Chapter 14. Adaptation Needs and Options

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Executive Summary

Since AR4 the framing of adaptation has moved further from a focus on biophysical vulnerability to the wider social and economic drivers of vulnerability (*high agreement, robust evidence*). These include the gender, age, health, social status and ethnicity of individuals and groups and the political system in place within a region and country. [14.1, 14.2]

An emphasis continues to be placed on engineered and technological adaptation options, but there is growing awareness of the need for ecosystem-based, institutional, and social measures, including the provision of climate-linked safety nets for those who are most vulnerable (*high agreement, robust evidence*). Adaptation measures are increasing and becoming more integrated within wider policy frameworks. Integration streamlines the adaptation planning and decision making process and embeds climate sensitive thinking in existing and new institutions and organizations. This helps avoid mismatches with development planning, facilitates the blending of multiple funding streams and reduces the possibility of maladaptive actions. [14.3]

Approaches to selecting adaptation options continue to emphasize minimizing costs, achieving co-benefits, and incremental change, but there is increasing recognition that transformative changes may be necessary in order to prepare for climate impacts (*medium agreement, medium evidence*). While no-regret, low-regret and win-win strategies have attracted most attention in the past, there is increasing recognition that an adequate adaptive response will mean acting in the face of continuing uncertainty about the extent of climate change and the nature of its impacts. While attention to flexibility and safety margins is becoming more common in selecting adaptation options, many see the need for more transformative changes in our perception and paradigms about the nature of climate change, adaptation and their relationship to other natural and human systems. [14.1, 14.3.4]

Among the many actors and roles associated with adaptation two are increasingly recognized as critical to progress; namely those associated with local governance and those with the private sector (*high agreement, medium evidence*). These two groups will bear the main responsibility for translating the top-down flow of risk information and financing, and in scaling up the bottom-up efforts of communities and households in planning and implementing their selected adaptation actions. Local institutions, including local governments, NGOs and civil society organisations, are among the key actors in adaptation but are often limited by lack of resources and capacity. [14.4.2, 14.4.3] Private entities, from individual farmers and SMEs (small to medium enterprises) to large

corporations, will seek to protect their production systems, supply lines and markets, by pursuing adaptation related opportunities. These goals will help expand adaptation activities but they may not align with government or community priorities without coordination and incentives. [14.4.8]

Adaptation assessments continue to evolve leading to a general awareness among decision makers and stakeholders of climate risks and adaptation needs and options, however, this is often not translated into the implementation of even simple adaptation measures within ongoing activities or risk management planning (the 'adaptation bottleneck') (*high agreement, medium evidence*). Most of the assessments of adaptation done so far have been restricted to impacts, vulnerability and adaptation planning, with very few assessing the processes of implementation and evaluation of actual adaptation actions [14.5.1]. Assessments that include include both top-down assessments of biophysical climate change risks and bottom-up assessments of what makes people vulnerable to those risks will help to deliver local solutions to globally derived hazards (the 'adaptation paradox'). Also, assessments that are linked more directly to particular decisions and that provide information tailored to facilitate the decision making process and best suited to delivering effective adaptation measures and overcoming the 'adaptation bottleneck' [14.5.3

Evaluation of adaptation effectiveness is still in its infancy (*high agreement, medium evidence*). Experience in selecting metrics to identify adaptation needs and to measure effectiveness is increasing. [14.6.2, 14.6.3] But the search for metrics for adaptation will remain contentious with multiple alternatives competing for attention as governments, institutions, communities and individuals value needs and outcomes differently and many of those values cannot be captured in a comparable way by metrics. [14.6.4] The demand for metrics to measure adaptation needs and effectiveness is increasing as more resources are directed to adaptation. These indicators need to track not just process and implementation, but also the extent to which targeted changes are occurring. [14.6.2.3]

Maladaptation is a cause of increasing concern to adaptation planners, where intervention in one location or sector could increase the vulnerability of another location or sector, or increase the vulnerability of the target group to future climate change (*high agreement, medium evidence*). [14.7.3] The definition of maladaptation used in AR5 has changed subtly to recognize that maladaptation arises not only from inadvertent badly planned adaptation actions, but also from deliberate decisions where wider considerations place greater emphasis on short-term outcomes ahead of longer-term threats, or that discount, or fail to consider, the full range of interactions arising from the planned actions. [14.7.1]

14.1. Introduction

The rapid pace of climate change and its associated impacts means that we must adapt. In AR5, adaptation is defined in the following way, "In human systems, the process of adjustment to actual or expected climate and its effects, which seeks to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate." The distinction between human and natural systems directs our attention to differences in planned and unplanned adaptation. Natural systems have the potential to adapt through evolutionary processes, although humans may intervene to promote particular adjustments. In contrast, adaptation in human systems requires intentionality and therefore, is the result of planned efforts to address needs and advance options. Coping behavior remains common, such as in instances where immediate actions are taken to prepare for and respond to natural hazards and other extreme events. However, as individuals, communities, and governments account for and take initiatives to address actual and expected climate impacts, they are engaging in planned modes of adaptation.

