, regional or local governments to allocate resources solely for adaptation and therefore, for dedicated initiatives to achieve widespread adoption (Huq and Reid, 2004; Handmer *et al*., 1999; Morduch and Sharma, 2002; Huq *et al*., 2003).

Rather than emphasize the distinct nature of adaptation, contemporary views of planning and scaling often are linked to notions of how to mainstream adaptation into existing plans, processes, policies, and work routines (Lemos *et al*., 2007; Agrawala and van Aalst, 2008; Ayers and Dodman, 2010; Chuku, 2010; Roberts, 2010; Preston, Westaway and Yuen, 2011). Most scholarship emphasizes the potential for mainstreaming adaptation into official development assistance (e.g., Agrawala, 2004; Ayers, 2009). However, evidence is emerging to suggest that acceptance of a climate agenda and successful preparations for climate impacts takes place when integrated into ongoing government initiatives (Nelson *et al.,* 2007; Agrawala and van Aalst, 2008; Ayers and Dodman, 2010).

14.2.3.2. Institutional Mismatches

Mainstreaming action is contingent on government ministries and departments taking a long term view of changes and challenges, integrating adaptation into their plans and agendas, and then working in a coordinated fashion to realize these ends (Conway and Shipper, 2011). However, this level of coordination can be a challenge since many of the problems and issues that will be addressed when preparing for climate impacts cut across the jurisdictions and mandates of different government bodies and actors (Schipper, 2007). For instance, despite the importance of integrating adaptation and disaster risk reduction, legislation and programs for disaster and climate management typically span multiple ministries and departments, each with their own mandates and agendas. Since disaster management focuses on preparing for emergencies and responding to disasters while adaptation emphasizes reducing long term vulnerabilities and preventing exposure to risks, their different institutional constraints, orientations, and time horizons hinder coordination (UNISDR, 2005; Schippner and Pelling, 2006; Birkmann and Teichman, 2010). In situations such as this, where there are spatial, temporal, and functional mismatches leading to lack of institutional coordination, it is difficult to fully integrate and implement action (Birkmann and Teichman, 2010; Falaleeva *et al*., 2011).

Studies of decision making across levels of government have focused on mitigation and demonstrated how local decisions are both facilitated and constrained by national level regulations, policies and institutions (Hooghe and Marks, 2003; Betsill and Bulkeley, 2004). However, there also is evidence to suggest that the extent to which national governments focus on and support adaptation can influence local level action (Urwin and Jordan, 2008). For example, a survey of Norwegian municipalities (Amundsen *et al*., 2010) found that local governments did not have a clear idea or sense of their role with regard to adaptation policies and measures. The authors conclude that the lack of familiarity with and attention to adaptation was directly related to the limited focus given to this issue by the national government. As this example suggests, national governments can establish priorities, create regulations and

policies, and allocate resources that have the potential to influence the degree to which local governments focus on and pursue adaptation.

Adaptation assessment and planning not only require action from the local to the global, but the engagement of diverse actors (Lu, 2011). Local stakeholders are knowledgeable about local issues and challenges (Li, 2002; Lane and McDonald, 2005; Crabbe and Robin, 2006; Dodman and Satterthwaite, 2008; Corfee-Morlot, 2011; Measham *et al.*, 2011). Local knowledge can complement expert views (Shackley and Deanwood, 2002) and enhance the design of adaptation strategies and policies by ensuring that they capture local realities (van Aalst et al., 2008). Engagement of local stakeholders also can lead to participation in the subsequent implementation of adaptation initiatives (Gero *et al,.* 2011). Although engaging stakeholders is important, there are institutional issues that must be overcome when implementing participatory adaptation planning. These include differences in access that different stakeholders have to participatory decision making processes (Few et al., 2007), lack of adequate and reliable mechanisms for information sharing (Lwasa, 2010), and different knowledge, values, and perspectives shaping the views and preferences of policymakers, experts, and the public (Veraat, 2010; Webb, 2011).

14.2.3.3. Financial and Capacity Limitations

Resources for adaptation have been slower to become available than for mitigation in both developed and developing countries. This has meant that there is less expertise in adaptation assessment and implementation, which is further confused by the lack of clarity about the distinction between adaptation and more common sustainable development and/or poverty reduction planning (Pew Center 2008).

Within developing countries only modest funding has been available for adaptation actions and much of this funding has been directed towards capacity building, stand alone projects or pilot programs. Least Developed Countries were supported via the GEF resources to prepare NAPAs (see section 5) prioritizing their immediate and urgent adaptation needs. However, funding to take action on these needs was slow to come and many governments were reluctant to move ahead without external support given the generally accepted responsibility of developed countries to support the incremental costs of adapting to climate change. The NAPAs were, in most countries, excellent opportunities to build technical capacity and institutional links, but with the long delays in moving to an implementation phase many of these skills dissipated.

There has been a significant increase in financial flows recently with replenishment of the GEF adaptation funds (LDCF & SCCF), support for the Pilot Program for Climate Resilience, and special purpose adaptation funds for UN Agencies, MDBs and major bi-lateral funds earmarked for adaptation. {Get citation and a table of amounts nearer completion of the Report – LDCF USD224 million; SSCF USD130 million; Adaptation Fund USD 305-408 million; PPCR USD970 million} The Adaptation Fund, which is set up under the Kyoto Protocol and funded through a levy on most CDM projects, is of particular importance to developing countries as it is pioneering the direct access mechanism which allows countries to access funds without having to work though a multi-lateral development agency. This mechanism has again bought home the need to build and maintain capacity, not just in the technical aspects of adaptation assessment and project design but also in financial management and due diligence (Brown *et al.*, 2010).

The Cancún Agreement calls on developed countries to provide new and additional resources for climate actions with USD 30 billion over the 2010-2012 period and a longer term goal of $100 billion per year by 2020, but with the share going to adaptation still undetermined. While efforts to integrate climate change adaptation will be led by developing country partners, international donors have a critical role to play in supporting such efforts as well as in integrating consideration of adaptation within their own plans and activities (OECD, 2011).

Payments required in the future for climate change will equal or dwarf those of current development expenditure (Peskett et al., 2009). Delivery channels will need to be designed to reach the poor who are also often most vulnerable to the impacts of climate change. For example, for adaptation financing, working at the sub-national level will be important and mechanisms like microfinance merit a closer look (Agrawala and Carraro, 2010). Another important concern is that with new money being made available for climate change research, policy development,

and practice, people may place too much emphasis on addressing this as an isolated priority to the detriment of other equally pressing social, economic, and environmental issues (Ziervogel and Taylor, 2008).

Capacity is not limited to finances alone, but extends to human, technological, informational, and social resources (Yohe and Tol, 2001; Adger, 2006; Eakin and Lemos, 2006; Smit and Wandel, 2006). These issues are critical capacity needs in all countries and regions, but become most pressing in local governments facing challenges at attending to ongoing needs and demands. Experience in Durban, South Africa, for example, shows that local government departments often have differing abilities to respond to climate challenges. As the city began pursuing adaptation, some departments were able to mainstream adaptation-oriented activities into their ongoing work, while others were struggling to cope with existing backlogs and to maintain business as usual and, therefore, did not have the capacity to address climate-related concerns (Roberts, 2010).

14.2.3.4. Availability of Data and Models Needed for Action

In recent years, an increasing emphasis has been placed on adaptation and the promotion of a climate risk management approach rather than on the assessment of the potential impacts of climate change (Martens *et al.*, 2009; Heinke *et al.*, 2009). The former approach involves identification and analysis of climate-related hazards and assessment of vulnerability and exposure of different elements at risk. Such a risk-based approach has been used to inform action and been incorporated in some climate change adaptation strategies, such as those adopted by the Greater London Authority (2008) and the City of Toronto (2008). In the case of Toronto, the city developed an inventory of climate vulnerabilities and risks, such as impacts and vulnerabilities expected under scenarios of hotter summers, milder winters, dryer summers, and more intense precipitation, and created an assessment and prioritization mechanism based on the probability and severity of risk (Toronto Environment Office, 2008)

A number of General Circulation Models (GCMs) have been used to predict global future climate. However, there are significant differences in downscaled climate scenarios obtained using regional dynamic downscaling model like PRECIS (UK Meteorological Office, 2007) and the statistical downscaling techniques applied in some countries (Wilby et al., 2001; Bannayan and Hoogenboom, 2008). Since reliable models are not available, considerable uncertainty remains about the magnitude of impacts at the local level. Because downscaled climate models are not available, local governments and communities often resort to scenario-building to assist in adaptation planning (Dessai et al., 2005). These scenarios need to be relevant to particular scales and timeframes in order for planners and policymakers to determine what it is they have to plan for (Amundsen et al., 2010; Measham et al., 2011).

It has been claimed that climate prediction has decreased the vulnerability of stakeholders in various contexts and for some specific situations (Sivakumar and Hansen, 2007). However, Lemos and Dilling (2007) contend that the benefits of climate forecasting are contingent on the amelioration of pre-existing social inequities. For example, decision-makers may not be able to make use of climate forecasts because of the inability to access information sources in the first place or to understand technical language and re-communicate the information to relevant, on-the-ground agencies (Lemos and Dilling, 2007). Also, an increasing emphasis on climate forecasting may displace resources for other political and human development priorities (Lemos and Dilling, 2007). To overcome the misuse of prediction, the selection of climate strategies and measures should be knowledge-based, taking local knowledge, views, and concerns into account, including those about non-climate stressors. By pursuing an integrated assessment of climate and non-climate scenarios, it is possible to gain a better understanding of future risks and vulnerability and, in turn, to develop and implement appropriate adaptation strategies (McEvoy *et al.*, 2008).

14.3. Synthesis of Adaptation Needs and Options

The recommended adaptation process is based on identifying needs that stem from climate risks and vulnerabilities, selecting options that promote adaptive capacity, and then implementing the chosen actions. The driver for adaptation stems from the threats that different systems face while action is predicated on the extent to which they are vulnerable or able to adapt. Often, identification of needs is rooted in assessments of different systems which, in turn, make it possible to generate options and determine appropriate actions.

14.3.1. Identification of Adaptation Needs

Adaptation involves building the capacity of nations, regions, cities, communities and individuals, groups to cope with climate impacts as well as mobilizing that capacity by implementing decisions and actions (Thompkins *et al.,* 2010). Adaptation requires that there is adequate information on what and how to adapt (Fussel and Klein, 2006). Consequently, the foundation for generating adaptation options and building capacity is the identification of adaptation needs. More often than not, this process of identifying needs is rooted in a formal assessment.

A number of different methods are used to assess climate risks and vulnerabilities, each having different orientations and strengths and weaknesses (Fussel and Klein, 2006). One approach is the risk-hazard framework. Drawn primarily from risk and disaster management, this approach focuses on the adverse effects that natural hazards and other climate impacts can have on a given location (Fussel and Klein, 2006). The emphasis in this approach is on the physical and biological aspects of impacts and adaptation (Burton *et al*., 2002). A second approach, which is rooted in a political economy perspective, examines the ways in which individuals, groups and communities are vulnerable to climate impacts. Here, the focus is on social vulnerability, with an emphasis on how structural factors such as institutions shape socioeconomic conditions that place human populations at risk (Blaikie *et al*., 1994; Adger and Kelly, 1999).

Adaptation policy has to be responsive to a wide variety of economic, social, political, and environmental circumstances (Burton *et al*., 2002). Therefore, a more integrated approach that has emerged that joins major elements associated with the risk-hazard and political economy perspectives (Fussel and Klein, 2006). This combination considers a range of climate impacts while placing an emphasis on the adaptive capacity of systems and populations (Heltberg *et al*., 2009). By integrating these approaches, it becomes possible to identify a broad spectrum of adaptation needs and then to draw on this information to select appropriate options.

Assessments are becoming more holistic in their consideration of risks and socio-economic systems, but they still tend to focus on specific levels government and specific sectors (Fekete *et al*., 2010), even though adaptation needs and options should account for the cross-cutting nature of climate impacts. Cross-level and cross-sector analyses offer important vantage points, but also come with some important tradeoffs. For instance, local level assessments offer detailed and often high quality information that captures complexity, but typically it is highly specific and limited in transferability. Sub-national data provides insight into large-scale patterns as well as offers insight into intermediate levels of analyses and processes. However, this level of aggregation makes it impossible to identify many vulnerabilities and validation is a challenge. Finally, national assessments are useful for allocating global funds, particularly in hazard prone regions, but there is little sensitivity to root causes (Fekete *et al*., 2010). In addition to up and down-scaling information within a given domain, moving across levels can be difficult translate when spanning natural systems, social dynamics, and institutional processes.

14.3.1.1.Institutional Needs

Institutions and institutional actors are integral to reducing vulnerability as they shape the distribution of climate risks, establish incentive structures that can promote adaptation, foster the development of adaptive capacity, and establish protocols for both making and acting on decisions (Agrawal and Perrin, 2008). At the international level, institutions and institutional actors offer adaptation resources and capacity support to developing countries. In many instances, international and national-level policies and programs can facilitate localized strategies through the creation of legal frameworks and the allocation of resources (Adger 2001; Corfee-Morlot *et al*., 2009; Bulkeley and Betsill, 2005). However, local governments have the potential to directly enhance the adaptive capacity of vulnerable areas and populations by developing regulations including those related zoning, stormwater management and building codes and attending to the needs of vulnerable populations through measures such as basic service provision and the promotion of equitable policies and plans (Adger *et al*., 2003; Nelson *et al*., 2007; Brooks *et al*., 2005). In the course of specific actions, local governments influence vulnerability and capacity by shaping access to resources and structuring individual and collective responses to climate impacts (Agrawal, 2010).

While some approaches to assessment identify institutional needs, there are four general design challenges that typically need to be addressed: adjusting to changing conditions, adopting a climate lens in ongoing activities, facilitating intergovernmental coordination, and attending to the needs of diverse stakeholders. First, institutions need to be designed so that they are flexible. The uncertainty associated with climate change and the availability of changing information and conditions, along with emerging ideas on how best to foster adaptation, requires experimentation, a willingness of governmental and nongovernmental actors to learn from both successes and mistakes, and to integrate this information into regulations, policies, plans, and ongoing activities (Gupta *et al.*, 2010; Agrawal**,** 2010).

Second, in keeping with the notion of mainstreaming, adaptation needs to become an integral aspect of policymaking, planning, and program development. Existing policies and plans may have the potential to support adaptation, but can be constrained in their ability to achieve this end. This may be the case due to misaligned instruments and timeframes within a given policy. Rather than focusing on short-term climate variability and disaster-response, government actors need to adopt a long-term perspective in order to address vulnerability reduction and promote the development of adaptive capacity (Conway and Shipper, 2011). A further issue with regard to mainstreaming adaptation into institutions is that policies that address the same issue, but at different scales, can result in conflicting aims and outcomes. An alternative is to re-calibrate existing policies and to climate proof new policies, plans and programs so that they advance adaptation planning (Urwin and Jordan, 2008).

Even if ministries or departments commit to addressing adaptation in the course of their ongoing activities, this remains a challenging issue for both national and local governments to achieve. In many instances, a single governmental body is not equipped to deal with a given climate impact while in other instances there are both gaps and overlaps in institutional mandates, conflicting time horizons, and multiple actors involved in decisions and actions (Sietz *et al.*, 2011; Hulme, 2009; Urwin and Jordan, 2008; Schipper, 2007; Adger *et al.*, 2005). As a result, a third challenge is designing institutions so that they facilitate foster coordination, communication, and cooperation (Schipper, 2007; Conway and Shipper, 2011; Agrawal, 2010). This needs to take place within levels of government, across levels of government, and both within and across sectors. Coordination and communication are central to adaptation since they not only affect efficiency and effectiveness, but influence the allocation of resources within and across governmental bodies as well as to numerous nongovernmental entities (Agrawal, 2010).

Further, in order to promote adaptive capacity, institutions need to attend to the needs of diverse stakeholders and foster means their engagement in adaptation decisions and actions. Top-down and bottom-up approaches each provide important information and views. The former can adapt existing policies and plans and establish protocols for mainstreaming adaptation into government initiatives (Urwin and Jordan, 2008). However, the latter approach offers a means for ensuring that diverse viewpoints are heard and integrated into measures in ways that enhance capacity. This not only requires that institutions are designed to encourage participation, but that they foster learning, promote the development of leadership qualities, and support fair governance principles (Gupta *et al.,* 2010).

14.3.1.2. Social Needs

Assessments of adaptation needs typically are based on existing vulnerabilities as well as those that countries and sub-national bodies face from climate change, relative to their capacity to adapt. However, even with sufficient capacity and will, there are numerous barriers to implementing adaptation. These barriers include natural, structural and institutional factors such as the inability of natural systems to adapt to the rate and magnitude of climate change and constraints associated with technology, finances, and political dynamics (Grothmann and Patt, 2005; Yohe and Tol, 2002). They also include social, cultural, and individual factors, including values, identity, cognitive denial, and behavioral opposition. While adaptation often focus on “hard” measures, such as those rooted in technology and engineering, fostering resilient settlements and societies not only means attending to basic needs such as the availability of food and water, but addressing social and psychological needs (Reser and Swim, 2011; Adger *et al.*, 2009; O’Brien, 2009; Frank, *et al.*, 2010).

Climate vulnerability is rooted in the ability of individuals and groups to cope with the impacts of climate change. At the individual level, women, the elderly, those with health challenges and disabilities, low social, minority, and class status are among the least able to cope with threats from climate impacts (Adger *et al*., 2009; Smit *et al*., 2001). These individual factors also are often associated with and compounded by community-level conditions. Many poor and ethnic minorities live in substandard housing, lack access to basic services, have compromised health, and are at threat due to excessive densities, poor access roads, and inadequate drainage (Moser and Satterthwaite, 2010; Huq *et al*., 2007; Shikanga *et al*., 2009; Kovats and Akhtar, 2008; Revi, 2009; Baker, 2011). In rural areas, adaptation needs also are linked to the viability of agricultural activity (Bosello *et al*., 2009).

In addition to social conditions, social psychological factors affect needs and adaptation capacity. For instance, based on a study of coffee farmers, Frank*, et al* (2010) found that social identity, particularly social group differentiation, ethnicity, and marginalization, shapes views of the credibility of information and perceptions of risk. These views and perceptions, in turn, affected the willingness of farmers to adapt their growing practices. Further, in a study of the response of the elderly to heat waves, Wolf, *et al* (2010), found that the bonds forged in social networks shape perceptions of vulnerability through the narratives that were communicated. Their findings suggest that vulnerability can either be reduced or enhanced, depending on the types of information that are disseminated through networks. Overall, these findings demonstrate that adaptation needs and measures are influenced by individual perceptions and social ties.

The causes and solutions of vulnerability take place at different social, geographic, and political scales (Ribot, 2010). Therefore, in order to identify critical needs of populations, and the underlying conditions giving rise to these needs, social assessments are best conducted across institutional domains and by spanning from the local to the national. Local assessments provide a means to identify existing vulnerabilities as well as policies, plans, and natural hazards contributing to these vulnerabilities. More specifically, at this level, social needs can be evaluated in terms of availability of natural, physical, human, political, and financial assets, stability of livelihood, and livelihood strategies (Moser, 2006; Heltberg *et al*., 2008). Alternatively, regional and national assessments can provide a basis for ascertaining institutional conditions associated with long-standing inequities and development paths that may need to be addressed in order to generate robust options.

Identifying pending needs requires attention to risk management. At the same time, people generally feel powerless when faced with significant threats such as climate change. Therefore, there is a need to create new institutions that address this sense of powerlessness and not only enable people to feel connected (O'Brien *et al*., 2009), but that address conditions that are entrenching socioeconomic and political inequities (Lemos and Thompkins, 2008). Technological measures are integral to protecting populations, but institutional strategies need to be pursued in order to ensure that the most vulnerable are able to cope with short and long term climate impacts (Gupta *et al*., 2010). Across levels of government, this means redesigning and implementing regulations, standards, and other institutional protocols that reduce exposure to disasters and other impacts of climate change while at the local level it means attending to basic and infrastructure services associated with development.

14.3.1.3. Physical and Infrastructure Needs

[to be developed]

14.3.1.4. Ecosystem Services and Environmental Needs

It has been observed that climate change is exacerbating the already existing adverse consequences and impacts of anthropogenic activities on the sustainability of biotic resources (Mooney *et al*., 2009, Vorosmarty *et al*., 2010).The impacts of climate change on biotic resources and their interactions may be looked at in terms of the capacity of ecosystems to deliver essential services. In order to sustain ecosystems services, there is a need for improved methods for tracking and monitoring, and modeling ecosystem changes (Davin and de Noblet-Ducoudre, 2010), better understanding of the biological processes and interactions critical in the delivery of ecosystems services, and

the creation of new tools and approaches for maintaining and restoring biological (Scholes *et al*., 2008; Mooney *et al*., 2009).

14.3.1.5. Financial and Capacity Needs

As discussed elsewhere in this Report (Sections 3.2.1.1.4 and 3.2.3.3; Chapter 17) estimating the financial needs to achieve effective and equitable adaptation to climate risks has proven a difficult task. AR4 did not provide estimates of the costs but concluded that most case studies showed high benefit cost rations for most adaptation activities. Recently, in response to the negotiations of under the UNFCC a series of estimates have emerged. These range from about USD10 billion to 40 billion per year to 'climate proof' development in developing countries (World Bank, 2006; Stern, 2006), which were revised upwards to USD80 billion and higher under revised assumptions (Oxfam, 200x) and new sectors (IIED, 2009). Two intensive studies by the UNFCCC and the World Bank came to estimates within the same range for developing countries (UNFCCC, 2007; World Bank, 2010), however often the distribution of costs across sectors differs significantly. The UNFCC estimate for the costs in developed countries was USD20 billion to USD100 billion. The core conclusion from these studies was that the costs of adaptation are of the same order of magnitude as those for mitigation although the distribution of these costs between the public and private sectors is not clear (IIED, 2009).