A further classification that is becoming increasingly important in negotiations and implementation, and integral to AR5, is between incremental and transformational adaptation. The former refers to actions where the central aim is to maintain the essence and integrity of incumbent socio-economic systems and institutions, such as incremental adjustments to cropping systems through new varieties and more efficient irrigation. Alternatively, transformational adaptation seeks to change the fundamental attributes of systems in response to actual or expected climate and its effects. It includes not just changes in activities, such as changing from cropping to livestock or migrating to take up cropping elsewhere, but also changes in our perception and paradigms about the nature of climate change, adaptation and their relationship to other natural and human systems (Kates *et al.,* 2012; IPCC SREX, 2012, Section 8.6.2.3). Differentiation between these two perspectives is essential since it affects how we approach adaptation, how we integrate it into planning and policy, and how we allocate adaptation funding in both developed and developing countries.

This chapter establishes a foundation for understanding adaptation by reviewing core concepts related to adaptation, with a focus on mapping out broad categories of needs and options. Adaptation needs refer to circumstances requiring action to ensure safety of populations and security of assets in response to climate impacts while adaptation options are the array of strategies and measures available and appropriate to address needs. Since identifying needs and selecting and implementing options requires the engagement of individuals, organizations, and governments at all levels, this chapter also considers the range of actors involved in these processes and summarizes the balance needed between adaptation and potential maladaptation. An ongoing theme throughout the chapter is the concept of mainstreaming or the integration of adaptation to climate change with other areas of government action and responsibility. This chapter also highlights some important tools in implementing adaptation, namely approaches to assessing needs at national, subnational and sectoral levels, and the challenges of applying metrics to determine adaptation needs and the effectiveness of adaptation actions. In the course of these discussions, this chapter establishes a foundation for the three adaptation chapters that follow. The existence of adaptation options does not necessarily mean that these options can be implemented when the need arises. Therefore, Chapter 15 examines adaptation planning and implementation, including the challenges faced and how these can be addressed. Chapter 16 focuses on adaptation opportunities and constraints while Chapter 17 assesses the economic costs and benefits of adaptation.

Summary of Key Findings from AR4

The Fourth Assessment Report (AR4) refined the basic terminology of adaptation and concluded that adaptation to climate change was already taking place, but on a limited basis. Societies have a long record of adapting to the impacts of weather and climate through a range of practices that include crop diversification, irrigation, water management, disaster risk management, and insurance, but climate change poses novel risks often outside the range of experience.

AR4 found that deliberate adaptation measures in response to anticipated climate change were being implemented by a range of public and private actors, on a limited basis, in both developed and developing countries. These measures are undertaken through policies, investments in infrastructure and technologies, and behavioral change, but they are seldom undertaken in response to climate change alone. Many actions that facilitate adaptation to climate change are undertaken to deal with current extreme events such as heat waves and cyclones and often embedded within broader sectoral initiatives such as water resource planning, coastal defense and disaster management planning.

AR4 concluded that there are individuals and groups within all societies that have insufficient capacity to adapt to climate change. The capacity to adapt is dynamic and influenced by economic and natural resources, social networks, entitlements, institutions and governance, human resources, and technology. But, high adaptive capacity does not necessarily translate into actions that reduce vulnerability. New planning processes were being implemented to attempt to overcome these barriers at local, regional and national levels in both developing and developed countries. AR4 noted the establishment of the National Adaptation Programmes of Action (NAPAs) and that some developed countries had established national adaptation policy frameworks. Other conclusions from the AR4 relating the implementation of adaptation policies and measures, barriers to adaptation and the economic costs of adaptation are summarized in Chapters 15, 16 and 17.

14.2. Adaptation Needs

Adaptation involves reducing risk and vulnerability, while building the capacity of nations, regions, cities, communities and individuals to cope with climate impacts as well as mobilizing that capacity by implementing decisions and actions (Tompkins *et al.,* 2010). Vulnerability is the degree to which a system is "susceptible to, and unable to cope with, adverse effects of change" and is traditionally viewed as being comprised of three elements: exposure, sensitivity, and adaptive capacity (IPCC, 2007a, IPCC SREX, 2012). In other words, vulnerability is 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*., 2004; Adger, 2006).

Adaptation requires that there is adequate information on risks and vulnerabilities to identify needs and appropriate adaptation options to mitigate risks and build capacity. This process of identifying needs is often rooted in a formal risk or vulnerability assessments. The risk-hazard framework, drawn primarily from risk and disaster management, focuses on the adverse effects that natural hazards and other climate impacts can have on a given location (Füssel and Klein, 2006). The emphasis in this approach is on the physical and biological aspects of impacts and adaptation (Burton *et al*., 2002). An alternative 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). Approaches to identifying needs and options are discussed further in the section 14.4 on assessments.

Assessments typically provide insight into the risks and vulnerabilities that will result from climate change in communities, cities, and nations and, in turn, offer a means to identify the presence of adaptation needs. Although needs are specific to particular groups and places, they tend to fit into a set of more general categories as summarized in 14-1. 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.

[INSERT TABLE 14-1 HERE
Table 14-1: Categories and examples of adaptation needs.]

14.2.1. Institutional Needs

Institutions consist of formal and informal rules and norms the provide the enabling environment for implementing adaptation actions (Bryan et al., 2009; Chuku, 2009; Aakre and Rübbelke, 2010; Compston, 2010; Moser and Ekstrom, 2011b). These institutions provide the guides, incentives, or constraints that 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 (See 14.2.3.2 and Agrawal, 2010). At the international level, institutions and institutional actors enable and facilitate the distribution of 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). Similarly, institutions, including political systems, policies, and politics at the national or sub-national levels can influence the vulnerability of certain sectors or can facilitate the success of adaptation actions within their jurisdictions (Chuku, 2009; Compston, 2010). For instance, drawing on case studies of water systems in the Middle East and North Africa, Sowers *et al*. (2011) maintain that the largely centralized systems of planning, taxation, and revenue distribution render governments more vulnerable since they are limited in their ability to adapt to climate change.

Local governments have the potential to directly enhance the adaptive capacity of vulnerable areas and populations by developing regulations including those related zoning, storm water 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). There also are a number of ongoing political issues that shape the relationships local governments have to managing climate risks (Corfee-Morlot et al. 2011). For instance, short-term election cycles, when dealing with long-term issues can limit incentives to make investments. Similarly, the proximity that authorities 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 (Corfee-Morlot et al. 2011).

There are four critical institutional design issues that can be evaluated in order to understand institutional needs (Gupta *et al*., 2010; Agrawal**,** 2010). The first is the extent to which institutions are flexible. The uncertainty associated with climate change, presence of rapidly changing information and conditions, and emerging ideas on how best to foster adaptation requires continual evaluation, learning, and refinement (Gupta *et al*., 2010; Agrawal**,** 2010). Second is the extent to which adaptation is or has the potential to be integrated into short and long term policymaking, planning, and program development (Conway and Shipper, 2011). Third, is the potential for effective coordination, communication, and cooperation within and across levels of government and sectors (Schipper, 2009; Conway and Shipper, 2011; Agrawal, 2010). Finally, in order to promote adaptive capacity, it is important to identify the extent to which institutions are robust enough to attend to the needs of diverse stakeholders and foster their engagement in adaptation decisions and actions (Urwin and Jordan, 2008; Gupta *et al.,* 2010).

14.2.2. Social Needs

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). 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, (Patz et al., 2008; Moser and Satterthwaite, 2010; Huq et al., 2007; Shikanga et al., 2009; Kovats and Akhtar, 2008; Revi, 2008; Tol et al., 2004; Gething et al., 2010; Rosenzweig et al., 2010). Due to limited financial resources and often compromised health and nutritional status, along with the sick and elderly, the poor 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;Haines et al., 2006; Costello et al., 2009; O’Neill and Ebi, 2009; Tonnang et al., 2010; Costello et al., 2011; Ebi, 2011; Harlan and Ruddell, 2011; Huang et al., 2011; McMichael and Lindgren, 2011; Semenza et al., 2012).

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).

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.

14.2.3. Biophysical and Environmental Needs

Climate change is altering ecological systems, biodiversity conservation, and resources associated with ecosystem services (Convention on Biological Diversity, 2009; Mooney *et al.,* 2009; Hoegh-Guldberg, 2011). For instance, González et al. (2010) used observed and modeled changes of global patterns of biome shifts under climate change and concluded that up to half of the terrestrial ecosystems were vulnerable often due to changes in stressors such as wildfire. They suggested that significant changes in management plans of natural resource management organisations. In addition to the responses of ecosystems to climatic change, a number of studies have identified impacts on ecosystem services, particularly the effects of climate change on agricultural productivity (Coles and Scott 2009), downstream industries and enterprises (Preston and Stafford Smith 2009), and freshwater ecosystems (Ormerod et al 2010).