Capacity Section – TBC --
1) What are capacity needs; 2) Capacity development to foster bottom-up planning and (3) need have means to maintain capacity. How do you make sure capacity stays – through regional institutional capacity building; south – south practitioners networks. UNEP Report (2011) to appear soon – will build upon this. Also ACCCA 2009.

14.3.2. Options for Adapting to Climate Change

Adaptation options typically are generated in response to anticipated climate impacts identified in risk and vulnerability assessments. Selecting specific adaptation options can be challenging due to the rate, uncertainty, and cumulative impacts of climate change, as well as the political, economic, and social issues that come into play, there are general strategies that can be used to guide the selection of measures. One approach is to select ''no-regret'' strategies. Often referred to as win-win, measures such as climate-proofing buildings and repairing leaks in water pipes produce desired benefits or outcomes whether regardless of whether climate impacts occur. A second option is to pursue flexible strategies that allow for adjustments as the climate changes. Incorporating ''safety margins'', such as building higher sea walls or greater storm drainage capacity, is a third strategy that can be pursued when selecting adaptation options. This latter approach is well-suited to new capital investments in areas such as infrastructure that are expected to be in place for a long duration (Hallegatte, 2009).

Different stakeholders have varying sensitivity to climate impacts and therefore, use different criteria for selecting adaptation options. It has been observed that criteria-based evaluation is more objective than pure expert judgment (Martens *et al*., 2009). Further, while technological solutions may directly address particular impacts, policy, informational, and other "soft" measures also are important (Martens *et al*., 2009). While the selection of adaptation measures must account for different stakeholder perceptions in light of the potential to reduce vulnerability, other factors that should be considered are cost effectiveness, equity, co-benefits, environmental impacts, sustainability, potential for upscaling and community acceptance (Martens *et al*, 2009). Integrated assessments that support consideration of multiple factors require the combined use of climate models, climate and non-climate scenario analysis, and systematic participatory approaches that solicit active involvement of diverse stakeholders in the decision-making process. Moreover, integrated assessment also involves sound economic valuation techniques, tradeoff analysis, and procedure to incorporate risk attitudes, and perceptions in decision-making (Martens, 2006; Kemp and Martens, 2007; Wilbanks and Sathaye, 2007).

Many options for adaptation can achieve important co-benefits. For instance economic development policies and strategies related to improvements in the management of water and governance of natural resources, the development of water, transportation, and communication infrastructure, and the promotion of credit and insurance

services can promote economic development, increase adaptive capacity and reduce the impact of climate change on the poor (Hertel, Rosch, 2010). Further, while adaptation activities often are developed and implemented in an *ad-hoc* fashion (Ahmed and Fajger, 2009), the potential exists to capitalize on complementarities and synergies by deriving them from and linking them to existing policies and management activities. Although existing options provide a foundation on which to build and help to normalize adaptation (Dovers, 2009), given the presence of uncertainty and need for adaptive management, it is important that the assessment and selection processes consider a range of stressors and management options (Moore *et al*., 2001).

The specific measures employed often are referred to as soft and hard. As discussed below, those in the former category include institutional and social measures while those in the latter category tend to be those that rely on technological and engineering solutions. It is important to note, however, that not all technological solutions are 'hard', as for example some of the changes in agricultural practice based on early warning systems and modeling. Ecosystem-based adaptation, such as the maintenance of wetlands that protect against storm surges, or floodways to manage extreme flows are often considered to be 'soft' measures, but are often linked with 'hard' measures such as levies, drainage and silt-trapping structures (CBD AHTEG 2009).

14.3.2.1. Institutional and Social Options

Numerous institutional measures can be used to foster adaptation. These range from financial instruments such as taxes, subsidies and insurance arrangements to social policies, to regulatory instruments such as building codes and land use plans (Hallegatte, 2009; Heltberg *et al.,* 2009; de Bruin *et al*., 2009). Informational strategies such as early warning systems, education programs, and dissemination of climate information are integral to adaptation as are measures designed to protect populations such as relocation and evacuation schemes. Numerous ctivities designed to account for changing weather and precipitation patterns are taking place in many nations. However, as previously noted, to ensure that that institutions provide an appropriate context for action, efforts must be made to coordinate across agencies and departments (Schipper, 2007; Conway and Shipper, 2011; Agrawal, 2010) and to account for stakeholder views and preferences while fostering widespread commitment and engagement (van Aalst *et* al., 2008; Few, *et* al., 2007; *Gero et al.,* 2011).

An institutional measure that provides support to the most vulnerable populations is social safety nets. For example, long-term and child malnutrition have been associated with reduced adult earnings (Hoddinott, et al., 2008; Alderman, et al, 2009). Malnutrition often results from extreme weather events, particularly floods and droughts, as both can alter the price or availability of food. While some studies have shown that food programs can be counterproductive to promoting livelihood or may not prevent malnutrition in nonemergency situations (e.g., Bhutta, et al., 2008), programs designed to provide support at times of extreme events can provide an important bridge for vulnerable populations (Alderman, et al, 2010). Responding to disasters is important, but so too are anticipatory initiatives. Pro-poor measures that foster health, nutrition, and education are no-regrets approaches that can promote development while enhancing adaptive capacity (Heltberg *et al.,* 2009).

Institutional approaches are associated with governance measures. Governance refers to the inclusion of diverse stakeholders in planning and implementation. In general, governance rests on the promotion of democratic and participatory principles as well as on ensuring access to information, knowledge, and networks. The basic premise is that robust governance measures can promote adaptation by building adaptive capacity (Adger *et al*., 2009). This argument is reflected in assessment of river-basin planning in Brazil, where Engle and Lemos (2010) found that governance mechanisms overall did enhance adaptive capacity. However, they also note that this is not a simple relationship as tradeoffs exist between different aspects of governance that can make some approaches more or less appropriate for given contexts.

14.3.2.2. Technological and Engineered Adaptations

Technological adaptation measures in various sectors are being developed based on available knowledge and recent advances in science and technology. In food and agriculture sector, for example, a suite of adaptation options are

developed and applied to reduce the adverse impacts of climate change on crop production. Wassmann *et al*. (2010) have presented some adaptation measures in rice production. The alternate wetting and drying technology has been shown to significantly improve water use efficiency and has also reduced methane emissions from rice fields. Sub1 rice variety which is being tested in several regions in Asia have been demonstrated to be flood-tolerant which can withstand prolonged submergence with no significant yield reduction. Other 'hard' adaptation measures in this sector include innovations in good agricultural practices (GAPs) in several areas such as adjusting the cropping calendar based on rainfall distribution or on simulated yield probabilities using process-based crop models under a downscaled climate scenarios (Semenov, 2006; Semenov, 2008; Bannayan and Hoogenboom, 2008).

There are repeated calls for technology transfer to and sharing between developing countries in adaptation to match the programs associated with mitigation. However, the circumstances are different. Unlike mitigation, where low-carbon technologies are often new and protected by patents held in developed countries, in adaptation the technologies are often familiar although often applied elsewhere or differently. For example, agricultural practices that are well known in a region some distance away may now be applicable but unfamiliar within a region of interest.

There are some technologies that are likely to become more important in adapting to climate change. Improved water transport and application through irrigation, or through water use efficiencies in industry all have particular technologies that need to be more widely available, as will desalination technologies. Revised building codes are another important opportunity to increase resilience to climate impacts, but again institutional issues such as enforcement are just as important.

14.3.2.3. Ecosystem-Based Adaptation

Climate change is altering ecological systems, biodiversity conservation, and resources associated with ecosystem services (Hoegh-Guldberg, 2011; Mooney *et al.,* 2009). These systems not only are important for their own sake, but because they contribute to human welfare on prosperity in the face of a changing climate. For instance, coastal wetlands and coral reefs can help to protect against rising sea level (Hoegh-Guldberg, 2011) while the maintenance of wetlands and green spaces can control run-off and flooding associated with increases in precipitation (Mooney *et al*., 2009; Jentsch and Beierkuhnlein, 2008). Consequently, there is a need to protect these systems and resources (Carpenter *et al*.2009).

There are a number of options for ecosystem-based adaptation. In addition to policy and planning options, these include integrative adaptive forest management (Bolte *et al*., 2009; Guariguata, 2009), the inclusion of climate change risk management and adaptation in ARD activities (Reyer *et al*., 2009), land and water protection and management, and direct species management (Mawdsley *et al*., 2009). Often, an emphasis is placed on technological and engineered approaches to adaptation. However, working with nature's capacity and pursing ecological options, such as coastal and wetland maintenance and restoration, to absorb or control the impact of climate change in urban and rural areas can be efficient and effective means of adapting (Huntjens *et al*., 2010).

Ecosystem-based adaptation measures are needed to enhance the capacity of natural systems to deliver sustainable ecological services. This requires more detailed analysis of the biological processes and underpinnings related to delivery of ecosystem services. In addition, the degree of uncertainty associated with projected impacts require new modeling tools and approaches, including those that combine biophysical models with socio-economic models to better understand and predict changes under various climate change scenarios and account for coupled natural and social systems (Challinor et al., 2009).

14.4. Actors and Roles in Adaptation

Climate adaptation requires the engagement of governmental, nongovernmental, and private sector actors across levels and sectors. The identification of diverse needs, generation of appropriate options, and successful implementation of adaptation measures is predicated on diverse actors contributing their views, ideas, and expertise.

14.4.1. Local Actors and Roles

14.4.1.1. Local Governments

Local governments are integral and critical actors in advancing adaptation and in shaping the options identified and selected. As institutional actors, they influence the distribution of climate risks, mediate between levels of government as well as between social and political processes, and they establish incentive structures that affect both individual and collective action at all levels (Agrawal and Perrin, 2008). As a result, local governments have the potential to strengthen the capacity of both the urban and rural poor through the acquisition and distribution of finances, knowledge and information, skills, training, and technological support (Agrawal and Perrin, 2008)

Local governments consist of elected officials as well as individuals who work in government agencies and departments, all of whom have the potential to thwart adaptation initiatives as well as to contribute to the formalization and institutionalization of adaptation initiatives. Critical to both caretaker and facilitation roles are the implementation of national mandates and the development of dedicated local policies. In addition to advancing policies, these individuals are in a pivotal position to promote widespread support for adaptation initiatives, foster intergovernmental coordination, and facilitate implementation, both directly and through mainstreaming into ongoing planning and work activities (Carmin *et al.*, forthcoming; Anguelovski and Carmin, 2011).

Despite the critical role they play, local governments, particularly those in developing countries, are faced with numerous challenges that limit their ability to identify needs and pursue adaptation options. Often, these governments must attend to backlogs of basic and critical services such as housing and water supply or focus their attention on addressing outmoded and outdated infrastructure. They also may lack institutional capacity or have difficulty gaining coordination among departments as conflicts emerge to obtain scarce resources (Dodman *et al.*, 2009; Hardoy and Romero Lankao, 2011). Attending to each and every one of these issues may be integral to advancing adaptation. However, government representatives may encounter roadblocks both from within their communities as well as from other levels of government in setting priorities, obtaining and allocating resources, and engaging in coordinated action if attention is oriented to adaptation rather than away from stated priorities.

Although they may encounter challenges, Roberts (2008) suggests that there are a number of indicators that demonstrate whether local government has institutionalized and mainstreamed adaptation. Specifically, she suggests that these include the presence of an identifiable champion from within government, climate change being an explicit issue in municipal plans, resources are dedicated to adaptation, and adaptation is incorporated into local political and administrative decision making (Roberts, 2008).

14.4.1.2. Households

As adaptation is local in nature, households play an important role in responding to climate impacts. At the farm level, for example, decision-making on farm activities and operations are made at the household level, and community or group of households. The identification of adaptation measures often involve household members including women and children (Sivakumar and Hansen, 2007; Sivakumar and Motha, 2007). Climate adaptation measures in this context consist of innovations to existing farm practices and operations from land preparation, crop and livestock management, harvesting and marketing. Adjusting the planting date is usually among the first decision to be made based on available knowledge and and information (Lansigan *et al.*, 2007).

14.4.1.3. Indigenous Peoples

Indigenous actors can contribute in important ways to adaptation. In most regions of the world, indigenous knowledge exists about how and when to respond to climate change and climate variability. Alexander et al. (2011) noted that the complementarities between traditional ecological knowledge and scientific information include an

increased ability to translate indigenous narratives to reflect patterns of regional change and the ability to produce expanded and multidimensional pictures of climate change impacts based in the context of human landscapes (Alexander et al., 2011). For example, indigenous knowledge on climate adaptation in farming operations has been transferred from generation to generation and ranges from activities associated with land preparation to those regarding harvesting methods (Sivakumar and Hansen, 2007). Furthermore, in Southeast Asia, the practice of rice terracing in sloping and fragile mountainous ecosystems have been practiced since time immemorial (Sivakumar and Hasen, 2007; Sivakumar and Motha, 2007). The choice of crops to plant during a dry or wet year has been found to be successful in reducing the adverse impacts of climate change and variability (Lansigan *et al*., 2007).

In addition to drawing on their traditional knowledge of adaptation measures, indigenous actors can be engaged by regional and local governments to support and advance adaptation initiatives. For instance, agro-pastoralists in Makueni District, Kenya are involved in monitoring, assessing, and adapting to the effects of drought through observing local weather and wildlife behavior signs (Speranza et al., 2010). In this case, indigenous peoples assess changes on the land in tandem with projection information from regional and ecosystem level climate models. Indigenous assessments are crucial for adding locally relevant climate impact information. However, because of preexisting poverty-related resource and capacity limitations, many indigenous communities continue to encounter difficulty in successfully implementing adaptation strategies (Speranza et al., 2010).

14.4.1.4. Local Communities

Many communities pursuing adaptation are engaging community-based, civil society, and nongovernmental organizations in planning and implementation. One approach that relies extensively on communities and community organizations is community-based adaptation (CBA). CBA is characterized by the engagement of local residents in exercises designed to identify measures that can reduce vulnerability while building local adaptation capacity. CBA can both engage as well as empower residents to plan for and take action to address the impacts of climate change (Reid *et al*., 2010; Ebi, 2008), but it relies on participatory processes and not only considers hazard prone areas, issues in service delivery, and gaps in infrastructure, but often attends to local social and cultural norms as a means to take a holistic approach to reducing vulnerability (Ayers and Forsyth, 2009). The outputs of these processes have included numerous recommendations and plans of action, including the design and implementation of early warning systems, infrastructure development, and improvements in service delivery (Ensor and Berger, 2009; Douglas *et al*., 2008).

Communities have a long history of participating in vulnerability assessments and risk-mapping in the context of disaster risk reduction (Yamin *et al*., 2005; Larsen and Gunnarsson-Östling, 2009). Many of these ideas and methods have carried over into adaptation initiatives as a means to identify climate-related hazards and risks (Van Aalst *et al*., 2008). For instance, CBA has been adopted in the Philippines and Bangladesh to plan for flood reduction and disaster management (Ensor and Berger, 2009) as well as in cities such as Durban where local communities are engaged in climate risk assessments and adaptation planning (Carmin *et al*., forthcoming). These activities are designed to foster the transition from assessment to planning to implementation and, in the process, to sensitize communities to climate-related issues while promoting wide-spread adaptation action.

Community members also can contribute to local knowledge in support of government initiatives. For instance, in efforts to address climate adaptation and sustainable resource management needs, local residents from the southwest Yukon in Canada supported forest management plans by providing input on strategic benchmarks and design of appropriate harvest activities (Ogden and Innes, 2009). Community engagement also has been used by governments to ensure that local needs are. One example is the Government of Fiji which introduced a provision for including disaster-affected communities in disaster assessments. Responsibility for surveying and assessing damage was delegated to the affected communities. The information that was collected was then used to inform the design of disaster response and recovery programs (Meheux et al., 2010).

14.4.1.5. Local Civil Society and Nongovernmental Organizations

Civil society actors, including NGOs and community-based organizations, also contribute to adaptation, both through dedicated initiatives as well as in the course of their ongoing work. NGOs have the potential to support government action as well as to take independent action that facilitates adaptation beyond government programs. Some programs are initiated by governments. For instance, in Quito, local NGOs receive funding from the government to train indigenous farmers to improve water resource management, particularly in the context of urban agriculture, diversify crops and privilege those that are native, and replant native tree species in hillside areas. The NGOs also work with indigenous communities, teaching them to monitor variations in rainfall and flows from local rivers and then sharing that data with municipal staff so that tracking of water levels is up-to-date (Carmin *et al.*, forthcoming; Anguelovski and Carmin, 2011).

Some programs are initiated by governments, while others originate from NGOs and CBOs. Cameroon, for example, has low adaptive capacity with limited ties within and across levels of government. While many government departments had limited awareness and were taking little to no action on climate change, Brown *et al.* (2010), found that NGOs and other civil society organizations contributed to government capacity. In particular, they found that while many NGOs working at the local level focus on sustainable development rather than climate change, organizational representatives took advantage of the synergies in these two areas and were helping local residents prepare for climate impacts (Brown *et al.*, 2010). As this example suggests, civil society actors can contribute to the capacity of local governments and foster mainstreaming by supporting and promoting adaptation activities (Brown, 2010; Carmin *et al.*, forthcoming).

14.4.2. District, State, and National Actors and Roles

14.4.2.1. District, State, and National Governments

Governments at all levels play important roles in advancing adaptation and in enhancing the adaptive capacity and resilience of diverse stakeholder groups. National governments are integral to advancing an adaptation agenda as they can develop regulations and provide policy direction to district, state, and local governments. Drawing on an analysis of published articles, Berrang-Ford, *et al.* (2011) found that upper levels of government, particularly national governments often used institutional mechanisms such as laws and policies to foster adaptation. In some instance financial support was made available, particularly where adaptation was taking place at the national level. In addition, the engagement of national government actors can help mobilize political will, support the creation and maintenance of climate research institutions, establish horizontal networks that promote information sharing (Westerhoff et al., 2011) and, in some cases, facilitate the coordination of budgets and financing mechanisms (Alam et al., 2011; Kalame et al., 2011). Although there are general trends in the impact that national actors have on adaptation efforts, there also are differences in developed and developing countries. Among the key differences noted are that higher income countries are more likely to include governmental engagement in planning and implementation, focus on non-resource-based sectors, pursue long-term planning processes that include activities such as building partnerships and research, and rely on institutional, governmental, and guideline-based protocols (Berrang-Ford, et al 2011).

14.4.2.2. National Civil Society and Nongovernmental Organizations

Civil society and nongovernmental organizations play critical roles in the climate adaptation agenda at different levels of social hierarchy. CSOs and NGOs can fill roles associated with monitoring and evaluation, be instrumental in information dissemination and awareness-raising, and stimulate individual and collective climate adaptation actions (Martens *et al.*, 2009). They also can serve as catalysts and facilitators. For instance, while many government departments in Cameroon had limited awareness and were taking little to no action on climate change, Brown *et al.* (2010) found that NGOs and other CSOs contributed to national government capacity by enhancing the ability to respond to new international policies, particularly with respect to climate change and forests.

14.4.2.3. Private Sector

The role of the private sector is fundamental in delivering adaptive changes. Most often, the focus falls on the role of the private financial sector in providing risk management options, including insurance and finance for large projects (see Chpt 15). However, the delivery of adaptation actions ranges more widely and spans different types of private enterprise, from small farmers, to SMEs to multinational companies. As suggested by Figure 14-1, **t**here are three general ways in which the private sector can become involved in adaptation (Khattri, *et al.,* 2010). The first, internal risk management is critical to firms and enterprises protecting their own interests and ensuring continuity. The second form of involvement is recognizing that business is a stakeholder and therefore, participates in public sector and civil society initiatives. One example of this type of engagement was the adaptation planning process in New York City. As part of the initiative, The New York City Panel on Climate Change was established and consisted of diverse stakeholders, including scientific experts and representatives from the private sector. In addition, the New York City Climate Change Adaptation Task Force, consisting of representatives from government agencies and the private sector was formed (Rosenzweig *et al*., 2011).

[INSERT FIGURE 14-1 HERE
Figure 14-1: A typology of private sector engagement in adaptation (Khattri et al., 2010).]

Climate adaptation also provides new opportunities to the business community. In addition to fostering cooperation across government departments, relationships and partnerships with the private sector and NGOs can help to promote climate resilience and build the adaptive capacity of the urban poor. In an assessment of business potential in the context of adaptation, Khattri *et al* (2010) concluded that there were a wide range of opportunities. In addition to financial instruments and risk management, they noted options for working in the healthcare, waste and water management, sanitation, housing, energy, and information sectors (Khattri *et al.,* 2010). The opportunities were based on their assessment of income potential in combination with enhancing adaptation in particular sectors as well as in building the capacity of the urban poor.

Despite some examples of private section engagement in adaptation, most assessments conclude that action in each in each of the potential arenas has been slow to emerge (Intellecap, 2010; UN Global Compact *et al*., 2011). Most of the private sector appears to be unaware of the scale of the threat and opportunities for their businesses or are awaiting further guidance and action by governments. They have trouble in accessing and applying information on the extent of the threats and impacts from climate change and have yet to engage in the detailed cost benefit analysis of adaptive actions. Also, there are still questions of whether and how adaptation finance should be made available to the private sector in developing countries (IFC cite to come).