Natural systems are important not only for their own sake, but also because they contribute to human welfare and prosperity in the face of a changing climate. For instance, coastal wetlands and coral reefs can help to protect against storm surges and rising sea levels (Hoegh-Guldberg, 2011) while the maintenance of wetlands and green spaces can control run-off and flooding associated with increases in precipitation (Jentsch and Beierkuhnlein, 2008; Mooney *et al.*, 2009). Consequently, there is a need to protect these systems and resources within the changing climate, but many practices to improve and maintain ecosystem services are based on untested assumptions and limited information (Carpenter *et al.,* 2009). Tallis *et al.* (2008) found that only 16% of projects designed to deliver "win-win" goals of alleviating poverty and protecting biodiversity actually delivered both goals. Goldman et al. (2008) found that research projects that focused on delivering ecosystem services, rather than on biodiversity goals, attracted a wider set of funders and better-encompassed landscapes and the people within them.

14.2.4. Resource Needs

Successful implementation of adaptation actions depends on the availability of appropriate human capacity, information, access to technology and funding (Yohe and Tol, 2001; Adger, 2006; Eakin and Lemos, 2006; Smit and Wandel, 2006, World Bank, 2010). In some cases a supposed lack of information has been used as a rationale for inaction (Moser and Ekstrom, 2011a). To address this concern, the Nairobi Work Program, established at COP12 in 2006 with a goal of helping developing countries make better informed decisions based on sound scientific, technical and socio-economic data, has made repeated calls for better observation systems, information sharing, and modeling capacity (UNFCCC/SBSTA/2008/3). Developed and developing countries have acted upon this priority by establishing institutions to provide information services at national, regional, and global scales (UKCIP, 2011; NCCARF, 2012; CCCCC, 2011; WMO, 2011), and there is an ongoing need to promote information acquisition and dissemination (OECD, 2009).

Financial resources for adaptation have been slower to become available for adaptation than for mitigation in both developed and developing countries. Within developing countries only modest funding has been available for adaptation actions and much of this funding has been directed towards capacity building, standalone projects, or pilot programs. This not only has left financial needs, but has meant that there is less expertise in adaptation assessment and implementation, which is further confounded by the lack of clarity about the distinction between adaptation and more common sustainable development and/or poverty reduction planning (Cruce, 2008; McGray *et al.*, 2007). Overall, at both international and national levels there is a need to develop financial instruments that are equitable in both their delivery of resources and in sharing the burden of supporting the instruments (Levina, 2007; World Development Report, 2010; Chapters 1,6 and 17). Also, financial mechanisms for disaster risk management are also inextricably linked with those for adaptation (Mechler *et al.,* 2010) and mechanisms for adaptation will have to balance immediate needs for essential development and disaster recovery with longer term goals directed to climate resiliency.

Financial transfers required in the future for climate change will likely approach those on current development expenditure (Peskett *et al.*, 2009). Therefore, there is a related need to design delivery channels so that funding reaches the poor as they often are 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 climate change as an isolated priority to the detriment of other equally pressing social, economic, and environmental issues (Ziervogel and Taylor, 2008).

14.3. Adaptation Options

Identifying needs stemming from climate risks and vulnerabilities provides a foundation for selecting adaptation options. Over the years, a number of categories of options have been identified. These options include a wide range of actions that, as summarized in Table 14-2, can be organized into three general categories: structural/ concrete, institutional, and social (Carmin, et al, forthcoming 2013).

[INSERT TABLE 14-2 HERE
Table 14-2: Categories and examples of adaptation options.]

14.3.1. Structural / Concrete Options

This category highlight adaptation options that are discrete, with clear outcomes and outputs that are well defined in scope, space and time. They include structural and engineering options, the application of discrete technologies, the use of ecosystems and their services to serve adaptation needs, and the delivery of specific services at the national, regional and local levels. The notion of 'concrete' reflects the orientation of the Adaptation Fund, where the focus is on "discrete activities with a collective objective(s) and concrete outcomes and outputs that are more narrowly defined in scope, space, and time." (Adaptation Fund Board, undated).

Engineering is often at the forefront of delivering adaptation technologies and strategies (Dawson, 2007). Most engineering options are expert driven, capital-intensive, large-scale, and highly complex (McEvoy et al., 2006; Morecroft and Cowan, 2010; Sovacool, 2011). The most commonly cited engineered options include building seawalls, beach nourishment, upgrading existing infrastructures, and retrofitting buildings (Blanco et al., 2009; Koetse and Rietveld, 2012; Ranger and Garbett-Shiels, 2012).

Engineered adaptation options typically have two general limitations. First, they often must cope with uncertainties associated with projecting climate impacts arising from assumptions about future weather, population growth, and human behavior (Dawson, 2007; Furlow et al., 2011). Second, the longevity and cost of engineered infrastructure affect the feasibility at the outset (Koetse and Rietveld, 2012). They also are subject to consequences that were not anticipated. For example, after coastal Eastern England was devastated by the North Sea storm surge in 1953, hard engineered sea walls were put in place to protect the coast from erosion and inundation. However, the engineered alterations resulted in a new array of coastal instabilities, including disturbances in sediment supply and damages to coastal ecosystems (Adger et al., 2009; Turner et al., 2010). As a result, many have promoted a "phased capacity expansion" strategy, which allows engineered projects to undertake design modification as conditions or knowledge change and facilitate incremental project construction to ease the burden of upfront financing (Colombo and Byer, 2012).

In addition to engineering, structural adaptation measures in various sectors are being developed based on recent advances in technology and information processing. In food and agriculture sector, a suite of adaptation options have been developed and applied to reduce the adverse impacts of climate change on production (FAO, 2007; Stokes and Howden, 2010; Chapters 7 and 9). Technologies range from improved irrigation methods, plant breeding for greater drought tolerance, adjusting planting based on simulated yields (Semenov, 2006; Semenov, 2008; Bannayan and Hoogenboom, 2008), to transfers of traditional technologies such as floating gardens (Irfanullah *et al.,*2008).

With the rapid diffusion of Information and Communication Technologies (ICT), such as mobile phones and the internet, the unprecedented speed at which information is produced and shared is posing a new set of possibilities for communication. ICT provides opportunities for both top-down dissemination of relevant information such as weather forecasts, hazard warnings, market information, and advisory services. It can also generate essential information through bottom-up processes such as 'crowd sourcing' of useful information such as local flood levels, disease outbreaks, and the management of disaster responses. MacLean (2008) identifies three kinds of effects of the rapid advances in ICT on adaptation and development in general: direct use for monitoring and measuring climate change as described above; as a medium for raising awareness; and as an enabler for a ‘networked governance’ based on networked open organisations.

Ecosystem-based adaptation (EBA), which is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change (Convention on Biological Diversity, 2009), is becoming an integral approach to adaptation. Often, when faced with climate related threats, first consideration is given to 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, Jones *et al.*, 2012). The use of mangroves and salt-marshes as a buffer against damage to coastal communities and infrastructure has been well researched and found to be effective both physically and financially in appropriate locations (Morris, 2007, Day *et al.*, 2007). They can also provide biodiversity co-benefits, support fish hatcheries and have mitigation value (Adger et al., 2005, Convention on Biological Diversity, 2009, Reid and Huq, 2005). Other EBA activities include integrative adaptive forest management (Bolte *et al.*, 2009; Guariguata, 2009; Reyer *et al.*, 2009), and the use of agro-ecosystems in farming systems (Tengö and Belfrage, 2004,), land and water protection and management, and direct species management (Mawdsley *et al.*, 2009).

Ecosystem-based approaches have a number of limitations. For instance, efforts at managing some ecosystems to provide particular services may be at the expense of other services. For example, to provide an effective wetland buffer for coastal protection may require emphasis on silt accumulation possibly at the expense of wildlife values and recreation (Convention on Biological Diversity, 2009, Dudley *et al.*, 2010). Similarly Goldstein et al (2012) found that in land-use decision making in Hawaii tradeoffs existed between carbon storage and water quality, and between environmental improvement and financial returns. A further consideration is that ecosystem-based approaches are often more difficult to implement and assess as they usually require cooperation across institutions, sectors and communities, and their benefits are also spread across a similarly wide set of stakeholders (Jones *et al.*, 2012). As yet it is difficult to demonstrate the effectiveness of this approach compared with others because, as with adaptation as a whole, there have been few formal assessments of the outcomes of ecosystem-based projects (Carpenter et al. 2009, Munroe et al. 2012).

Service provision consists of a diverse range of concrete measures. For instance, one measure to support to the most vulnerable populations is social safety nets. Efforts to address long-term and child malnutrition, which often result from loss of livelihood due to extreme weather events, particularly floods and droughts, (Hoddinott, *et al.*, 2008; Alderman, et al, 2009) offer an example of how safety nets can serve as a climate adaptation measure. While some studies have shown that food programs can be counterproductive to promoting livelihood or may not prevent malnutrition in non-emergency situations (e.g., Bhutta, *et al.*, 2008), programs designed to provide support via food programs, micro-finance or insurance at times of extreme events can provide an important bridge for vulnerable populations (Alderman *et al.*, 2010; Hoeppe and Gurenko, 2006; Hochrainer *et al.*, 2007; Meze-Hausken *et al.*, 2009).

Public health services also are important for tackling projected increases of disease incidences spurred on by climate change (Ebi and Burton, 2008; Garg et al., 2009; Edwards et al., 2011; Huang et al., 2011). For example, in countries where malaria is endemic, frequent adaptation options for addressing possible outbreaks include increasing use of mosquito nets, insecticides sprays, and controlling mosquito breeding by reclaiming land and filling drains(Garg et al., 2009). Governments at all levels are often also responsible for maintaining adequate access to services that are projected to be further stressed due to climate change (Laukkonen et al., 2009; Ernstson et al., 2010). Frequently cited options in this domain include, among others, clearing drainage systems to prevent floods, diversifying water supple services to account for changing water supplies (Kiparsky et al., 2012), and maintaining open public spaces dedicated for disaster recovery and other emergency purposes (Hamin and Gurran, 2009).