14.4.2.4. International Organizations and Institutions

International organizations and institutions include intergovernmental organizations, multilateral and bilateral agencies, multinational corporations, and nongovernmental organizations. These actors engage in a variety of activities that affect adaptation at the international, national, and local levels. Among the roles played by intergovernmental organizations is the formation of treaties and agreements and creation of international funding mechanisms. For instance, the Adaptation Fund and the Nairobi Work Programme, among others, are international institutions designed to facilitate adaptation at the national and regional levels (Ayers, 2009; Ayers and Huq, 2009; Flam and Skjaerseth, 2009; Hardee and Mutunga, 2009; Kalame *et al*., 2011; Lu, 2011). Multilateral and bilateral agencies typically focus on the provision of development assistance and the creation and implementation of capacity building programs. Through these efforts, agencies allocate funds, transmit information, and disseminate technology.

International NGOs, particularly international development, aid, and humanitarian organizations, have long histories of working on adaptation-related activities. Organizations such as CARE and Red Cross/Red Crescent work directly with communities to plan for water and sanitation as well as offer educational programs designed to provide information about climate risks (Suarez *et al*., 2008). Numerous development organizations work on issues related

to livelihood. Development initiatives not only have the potential to address poverty alleviation, but can reduce vulnerability by promoting adaptive capacity (Burton *et al*., 2002; Huq *et al*., 2003). As a number of studies show, while these activities may be oriented to promoting rural livelihoods in the context of environmental and development projects, they have co-benefits of building local capacity and promoting adaptive responses that enable communities to be better prepared to cope with climate impacts (Rojas Blanco, 2006; Pouliotte, 2009).

14.5. International, National, and Sectoral Assessments

[Need introduction on purposes and types of assessments. Should there be a section on the frameworks etc and process of assessment?]

14.5.1. National Communications to the UNFCCC

Under the Convention, all Parties are encouraged (Annex 1 countries are required) to report on their activities in relation to "vulnerability assessment, climate change impacts and adaptation measures" (FCCC/CP/1999/7). Parties are encouraged to use the IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations (Carter et al 1994) and the UNEP Handbook on Methods for Climate Change Impacts Assessment and Adaptation Strategies. Annex 1 countries are due to submit their 6th Communications by 2014 and most non-Annex1 countries have submitted at least one Communication and some their second.

Non-Annex I Parties are encouraged to provide information their vulnerability to the impacts of climate change in key vulnerable areas and, to the extent possible, an evaluation of strategies and measures for adapting to climate change in key areas. The UNFCCC model for dealing with adaptation was to follow three phases; (i) identifying possible impacts and options; (ii) measures to increase capacity; and (iii) measures to facilitate adaptation. There has been concern whether the National Communications within developing countries are sufficiently well supported and frequent to move through these stages as quickly as now appears necessary (Burton *et al*. 2002).

A stronger indicator of an increased recognition of the need for adaptation actions is the increase in its inclusion in Poverty Reduction Strategy Papers (PRSP) that are prepared by developing countries through a participatory process involving domestic stakeholders as well as development partners. PRSPs describe the country's macroeconomic, structural and social policies and programs over a three-year or longer horizon to promote broad-based growth and reduce poverty, as well as associated financing needs and sources. However, there is still an opportunity for better integration of the PRSPs with NAPAs and, in the future, presumably with the NAPs (Kramer 2007).

TBC
FINADAPT (Carter, 2007)
UKCIP
Australia (Australian Govt, 2005)

14.5.2. National Adaptation Plans of Action

Established in 2001, the National Adaptation Programme of Action (NAPA) is an organised planning process for adaptation (Ciplet *et al*., in press). By allowing Least Developed Countries to identify priority actions regarding adaptation to climate change, a 'new approach' is being created that would focus on enhancing adaptive capacity to climate variability. This would help address the adverse effects of climate change (UNFCC website). As of November 2010, the date of submission by Nepal of its NAPA, forty-five NAPAs were received by the UNFCCC Secretariat.

In terms of sectoral priority, it appears that food security, terrestrial ecosystems and water resources are respectively the three sectors that gather the highest number of projects, amounting to a little more than 50% of them. The importance of 'food security' is confirmed by its rank in the priorities of the different states: it constitutes 26.7% of

all the priorities (ranked number one). In this same category, 'come just after early warning and disaster management' comes after (15.5%), and, at equal level, just before, in third position, ex-aequo 'cross-sectoral' and 'water resources' (13.3%).

14.5.2.1. Barriers to Implementation

Countries refer to several elements that could hinder the implementation of the priority projects defined in the NAPAs. Although some of them are particular to a specific national situation, these barriers can be gathered under four main headings: the lack of financial resources, the shortage of human resources, a lack of strong institutional framework, a low awareness of the population as well as of policy-makers.

Least Developed Countries (LDCs) are characterized by a state of poverty that not only increases their populations' vulnerability but also makes financial capacity one of the central problems that surrounds the implementation of environment-related measures. This situation has sometimes been worsened by a 'post-conflict situation', 'conflict', or political instability, which is clearly identified by some countries (respectively Liberia, 6, Afghanistan, 77 and Haiti) as additional barriers to implementation. One consequence, recurrently stated as a crucial hindrance by the NAPAs, is the lack of financial resources and therefore 'inadequate funding' for the identified projects (Eritrea, p.9). This often implies the lack of internal capacity of funding faced by most countries. Gambia, for instance, notes that **'**debt payments exceeding 35 per cent of national budget create a difficult environment for financing social investments that could complement and further reduce vulnerability to climate change.' (.34). This financial risk also refers to issues such as the possibility of 'overstretched' donors' funding, allocated to other priorities (cited by Afghanistan, 77), weak financial resources of the NGOs, local communities and professional organisations (Togo, 43), and the difficulty that countries have in obtaining funds (as evoked by Comoros and Mauritania).

A second crucial concern appears to be a lack of human resources/ capacity. At a first level, several countries do not have the tools to know exactly the vulnerability and risks across their territories (case of the Solomon Islands) or a specific agency responsible for climate change (case of the Lao People's Democratic Republic). Beyond that, data is missing in other related sectors, such as health and water (Solomon Islands, 23). Tuvalu notes that this 'lack of appropriate tools, knowledge and methodologies both at the technical and grassroots levels' will hamper the setting up of adaptation actions at the local level (Tuvalu, 35). These actions will be all the more difficult to launch as poor infrastructure is seen as a barrier in several countries: making some areas less reachable, it also makes it difficult to deliver farm inputs and access markets (Malawi, 5; Tanzania, 20). Yet, in some cases, its cost may exceed this of some adaptation projects (Liberia, 6; Sudan, 8). At a second level, poverty and weak education in rural areas have been seen by some countries as possible hindrances to implementation of the NAPAs, notably because of their impact on the success of technology transfer at a local level (Madagascar, 10; Malawi, 5).

Nepal explains the weakness of the state in fulfilling what its NAPA calls 'development functions' by the political transition that it has undergone, which explains a 'weak governance' (Nepal, 31). However, other states also identify the overcoming of possible 'institutional weaknesses' (Comoros, 42) as necessary to secure the implementation of the NAPAs. These institutional issues have been specified as: a lack of institutional coordination 'in the implementation of development projects and Multilateral Environmental Agreements' because of 'unclear legal frameworks' (Eritrea, 9), a lack of coordination between institutions dealing with environmental issues (Haiti, 19), and, as inadequate or missing links between ministries and line departments on the one hand, and 'federal and regional sector offices involved in environment and development' on the other hand (Ethiopia, 7). To a large extent, (de)coordination between the sectors concerned by climate change is a potential barrier to the implementation of the NAPAs (Lao PDR, 40). Another kind of institutional issue rests in the presence of gaps in legal frameworks of many countries. This ranges from the absence of environmental law (case of Tuvalu) to the lack of more sectoral law and clear 'institutional mandates' (Kiribati, 9), and their obsolescence in relation to Multilateral Environment Agreements (Mauritania, 23). Finally, there is a need to further mainstream environmental and adaptation issues into other national, notably development, policies.

Whereas institutional problems concern the government first, the lack of awareness and knowledge of climate change issues concerns policy-makers as much as local communities. A third important barrier is the fact that

climate change is a relatively new problem for many (Tuvalu, 35). For many countries, it consequently seems that substantial efforts need to be deployed in order to make the governing leaders as well as the governed people understand the environmental problems motivating the NAPAs. Djibouti's NAPA outlines, for instance, that the country does not have an orientation or advisory body to guide policy-makers and the people (Djibouti, 44). A risk that exists is that 'ministries and decision makers may discount climate change as a contributing factor to observed environmental changes' (Kiribati, 25). On the other hand, being more aware of the nature of climatic events would enable the government and the people to anticipate it better (Djibouti identifies anticipation as the hardest and most expensive task, 43). An effort of global sensitization to climate change is thus important. Potential solutions would involve: the dissemination of information, such as the IPCC reports and assessments, which can be distributed to the government and its bodies (Kiribati, 25), possibly devising new outreach mechanisms targeting local communities (Ethiopia, 7) and 'awareness programmes' that would take into account 'cultural sensitivities' (Solomon Islands, 23). Indeed, as a less often mentioned barrier, cultural values can nonetheless have an influence on the implementation of the NAPAs. As an example, Tuvalu considers the 'religious misconception of the sea level rise' to be a barrier for their country (Tuvalu, 35).

In view of these potential barriers, several recommendations were explicitly made and emphasized the need for:

- External funding (Kiribati, 25; Rwanda, 8)
- 'Clear rules of participation (roles/responsibilities/benefits)' and 'government commitment' (Gambia, p.34)
- Strengthening human resources at all levels (Rwanda, 8)
- Mainstreaming NAPAs into relevant sectors and national strategies (Ethiopia, 37; Chad, 10) and increasing their coordination
- Involving journalists in diffusing information about climate change and draft an action plan on this topic for the media(Chad, 10)
- Devising a 'social discourse' targeting stakeholders and **'**demonstrating a willingness to learn and flexibility in approach' (Gambia, 34)

In conclusion, the section on barriers to implementation stresses that many efforts to carry out the NAPAs objectives and priority projects remain to be done. A strong political commitment and concrete support are still needed –as Kiribati defines it succinctly: a mental, institutional and financial preparation (Kiribati, 25).

14.5.2.2. Implementation

NAPAs sets and defines priority projects to be subsequently implemented by the states that produced them. Yet, only around 30% of the NAPAs dedicate a specific paragraph on an implementation strategy or framework[1], while a little more than 20% of them have general implementation arrangements detailed.[2] From this, several observations can be drawn: the fact that the long-term role and impact of NAPAs are often not clearly defined, that the execution of the projects tend to be still very centralized and state-based and that the roles and responsibilities of non-state actors, notably NGOs, tend to be unclear. Some problems were identified (notably regarding actor's technical capacity and funding), which did not prevent some countries to devise elaborate and innovative strategies.

[INSERT FOOTNOTE 1 HERE: These countries are Bhutan, Comoros, Djibouti, Lesotho, Malawi, Maldives, Nepal, Samoa, Sao Tome E Principe, Senegal, Solomon Islands, Tanzania, and Uganda.]

[INSERT FOOTNOTE 2 HERE: These countries are Burundi, Cape Verde, Gambia, Guinea, Haiti, Kiribati, Lao PDR, Mali, Mauritania, and Tuvalu.]

A few countries only explicitly consider the long-term dimension of the NAPAs and their use for future adaptation planning. As one of them, Samoa envisages that '(in) the long term, it is envisaged that the NAPA will continue to serve as the country's national adaptation programme' (Samoa, 66).

Regarding the inclusion of non-state actors in the implementation process, one observes a marked heterogeneity between the NAPAs. Lists of involved actors are more or less exhaustive, ranging from several pages consecrated? to a very detailed assignation of roles (in the case of Nepal) to the absence of mention of NGOs, communities or

civil society in the implementation of the first three priority projects (in the case, for instance, of Liberia, Ethiopia and the Central African Republic[3]). Actors assisting in the implementation of NAPAs or directly responsible for it have been identified as NGOs, CBOs, civil society, local communities and local governments and, to a lesser extent, research institutions, the private sector, media, UN agencies, etc. Yet it seems that these local actors are often not clearly identified: as a particularly noteworthy example of the vagueness of local actors, Lao PDR's NAPA states that in the first three priority projects, ministries and governmental offices as implementing agencies will receive the support of 'relevant organisations' (Lao PDR, 45) 'relevant agencies' (Lao PDR, 46) and 'related agencies' (Lao PDR, 47). The first priority project of Gambia evokes 'stakeholders' (Gambia, 61).

[INSERT FOOTNOTE 3 HERE: In the last case, the first priority project specifies only that the 'Réseau des organes communautaires d'éco-développement du site.' will be associated.' (p.55)]

In the same line, a minority of NAPAs clearly demonstrate a consciousness of the importance of the involvement of local communities, civil society, and NGOs. Furthermore, the projects tend to overlook the role of rural institutions, whether in terms of consultation or coordination (Agrawal and Perrin, 2008). A relative exception to this is Gambia, which stresses the fact that '(effective) partnerships are vital to the successful implementation of priority adaptation activities' (Gambia, 4), an idea explicitly supported by Lesotho, which notes that '(implementation) of NAPA will require active participation of all stakeholders (Lesotho, 17-18). In this respect, it is interesting to point out the mentioning of NGOs as the main implementing partners by Djibouti (Djibouti, 50), along with its mentioning of women and children as defined vulnerable groups to keep in mind in the selection of actions to be implemented. The Democratic Republic of Congo further develops the importance of '*groupe cible'* and the participation of local communities. One particularity, one section of its first priority project is dedicated to target groups and emphasizes the need to mobilize as many actors as possible from the whole range of civil society (DRC, 55). Sao Tome E Principe also stresses the need to implement 'in narrow collaboration and cooperation with the vulnerable communities.' (Sao Tome E Principe, 31), while Afghanistan acknowledges the importance of 'community participation' for the success of the projects (Afghanistan, 82).

In terms of role definitions between actors, one can see that, if defined, these definitions change from one NAPA to the other. Several NAPAs mention NGOs as implementing actors; however, roles of non-state actors seem to be often ill-defined. For example, Cape Verde is content with stating that '(many) institutions (…) should be involved in the NAPA implementation.' and lists them (Cape Verde, 19) without defining the role of each actor project by project. One result of this could be that, globally, the observation made by Agrawal and Perrin in 2008 that the projects tend to build the capacity of national governments and agencies rather than local actors and local institutions seems to remain valid (Agrawal and Perrin, 2008). On the other side of the spectrum, Nepal's NAPA delineates clear responsibilities not only for the Ministry of Environment and the Climate Change Program Coordination and Monitoring Unit, but also for each level of competency: the central, the project and the local levels. Djibouti and Gambia also define national, regional, and local/community levels of competency, and Lesotho assigns to NGOs an additional role of advocacy and awareness-building on adaptation needs (Lesotho. 18). In the same line, and again an exception, Senegal differentiates itself by highlighting its '*approche communautaire'*: guided by a team. Populations themselves will be in charge of implementation (Senegal, 49). Particularly noteworthy, it also notes the need to give a sense of responsibility to local communities through local committees who, managing the projects, will link populations to a national committee (Senegal, 61).

Comoros and Tuvalu underline some potential issues that may account for the difficulty in involving local actors and institutions during the implementation of the projects. They have been mentioned the actors' lack of technical ability, the lack of experience, the difficulty of new decentralised institutions in having substantial means, the difficulty in getting the necessary resources in time (Comoros, 63), and the lack of tools, knowledge and methodologies, already referred in the paragraph on 'barriers to implementation' (Tuvalu, 35).

In several cases, the fact that implementation sections mention a search for funds highlights another problem faced by many countries: funding7. So far, the NAPAs projects have not been substantially financed, which, according to LDC delegates, adds to the hindrances posed by the access procedures to LDCF funding and by slow funding (Ciplet *et al.*, in press). This partly explains why several NAPAs, such as the Uganda's, Sao Tome E Principe's, Guinea's, Samoa's express their will to launch consultations and meetings with potential donors and partners of development

or stress the common efforts needed to reach a satisfactory financial situation. To note, the Maldives suggests a 'special interagency task force' dedicated to 'ensure the respective agencies of the government mobilise international financial assistance and allocate public financing to the priority project profiles in the NAPA' (Maldives, 46).

Despite ideas of mechanisms such as this one, Ciplet *et al.* observe that, as of May 2011, the GEF Chief Executive Officer endorsed or approved only 28 NAPA projects to be funded. One result of this financial issue seems to have been the accumulation of delays and the outdatedness today of many of the needs first assessed in the NAPAs (Ciplet *et al.*, in press).

Nevertheless, some NAPAs developed several innovative mechanisms and frames aimed at integrating more local actors and ensuring multi-level implementations. For example:

- In order to mobilize actors in its first priority project, the Democratic Republic of Congo suggests to distribute leaflets about the project to resident local communities, local administrations, NGOs, etc., to use an Internet website as an exchange platform and to involve NGOs and community organisations in fairs (DRC, 55).
- Some countries plan to set up or have already established new bodies to make implementation easier: a National Strategic Risk Management Unit to 'coordinate adaptation activities' (Kiribati, 29), a 'Project Steering Committee (…) to guide implementation of related projects (…) composed of members drawn from the Private Sector, Government Departments, Local Councils, Local Initiators, Civic Associations, Development Agencies, National University and NGOs. Membership will also include the UNFCCC and GEF operational Focal Points.' (Lesotho, 17). The Solomon Islands have created a Ministry of Environment, Conservation and Meteorology encompassing a Climate Change Division. In the Comoros, an island-specific pilot committee representing the concerned actors (vulnerable groups, NAPA island committee, civil society, the islands' guidance committee, local institutions, associations, experts) will be in charge of the implementation of the NAPA. Mali foresees pilot local committees to support the technical services of Ministries (Mali, 90).
- At another level, Senegal and Burundi suggest special bodies for monitoring purposes.
- Mauritania distinguishes the actors involved in different implementing bodies, including a Coordinator of the climate change project, a project team of experts, a NAPA network or implementation committee and a supervisory steering committee (Mauritania, 31).

Interestingly, some countries evoke the diffusion of the NAPAs and outline their strategy in this respect. They plan:

- The involvement of the media to help popularize the NAPAs (Comoros, 8)
- Television and radio-based debates to explain the NAPA, the progress made in its implementation and inform beneficiary populations (Guinea: ix). Guinea-Bissau sees NGOs as potential actors to do this (Guinea-Bissau, 47).
- A local outreach program (Samoa, 65)

_____ START BOX 14-1 HERE _____

Box 14-1. The Case of Nepal

Among the NAPAs, Nepal stands out as with a very elaborate implementation strategy that is part of a broader framework. As Ciplet *et al.*explains, it 'has gone far beyond the basic NAPA criteria to build institutional capacity for long-term adaptation planning and action' (Ciplet et *al.*, in press: 2). The Government of Nepal developed an "expanded NAPA" that 'acts as a catalyst for building broader institutional capacity, knowledge, and leveraging investment around long term adaptation planning' (Ciplet et *al.*, in press: 3). The NAPA is seen as 'the basis for all support to adaptation activities in Nepal in order to ensure a coherent programmatic approach and systematic reduction of vulnerability and climate change impacts nationwide.' (Nepal: 22). This implies the setting up of a 'common coordination, management and monitoring mechanism' for the implementation of all adaptation projects to come. It is also noted that '(the) framework will facilitate the channelling of financial resources and technical expertise for adaptation to the local level as efficiently as possible'.

Concretely, the proposed framework, ensuring the long-lasting impact of the NAPA and the future use of the information and lessons it allowed to gather, is structured as follows:

- Preparation and dissemination of a NAPA document (…);
- Development and maintenance of a Climate Change Knowledge Management and Learning Platform for Nepal
- Development of a Multi-stakeholder Framework of Action for Climate Change in Nepal. (Nepal: 6).

_____END BOX 14-1 HERE _____

In light of the above-mentioned remarks, a few recommendations for future adaptation planning and implementation could be made. First, to take more into consideration in the role that 'local civic institutions and institutional partnerships both at the local level and across multiple scales' can play, considering that local actors and institutions are crucial to the success of local adaptation (Agrawal and Perrin, 2008). Second, to better integrate the different (national and local) levels of implementation and lastly, to pay more attention to the medium and long-term climate impacts, which will necessitate, as Ciplet *et al*. puts it, a 'more serious and strategic intergovernmental commitment to the process' (Ciplet *et al*., in press).

14.5.2.3. Climate Hazards and Adaptation Needs

Recognized under the United Nations Framework Convention on Climate Change, LDCs are the most vulnerable countries to the adverse impacts of climate change. NAPAs identify the main climate hazards faced by each LDC, partly from which they subsequently analyze each country's specific adaptation needs. Hazards and needs are consequently closely linked. Keeping in mind that each country has its national particularities, that some crucial factors (such as the geographic position and economic, political and social situations) differ from one country to the other and, as some NAPAs remind, that some countries lacked data or could not generate them themselves, one can nonetheless observe that the NAPAS reveal several common trends[4]. This section first looks at the main climate hazards observed in the countries, before focusing on the predictions as regards their evolution. Lastly, it summarizes the foreseen consequences of these climate changes in terms of broader ecological, social and economical impacts.

[INSERT FOOTNOTE 4 HERE: As an example, the Government of Lao PDR stated having not had the means yet to use climate change models in their research (Lao PDR: 20). In The Gambia, research has been weak or inexistent on 'the linkages between climate change and biophysical processes' and on some indirect adverse effects of climate change (Gambia: 14).]

Main climate hazards observed: The NAPAs confirm that the evolution of climate these past decades[5] is a reality. A major expression of this seems to be the experience by the countries of 1) higher average temperatures 2) changes in rainfall patterns expressed by a decrease of pluviometry and/or stronger shorter rains, 3) an often concomitant increase in number of extreme events, whether drought, or floods, and, in some cases, a higher frequency of storms and cyclones. Generally speaking, variability has increased. As illustrated by the case of Sierra Leone, these hazards are very often combined:

> '*(Recent) events as evidenced by the erratic behaviour of the weather such as fog in places where they did not occur before during the dry season, flash floods, cyclone and severe storms, scarcity of fresh water due to less rain, higher evapo-transpiration in the dry season, frequent prolonged and wide spread drought/dry spells have suggested that some major changes are occurring*.'(Sierra Leone: 5)

[INSERT FOOTNOTE 5 HERE: Data differ between countries; however, many of them cover at least the past thirty, if not the past fifty years.]

Most countries have witnessed a clear rise of their average temperature (Afghanistan, Burkina Faso: iv, Comoros, RDC: 12, Ethiopia: 1, Kiribati: 21, Nepal: xi, Samoa: 10, Sierra Leone: 8, Solomon Islands: 15…). Chad evokes 'excessive temperatures' (Chad: vi), while Djibouti notes that all the monthly average temperatures of the nineties were higher than the normal. The decade 1991-2000 was the warmest ever in the country (Djibouti: 10). Some

countries have experienced in particular a very high increase of their minimal temperatures (Chad: ix, Sao Tome E Principe: 8). One consequence of this increase has been the multiplication of bushfire in some countries (Chad: x, Niger: 21). Another related effect: Nepal evokes the melting of the Himalayan glacier (Nepal: x).

Simultaneously, the frequency and intensity of extreme events such as droughts and/or floods have often increased. Many countries[6] have experienced recurrent droughts for at least a decade (Djibouti; 22), often for longer, as Guinea and Mali that recorded them since the seventies (Guinea: vi, Mali, 6). Example of this phenomenon and its severity: the NAPA from Lesotho explains that '(the) period 1979 to 1996 has experienced the highest incidence of drought in almost 200 years with the longest drought in the country's history lasting from April 1991 to October 1995' (Lesotho: 7). In some regions of Mali or Rwanda, for instance, situation has involved a trend of desertification (Mali: 20, Rwanda: 7), also already perceptible in Mauritania (Mauritania: 13). Droughts are not only more frequent; in some cases, they come earlier and last longer than they used to (Comoros: 5), or they are longer and more widespread (Haiti: 8).

[INSERT FOOTNOTE 6 HERE: (Mozambique: 10, Uganda: xiv)]

In many countries, droughts have been accompanied by floods. As an example, Rwanda notes that '(the) period between 1991 and 2000 has been the driest since 1961' (Rwanda: 24) but also witnessed 'two pronounced pluviometric excesses (1998, 2001)', while rainy seasons tended to be progressively shorter (ibid: 25). A similar tendency towards less annual rainfall but more rainfall variability, a configuration favourable to the increase of droughts, has been noticed in Sudan (Sudan: 4) and Ethiopia (Ethiopia: 4, 16), where they constitute with droughts the most important hazards almost every year (ibid). Zambia notes that, although historically present, in 'recent decades the frequency and severity of these climatic hazards have increased.' (Zambia: 8). To a large extent, floods are more frequent in many countries (Benin, Chad, Haiti: 8, Mauritania: 10), more early in some (Guinea: vi) and more 'flash flooding' happen (Eritrea: 5). It seems that their intensity has also increased: they have been more severe than in the past (RDC: 14, Lao PDR: 13).

As already mentioned, and correlated to what has been said previously, one can observe changes in rain patterns regardless of the geographic location, expressed by a trend towards more variability and an overall reduction of rainfalls. Partly an exception, the RDC has experienced an increase of rains in a region and the contrary elsewhere (RDC: 12). Another special case, in Ethiopia, temperature intensified but the average rainfall has not significantly (Ethiopia: 1). Generally speaking, many countries have not only undergone more variability of pluviometry in and between years, they have also tended to receive less rain than they used to (Guinea: vi, Guinea-Bissau: 35, Mali: 11, Burkina Faso: 22, Senegal: 14), which has involved more dryness (Benin, Chad: vi). In some cases, rains have tended to come later (Benin: viii) or to be concentrated in a shorter period (Guinea-Bissau: 35). This phenomenon is not exclusive to Africa as Haiti has also experienced shorter, but sometimes very 'dense', rains (Haiti: 8), while Comoros notes 'irregular precipitation' combined to a diminution of precipitation between 1960-1975 (Comoros: 20). Yemen also notices that '(in) recent decades (…) rainfall has decreased considerably' although 'flooding was clearly observed in 1996 and during the period 2005-2008' (Yemen: 2).

Albeit less widespread, storms and tropical cyclones have also been mentioned, as they have tended to be more prevalent, notably in coastal areas in Bangladesh (Bangladesh: xv), in islands such as the Solomon Islands (Solomon Islands: 19), Vanuatu (Vanuatu: 16) and Samoa (Samoa: 10). Vanuatu has undergone 124 cyclones since 1939 (Vanuatu: 16). Comoros also experienced an increase in 'extreme meteorological phenomenon' over the past 30 years (Comoros: 5), as Tuvalu did, mentioning cyclones, storms and surges (Tuvalu: 6). In other parts of the world, strong winds have become more common (Chad: vi, Niger: 21, Benin: viii) and, in some cases, are now often accompanied by rains (Guinea-Bissau: 35).

More localized hazards, such as coastal erosion (RDC 17: Sao Tome E Principe: 8, Tuvalu: 6) and sea level rise (Benin, Maldives: 13, Sao Tome E Principe: 8) have been observed. To give an idea of scale, the sea level rise has been of 10 to 20 centimetres during the twentieth century in the Maldives (Maldives: 13).

Scenarios and models are very pessimistic about the potential risks in the future and the most likely impacts of climate change. They often predict a strengthening of the current already visible trends, therefore confirming

changes of climate patterns. In many countries, this consequently involves a continuous rise of temperature and an increase of the frequency and intensity of extreme events. Scenarios regarding rains between and within countries are more varied.

In many parts of the world and in the long run, models foresee an increase of temperature (Chad: ix, Guinea: vi, Sierra Leone: 5, Sudan: 5, Tanzania: 5, Togo: 11, Vanuatu: 16, Yemen: 2, Mali: 20). This should be often accompanied by more climate variability, involving, in countries such as Cape Verde, 'more storms, floods and droughts' (Cape Verde: 5); This should also generate more floods and flooding (Bhutan: 14, Guinea: vi, Cambodia: 2), more floods and strong winds (Mali: 20) or more storms (Madagascar: 6).

In terms of rainfalls, already noticeable tendencies of decreased annual rainfall should persist in many countries (Burkina Faso: 14, Guinea-Bissau: 35, Samoa: 11). Cape Verde foresees a shorter rainy season and a decrease in rainfall 'by up to 20% can be expected by 2100' (Cape Verde: 5). However, in a minority of countries or some of their regions, models predict an increase of average precipitations. Among them are the Maldives, where the average precipitations may rise during the twenty-first century (Maldives: 14), and some regions of Chad and Nepal (Chad: x, Nepal: x). In some parts of Niger, monthly average rainfall may increase by 2025 in some regions, while it may decrease in some others (Niger: 18). The phenomenon of differentiation could be the same in Tanzania. These predictions are in line with a general observation of changes in precipitation patterns, as observed in other countries. Lesotho foresees fewer rainfalls in spring and summer seasons and more rainfalls in winter, which should have a strong impact on 'agro-ecological conditions' (Lesotho: 7).

Lastly, sea level rise (Guinea: vi, Guinea-Bissau: 35, Cambodia: 2, Samoa: 11) and coastal erosion (Togo: 11) are predicted in several countries.

Present and foreseen consequences/ correlative impacts

The example of Comoros illustrates a range of possible consequences due to climate changes:

> '*(Possible) anticipated impacts are an accelerated reduction of the agricultural and fishing production, an increased saline intrusion in the coastal aquifers; a 20 cm rise in sea level, in 2050, with the destruction of 29% of the roads and works, by flooding; a paralysis of the economic activities; the moving of at least 10% of the population and a loss of 734 acres of cultivable lands; the disappearance of reefs and beaches with higher risks on the tourist potential; the geographic amplification and spreading of malaria and other vectorial transmitted diseases. Lastly, significant losses at the level of coastal infrastructures estimated at about 400 millions US$, e.g. 2,2 times the GDP of 2001'* (Comoros: 5)

As shown in an example given by Eritrea, climate changes have already had far-reaching secondary consequences:

> '*Small rains that usually occurred during April/May have all but disappeared. In recent years, the main rainy season starts later and finishes earlier than the historical pattern resulting in some wheat and millet varieties, as well as some native cultivars, disappearing from production, due to recurring rain-fed crop failures. New crops pests are appearing that have been previously unknown or uncommon. Irrigated crops are also adversely affected due to depletion and drying of water wells on which irrigation depends, as well as unusually heavy flooding during the rainy season. These circumstances are increasing the heavy toll on subsistence farmers.*' (Eritrea: 5)

The evolution of climate has and, according to predictions, should have in the future many unwanted consequences and serious correlatives ecological impacts. In the case of the LDCs, they would turn out to have all the more serious economic impacts as economic activities and resources often heavily rely on climate.

The evolution of climate would first have a responsibility in the degradation of the ecosystem (Cape Verde: 5). In this respect, Djibouti noted, for instance, the negative impact of higher sea level on mangroves, because of the salinity that it will entail, but also of higher temperatures on corals (Djibouti: 10). Other consequence of the evolution of climate: it would also entail the deterioration of the conditions for agriculture. Referring to its economic

impacts, Bangladesh, for instances, notes that droughts have a significant negative effect on crop productivity almost annually, which will jeopardize 'food-grain self-sufficiency' (Bangladesh: xv). This comment has been developed by other NAPAs stating that the changes related to climate have resulted in a global decrease of general productivity in the economy (Burkina Faso: iv, Chad: xii). In Haiti, one can already observe a decrease in agricultural and livestock productions as well as in fisheries (Haiti: 8). Malawi notes that, because of floods and droughts, 'chronic food deficits in many parts of the country on a year-round-basis' are already observable, just as 'acute crop failure' is, which itself explains food insecurity and malnutrition (Malawi: 4). Tuvalu highlights the fact that fruit tree yields will suffer from increasingly intense impacts of climate change, which should seriously jeopardize the availability of domestic foods, affecting the livelihood of the population (Tuvalu: 21). The effect of these impacts on livelihood are also underlined by the NAPA of Lao PDR, which points out that floods and droughts are not only detrimental to the economy but that they also generate 'public health hazard' (Lao PDR: 36). Other countries, such as Cambodia, also fear the increase of vector-borne deceases such as malaria (Cambodia: 2). This is already a reality: Comoros mentions a rapid increase of 'malaria, dengue, cholera, hepatitis A, typhoid as well as blindness' (Comoros: 5); Eritrea sees the recent spread of malaria to higher altitudes as linked to climate change (Eritrea: 5). It also indicates issues in terms of water supply, 'lower income, high access costs to food and an increase in food insecurity' (Comoros: ibid). Cape Verde also mentions water issues, pinpointing to the fact that fewer rainfalls entail less available surface water in seasonal rivers, that is less water to recharge reservoirs and fill dams (Cape Verde: 6). This would have an impact on small farmers, leading them to rural exodus, which would itself put more pressure on urban resources.

These important adverse effect of climate noticed in every country explain adaptation needs that each NAPA has attempted to identify.

As stressed by the NAPAs, climate hazards have been exacerbated by environmental stresses, which have themselves often been worsened by a strong demographic growth, behaviours entailed by poverty and what Ethiopia calls 'unchecked human activities' (Ethiopia: 16). These conditions have indeed been causes of a deterioration of the environment, soils and forestry resources (Burundi: vii). Among negative practices, Cape Verde mentions, for instance, 'the man-made destruction of natural barriers along the coastal edge' due to the mining of sand and the over-exploitation of wells (Cape Verde: 6), a practice that has undermined its coastal zones.

The negative impacts linked to climate are even more substantial in the LDCs as most of the countries rely on agriculture and that the population has a low adaptive capacity. This generates a particularly high vulnerability. The NAPAs assessed this vulnerability by sectors and by people. Although The Gambia notes that explains possible differences in the choice of key sectors by each country because of differences in terms of natural resources, economic level, social systems and national aspirations (Gambia: 15), it already appeared that some key economic sectors are particularly affected almost everywhere. Liberia, for instance, refers to agriculture, fisheries, forestry, energy, health and meteorology/hydrology (Liberia: 3), sectors that are there all heavily dependent on temperatures and climatic conditions. Identifying these key sectors led to distinguishing key adaptation needs. This itself grounded the choice of priority projects. This explains that the sectors in question are the same as those targeted by the final projects:

- Agriculture (Bangladesh: xv, Benin: 19, Bhutan: 14, Burkina Faso: iv, Chad: vi, Djibouti: 10, Gambia: 15, Haiti: 12, Mali: 21, Sao Tome E Principe: 8, Sudan: 5, RCA: 26, Ethiopia: 25).
- Water resources (Benin: 19, Burkina Faso: iv, Chad: vi, Djibouti: 10, Haiti: 12, Lesotho: 3, Mali: 21, Samoa: 33, Sudan: 5, Bhutan: v, Sierra Leone: 9)
- Energy (Benin: 19, Gambia: 15, Mali: 21, Sao Tome E Principe: 8)
- Health (Benin: 19, Mali: 21, Sudan: 5, Ethiopia: 25)
- Forestry (Benin: 19, Chad: vi, Djibouti: 10, Mali: 21) /biodiversity
- Animal resources (Burkina Faso: iv)
- Fisheries (Chad: vi, Gambia: 15, Mali: 21)
- Livestock farming (Chad: vi, Djibouti: 10, Sao Tome E Principe: 8)
- To a lesser extent, industry, habitat and education (Mali: 21)

Many NAPAs highlight the vulnerability of ecosystems themselves, distinguishing notably coastal zones (Djibouti: 10, Benin: 19, Haiti: 12), sea zones (Djibouti: 10) and soils (Haiti: 12).

One observes that the NAPAs locate the highest vulnerability to climate change in different population groups, depending on the region they live in, their occupation and their gender/age. Some trends can be distinguished: first, most NAPAs identify as the most vulnerable ones the populations that depend on natural resources. Depending on the country, this group includes 'traditional rain-fed farmers and pastoralists' (Sudan: 0), 'les petits exploitants agricoles' (Togo: 12), 'the rural poor who depend directly on crops and livestock' (Bhutan: 14), livestock and crop farmers (Lesotho:8), and, more generally, those who directly 'depend upon natural resources for their livelihood', as it is the case in Eritrea (Eritrea: 10). However, in a country such as the RDC, the urban poor are also identified as the most vulnerable people, just before small farmers (RDC: 19). To a large extent, both rural and urban areas can have highly vulnerable populations, which, in the case of Haiti, has led to the growth of slums (Haiti: 12). A rationalization of who is the most vulnerable group is even more blurred by the fact that these groups can differ in a same country. In the North and centre Benin, for instance, 'les petits exploitants agricoles, les maraîchers et exploitants agricoles émergeants, et les pêcheurs' would be the most vulnerable, whereas 'les petits exploitants agricoles, les pêcheurs et les éleveurs' would be so in the South (Benin: viii). The degree of vulnerability seems to be also higher for populations living in particular zones, such as the coastal areas (Bangladesh, Liberia). Lastly, group within a group, women, children and elderly people are seen in several NAPAs as the most vulnerable group, whether among the rural poor (Burkina Faso: 22) or in general (Eritrea 10).

If anything, the NAPAs seem to confirm the occurrence for several decades and until now of increasingly intense and numerous climate hazards in all the LDCs countries. They also seem to agree on the gravity of their current as well as predicted impacts not only on the environment but also on the economy and broader condition of the concerned populations, a majority of which is often highly vulnerable. As Comoros notes, the current climate hazards and the ones to come raise the broader issue of the possibility to efficiently fight against poverty and to realize the Development Millennium Goals in the LDCs.

14.5.2.4. From NAPAs to NAPs

[to be developed]

14.5.3. Sector-Based Assessments

This section will be fleshed out our next meeting. We expect that among others, it will cover:

- *Ecosystem assessments*
- *Water assessments*
- *Urban/ community*
- *Agriculture*

14.5.4. Project and Program Evaluation

[to be developed]

14.6. Measuring Adaptation

Adaptation has been described as the "hand-maid of mitigation" both in research and in the climate negotiations (Burton *et al*., 2002; Arnell, 2009). A partial reason is that adaptation and development specialists, governments, NGOs and international agencies have found it difficult to clearly define and identify precisely what constitutes adaptation [14.2.1]. Adaptation has no common reference metric as does mitigation; namely tonnes of GHG, or radiative forcing values. The definition of adaptation still remains ambiguous and there are no commonly accepted ways to measure its effectiveness of adaptation or even to distinguish it from effective development.

14.6.1. Understanding Measurement

Adaptation metrics may be defined as *quantitative, semi-quantitative or qualitative measures for monitoring the effectiveness of adaptation actions* (Srinivarsan and Prabhakar, 2008). The search for metrics for adaptation will remain contentious with multiple alternatives competing for attention. This is inevitable as there are multiple purposes and viewpoints in approach the measurement of adaptation. Initially the predominant approach was to measure vulnerability from an impacts point of view. Here vulnerability is usually defined as a function of (i) exposure to specific hazards or stressors, (ii) sensitivity to their impacts and (iii) the target population's capacity to adapt (IPCC 2001, Chpt 17). This approach continues to be used as the basis of many assessments and adaptation prioritization efforts. The emphasis has moved from better defining exposure and potential impacts to a better understanding of the factors affect societies' sensitivity to those impacts and their adaptive capacity. This reflects the increasing recognition of the importance of considering social vulnerability alongside biophysical vulnerability. Various terms have been used including biophysical versus social vulnerability, outcome versus contextual vulnerability (Eakin & Luers, 2006; Fussel and Klein, 2006; Eriksen and Kelly, 2007; Fussel, 2007; and Fussel, 2011) and scientific framing versus a human-security framing of vulnerability (O'Brien, 2006). O'Brien et al. (2007) argue that scientific and human-security frameworks affect the way we approach adaptation, with the scientific framework leading to building local and sectoral capacity to make changes rather than address the fundamental causes of vulnerability, or climate change itself, within their geopolitical and economic contexts. Downing (2003) noted that the climate change was far from adopting common standards, paradigms or analytic language. This still appears to be true, making the search for commonly accepted metrics, even within well-specified contexts, a challenging task.

Other questions also arise even within a given conceptual framework for considering vulnerability. A system of measurement is usually developed to allow comparisons between different places, social groups or sectors of activity. But experience repeatedly cautions us to be conservative in applying common questions and metrics of vulnerability across diverse places, groups or sectors (Schroter, Polsky & Patt, 2005). Also, a system's vulnerability is not static but responds to changes in economic, social, political and institutional conditions over time (Smit & Wandel 2006; Smit & Pilifosova, 2001,2003).

It has also been suggested that a resilience framework is more appropriate than a vulnerability framework in many contexts. For example, in a development context resilience "evokes positive and broad development goals (e.g., education, livelihood improvements, food security), includes multiple scales (temporal and spatial) and objectives, better captures the complex interactions between human societies and their environments, and emphasizes learning and feedbacks" (Moss et al., to appear). A resilience approach leads to more focus on interactions between social and biophysical systems (Nelson et al., 2007). However, the concept of resilience has proven very difficult to apply in practice and particularly resistant to attempts to establish commonly accepted sets of indicators. Some (e.g. Klein, Nicholls & Thomalla, 2005) have suggested that it has become umbrella concepts that has not been able to support effectively planning or management.

But vulnerability is not adaptation. Smit *et al*. (2001), Osman-Elasha *et al*. (2008) and others have suggested that our focus should be on increasing adaptive capacity within the context of the full range of biophysical and socio-economic stressors. But metrics designed to capture these aspects are likely to become less suitable for distinguishing 'adaptation' from 'sustainable development' (McGray et al., 2007) and thus be less suitable for other purposes such as identifying "the full additional costs of adaptation".

Why, When, and for Whom is Measurement Important?

Despite all of the perplexities and barriers described above, measurement in relation to adaptation remains important and necessary. Indicators selected systematically and transparently using a consistent set of definitions, data, and analytic techniques, even if subjectively chosen by the analysts, and ideally with input from stakeholders, will remain a valuable aid to decision making (Gallopin 1997; Moss *et al.,* to appear).

The primary purposes for measurement include (i) identifying vulnerabilities to help determine adaptation needs and priorities; (ii) identifying the best options to meet those needs; and (iii) monitoring the effectiveness of adaptation actions. Often the goal is not to produce a score or rating for application but to elucidate information on the nature of vulnerability and to better identify adaptation options (Adger & Wandel, 2006).