At the local level, infrastructure associated with the provision of basic services, such as water, sanitation, solid waste disposal, power, storm water and roadway management, and public transportation are integral to increasing adaptive capacity (Paavola, 2008; Hardoy and Pandiella, 2009; Bambrick et al., 2011; Barron et al., 2012). Housing services are particularly critical because new patterns in temperature and precipitation will alter the habitability and stability of residences while increased frequency and intensity of natural disasters will place settlements and homes on both stable and unstable land at greater risk (Dodman and Satterthwaite, 2008). Although one option is to relocate people inhabiting vulnerable areas, some argue that in situ upgrading may be more cost effective, especially for addressing informal settlements in developing countries (Revi, 2008).

There are repeated calls for technology transfer to and sharing between developing countries in adaptation to match the programs associated with mitigation (UNFCCC, 2006). 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 and applied elsewhere. 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 may 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. Institutional 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 and regulations (Hallegatte, 2009; Heltberg *et al.,* 2009; de Bruin *et al*., 2009). For instance, in the U.S., post-disaster funds for loss reduction are added to funds provided for disaster recovery and can be used to buy out properties that have experienced repetitive flood losses and to relocate residents to safer locations, to elevate structures, to assist communities with purchasing property and altering land-use patterns in flood-prone areas and undertaking other activities designed to lessen the impacts of future disasters (FEMA, 2010). Planning measures such as building codes and rezoning are institutional measures that can improve the safety of hazard-prone communities (Biderman et al., 2008; Bartlett et al., 2009). While zoning can be used to procure sites for low-income populations (Dodman and Satterthwaite, 2008; Biderman et al., 2008; Bartlett et al., 2009), if it increases property and housing values it also has the potential to exclude the poor from these areas.

A number of funding and financial issues are linked to institutions. At the international level, agreements and donors have a critical role to play in promoting and supporting the allocation and flow of financial resources (OECD, 2011). For instance, 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 through a multi-lateral development agency. The direct access mechanism highlights the role of institutions in building and maintaining 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).

Effective governance is important for the efficient operations of institutions. 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 improving governance mechanisms appears to 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.

14.3.3. Social Options

The complexity of climate adaptation means that adaptation options are heavily influenced by forms of learning and knowledge sharing (Collins and Ison, 2009). Many have noted that education is a key indicator for how people select adaptation options (Chinowsky et al., 2011; Sovacool et al., 2012), while a lack of education is a constraint that contributes to vulnerability (Paavola, 2008). For example, in a study of how farmers in the Nile Basin of Ethiopia select adaptation options, the researchers found a positive relationship between the education level of the household head and the adoption of improved technologies and adaptation to climate change (Deressa et al., 2009).

Awareness raising, extension, outreach, and other educational programs are important for disseminating knowledge about adaptation options (Aakre and Rübbelke, 2010; Birkmann and Teichman, 2010) as well as for helping to build social capital that is critical for social resilience (Adger, 2003; Krasny et al., 2010; Wolf et al., 2010). In this regard, education can be seen as a public good that promotes dialogue and networks (Boyd and Osbahr, 2010), and, therefore, allows the development of resilience at both the level of the individual learner and at the level of socio-ecological systems (Krasny et al., 2010).

Informational strategies are integral to adaptation. Early warning systems are critical to ensuring awareness of natural hazards and to promoting timely response, including evacuation. A number of approaches being employed around the world, including tone alert radio, emergency alert system, presentations and briefings, and reverse 911 (Pulwarty 2007; Van Aalst et al. 2008, Ferrara de Giner *et al.,* 2011). Awareness raising through scenario development, computer modeling and role playing is effective in preparing both responsible authorities and the public (Box 14-1). As previously noted, ICT is facilitating rapid dissemination of information. However, low-tech measures such as brochures, public service announcements, and direct contact with local residents also are important to fostering awareness and response (National Research Council 2007).

_____ START BOX 14-1 HERE _____

Box 14-1. Scenarios and Public Education

Recently the U.S. Geological Survey's Multi-hazard Demonstration Project developed a hypothetical but realistic scenario for large winter storms called ARkStorm (the "AR" refers to atmospheric rivers) in California that was partially based on storms that struck California in 1861 and 1862, but that used state-of-the art modeling approaches. The scenario, which was developed by more than 100 scientists, engineers, and policy and insurance experts, included data on the meteorological aspects of the storms and on impacts such as flooding, landsides, damage to the built environment, and direct and indirect economic losses, as well as activities and expenditures required for recovery (see Porter et al. 2011 for details). ARkStorm was preceded by an earthquake scenario for Southern California, which was connected to a public education campaign and large-scale earthquake exercise known as the Great Southern California Shakeout. The same team is now developing a tsunami scenario for the ports of Los Angeles and Long Beach. All scenarios are accompanied by outreach to constituencies such as government officials and owners and managers of critical infrastructure systems, and include media collaborations, public service announcements, billboards, and other materials aimed at informing the public about hazards and their potential impacts.

_____ END BOX 14-1 HERE _____

Behavioral measures are among the suite of options that are integral to advancing climate adaptation. Government incentives can spark behavioral change. For example, to slow runoff into storm sewers and reduce flooding, a number of cities in the U.S. run "Disconnect your Downspout" programs. These programs will provide information to households and some offer rebates on supplies. Many poor and vulnerable communities have taken steps to adapt to changes in climate, particularly those in flood prone areas. For instance, some local communities in Manila are increasing the number of floors in homes and building makeshift bridges (Porio, 2011).

14.3.4. Selecting Adaptation Options

Selecting specific adaptation options can be challenging partly due to the rate, uncertainty, and cumulative impacts of climate change. However, such signals need to be interpreted and weighed against other cultural, economic, political or social signals that may encourage change. Indirect signals from regulators or customers may be a stronger signal to the agents responsible for adapting than the observed climate itself (Berkhout *et al*., 2006). Also, rarely will adaptation options be designed to address climate risks or opportunities alone (IPCC, 2007b), instead actions will often be undertaken with other goals (such as profit or poverty reduction) in mind, while also achieving climate-related co-benefits. Gains in reduced vulnerability, enhanced resilience or greater welfare will often be co-benefits generated as a result of changes and innovations driven by other factors. Thus, rather than focusing on adaptation options addressing specific dimensions of climate change, more attention is being paid to mainstreaming climate change into wider government policy and private sector activities (Sietz *et al*., 2011).

A variety of systematic techniques have been developed for selecting options (e.g., DeBruin, 2009; Ogden and Innes 2007, 2009; Füssel 2009). Quantification and other systematic approaches to selecting options have many virtues. However, they also have limitations. For instance, most of these methodologies do not account for a range of critical factors such as leadership, institutions, resources, and barriers (Smith, et al., 2009). As an alternative, a variety of strategies have been recommended for selecting options. Strategies dominating the early adaptation literature emphasized maintaining the current system and minimizing costs while achieving some form of benefit. For instance, no-regrets, low-regrets strategies draw on measures that minimize costs and support existing or complementary goals. Win-win approaches are measures that both reduce climate risk and provide other social, economic or environmental benefits (Hallegatte, 2009). Adaptive management also is a strategy that is highlighted in the early adaptation literature. This approach, which draws on natural systems perspectives, places an emphasis on taking incremental action and then using the lessons learned to inform future actions. The intent is that by monitoring changes that take place and learning from the process, it will be possible to make better-informed decisions in the face of uncertainty (Holling 1978).

As ideas about adaptation have evolved, there has been a shift in orientation from traditional approaches that emphasize maintaining the status quo to more transformative strategies. This is best characterized by the integration of sustainable development into general conceptualizations of adaptation and from an emphasis on natural evolution to recognition of the centrality of human and policy intervention (IPCC SREX, 2012) and from engineering solutions to a balance of structural, institutional and social measures. Emerging trends in adaptation place an emphasis on the need for transformation, which has a distinct logic that differs from traditional strategies. Transformation refers to changes "in the fundamental attributes of a system, often based on altered paradigms, goals, or values. Transformations can occur in technological or biological systems, financial structures, and regulatory, legislative, or administrative regimes" (Glossary, AR5).

Whether the focus is on traditional or transformational strategies, a number of recommendations have been advanced for guiding the selection and sequencing of adaptation options. Given uncertainty, most approaches emphasize the need for basing decisions on multiple scenarios and for taking a long-term perspective. In terms of selecting specific options, the trend has remained consistent in noting the importance of accounting for resource availability and capacity limitations, and ensuring that overall approaches are (Table 14-3): flexible so they can be altered as conditions change, include safety margins so that more rapid rates of climate change are taken into account, can be implemented incrementally over time so that the financial burden is distributed, and find complementarities in structural/ concrete, institutional, and social measures (Hallegatte, 2009; Carmin and Dodman, forthcoming). In addition, the selection of measures must take into account both expert and local knowledge, equity, and stakeholder perceptions (Martens et al, 2009). Further, as discussed in detail in Chapter 16, an emphasis has been placed on identifying options that can be mainstreamed into sector initiatives and, in particular, with efforts in areas of climate mitigation, disaster risk reduction, and sustainable and economic development (Agrawala, 2005; Stern, 2006; Nelson et al., 2007; Agrawala and van Aalst, 2008; Ayers and Dodman, 2010; Willbanks and Kates, 2010; Willbanks et al. , 2003; Dowlatabadi, 2007; Klein, et al. , 2007; Swart and Raes, 2007; Larsen and Gunnarsson-Ostling, 2009).