14.6.2. What Needs to be Measured?

While there has been much discussion in the technical literature about the concept of vulnerability and indices for assessing vulnerability, coping/adaptive capacity etc., there are few thoroughly worked examples. Also, vulnerability indices have usually been designed to better understand the drivers of vulnerability or to compare countries, regions, communities etc. in terms of the risks they face from climate change and their capacity to deal with them. This is not necessarily the same as designing an allocation index or rule to be used to allocate limited resources equitably and efficiently among countries (or other groups). For allocation we might expect that vulnerability and coping/adaptive capacity would remain a core consideration, but so also should the needs of the country in terms of its size and population (i.e. what is needed to make a difference) and its capacity to absorb funding.

In deriving indices of vulnerability there are again two broadly different approaches. One is to deductively identify indicators that theoretically should be strongly related to vulnerability, while the other is inductive and uses observed data to seek correlations between indicators and observed consequences of vulnerability, such as the number of people killed or affected by climate related events in recent history. There is some commonality in identifying the desirable characteristics of suitable indicators which have been concisely summarized by Perch-Nielsen (2010) in Table 14-1.

[INSERT TABLE 14-1 HERE
Table14-1: Set of criteria for selection of indicators (Perch-Nielsen, 2010 – based on Aitkins *et al*., 1998; Esty *et al*., 2006; Kaly *et al*., 2003; OECD, 2002).]

14.6.3. Established Metrics

Several reviews including Moss (2001, to appear), Srinivarsan & Prabhakar (2008), Anderson *et al*. (to appear) that discuss both the design and effectiveness of many of the existing proposals for adaptation metrics. TBC

Eriksen & Kelly (2007) compared five national level measures of vulnerability published over the period 1995 to 2003. (Namely the Vulnerability-resilience indicators of Moss et al., 2001; the Environmental Sustainability Index of the World Economic Forum, 2002; the Dimensions of vulnerability of Downing et al., 1995; the Index of Human Insecurity (IHI) of Lonergan et al. 1999; and the Country-level risk measures, Brooks and Adger 2003.) Between them, 29 indicators were used with only five appearing in more than one study. They were able to compare the top 20 ranked countries derived from three of the studies. Only five countries appear more than once and only one in all three lists; 49 countries appeared only once. However, it must be noted that the indices were developed at different times and for different purposes. They concluded that the indices focused on measuring a snapshot of aggregate conditions nations rather than delivering guidance on societal processes that can be targeted to reduce vulnerability.

There are a series of disaster related indices designed to assess relative risks across countries and regions, and to provide benchmarks on which to assess progress (UNDP Disaster Risk Index,2004; Hotspots Index of Dilley *et al*., 2005; and the Americas Index of Cardona, 2005).

14.6.3.1. Metrics for Resource Allocation

Metrics for adaptation do come into play in major decision making processes about the allocation of funding. One of the longest running and prominent use of metrics in funding is the World Bank's process of allocating IDA

concessional funds to developing countries which faces many issues analogous to the same process for adaptation. The World Bank uses the Country Policy and Institutional Assessment (CPIA) based on 16 criteria to estimate the extent to which a country's policy and institutional framework supports sustainable growth and poverty reduction, and consequently the effective use of development assistance. These criteria are the main components used to calculate a Country Performance Rating, which in turn is a major component, along with population and recent performance measures, in calculating IDA allocations. The CPIA and the ultimate IDA allocation formulae are controversial, much debated (Alexander 2010), often fine-tuned (IEG, 2009) but still commonly used a s a reference point for this type of procedure (GTZ, 2008).

An explicit example of the use, and non-use, of adaptation metrics was in establishment of the Pilot Program for Climate Resilience (PPCR). The governing body (made up of contributors, recipients and other stakeholders) set up an expert group to make recommendations as to which countries might be included as pilots within the c. USD1billion program CIF 2008). The expert group refrained from using a simple index, but instead country selection was done across 9 regions and based on a suite of indices appropriate for the region and expert judgment. The twelve indicators were used by the expert group reflected both the outcome and contextual concepts of vulnerability and the most consistently used were:

1) The Human Dimension Index
2) An index based on the proportion of the population affected by climate related disasters in the past 30 years
3) The percentage of the population undernourished
4) The percentage of the population without access to improved water
5) The percentage of the population in the low elevation coastal zone.

It is interesting to note that on moving to the next step of deciding on allocation of financial resources to the pilot countries the governing body of the PPCR chose not to use an approach based on indicators, but to provide guidance to the countries of the possible range of funding and to base allocations on the quality of the proposals bought forward (CIF 2009). None of the other governing bodies of international funding mechanisms (e.g. the GEF, the Adaptation Fund) has chosen to use a defined set of metrics within their decision making. Klein & Möhner (2011) have discussed the options for the Green Climate Fund based on experience to date and conclude that that science cannot be relied upon for a single objective ranking of vulnerability.

14.6.3.2. Metrics for Monitoring and Evaluation

T.B.C. But include …
Mention - Hedger et al. (2008) pyramid of adaptation evaluation which links scale, evaluation purposes and indicators.
IDRC (2008) outcome mapping framework.
UNDP Adaptation Monitoring Framework (Brooks and Frankel Reed, 2008)

14.6.4. Validation of Metrics

The practice of developing and applying metrics in adaptation has been subject to criticism. Eakin & Luers (2006) express serious concerns about national-scale vulnerability assessments ranging from the quality of the available data, to the selection and creation of indicators, to the assumptions used in weighting of variables and the mathematics of aggregation. Downing (to appear???). Nevertheless indices will continue to be used and the challenge is to identify and maintain basic standards of best practice.

One of the most comprehensive attempts to validate a system for measuring important components of adaptation is that of Brooks, Adger and Kelly, 2004. They used the probability of climate related mortality from the CRED data-base as a proxy for risk and a set of 46 social, governance, economic and biophysical measures as indicators of essentially social vulnerability. They then used an inductive approach to identifying indicators by analyzing the number of people killed in climate related disasters over recent decades in relation to a wide range of potential indicator variables. They found 11 that were selected as effective indicators and these were confirmed as useful by a

small focus group (7 people) of adaptation experts. These experts also ranked the variables in terms of their perception of their usefulness leading to a total of 12 different rankings to which was added a equal ranked set to give 13 measures of vulnerability. Countries were then scored against these 13 rankings and the number of times a country appeared in the top quintile of countries in a particular ranking was used as an indicator of its overall vulnerability.

Perch-Nielsen (2010) has developed an index to estimate the vulnerability of beach tourism using a systematic approach in establishing a framework to identify the types of measures needed and a systematic approach to identifying measures covering the range of countries and time scales. The derivation of the index from the separate measures was also subjected to robustness (sensitivity) testing to determine the most appropriate methods of scaling and combining the measures.

14.6.5. Assessment of Existing and Proposed Metrics for Adaptation

Srinivarsan & Prabhakar (2008) conducted a wide-ranging stakeholder survey to assess the attitudes to and requirements of indicators for adaptation. Stakeholders agreed that no single metric can capture the multiple dimensions of adaptation and that refinements of methodologies (e.g. rationale for index selection, aggregation methods, data checking) are badly needed. But metrics for adaptation remain a necessity. Their derivation challenges the adaptation community to clarify its goals, conceptual models, definitions and applications. But indicators alone are not sufficient to guide decisions on which adaptation actions to take, on how to modify sustainable development activities, or on resource allocation.

14.7. Addressing Maladaptation

14.7.1. Defining Maladaptation

Fundamentally development interventions in a specific sector contribute to reducing vulnerability and improve the overall adaptive capacity of that sector to potential climate change impacts. However, in some cases, the development approach followed may unintentionally result in increased vulnerability. For example the development of a dam in the upper stream to increase the water supply may negatively impact the flood irrigated agricultural lands in the lower stream rendering the people highly exposed to climate variability. This could be described as state of a maladaptation, which is defined by the IPCC as "a change in natural or human systems that leads to an increase rather than a decrease in vulnerability". The IPCC further states that maladaptation result from decisions that prevent or constrain the ability of others to manage, reduce or otherwise adapt to the effects of climate change (IPCC, 2001b). UNDP defines it as an action or process that increases vulnerability to climate change-related hazards. OECD defines “Maladaptation” as the implementation of adaptation measures that turn out to be ineffective once the impacts of climate change materialize.

Five dimensions of maladaptation are identified by Barnett J and, O’Neill S., 2010. including: 1- actions that increase emissions of greenhouse gases such as the use of air conditions to ameliorate the high temperature resulting from climate change2- Actions that disproportionately burden the most vulnerable 3-actions involving have high opportunity costs 4-reducing incentives and capacity to adapt 5- setting paths that limit future choices.

Maladaptive actions and processes often include planned development policies and measures that deliver short-term gains or economic benefits but lead to exacerbated vulnerability in the medium to long-term. These measures are generally characterized as having high cost compared to their net benefits, and being structured around hard ware interventions that lack flexibility in terms of adaptation policy, involving e.g. the construction of infrastructure, (OECD**,** 2009).

14.7.1.1. Overview of Maladaptation / Misadaptation

There is always a risk that meeting urgent, short term priorities in responses to climate variability undermine adaptation and create maladaptation over the long term. This is synonymous with the description of maladaptation as actions that instill safety, or the sense of stability, in the short term, but might actually increase vulnerability and fail to enhance adaptive capacity in the long term (Barnett and O'Neill 2010). For example intensifying the use of inputs to increase the overall productivity may lead to soil exhaustion, land degradation and desertification. A policy developed in one sector in response to a specific climate stimuli may indirectly undermine or hinders adaptation in another sector. An example is a hydropower generation project developed by the energy sector, could lead to the inundation of agricultural land and damages livelihoods. Similarly an agricultural policy that promote the growing of a high yielding crop varieties through subsidies —with the objective of boosting production and increase revenues, will damage the agro-biodiversity, increased exposure/vulnerability of mono-crops to climate variability and change and finally undermining the adaptive capacity of farmers. A development or adaptation strategy implemented in one region may increase the vulnerability of other systems, sectors, or groups and could impact the livelihood in another region. This is shown in an assessment of the downstream impacts of rainwater harvesting in a semi-arid basin in Southern India. The assessment which focused on the trade-offs arising from the re-allocation of a downstream surface water irrigation system to groundwater irrigated agriculture upstream, highlighted a significant impact on the downstream with net benefits that is insufficient to pay back investment costs (Bouma, J.A, 2011).

14.7.1.2. Relationship of Failure to Adaptation and Maladaptation

Adaptation deficit is a different concept from maladaptation. It is defined as the inadequate adaptation to the current climate conditions (Parry et al., 2009). It also refers to the lack of resilience to current climatic conditions arising from past inaction. Mismanagement of natural resources in fragile zones, poor irrigation systems, lack of extension services and market access to agricultural products, are examples of adaptation deficits in the agricultural sector.

In the process of building future adaptive capacity it is important to reduce the current adaptation deficit, in addition to the need for designing effective risk management and climate change adaptation measures. (Hallegatte S et al, 2011). It is equally important to identify all the potential socio-economic and environmental impacts that could present maladaptation by assessing potential risks and incorporating adaptation strategies in the development planning (Satterthwaite, *et a*l, 2009).

14.7.2. Experiences with Maladaptation

[to be developed]

14.7.3. Screening for Maladaptation

14.7.3.1. Methods for Assessing Viability of Adaptation Measures

[to be developed]

14.7.3.2. Methods for Preventing Maladaptation

Maladaptation is not necessarily associated with climate change as it can take place even under normal conditions due to inappropriate decision. An example is the expansion of infrastructural development in low coastal zones, which are frequently subjected to floods and storms. Avoiding these practices would be the first step in addressing maladaptation. The next step would be, to plan and design adaptation strategies, for implementation and monitoring and evaluation of their performance. To this end it is critical to make use of existing technologies to develop information and awareness for adaptation in highly vulnerable zones (Basher, R. E., 2001).

14.8. Research Gaps and Data Gaps

[to be developed]

References

Abrahams, C., 2008: Climate change and lakeshore conservation: a model and review of management techniques. *Hydrobiologia*, **613(1)**, 33-43.

ACCCA, 2009. Synthesis Report: Lessons learned on climate change science and risk communication in the ACCCA Project, UNITAR http://www.acccaproject.org/accca/?q=node/17

Adger, W.N. and J. Barnett, 2009: Four reasons for concern about adaptation to climate change. *Environmental Planning A*, **41**, 2800–2805.

Adger, W.N., S. Dessai, M. Goulden, M. Hulme, I. Lorenzoni, D. Nelson, L.-O. Naess, J. Wolf, and A. Wreford, 2009: Are there social limits to adaptation to climate change? *Climatic Change*, **93(3-4)**, 335–354.

Adger, W.N., S. Agrawala, M.M.Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit, and K. Takahashi, 2007: Assessment of adaptation practices, options, constraints and capacity. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.)]. Cambridge University Press, Cambridge, UK, pp. 717-743.

Adger, W.N., 2006: Vulnerability. *Global Environmental Change*, **16**, 268–281.

Adger, W.N., N.W. Arnell, and E.L. Tompkins, 2005: Successful adaptation to climate change across scales. *Global Environmental Change,* **15(2)**, 77-86.

Adger, W.N., N. Brooks, G. Bentham, M. Agnew, and & S. Eriksen, 2003: *New Indicators of Vulnerability and Adaptive Capacity*. Technical Report No. 7, Tyndall Centre, Norwich, UK, 128 pp.

Afghanistan. National Environmental Protection Agency, Afghanistan, 2009*: National Capacity Needs Self-Assessment for Global Environmental Management (NCSA) an National Adaptation Programme of Action for Climate Change (NAPA)*. Final Joint Report.

Agrawal, A., 2010, Local institutions and adaptation to climate change. In: *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World* [R. Mearns and A. Norton (eds.)]. The World Bank, Washington DC, pp. 173-198.

Agrawal, A. and N. Perrin, 2008: *Climate Adaptation, Local Institutions, and Rural Livelihood*. IFRI, Working Paper #W08I-6.

Agrawala, S. and M. Carraro, 2010: *Assessing the role of microfinance in fostering adaptation to climate change*. OECD Environment Working Papers No. 15, Organizations for Economic Co-Operation and Development Publishing, Paris, France, 38 pp.

Agrawala, S. and M. van Aalst, 2008: Adapting development cooperation to adapt to climate change. *Climate Policy*, **8(2)**, 183-193.

Agrawala, S., 2005: Putting climate change in the development mainstream: introduction and framework. In: *Bridge Over Troubled Waters: Linking Climate Change and Development* [S. Agrawala (ed.)]. Organization for Economic Co-Operation and Development, Paris, France, pp. 23-43.

Ahmed, S. and E. Fajber, 2009: Engendering adaptation to climate variability in Gujarat, India. *Gender and Development*, **17(1)**, 33-50.

Alam, K., M. Shamsuddoha, T. Tanner, M. Sultana, M.J. Huq, and S.S. Kabir, 2011: The political economy of climate resilient development planning in Bangladesh. *IDS Bulletin*, **42(3)**, 52-61.

Alderman, H., H. Hoogeveen, and M. Rossi, 2009: Preschool nutrition and subsequent schooling attainment: longitudinal evidence from Tanzania. *Economic Development and Cultural Change*, **57**, 239-260.

Amundsen, H., F. Berglund, and H. Westskog, 2010: Overcoming barriers to climate change adaptation—a question of multilevel governance? *Environment and Planning C: Government and Policy*, **28**, 276-289.

Anderson, S., J. Cavanagh, J. and Redman, 2008: *Skewed Priorities: How the Bailouts Dwarf Other Global Crisis Spending*. Institute for Policy Studies, London, UK, 18 pp.

Anguelovski, I. and J. Carmin, 2011: Climate Action Planning in Quito, Ecuador. In: *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network* (C. Rosenzweig, W.D. Solecki, S.A. Hammer, and S. Mehotra (eds.)]. Cambridge University Press, Cambridge, UK, pp. 262.

Anon, 2010: *Economic Vulnerability and Disaster Risk Assessment in Malawi and Mozambique: Measuring Economic Risks of Droughts and Floods*. World Bank, RMSI, IFPRI and GFDRR, Washington DC, USA, 16 pp.

Arnell, N.W., 2009: Adapting to climate change: An evolving research programme. *Climatic Change*, **100**, 107-111.

Asian Development Bank and International Food Policy Research Institute, 2009. Building climate resilience in the agriculture sector in Asia and the Pacific. Mandaluyong City, Philippines: Asian Development Bank.

Australian Government. 2005. Climate change risk and vulnerability: Promoting an effective adaptation response in Australia. Report to the Australian Greenhouse Office, Department of Environment and Heritage.

Ayache, I., J.R. Thompson, R.J. Flower, A. Boujarra, F. Rouatbi, and H. Makina, 2009: Environmental characteristics, landscape history and pressures on three coastal lagoons in the southern Mediterranean region: Merja Zerga (Morocco), Ghar El Melh (Tunisia) and Lake Manzala (Egypt). *Hydriobiologica*, **622(1)**, 15-43.

Ayers, J. and D. Dodman, 2010: Climate change adaptation and development I: the state of the debate. *Progress in Development Studies*, **10(2)**, 161-168.

Ayers, J. and S. Huq, 2009a: Supporting adaptation to climate change: what role for official development assistance? *Development Policy Review*, **27(6)**, 675-692.

Ayers, J.M. and S. Huq, 2009b: The value of linking mitigation and adaptation: a case study of Bangladesh. *Environmental Management*, **43**, 753-764.

Bangladesh. Ministry of Environment and Forest, Bangladesh, 2005: *National Adaptation programme of action (NAPA)*. Final report.

Bannayan, M. and G. Hoogenboom, 2008: Weather analogue: a tool for real-time prediction of weather data realizations based on a modified k-nearest neighbor approach. *Environmental Modeling and Software*, **23(6)**, 703-713.

Barnett, J. and S. O'Neill, 2010: Maladaptation. *Global Environmental Change*, 20(2), 211-213.

Barnett, J., 2008: The worst of friends: OPEC and G-77 in the climate regime. *Global Environmental Politics*, **8(4)**, 1-8.

Barnett, J., 2006: Climate change, insecurity and injustice. In: *Fairness in Adaptation to Climate Change* [W.N. Adger, J. Paavola, S. Huq, and M.J. Mace (eds.)]. Massachusetts Institute of Technology Press, Cambridge, MA, USA, 11. 115-129.

Basher, R.E., 2001: Data requirements for developing adaptations to climate variability and change. *Mitigation and Adaptation Strategies for Global Change*, **6**, 227–237.

Bauer, S. and I. Scholz, 2010: Adaptation to climate change in southern Africa: new boundaries for sustainable development. *Climate and Development*, **2**, 83-93.

Bedsworth, L.W. and E. Hanak, 2010: Adaptation to climate change: a review of challenges and tradeoffs in six areas. *Journal of the American Planning Association*, **76(4)**, 477-495.

Benin. Ministère de l'Environnement et de la Protection de la Nature, République du Bénin, 2008: *Convention-cadre des Nations Unies sur les changements climatiques -Programme d'action d'adaptation aux changements climatiques du Bénin (NAPA-Benin)*. Cotonou : Ministère de l'Environnement et de la Protection de la Nature, République du Bénin.

Berrang-Ford, L., J.D. Ford, and J. Paterson, 2011: Are we adapting to climate change*? Global Environmental Change*, **21(1)**, 25–33.

Betsill, M.M. and H. Bulkeley, 2006: Cities and multilevel governance of global climate change. *Global Governance*, **12**, 141-159.

Bhutan. National Environment Commission, Royal Government of Bhutan*: Bhutan National Adaptation Programme of Action*.

Bhutta, Z.A., T. Ahmed, R.E. Black, S. Cousens, K. Dewey, E. Giugliani, B.A. Haider, B. Kirkwood, S.S. Morris, H.P.S. Sachdev, and M. Shekar, 2008: What works? Interventions for maternal and child undernutrition and survival. *Lancet*, **371(9610)**, 417-440.

Biesbroek, G.R., R.J. Swart, T.R. Carter, C. Cowan, T. Heinrichs, H. Mela, M.D. Morecroft, and D. Rey, 2010 : Europe adapts to climate change : comparing national adaptation strategies. *Global Environmental Change*, **20**, 440-450.

Biesbroek, G.R., R.J. Swart, W.G.M. van der Knaap, 2009: The mitigation-adaptation dichotomy and the role of spatial planning. *Habitat International*, **33**, 230-237.

Birkmann, J. and K. von Teichman, 2010: Integrating disaster risk reduction and climate change adaptation: key challenges—scales, knowledge, and norms. *Sustainability Science*, **5(2)**, 171-184.

Blaikie, P., T. Cannon, I. Davis, and B. Wisner, 1996: *At Risk: Natural Hazards, Peoples Vulnerability and Disasters*. Routledge, London and New York.

BMU, 2008: *German Strategy for Adaptation to Climate Change*. Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, Berlin, Germany, 73 pp.

Bolte, A., C. Ammer, M. Löf, P. Madsen, G. Nabuurs, P. Schall, P. Spathelf, and J. Rock, 2009: Adaptive forest management in central Europe: climate change impacts, strategies and integrative concept. *Scandinavian Journal of Forest Research*, **24(6)**, 473-482.

Bosello, F., C. Carraro, E. De Cian, 2009: *An analysis of adaptation as a response to climate change*. Department of Economics Research Paper Series No. 26.09, University Ca'Foscari of Venice, Italy.

Bouma, J.A., W. Trent, and M. Laurens, 2011: The downstream externalities of harvesting rainwater in semi-arid watersheds: an Indian case study. *Agricultural Water Management*, **98(7)**, 1162-1170.

Boyd, E., N. Grist, S. Juhola, and V. Nelson, 2009: Exploring development futures in a changing climate: frontiers for development policy and practice. *Development Policy Review*, **27(6)**, 659-674.

Brauch, H.G., 2008: Conceptualising the environmental dimension of human security in the UN. *International Social Science Journal*, **59(s1)**, 19-48.

Brooke, C., 2008: Conservation and adaptation to climate change. *Conservation Biology*, **22(6)**, 1471-1476.

Brooks, N., 2003: *Vulnerability, Risk and Adaptation: A Conceptual Framework*. Tech Working Paper 38, Tyndall Centre, Norwich, UK, 20 pp.

Brooks, N., W.N. Adger, and P.M. Kelly, 2005: The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change Part A*, **15(2)**, 151-163.

Brooks. N, and J. Frankel-Reed 2008. Proposed framework for monitoring and evaluating adaptation to climate change. Paper for the GEF International Workshop on Evaluating Climate Change and Development. UNDP.

Brown, J., N. Bird, and L. Schalatek, 2010: *Direct Access to the Adaptation Fund: Realising the Potential of National Implementing Entities*. ODI Climate Finance Policy Brief No. 3, Overseas Development Institute, London, UK, 10 pp.

Brown, O., A. Hammill, and R. Mcleman, 2007: Climate change as the 'new' security threat: implications for Africa. *International Affairs,* **83(6)**, 1141-1154.

Buhaug, H., N.P. Gleditsch, and O.M. Theisen, 2010: Implications of climate change for armed conflict. In: *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World* [R. Mearns and A. Norton (eds.)]. The World Bank, Washington DC, pp. 75-102.

Burkina Faso. Ministère de l'Environnement et du Cadre de Vie, Secrétariat Permanent du Conseil National pour l'Environnement et le Développement Durable, Burkina Faso, 2007: *Programme d'Action National d'Adaptation à la Variation aux Changements Climatiques (PANA du Burkina Faso)*.

Burton, I., S. Huq, B. Lim, O. Pilifosova, and E.L. Schipper, 2002: From impacts assessment to adaptation priorities: the shaping of adaptation policy. *Climate Policy*, **2(2)**, 145–159.

Burundi. Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement, République du Burundi, 2007: *National Adaptation Plan of Action to Climate Change "NAPA"*. Bujumbura : Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement, République du Burundi.

Byers, M. and N. Dragojlovic, 2004: Darfur: a climate change-induced humanitarian crisis? *Human Security Bulletin*, October.

Camacho, A.E., 2009: Adapting governance to climate change: managing uncertainty through a learning infrastructure. *Emory Law Journal*, **59**, 1-78.

Cambodia. Ministry of Environment, Royal Government of Cambodia, 2006: *National Adaptation Programme of Action to Climate Change (NAPA)*.

Cape Verde. Ministry of Environment and Agriculture -National Meteorology and Geophysics Institute, Republic of Cape Verde, 2007: *National Adaptation Programme of Action on Climate Change 2008-2012*. Executive Version.

Capoor, K. and P. Ambrosi, 2009: *State and Trends of the World's Carbon Markets 2009*. The World Bank, Washington, DC, 78 pp.

Carmin, J., I. Anguelovski, and D. Roberts, forthcoming: Urban climate adaptation in the global south: planning in an emerging policy domain. *Journal of Planning Education and Research*, in press.

Carpenter, S.R., H.A. Mooney, J. Agard, D. Capistrano, R.S. DeFries, S. Diaz, T. Dietz. A.K. Duraiappah, A. Oteng-Yeboah, H.M. Pereira, C. Perrings, W.V. Reid, J. Sarukhan, R.J. Scholes, and A. Whyte, 2009: Science for managing ecosystem services: beyond the millennium ecosystem assessment. Proceedings of the National Academy of Sciences, **106(5)**, 1305-1312.

Carr, E.R., 2008: Between structure and agency: livelihoods and adaptation in Ghana's central region. *Global Environmental Change*, **18**, 689-699.

Cardona, O.D., 2005. Indicators of Disaster Risk and Risk Management: Program for Latin America and the Caribbean. Summary Report. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, http://idea.unalmzl.edu.co

Carter, T.J. (ed.) 2007 Assessing the adaptive capacity of the Finnish environment and society under a changing climate: FINADAPT. Summary for Policy Makers. Helsinki, Finland.

CBD AHTEG, 2009: *Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change*. Technical Series No. 41, Secretariat of the Convention on Biological Diversity, Montreal, Canada, 126 pp.

Central African Republic. Ministères des Eaux, Forêts, Chasse & Pêche et de l'Environnement, République Centrafricaine, 2008: *Programme d'Action National d'Adaptation (PANA) aux Changements Climatiques*.

Chad. Ministère de l`Environnement, de l`Eau et des Ressources Halieutiques, République du Tchad, 2010: *Programme d'action national d'adaptation aux changements climatiques (PANA-Chad)*.

Challinor, A.J., F. Ewert, S. Arnold, E. Simleton, and E. Fraser, 2009: Crops and climate change: progress, trends, and challenges in simulating impacts and informing adaptation. *Journal of Experimental Botany*, **60(10)**, 2775-2789.

Chuku, C.A., 2010: Pursuing an integrated development and climate policy framework in Africa: options for mainstreaming. *Mitigation and Adaptation Strategies for Global Change*, **15(1)**, 41-52.

Ciplet, D., A. Chandani, and S. Huq, in press: Lessons for national adaptation planning from the least developed countries. *Nature*.

Climate Investment Funds, 2009: *The Selection of Countries to Participate in the Pilot Program for Climate Resilience (PPCR)*. World Bank, Washington DC, USA, 15 pp.

Climate Investment Funds, 2008: *Terms of Reference (TORs)/Guidance for the Expert Group on the Selection of Countries to Participate in the Pilot Program for Climate Resilience (PPCR)*. World Bank, Washington DC, USA, 5 pp.

Cliquet, A., C. Backes, J. Harris, and P. Howsam, 2009: Adaptation to climate change: legal challenges for protected areas. *Utrecht Law Review*, **5(1)**, 158-175.

Coles, A.R. and C.A. Scott, 2009: Vulnerability and adaptation to climate change and variability in semi-arid rural southeastern Arizona, USA. *Natural Resources Forum*, **33**, 297–309.

Comoros. Ministry of Rural Development, Fisheries, Handicraft and Environment, Union of the Comoros, 2006: *National action programme of adaptation to climate change (NAPA)*.

Connelly, S., 2007: Mapping sustainable development as a contested concept. *Local Environment*, **12(3)**, 259–278.

Conway, D. and L. Schipper, 2011: Adaptation to climate change in Africa: challenges and opportunities identified from Ethiopia. *Global Environmental Change, **21(1)**, 227-237*.

Corfee-Morlot, J., I. Cochran, S. Hallegatte, and P.-J. Teasdale, 2011: Multilevel risk governance and urban adaptation policy. *Climatic Change*, **104(1)**, 169–197.

Corfee-Morlot, J., L. Kamal-Chaoui, M.G. Donovan, I. Cochran, A. Robert, and P.-J. Teasdale, 2009: *Cities, Climate Change and Multilevel Governance*. OECD Environmental Working Papers No. 14, OECD, Paris, France, 126 pp.

Cornell, S., 2010: Valuing ecosystem benefits in a dynamic world. *Climate Research*, **45**, 261–272.

Crabbe, P. and M. Robin, 2006: Institutional adaptation of water resource infrastructures to climate change in eastern Ontario. *Climatic Change*, **78(1)**, 103-133.

Cutter, S.L., B.J. Boruff, and W.L. Shirley, 2003: Social vulnerability to environmental hazards. *Social Science Quarterly*, **84**, 242.261.

Cutter, S.L., 1996: Vulnerability to environmental hazards. *Progress in Human Geography*, **20**, 529-539.

Dacko, M., 2010: Systems dynamics in modeling sustainable management of the environment and its resources. *Polish Journal of Environmental Studies*, **19(4)**, 699-706.

DAFF, 2006: *National Agriculture and Climate Change Action Plan 2006-2009*. Department of Agriculture, Fisheries, and Forestry and the Natural Resource Management Managerial Council, Canberra, Australia, 28 pp.

Davin, E. and N. de Noblet-Ducoudre, 2010: Climatic impacts of global-scale deforestation: radiative versus nonradiativeprocesses. Journal of Climate, **23**, 97-112.

Dawson, R.J., M.E. Dickson, R.J. Nicholls, J.W. Hall, M.J.A. Walkden, P.K. Stansby, M. Mokrech, J. Richards, J. Zhou, and J. Milligan, 2009: Integrated analysis of risks of coastal flooding and cliff erosion under scenarios of long term change. *Climatic Change*, **95(1-2)**, 249-288.

De Bruin, K., R.B. Dellink, A. Ruijs, L. Boldwidt, A. van Buuren, J. Graveland, R.S. de Groot, P.J. Kuikman, S. Reinhard, R.P. Roetter, V.C. Tassone, A. Verhagen, and E.C. van Ierland, 2009: Adapting to climate change in the Netherlands: an inventory of climate adaptation options and ranking of alternatives. *Climatic Change*, **95(1-2)**, 23-45.

deFur P.L., G.W. Evans, E.A.C. Hubal, A.D. Kyle, R.A. Morello-Frosch, and D.R. Williams, 2007: Vulnerability as a function of individual and group resources in cumulative risk assessment. *Environmental Health Perspectives*, **115**, 817-824.

Democratic Republic of Congo (DRC). Ministère de l'Environnement, République Démocratique du Congo, 2006: *Programme d'Action National d'Adaptation au Changement Climatique de la République Démocratique du Congo*.

Dilley, M., R.S. Chen, U. Deichmann, A.L. Lerner-Lam, and M. Arnold, with J. Agwe, P. Buys, O. Kjekstad, B. Lyon, and G. Yetman, 2005. Natural Disaster Hotspots: A Global Risk Analysis. Washington, D.C: International Bank for Reconstruction and Development/The World Bank and Columbia University. http://www.ldeo.columbia.edu/chrr/research/hotspots/

Djibouti. Ministère de l'Habitat, de l'Urbanisme, de l'Environnement et de l'Aménagement du Territoire, République de Djibouti, 2006: *Programme d'Action National aux Changements Climatiques*.

Dodman, D., D. Satterthwaite, 2009: The costs of adapting infrastructure to climate change. In: *Assessing the Costs of Adaptation to Climate Change: A Review of the UNFCCC and Other Recent Estimates* [Parry, M., N. Arnell, P. Berry, D. Dodman, S. Fankhauser, C. Hope, S. Kovats, R. Nicholls, D. Satterthwaite, R. Tiffin, and T. Wheeler (eds.)]. Institute for Environment and Development and Grantham Institute, London, UK, pp. 73-89.

Doria, M.D., E. Boyd, E.L. Tompkins, and W.N. Adger, 2009: Using expert elicitation to define successful adaptation to climate change. *Environmental Science and Policy*, **12(7)**, 810-819.

Dovers, S., 2009: Normalizing adaptation. *Global Environmental Change*, **19(1)**, 4-6.

Dow, K., R. Kasperson, and M. Bohn, 2006: Exploring the social justice implications of adaptation and vulnerability. In: *Fairness in Adaptation to Climatic Change* [W.N. Adger, J. Paavola, S. Huq, and M.J. Mace (eds.)]. Massachusetts Institute of Technology Press, Cambridge MA, USA, pp. 79-96.

Dowlatabadi, H., 2007: On integration of policies for climate change global change. *Mitigation and Adaptation Strategies for Global Change*, **12**, 651-663.

Downing, T.E., Watts, M.J. and Bohle, H.G., 1995. Climate change and food insecurity: Towards a sociology and geography of vulnerability. In: *Climate Change and World Food Security*, [T.E. Downing (ed.)], Berlin, Springer, pp. 183–206.

Downing, T. 2003: Toward a vulnerability/adaptation science: lessons from famine early warning and food security. In: *Climate Change Adaptive Capacity and Development* [J. Smith, R. Klein, and S. Huq (eds.)]. Imperial College Press, London, UK, pp. 77-100.

Dupont, A., 2008: The strategic implications of climate change. *Survival*, **50(3)**, 29–54.

Eakin, H. and M.C. Lemos, 2006: Adaptation and the state: Latin America and the challenge of capacity-building under globalization. *Global Environmental Change*, **16(1)**, 7-18.

Eakin, H. and A. Luers, 2006: Assessing the vulnerability of social–environmental systems. *Annual Review of Environment and Resources*, **31**, 365-394.

Ebi, K.L. and J.G. Semenza, 2008: Community-based adaptation to the health impacts of climate change. *American Journal of Preventive Medicine,* **5(35)**, 501-507.

Engle, N.L., 2011: Adaptive capacity and its assessment. *Global Environmental Change*, **21(2)**, 647-656.

Engle, N.L. and M.C. Lemos, 2010: Unpacking governance: building adaptive capacity to climate change of river basins in Brazil. *Global Environmental Change*, **20(1)**, 4-13.

Ensor, J. and R. Berger, 2009: *Understanding Climate Change Adaptation: Lessons from Community-Based Approaches*. Practical Action Publishing, Bourton-on-Dunsmore, UK, 208 pp.

Eriksen, S.H. and J. Lind, 2009: Adaptation as a political process: adjusting to drought and conflict in Kenya's drylands. *Environmental Management*, **43(5)**, 817-835.

Eriksen, S.H. and P.M. Kelly, 2007: Developing credible vulnerability indicators for climate adaptation policy assessment. *Mitigation and Adaptation Strategies for Global Change*, **12**, 495-524.

Eriksen, S.H. and K. O'Brien, 2007: Vulnerability, poverty and the need for sustainable adaptation measures. *Climate Policy*, **7(4)**, 337-352.

Eritrea. State of Eritrea. Ministry of Land, Water and Environment. Department of Environment, 2007: *National Adaptation Programme of Action*.

Ethiopia. Ministry of Water Resources, National Meteorological Agency, the Federal Democratic Republic of Ethiopia, 2007*: Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia*. Addis Ababa: Ministry of Water Resources, National Meteorological Agency, the Federal Democratic Republic of Ethiopia.

Falaleeva, M., C. O'Mahony, S. Gray, M. Desmond, J. Gault, and V. Cummins, 2011: Towards climate adaptation and coastal governance in Ireland: Integrated architecture for effective management? *Marine Policy*, **35**, 784–793.

Farber, D.A., 2007: Adapting to climate change: who should pay. Journal of Land Use, **23**, 1-38.

Farhana, Y., A. Rahman, and S. Huq, 2005: Vulnerability, adaptation and climate disasters: a conceptual overview. *IDS Bulletin*, **36(4)**, 1-14.

Fedrigo, D. and J. Hontelez, 2010: Sustainable consumption and production an agenda beyond sustainable consumer procurement. *Journal of Industrial Ecology,* **14(1)**, 10-12.

Fekete, B.M., D. Wisser, C. Kroeze, E. Mayorga, L. Bouwman, W.M. Wollheim, and C. Vorosmarty. Millenium ecosystem assessment scenario drivers (1970-2050): climate and hydrological alterations. *Global Biogeochemical cycles*, **24(4)**, GB0A12.

Few, R., K. Brown, and E.L. Tompkins, 2007: Public participation and climate change adaptation: avoiding the illusion of inclusion. *Climate Policy*, **7**, 46-59.

Fields, S., 2005: Continental divide. *Environmental Health Perspectives*, **113(8)**, A534-A537.

Flam, K.H. and J.B. Skjaerseth, 2009: Does adequate financing exist for adaptation in developing countries? *Climate Policy*, **9(1)**, 109-114.

Ford, J.D., L. Berrang-Ford, and J. Paterson, 2011: A systematic review of observed climate change adaptation in developed nations. *Climatic Change*, **106**, 327-336.

Ford, J.D., B. Smit, J. Wandel, M. Allurut, K. Shappa, H. Ittusarjuat, and K. Qrunnut, 2008: Climate change in the Arctic: current and future vulnerability in two Inuit communities. *The Geographical Journal*, **174(1)**, 45-62.

Frank, E., H. Eakin, and D. López-Carr, 2011: Social identity, perception and motivation in adaptation to climate risk in the coffee sector of Chiapas, Mexico. *Global Environmental Change*, **21(1)**, 66–76.

Füssel, H.-M., 2010: How inequitable is the global distribution of responsibility, capability, and vulnerability to climate change: a comprehensive indicator-based assessment. *Global Environmental Change*, **20(4)**, 597-611.

Füssel, H.-M., 2009: An updated assessment of the risks from climate change based on research published since the IPCC Fourth Assessment Report. Climatic Change, **97**, 469–482.

Füssel, H.-M., 2008: Assessing adaptation to the health risks of climate change: what guidance can existing frameworks provide? *International Journal of Environmental Health Research*, **18(1)**, 37–63.

Füssel, H.-M., 2007: Vulnerability: a generally applicable conceptual framework for climate change research. *Global Environmental Change*, **17(2)**, 155-167.

Füssel, H.-M. and R.J.T. Klein, 2006: Climate change vulnerability assessments: an evolution of conceptual thinking. *Climatic Change*, **75(3)**, 301–329.

Gambia. Government of the Gambia, 2007: *Gambia National Adaptation Programme of Action (NAPA) on Climate Change*. Banjul: Government of the Gambia.

Gallopin, G.C. 1997. Situational indicators. In: *Sustainability indicators: a report on the project on indicators of sustainable development*. [B. Moldan, S. Bilharz, and R. Matravers, (eds.)]. SCOPE 58, Chicester, UK: John Wiley & Sons.

Gemenne, F, 2011. Climate-induced population displacements in a 4°C+ world. *Philosophical Transactions of the Royal Society*, **369(1934)**, 182-195.

Gero, A., K. Heheux, and D. Dominey-Howes, 2011: Integrating community based disaster risk reduction and climate change adaptation: examples from the Pacific. *Natural Hazards and Earth System Sciences*, **11**, 101-113.

Ghesquiere, F. and O. Mahul, 2010: *Financial Protection of the State against Natural Disasters: A Primer*. World Bank Policy Research Working Paper 5429, World Bank, Washington DC, USA, 26 pp.

Grothmann, T. and A. Patt, 2005: Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Global Environmental Change*, **15(3)**, 199–213.

GTZ, 2008: *Adaptation and Refinement of the World Bank's "Country Policy and Institutional Assessment" (CPIA)*. Global Public Policy Institute, Eschborn, Germany, 94 pp.

Guariguata, M., 2009: El manejo forestal en el contexto de la adaptación al cambio climático. *Revista de Estudios Sociales,* **32**, 98-112.

Guillaumont, P. and C. Simonet, 2011: *Designing an Index of Structural Vulnerability to Climate Change*. Serie "Indicateurs de developpement innovants" I08, Foundation pour les Etudes et Recherches sur le Developpment International, Paris, France, 42 pp.

Guinea. Ministère de l'Agriculture, de l'Elevage, de l'Environnement, des Eaux et des Forêts -Conseil National de l'Environnement, République de Guinée, 2007: *Plan d'Action National d'Adaptation aux Changements Climatiques (PANA) de la République de Guinée*. Conakry: Ministère de l'Agriculture, de l'Elevage, de l'Environnement, des Eaux et des Forêts -Conseil National de l'Environnement, République de Guinée.

Guinea-Bissau. Ministry of Natural Resources and Environment, Republic of Guinea-Bissau, 2006: *National Programme of Action of Adaptation to Climate Changes*.

Gupta, J., C. Termeer, J. Klostermann, S. Meijerink, M. van den Brink, P. Jong, S. Nooteboom, and E. Bergsma, 2010: The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science and Policy*, **13(6)**, 459–471.

Haïti. Ministère de l'Environnement –Programme Changements Climatiques, République d'Haïti, 2006: *Plan d'Action National d'Adaptation (PANA)*.

Hallegatte S., F. Lecocq, and C. de Perthuis, 2011: *Designing Climate Change Adaptation Policies: An Economic Framework*. Policy Research Working Paper No. 5568, World Bank, Washington DC, USA, 41 pp.

Hallegatte, S., 2009: Strategies to adapt to an uncertain climate change. *Global Environmental Change*, **19(2)**, 240–247.

Halsnaes, K and S. Traerup, 2009: Development and climate change: a mainstreaming approach for assessing economic, social, and environmental impacts of adaptation measures. *Environmental Management*, **43(5)**, 765–778.

Hamilton, C. and T. Kasser, 2009: Psychological Adaptation to the Threats and Stresses of a Four Degree World. In: *Four Degrees and Beyond*. Environmental Change Institute, Oxford University, Oxford, UK, 10 pp.

Hamin, E.M. and N. Gurran, 2009: Urban form and climate change: balancing adaptation and mitigation in the U.S. and Australia. *Habitat International*, **33(3)**, 238-245.

Handmer, J.W., S. Dovers, T.E. Downing, 1999: Societal vulnerability to climate change. *Mitigation and Adaptation Strategies for Global Change*, **4(3-4)**, 267-281.

Hardee, K. and C. Mutunga, 2009: Strengthening the link between climate change adaptation and national development plans: lessons from the case of population in National Adaptation Programmes of Action (NAPAs)." *Mitigation and Adaptation Strategies for Global Change*, **15(2)**, 113-126.

Hardoy, J. and P. Romero Lankao, 2011: Latin American cities and climate change: challenges and options to mitigation and adaptation responses. *Current Opinion in Environmental Sustainability*, **3(3)**, 158-163.

Head, L., 2010: Cultural ecology: adaptation—retrofitting a concept? *Progress in Human Geography*, **34(2)**, 234-242.

Hedger, M.M., T. Mitchell, J. Leavy, M. Greeley, A. Downie, and L. Horrocks. 2008. Desk Review: Evaluation of adaptation to climate change from a development perspective. A study commissioned by the GEF Evaluation Office and financed by Department for International Development (DFID). Institute of Development Studies, UK. http://www.preventionweb.net/files/7845_GEF20final20report20Oct20081.pdf

Heinke, M., S.M. Howden, P.C. Struik, R. Nelson, D. Rordriguez, and S. Chapman, 2009: Adaptation science for agriculture and natural resource management- urgency and theoretical basis. *Current Opinion in Environmental Sustainability*. **1**, 69-76.

Heltberg, R. and N. Lund, 2009: Shocks, coping, and outcomes for Pakistan's poor: health risks predominate. *Journal of Development Studies*, **45(9)**, 889-910.

Heltberg, R., P.B. Siegel, and S.L. Jorgensen, 2009: Addressing human vulnerability to climate change: toward a 'no-regrets' approach. *Global Environmental Change*, **19(1)**, 89–99.
Hertel, T.W. and S.D. Rosch, 2010: Climate change, agriculture, and poverty. *Applied Economic Perspectives and Policy*, **32(3)**, 355-385.
Herweijer, C., N. Ranger, and R.E.T. Ward, 2009: Adaptation to climate change: threats and opportunities for the insurance industry. *Geneva Papers on Risk & Insurance - Issues & Practice*, **34(3)**, 360-380.
Hoegh-Guldberg, O., 2011: Coral reef ecosystems and anthropogenic climate change. *Regional Environmental Change*, **11(Suppl. 1)**, 215–227.
Hoddinott, J., J.A. Maluccio, J.R. Behrman, R. Flores, and R. Martorell, 2008: Effect of a nutrition intervention during early childhood on economic productivity in Guatemalan adults. *Lancet*, **371**, 411-416.
Hope, K.R., 2009: Climate change and poverty in Africa. *International Journal of Sustainable Development and World Ecology,* **16(6)**, 451-461.
Hulme, M., 2009: *Why We Disagree about Climate Change: Understanding Controversy, Inaction and Opportunity*. Cambridge, UK: Cambridge University Press, 432 pp.
Huntjens, P., C. Pahl-Wostl, and J. Grin, 2010: Climate change adaptation in European river basins. *Regional Environmental Change*, **10(4)**, 263–284.
Huq, S., S. Kovats, H. Reid, and D. Satterthwaite, 2007: Editorial: reducing risks to cities from disasters and climate change. *Environment and Urbanization*, **19(1)**, 3-15.
IEG Independent Evaluation Group, 2009: *The World Bank's Country Policy and Institutional Assessment: An Evaluation*. 170 pp.
Intellecap, 2010: *Opportunities for Private Sector Engagement in Urban Climate Change Resilience Building*. Rockefeller Foundation and Intellecap, Bangkok, Thailand, 94 pp.
Ionescu, C., R.J.T. Klein, J. Hinkel, K.S. Kavi Kumar, and R. Klein, 2009: Towards a formal framework of vulnerability to climate change. *Environmental Model Assessment*, **14(1)**, 1–16.
IPCC, 2007: *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [R.K. Pachauri and A. Reisinger (eds.)]. Intergovernmental Panel on Climate Change, Geneva, Switzerland, 104 pp.
IPCC, 2007: *Contributions of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.)]. Cambridge University Press, Cambridge, UK, 976 pp.
IPCC, 2001: Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change [J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White (eds.)]. Cambridge University Press, Cambridge, UK.
Jackson, L., M. van Noordwijk, J. Bentsson, W. Foster, L. Lipper, M. Pulleman, M. Said, J. Snaddon, and R. Vodouhe, 201: Biodvidersity and agricutlural sustainabgility: from assessment to adaptive management. *Curent Opinion in Environmental Sustainability*, **2(1-2)**, 80-87.
Jacob, C., T. McDaniels, and S. Hinch, 2010: Indigenous culture and adaptation to climate change: sockeye salmon and the St'at'mic people. *Mitigation and Adaptation Strategies for Global Change*, **15(8)**, 859-876.
Jentsch A., J. and C. Beierkuhnlein, 2008: Research frontiers in climate change: effects of extreme meteorological events on ecosystems. *Comptes Rendus Geoscience*, **340**, 621-628.
Jentsch A., J. Kreyling, and C. Beierkuhnlein, 2007: A new generation of climate change experiments: events, not trends. *Frontiers in Ecology and the Environment*, **5**, 365-374.
Jernek, A. and L. Olsson, 2008: Adaptation and the poor: development, resilience and transition. *Climate Policy*, **8(2)**, 170-182.
Juhola, S. and L. Westerhoff, 2011: Challenges of adaptation to climate change across multiple scales: a case study of network governance in two European countries. *Environment Science and Policy*, **14(3)**, 239-247.
Kalame, F.B., D. Kudejira, and J. Nkem, 2011: Assessing the process and options for implementing National Adaptation Programmes of Action (NAPA): a case study from Burkina Faso. *Mitigation and Adaptation Strategies for Global Change*, **16(5)**, 535-553.
Kasperson, J.X. and R.E. Kasperson, 2001: *Global Environmental Risk*. United National University Press, Tokyo, London, New York.
Kemp, R., and P. Martens, 2007: Sustainable development: how to manage something that is subjective and never can be achieved? *Science, Practice, and Policy*, **3(2)**, 1-10.

Khattri, A., D. Parameshwar, and S. Pellech. 2010. *Opportunities for Private Sector Engagement in Urban Climate Change Resilience Building*. Rockefeller Foundation, Bangkok, Thailand, 94 pp.

Kiribati. Environment and Conservation Division, Ministry of Environment, Land and Agricultural Development, Republic of Kiribati, 2007: *National Adaptation Program of Action (NAPA)*. Tawara: Environment and Conservation Division, Ministry of Environment, Land and Agricultural Development, Republic of Kiribati.

Kithiia, J. and R. Dowling, 2010: An integrated city-level planning process to address the impacts of climate change in Kenya: the case of Mombasa. *Cities*, **27**, 466-475.

Klein, R.J.T. and A. Möhner, 2011: The political dimension of vulnerability: implications for the Green Climate Fund. *IDS Bulletin*, **42(3)**, 15-22.

Klein, R.J.T., S. Huq, F. Denton, T.E. Downing, R.G. Richels, J.B. Robinson, and F.L. Toth, 2007: Inter-relationships between adaptation and mitigation. In: *Contributions of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [M.L. Parry, O.F. Canziani, J.P. Palutikot, P.J. van der Linden, and C.E. Hanson (eds.)]. Cambridge University Press, Cambridge, UK, pp. 745-777.

Klein, R.J.T., R.J. Nicholls, and F. Thomalla, 2003: Resilience to natural hazards: How useful is this concept? *Global Environmental Change Part B: Environmental Hazards*, **5(1-2)**, 35-45.

Kovats, S. and R. Akhtar, 2008: Climate, climate change and human health in Asian cities. *Environment and Urbanization,* **20(1)**, 165-175.

Kramer, A.M. 2007. Adaptation to Climate Change in Poverty Reduction Strategies. Human Development Report 2007/2008 Human Development Report Office Occasional Paper 2007/34.

Kuwali, D., 2008: From the West to the rest: climate change as a challenge to human security in Africa. *African Security* Review, **17(3)**, 18-38.

Lane, M.B. and G. McDonald, 2005: Community-based environmental planning: operational dilemmas, planning principles and possible remedies. *Journal of Environmental Planning and Management*, **48(5)**, 709-731.

Lansigan, F.P., W.L. delos Santos, and J. Hansen, 2007. Delivering Climate Forecast Products to Farmers: Ex Post Assessment of Impacts of Advanced Climate Information on Corn Production Systems in Isabela, Philippines. In: *Climate Prediction and Agriculture: Advances and Challenges* [M.V.K. Sivakumar and J.W. Hansen (eds.)]. Springer, Berlin, Germany, pp. 41- 48.

Lao People's Democratic Republic (Lao DPR). Water Resources and Environment Administration, Lao People's Democratic Republic, 2009: *National Adaptation programme of Action to Climate Change*.

Larsen, K. and U. Gunnarsson-**Östling, 2009:** Climate change scenarios and citizen-participation: mitigation and adaptation perspectives in constructing sustainable futures. *Habitat International*, **33(3)**, 260-266.

Larsen, S. and L. Kørnøv, 2009: SEA of river basin management plans: incorporating climate change. *Impact Assessment & Project Appraisal*, **27(4)**, 291-299.

Laukkonen, J., P.K. Blanco, J. Lenhart, M. Keiner, B. Cavric, and C. Kinuthia-Njenga, 2009: Combining climate change adaptation and mitigation measures at the local level. *Habitat International*, **33(3)**, 287-292.

Leichenko, R.M. and K.L. O'Brien, 2008: *Environmental Change and Globalization: Double Exposures*. Oxford University Press, Oxford, UK.

Lempert, R.J. and M.T. Collins, 2007: Managing the risk of uncertain threshold responses: comparison of robust, optimum, and precautionary approaches. *Risk Analysis*, **27(4)**, 1009-1026.

Lemos, M.C and L. Dilling, 2007: Equity in forecsting climate: can science save the world's poor? *Science and Public Policy*, 34(2), 109-116.

Lemos, M.C. and E.L. Tompkins, 2008: Creating less disastrous disasters. *IDS Bulletin***, 39(4)**, 60-65.

Lesotho. Ministry of Natural Resources –Lesotho Meteorological Services, Lesotho: *Lesotho's National Adaptation Programme of Action (NAPA) on Climate Change Under the United Nations Framework Convention on Climate Change*.

Liberia . Environmental Protection Agency, Liberia, 2008: *National Adaptation Programme of Action (NAPA).* Monrovia: Environmental Protection Agency, Liberia.

Lobell, D.B., M.B. Burke, C. Tebaldi, M.D. Mastrandrea, W.P. Falcon, and R.L. Naylor, 2008: Prioritizing climate adaptation needs for food security in 2030. *Science*. **319(5863)**, 607-610.

Lonergan, S., Gustavson, K. and Harrower, M. 1999. Mapping human insecurity. In: *Environmental Change, Adaptation, and Security*, [S.C. Lonergen (ed.)], Dordrecht, NATO/Kluwer, pp. 397– 413.

Lu, X, 2011: Provision of climate information for adaptation to climate change. *Climate Research*, **47**: 83-94.

Lwasa, S., 2010: Adapting urban areas in Africa to climate change: the case of Kampala. *Current Opinion in Environmental Sustainability*, **2**, 166-171.

Madagascar. Ministère de l'Environnement, des Eaux et des Forêts –Direction Générale de l'Environnement, République de Madagascar: *Programme d'Action National d'Adaptation au Changement Climatique*.

Malawi. Ministry of Mines, Natural Resources and Environment –Environmental Affairs Department, Republic of Malawi, 2006: *Malawi's National Adaptation Programmes of Action (NAPA) under the United Nations Framework Convention on Climate Change (UNFCCC)*. First Edition.

Maldives. Ministry of Environment, Energy and Water, Republic of Maldives, 2007: *National Adaptation Program of Action*. Male: Ministry of Environment, Energy and Water, Republic of Maldives.

Mali. Ministère de l'Equipement et des Transports, République du Mali, 2007: *Programme d'Action National d'Adaptation aux Changements Climatiques*.

Martens, P., 2006: Sustainability: science or fiction? *Sustainability: Science, Practice and Policy*, **2**, 1-5.

Martens, P., D. McEvoy, and C. Chang, 2009: The climate change challenge: linking vulnerability, adaptation, and mitigation. *Current Opinion in Environmental Sustainability*. **1**, 14-18.

Martins, R.D. and L.D. Ferreira, 2011: Opportunities and constraints for local and subnational climate change policy in urban areas: insights from diverse context. *International Journal of Global Environmental Issues*, **11(1)**, 37-53.

Marttila, V., H. Granholm, J. Laanikari, T. Yrjola, A. Aalto, P. Heikinheimo, J. Honkatuki, H. Jarvinen, J. Liski, R. Merivirta, and M. Paunio (eds.), 2005: F*inland's National Strategy for Adaptation to Climate Change*. Ministry of Agriculture and Forestry, Helsinki, Finland, 281 pp.

Mauritania. Ministry of Rural Development and Environment –Department of the Environment Project Coordination Unit, Islamic Republic of Mauritania, 2004: *National Adaptation Programme of Action to Climate Change NAPA-RIM*.

Mawdsley, J. R., R. O'Malley, and D.S. Ojima, 2009: A review of climate-change adaptation strategies for wildlife management and biodiversity conservation. *Conservation Biology*, **23(5)**, 1080-1089.

McEvoy, D., S. Lindley, and J. Handley, 2006: Adaptation and mitigation in urban areas: synergies and conflicts. *Proceedings of the Institution of Civil Engineers: Municipal Engineer*, **159(4)**, 185-191.

McGray, H., R. Bradley, and A. Hammill. 2007. Weathering the Storm: Options for Framing Adaptation and Development. Washington DC: World Resources Institute (WRI).

McLeman, R., 2010: Impacts of population change on vulnerability and the capacity to adapt to climate change and variability: a typology based on lessons from 'a hard country'. *Population and Environment*, **31(5)**, 286-316.

Measham, T.G., B.L. Preston, T.F. Smith, C. Brooke, R. Gorddard, G. Withycombe, and C. Morrison, 2011: Adapting to climate change through local municipal planning: barriers and challenges. *Mitigation and Adaptation Strategies for Global Change*, in press.

Méheux, K., D. Dominey-Howes, and K. Lloyd, 2010: Operational challenges to community participation in post-disaster damage assessments: observations from Fiji. *Disasters*, **34(4)**, 1102–1122.

Mertz, O., K. Halsnaes, J.E. Olesen, and K. Rasmussen, 2009: Adaptation to climate change in developing countries. *Environmental Management*, **43(5)**, 743-752.

Mooney, H., A. Larigauderie, M. Cesario, T. Elmquist, O. Hoegh-Guldberg, S. Lavorel, G. Mace, M. Palmer, R. Scholes, and T. Yahara, 2009: Biodiversity, climate change, and ecosystem services. *Current Opinion in Environmental Sustainability*, **1**, 46-54.

Moore, D.R.J., 2001: The Anna Karenina principle applied to ecological risk assessments of multiple stressors. *Human and Ecological Risk Assessment*, **7(2)**, 231-237.

Moser, C. and D. Satterthwaite, 2010. Toward pro-poor adaptation to climate change in the urban centers of low- and middle-income countries. In: *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World* [R. Mearns and A. Norton (eds.)]. The World Bank, Washington DC, USA, pp. 231-258.

Moser, C., 2006: *Asset-based approaches to poverty reduction in a globalized context: an introduction to asset accumulation policy and summary of workshop findings*. Brookings Institution, Washington, DC, USA, 41 pp.

Moss, R.H., E.L. Malone, N.L. Engle, A. de Bremond, and A. Delgado, To appear: *Ready or Not: Towards a Resilience Framework for Making Climate-Change Adaptation Decisions*. To be published.

Moss, R.H., A.L. Brenkert, E.L. Malone, E.L., 2001: *Vulnerability to Climate Change: A Quantitative Approach*. Technical Report PNNL-SA-33642, Pacific Northwest National Laboratory and Department of Energy, Oak Ridge and Springfield, USA, 88 pp.

Mozambique. Ministry of the Co-ordination of Environmental Affairs (MICOA), Mozambique, 2007: *National Adaptation Programme of Action (NAPA)*. Maputo: Ministry of the Co-ordination of Environmental Affairs, Mozambique.

Mustelin, J., R.G. Klein, B. Assaid, T. Sitari, M. Khamis, A. Mzee, and T. Haji, 2010: Understanding current and future vulnerability in coastal settings: community perceptions and preferences for adaptation in Zanzibar, Tanzania. *Population and Environment*, **31(5)**, 371-398.

Nath, P. and B. Behera, 2011: A ciritical review of impact of and adaptation to climate change in developed and developing economies. *Environment, Development and Sustainability*, **13(1)**, 141-162.

Nelson, D.R., C. West, and T.J. Finan, T., 2009: Introduction to "In focus: global change and adaptation in local places". *American Anthropologist*, **111(3)**, 271-274.

Nelson, K.C., M.A. Palmer, J.E. Pizzuto, G.E. Moglen, P.L. Angermeier, R.H. Hilderbrand, M.Dettinger, and K. Hayhoe, 2009: Forecasting the combined effects of urbanization and climate change on stream ecosystems: from impacts to management options. *Journal of Applied Ecology*, **46(1)**, 154-163.

Nelson, D.R., W.N. Adger, and K. Brown, 2007: Adaptation to environmental change: contributions of a resilience framework. *Annual Review of Environment and Resources*, **32**, 395-419.

Nepal. Ministry of Environment, Government of Nepal, 2010: *National Adaptation Programme of Action to Climate Change (NAPA-Nepal)*.

Neufeldt, H., E. Jochem, J. Hinkel, D. Huitema, E. Massey, P. Watkiss, D. McEvoy, T. Rayner, A. Hof, and K. Lonsdale, 2010: Climate policy and inter-linkages between adaptation and mitigation. In: *Making Climate Change Work for Us: European Perspectives on Adaptation and Mitigation Strategies* [M. Hulme and H. Neufeldt (eds.)]. Cambridge University Press, Cambridge, UK, pp. 3-30.

Niger. Republic of Niger, 2006: *National Adaptation Programme of Action*.

O'Brien, K.L., 2009: Do values subjectively define the limits to climate change adaptation? In: *Adapting to Climate Change: Thresholds, Values, Governance* [W.N. Adger, I. Lorenzoni, and K.L. O'Brien (eds.)]. Cambridge University Press, Cambridge, UK, pp.164-180.

O'Brien, K., B. Hayward, and F. Berkes. 2009: Rethinking social contracts: building resilience in a changing climate. *Ecology and Society,* **14(2)**, 12-29.

O'Brien, K., S. Eriksen, L.P. Nygaard, and A. Schjolden, 2007: Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy*, **7**, 73–88.

O'Brien, K., 2006. Are we missing the point? Global environmental change as an issue of human security. *Global Environmental Change,* **16**, 1–3.

O'Brien, K. and R. Leichenko, 2006: Climate change, equity and human security. *Die Erde*, **137(3)**, 223-240.

O'Brien, K.L., S. Eriksen, A. Schjolden, and L. Lygaard, 2004: *What's in a Word? Conflicting Interpretations of Vulnerability in Climate Change Research*. Working Paper 2004:04, Center for International Climate and Environmental Research, Oslo, Norway, 19 pp.

OECD, 2011: *Financing Climate Change Action and Boosting Technology Change: Key Messages and Recommendations from Current OECD Work*. Organisation for Economic Co-Operation and Development, Paris, France, 12 pp.

OECD, 2009 : *Integrating Climate Change Adaptation into Development Co-Operation* : Policy Guidance. OECD, Paris, France, 193 pp.

Ogden, A.E. and J. L. Innes, 2009: Adapting to climate change in the southwest Yukon: locally identified research and monitoring needs to support decision making on sustainable forest management. *Arctic*, **62(2)**, 159-174.

Ormerod, S.J., M. Dobson, A.G. Hildrew, and C.R. Townsend, 2010: Multiple stressors in freshwater ecosystems. *Freshwater Biology*, **55(s1)**, 1-4.

Osman-Elasha, B., N. Goutbi, E. Spanger-Siegfried, B. Dougherty, A. Hanafi, S. Zakieldeen, E-A. Sanjak, H.A. Atti, and H.M. Elhassan. 2009. Community development and coping with drought in rural Sudan. P.90-108. In: *Climate Change and Adaptation*. [N. Leary, J. Adejuwon, V. Barros, I. Burton, J. Kulkarni and R. Lasco (eds.)]. London, Earthscan.

Otto-Banaszak, I., P. Matczak, J. Wesseler, and F. Wechsung, 2011: Different perceptions of adaptation to climate change: a mental model approach applied to the evidence from expert interviews. *Regional Environmental Change*, **11(2)**, 217-228.

Oxfam, 2007: *Adapting to Climate Change. What is Needed in Poor Countries and Who Should Pay?* Oxfam Briefing Paper 104, 44 pp.

Pahl-Wostl, C., 2009: A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, **19(3)**, 354-365.
Paterson, J., M.B. Araújo, P.M. Berry, J.M. Piper, and M.D.A. Rounsevell, 2008: Mitigation, adaptation, and the threat to biodiversity. *Conservation Biology*, **22(5)**, 1352–1355.
Parry, M., N. Arnell, P. Berry, D. Dodman, S. Fankhauser, C. Hope, S. Kovats, R. Nicholls, D. Satterthwaite, R. Tiffin, and T. Wheeler, 2009: Assessing the Costs of Adaptation to Climate Change: A Review of the UNFCCC and Other Recent Estimates. International Institute for Environment and Development and Grantham Institute for Climate Change, London, UK, 113 pp.
Perch-Nielsen, S., 2010: The vulnerability of beach tourism to climate change – an index approach. *Climatic Change*, **100**, 579-606.
Perch-Nielsen, S.L., M.B. Bättig, and D. Imboden, 2008: Exploring the link between climate change and migration. *Climatic Change*, **91(3-4)**, 375–393.
Peskett, L., N. Grist, M. Hedger, T. Lennartz-Walker, and I. Scholtz, 2009: *Climate Change Challenges for EU Development Cooperation: Emerging Issues*. Working Paper No. 3, European Development Cooperation 2020 Project, Bonn, Germany, 23 pp.
Pew Center, 2008: *Adaptation Planning – What U.S. States and Localities are Doing*. 21 pp.
Pouliotte, J., B. Smit, and L. Westerhoff, 2009: Adaptation and development: livelihoods and climate change in Subarnabad, Bangladesh. *Climate and Development*, **1(1)**, 31–46.
Prabhakar, S.V.R.K., A. Srinivasan, and R. Shaw, 2009: Climate change and local level disaster risk reduction planning: need, opportunities and challenges. *Mitigation and Adaptation Strategies for Global Change*, **14**, 7–33.
Preston, B.L., R.M. Westaway, and E.J. Yuen, 2011: Climate adaptation planning in practice: an evaluation of adaptation plans from three developed nations. *Mitigation and Adaptation Strategies for Global Change*, **16(4)**, 407-438.
Princiotta, F., 2009: Global climate change and the mitigation challenge. *Journal of the Air and Waste Management Association*, **59(10)**, 1194-1211.
Raleigh, C, 2010: Political marginalization, climate change, and conflict in African Sahel states. *International Studies Review*, **12(1)**, 69–86.
Ranger, N., A. Millner, S. Dietz, S. Fankhauser, A. Lopez, and G. Ruta, 2010: *Adaptation in the UK: A Decision-Making Process*. London School of Economics and Political Science, Centre for Climate Change Economics and Policy and the Grantham Research Institute on Climate Change and Environment, London, UK, 64 pp.
Reid, H., M. Alam, R. Berger, T. Cannon, S. Huq, and A. Milligan, 2010: Community-based adaptation to climate change: an overview. *Participatory Learning and Action*, **60**: 11-33.
Reser, J.P. and J.K. Swim, 2011: Adapting to and coping with the threat and impacts of climate change. *American Psychologist*, **66(4)**, 277-289.
Revi, A., 2008: Climate change risk: an adaptation and mitigation agenda for Indian cities. *Environment and Urbanization*, **20(1)**, 207-229.
Reyer, C., M. Guericke, and P.L. Ibisch, 2009: Climate change mitigation via afforestation, reforestation and deforestation avoidance: and what about adaptation to environmental change? *New Forests*, **38(1)**, 15–34.
Ribot, J. 2010: Vulnerability does not fall from the sky: toward multiscale, pro-poor climate policy. In: *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World* [R. Mearns and A. Norton (eds.)]. The World Bank, Washington DC, pp. 47-74.
Roberts, D., 2010: Prioritizing climate change adaptation and local level resilience in Durban, South Africa. *Environment and Urbanization,* **22(2)**, 397-413.
Roberts, D., 2008: Thinking globally, acting locally— institutionalizing climate change at the local government level in Durban, South Africa. *Environment and Urbanization,* **20(2)**, 521-537.
Rojas Blanco, A.V., 2006: Local initiatives and adaptation to climate change. *Disasters*, **30(1)**, 140–147.
Rosenzweig, C., W. D. Solecki, R. Blake, M. Bowman, C. Faris, V. Gornitz, R. Horton, K. Jacob, A. LeBlanc, R. Leichenko, M. Linkin, D. Major, M. O'Grady, L. Patrick, E. Sussman, G. Yohe, and R. Zimmerman, 2011: Developing coastal adaptation to climate change in the New York City infrastructure-shed: process, approach, tools, and strategies. *Climatic Change*, **106**, 93–127.
Rosenzweig, C., W. Solecki, S.A. Hammer, S. Mehrotra, 2010: Cities lead the way in climate–change action. *Nature*, **467**, 909–911.

Rwanda. Ministry of Lands, Forestry, Water and Mines, Republic of Rwanda, 2006: *National Adaptation Programme of Action to Climate Change NAPA-RWANDA*. Kigali: Ministry of Lands, Forestry, Water and Mines, Republic of Rwanda.

Samoa. Ministry of Natural Resources, Environment & Meteorology, Samoa, **2005?**: *National Adaptation Programme of Action*. Compiled by: National Adaptation Programme of Action Task Team (NTT), 2005. Implementing Agency: Ministry of Natural Resources, Environment & Meteorology (MNREM), 2005

Sánchez-Arcilla, J., A. Jiménez, H. I. Valdemoro, and V. Gracia, 2008: Implications of climatic change on Spanish Mediterranean low-lying coasts: The Ebro Delta Case. *Journal of Coastal Research*, **24(2)**, 306-316.

São Tomé e Príncipe. Ministério dos Recursos Naturais e Ambiente, Republica Democrática de São Tomé e Príncipe, 2006: *National Adaptation Programmes of Action on Climate Change*.

Satterthwaite, D., S. Huq, and H. Reid, M. Pelling, and P. Romero Lankao, 2009: Adapting to climate change in urban areas: the possibilities and constraints in low- and middle-income nations. In: *Adapting Cities to Climate Change* [J. Bicknell, D. Dodman, and D. Satterthwaite (eds.)]. Earthscan, London, UK, pp. 3-47.

Schindler, D.W., 2001: The cumulative effects of climate warming and other human stresses on Canadian freshwaters in the new millennium. *Canadian Journal of Fisheries and Aquatic Sciences,* **58(1)**, 18-29.

Schneider, S.H., S. Semenov, A. Patwardhan, I. Burton, C.H.D. Magadza, M. Oppenheimer, A.B. Pittock, A. Rahman, J.B. Smith, A. Suarez, and F. Yamin, 2007: Assessing key vulnerabilities and the risk from climate change. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds.)]. Cambridge University Press, Cambridge, UK, pp. 779-810.

Schröter, D., C. Polsky, and A. Patt, 2005: Assessing vulnerabilities to the effects of global change: an eight step approach. *Mitigation and Adaptation Strategies for Global Change*, **10(4)**, 573-595.

Scott, D. and S. Becken, 2010: Adapting to climate change and climate policy: progress, problems and potentials. *Journal of Sustainable Tourism*, **18(3)**, 283-295.

Semenov, M.A,. 2008: Simulation of extreme weather events by a stochastic weather generator. *Climate Research*, **35(3)**, 203-212.

Semenov, M.A., 2006: Using weather generators in crop modeling. *Acta Horticulturae*, **707**, 93-100.

Senegal. Ministère de l'Environnement et de la Protection de la Nature, République du Sénégal, 2006: *Plan d'Action National pour l'Adaptation aux Changements Climatiques*.

Seto, K., R. Sanchez-Rodriguez, and M. Fragkias, 2010: The new geography of contemporary urbanization and environment. *Annual Review of Environment and Resources*, **35**, 167-194.

Shackley, S. amd R. Deanwood, 2003: Constructing social futures for climate-change impacts and response studies: building qualitative and quantitative scenarios with the participation of stakeholders. *Climate Research*, **24**, 71-90.

Sietz, D., M. Boschütz, and R.J.T. Klein, 2011: Mainstreaming climate adaptation into development assistance: rationale, institutional barriers and opportunities in Mozambique. *Environmental Science and Policy*, **14(4)**, 493-502.

Sierra Leone. Ministry of Transport and Aviation, Government of Sierra Leone, 2007: *National Adaptation Programme of Action (NAPA)*. Final Report.

Silva, J.A., S. Eriksen, and Z.A. Ombe, 2010: Double exposure in Mozambique's Limpopo River basin. *Geographical Journal*, **176(1)**, 6-24.

Simpson, M.C., S. Gössling, D. Scott, C.M. Hall, and E. Gladin, 2008: *Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools and Practices*. United National Environment Programme and University of Oxford, Paris, France, 152 pp.

Sivakumar, M.V.K. and J.W. Hansen, 2007: *Climate Prediction and Agriculture: Advances and Challenges*. Springer, Berlin, Germany, 332 pp.

Sivakumar, M.V.K. and R. P. Motha, 2007: *Managing Weather and Climate Risks in Agriculture*. Springer, Berlin, Germany, 504 pp.

Smit, B. and J. Wandel, 2006: Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, **16**, 282–292.

Smit, B. and O. Pilifosova, 2003: From adaptation to adaptive capacity and vulnerability reduction. In: *Climate Change, Adaptive Capacity and Development* [J.B. Smith, R.J.T. Klein, and S. Huq (eds.)]. Imperial College Press, London, UK, 9-28 pp.

Smit, B. and O. Pilifosova, 2001: Adaptation to Climate Change in the Context of Sustainable Development and Equity. In: *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contributions of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK, pp. 877-912.

Solecki, W., R. Leichenko, and K. O'Brien, 2011: Climate change adaptation strategies and disaster risk reduction in cities: connections, contentions, and synergies. *Current Opinion in Environmental Sustainability*, **3(3)**, 135-141.

Solomon Islands. Ministry of Environment, Conservation and Meteorology, Solomon Islands, 2008: *National Adaptation Programmes of Action*. Honiara: Ministry of Environment, Conservation and Meteorology, Solomon Islands.

Sovacool, B.K., 2011: Hard and soft paths for climate change adaptation. *Climate Policy*, **11**, 1177-1183.

Sowers, J., A. Vengosh, and E. Weinthal, 2011: Climate change, water resources, and the politics of adaptation in the Middle East and North Africa. *Climatic Change*, **104(3-4)**, 599-627.

Speranza, C.I., B. Kiteme, P. Ambenje, U. Wiesmann, and S. Makali, 2010: Indigenous knowledge related to climate variability and change: insights from droughts in semi-arid areas of former Makueni District, Kenya. *Climatic Change*, **100**, 295-315.

Srinivarsan, A., SVRK. Prabhakar, 2008. Measures of Adaptation to Climatic Change and Variability (Adaptation Metrics). Report for World Bank, IGES, Tokyo, Japan.

Stafford Smith, M., L. Horrocks, A. Harvey, and C. Hamilton, 2010: Rethinking adaptation for a 4C world. *Philosophical Transactions of the Royal Society A*, **369**, 196-216.

Stahel, W., 2008: Global climate change in the wider context of sustainability images. *Geneva Papers on Risk & Insurance - Issues & Practice*, **33(3)**, 507-529.

Stern, N., 2006: *The Economics of Climate Change*. Cambridge University Press, Cambridge, UK: 712 pp.

Stott, P.A., N.P. Gillett, G.C. Hegerl, D.J. Karoly, D.A. Stone, X. Zhange, F. Zwiers, 2010: Detection and attribution of climate change: a regional perspective. *Wiley Interdisciplinary Reviews: Climate Change*, **1(2)**, 192-211.

Sudan. Ministry of Environment and Physical Development –Higher Council For Environment and Natural Resources, Republic of the Sudan, 2007: *National Adaptation Programme of Action*.

Swart, R. and F. Raes, 2007: Making integration of adaptation and mitigation work mainstreaming into sustainable development policies? *Climate Policy*, **7**, 288-303.

Tanzania. Vice President's office, Division of Environment, United Republic of Tanzania, 2007: *National Adaptation Programme of Action (NAPA)*.

Togo. Ministère de l'Environnement et des Ressources Forestières, Togo, 2009: *Plan d'Action National d'Adaptation aux Changements Climatiques –PANA*.

Tol, R.S.J. and S. Wagner, 2010: Climate change and violent conflict in Europe over the last millennium. *Climatic Change*, **99(1-2)**, 65–79.

Tol, R.S.J., T.E. Downing, O.J. Kuik, and J.B. Smith, 2004: Distributional aspects of climate change impacts. *Global Environmental Change*, **14(3)**, 259–272.

Tompkins, E.L., W.N. Adger, E. Boyd, S. Nicholson-Cole, K. Weatherhead, and N. Arnell, 2010: Observed adaptation to climate change: UK evidence of transition to a well-adapting society. *Global Environmental Change*, **20(4)**, 627-635.

Toronto Environment Office, 2008. *Ahead of the Storm: Preparing Toronto for Climate Change*. City of Toronto, Canada, 46 pp.

Turner, W.R., B.A. Bradley, L.D. Estes, D.G. Hole, M. Oppenheimer, and D.S. Wilcove, 2010: Climate change: helping nature survive the human response. *Conservation Letters*, **00**, 1-9.

Tuvalu. Ministry of Natural Resources, Environment, Agriculture and Lands –Department of Environment, Tuvalu, 2007: *Tuvalu's National Adaptation Programme of Action under the auspices of the United Nations Framework Convention on Climate Change*.

Uganda. The Republic of Uganda, Ministry of State for Environment, 2007: *Climate Change –Uganda National Adaptation Programmes of Action*.

UNDP, 2004: Reducing Disaster Risk: A Challenge for Development. New York: United Nation Development Programme, Bureau for Crisis Prevention and Recovery. http://www.undp.org/bcpr/disred/documents/publications/rdr/english/rdr_english.pdf

UNDP, 2008: *Human Development Report 2007/8: Fighting Climate Change: Human Solidarity in a Divided World: Human Development and Climate Change*. United Nations Development Programme, New York, US, 399 pp.

UNEP, Oxfam, and World Resources Institute, 2010: *Adapting for a Green Economy: Companies, Communities and Climate Change: A Caring for Climate*. United Nations Global Compact, United Nations Environment Programme (UNEP), Oxfam, and World Resources Institute (WRI), 72 pp.

UNEP, 2011: *Visions for Change: Recommendations for Effective Policies on Sustainable Lifestyles*. United National Environment Programme, Paris, France, 88 pp.

UNFCCC, 2007: Investment and Financial Flows to Address Climate Change. Climate Change Secretariat, Bonn, Germany, 111 pp.

Urwin, K. and A. Jordan, 2008: Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance. *Global Environmental Change,* **18(1)**, 180-191.

Van Aalst, M.K., T. Cannon, and I. Burton, 2008: Community level adaptation to climate chnage: the potential role of participatory risk assessment. *Global Environmental Change*, **18(1)**, 165-179.

Van der Brugge, R. and R. van Raak. 2007. Facing the adaptive management challenge: insights from transition management. Ecology and Society **12**, no. 2: 33.

Van Ierland, E.C., K. de Bruin, R.B. Dellink, A.J.W. Ruijs, L. Bolwidt, A. Van Buuren, J. Graveland, R.S. de Groot, P.J. Kuikman, E.E.M. Nillesen, M. Platteeuw, S. Reinhard, V.C. Tassone, A. Verhagen, R.P. Roetter, S.J.E. Verzandvoort-van Dijk, 2007: *A Quantitative Assessment of Climate Change Adaptation Options and Some Estimate of Adaptation Costs*. Routeplanner Projects 3,4, 5, Wageningen, Netherlands, 155 pp.

Van Zeijl-Rozema, A., R. Corvers, R. Kemp, and P. Martens, 2008. Governance for sustainable development: a framework. *Sustainable Development*. **16**: 410-421.

Vanuatu. National Advisory Committee on Climate Change (NACC), Republic of Vanuatu, **2007?:** National Adaptation programme for Action (NAPA). Port Vila: National Advisory Committee on Climate Change, Republic of Vanuatu.

Venema, H.D. and I.H. Rehman, 2007: Decentralized renewable energy and the climate change mitigation-adaptation nexus. *Mitigation and Adaptation Strategies for Global Change*, **12**, 875-900.

Veraart, J.A., E.C. van Ierland, S.E. Werners, A. Verhagen, R.S. de Groot, P.J. Kuikman, and P. Kabat, 2010: Climate change impacts on water management and adaptation strategies in The Netherlands: stakeholder and scientific expert judgments. *Journal of Environmental Policy and Planning*, **12(2)**, 179-200.

Vorosmarty, C.J., P.B. McIntyre, M.O. Gessmner,D. Dudgeon, A. Prusevich, P. Green, S. Glidden, S.E. Bunn, C.A. Sullivan, C. Reidy Liermann, and P.M. Davies, 2010: Global threats to human water security and river biodiversity. *Nature*, **467**, 555-561.

Warner, K., M. Hamza, A. Oliver-Smith, F. Renaud, and A. Julca, 2010: Climate change, environmental degradation, and migration. *Natural Hazards*, **55(3)**, 689-715.

Webb, J., 2011: Making climate change governable: the case of the UK climate change risk assessment and adaptation planning. *Science and Public Policy*, **38(4)**, 279–292.

Werner, A.D. and C.T. Simmons, 2009: Impact of sea-level rise on sea water intrusion in coastal aquifers. *Ground Water*, **47(2)**, 197–204.

Westerhoff, L., E.C.H. Keskitalo, S. Juhola, 2011: Capacities across scales: local to national adaptation policy in four European countries. *Climate Policy*, **11**, 1071-1085.

Wheeler, S.M., 2008: State and municipal climate change plans: the first generation. *Journal of the American Planning Association*, **74(4)**, 481-496.

Wilbanks, T.J. and R.W. Kates, 2010: Beyond adapting to climate change: embedding adaptation in responses to multiple threats and stresses. *Annals of the Association of American Geographers*, **100(4)**, 719-728.

Wilbanks, T.J., and J. Sathaye, 2007: Integrating mitigation and adaptation as responses to climate change: a synthesis. *Mitigation and Adaptation Strategy for Global Change*. **12**, 957-962.

Willbanks, T.J., S.M. Kane, P.N. Leiby, R.D. Perlack, C. Settle, and J.F. Shogren, 2003: Integrating mitigation and adaptation as possible responses to global climate change. *Environment*, **45**, 28-38.

Wolf, J., W.N. Adger, I. Lorenzoni, V. Abrahamson, and R. Raine, 2010: Social capital, individual responses to heat waves and climate change adaptation: An empirical study of two UK cities. *Global Environmental Change*, **20(1)**, 44-52.

World Bank, 2011: Climate Change, Disaster Risk and the Urban Poor: Cities Building Resilience for a Changing World. World Bank, Washington DC, USA, 33 pp.

World Bank, 2010: World Development Report: Development in a Changing Climate—Concept Note. World Bank, Washington DC, USA, 45pp.

World Bank, Economics of Climate Adaptation Working Group, 2010: Shaping Climate Resilient Development: A Framework for Decision making. World Bank, Washington DC, USA, 164 pp.

World Bank, 2006: *Investment Framework for Clean Energy and Development*. World Bank, Washington DC, USA, 108 pp.

World Economic Forum, 2002. Environmental Sustainability Index, An Initiative of the Global Leaders for Tomorrow Environment Task Force, World Economic Forum, Annual Meeting 2002, World Economic Forum/CIESIN/Yale Center for Environmental Law and Policy, Geneva/New York/New Haven. http://www.ciesin.columbia.edu/indicators/ESI. Accessed August 17, 2004.

Yamin, F., A. Rahman, and S. Huq, 2005: Vulnerability, adaptation and climate disasters: a conceptual overview. *IDS Bulletin*, **36(4)**, 1-14.

Yemen. Environment Protection Authority, Republic of Yemen, **2009**: *National Adaptation Programme of Action*.

Yohe, G. and R.S.J. Tol, 2002: Indicators for social and economic coping capacity—moving toward a working definition of adaptive capacity. *Global Environmental Change*, **12(1)**, 25-40.

Zambia. Ministry of Tourism, Environment and Natural Resources, Republic of Zambia, 2007: *Formulation of the National Adaptation Programme of Action on Climate Change*. Final Report.

Zhang D.D., C.Y. Jim, G.C.S. Lin, Y.Q. He, J.J. Wang, and H.F. Lee, 2006: Climatic change, wars and dynastic cycles in China over the last millennium. *Climatic Change*, **76(3-4)**, 459–477.

Ziervogel, G. and A. Taylor, 2008: Feeling stressed: integrating climate adaptation with other priorities in South Africa. Environment, **50(2)**, 32-41.

Zinn, M.D. 2007. Adapting to climate change: environmental law in a warmer world. *Ecology Law Quarterly*. **34**, 61-105.

Table14-1: Set of criteria for selection of indicators.

	Criterion	Explanation
Validity	Well-founded	Based on a tested theoretical framework
	Accurate	Really measuring what it should
	Non-ambiguous	Agreement on the direction of influence between the indicator and vulnerability
Use	Comprehensible	Relatively easy for users to understand
Type	Relevant	Applicable to many geographic and economic conditions
	Responsive to changes	Can be influenced by action
	High information content	No yes/no indicators, and preferably actual performance data instead of model-based data
Data	Available	Data that is publicly and easily available
	Homogenous and periodical data	Data that is collected homogeneously, making it suitable for international comparisons

From Perch-Nielsen, 2010 based on Aitkins et al., 1998; Esty et al., 2006 Kaly et al., 2003 and OECD, 2002.

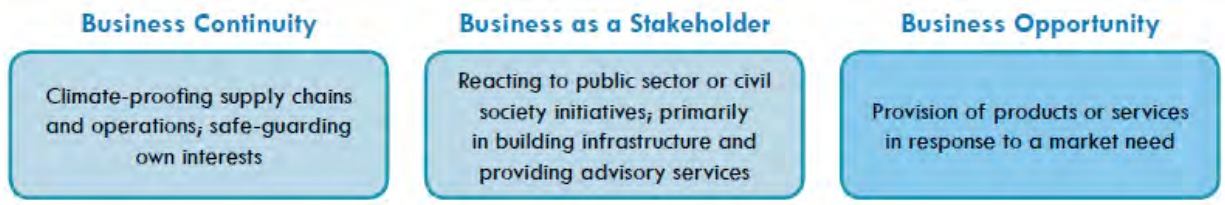

Figure 14-1: A typology of private sector engagement in adaptation (Khattri et al., 2010).