[INSERT Table 14-3 HERE
Table 14-3: Considerations when selecting adaptation options.]

14.4. Actors and Roles in Adaptation

Climate adaptation requires the engagement of governmental, nongovernmental, private sector and community 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. This section outlines the roles of some of the main groups of actors and the challenges facing those groups in responding to climate change.

14.4.1. National and State 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 decide many of the funding priorities and tradeoffs, develop regulations, promote institutional structures, and provide policy direction to district, state, and local governments. In developing countries national governments are usually the contact point and initial recipient of international adaptation financing. State governments may have similar powers, the extent depending on the federal arrangements applicable to the country. In some countries, both developed and developing, state governments lead the national government in promoting and implementing adaptation (Mertz *et al*., 2009).

Drawing on an analysis of published articles, Berrang-Ford *et al*. (2011) found that upper levels of government, particularly national governments, tended to be more anticipatory, used institutional mechanisms such as laws and policies to foster adaptation. In some instances 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 between developed and developing countries. Among the key differences noted are that higher income countries more often 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. Low and Middle-income countries tend to be engaged more in reactive adaptations based on community level mobilization often with weak engagement by governments (Berrang-Ford *et al*., 2011).

14.4.2. Local Governments

Local governments are integral and critical actors in advancing, or impeding, 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). They 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*., 2012; 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). Also, they 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 their attention is focused on adaptation rather than more commonly accepted priorities.

Tompkins et al (2010) found from a survey of 300 adaptive[1] projects in the UK, that more than half were driven by concerns not directly related to climate change. Nevertheless, there are a number of indicators that demonstrate whether local government has institutionalized and mainstreamed adaptation. 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, 2010).

[FOOTNOTE 1: The definition of adaptation was extended to include any actions that affected the ability to cope with or adapt to climate change whether or not motivated by climate change.]

14.4.3. Local Civil Society and Nongovernmental Organizations

Civil society actors, including NGOs and community-based organizations (CBO), contribute to adaptation, both through dedicated initiatives as well as in the course of their ongoing work. They play a particular role in community-based adaptation (Menard, 2013). NGOs also have the potential to support government action, or highlight inaction, as well as to take independent action that facilitates adaptation across and beyond government programs. 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. 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.

Governments initiate some programs, while others originate from NGOs and CBOs. 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*., 2012; Anguelovski and Carmin, 2011).

Civil society actors can play a role in hindering adaptation actions as well as alerting governments and the public to critical issues. These range from those who call into question the validity or urgency of climate change (Boykoff, 2008, McCright and Dunlap, 2013) to questioning the risks of particular approaches to adaptation, such as the use of gene technologies for developing new crop varieties (Hällström, 2008).

14.4.4. 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).

14.4.5. Local Communities

Many communities pursuing adaptation are engaging community-based, civil society, and nongovernmental organizations (NGOs) 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 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). 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*., 2012). 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). Governments have also used community engagement to ensure that local needs are met. For example, the Government of Fiji introduced a provision to delegate responsibility for surveying and assessing damage 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).

14.4.6. Households

As adaptation is local in nature, households are the front line both in making decision about when and how to adapt and suffering the consequences increasing climate risks (Lansigan *et al*., 2007). The ability to respond to climate impacts is strongly related to household income, with wealthier households often being less exposed and having greater resources to draw upon, both to adapt and to recover from climate shocks (Masozera et al. 2007). Nevertheless, even they remain vulnerable weather shocks and the flow-on consequences, such as loss of power and/or water and livelihood disruption. Similarly cultural, social circumstances, gender and age affect the roles, empowerment and expectations of individual household members in both adaptation actions and in responses to climate impacts (Demetriades and Esplen, 2008). Poor rural households face some of the greatest difficulties from climate change. Climate related shocks threaten to overwhelm their current methods of income and consumption smoothing (Baez *et al*. 2013). For example many households protect consumption by sharing with and borrowing from relatives and friends, but such systems can fail as the frequency of damaging events increase (Deressa *et al*., 2009). There is also some evidence that poor farmers will seek to protect income by relying on low risk crops rather than higher value production systems (Azariadis and Stachurski, 2005). Frequent shocks can lead to a depletion of assets, both financial and human and eventually to a poverty trap. Evidence shows that school attendance suffers, especially for girls, and early childhood malnutrition can impede development and capacity for the rest of life (Carter *et al*., 2007; World Bank 2010: Chpt 1). Stresses from climate events often adds to other pressures leading to rural to urban migration, which can increase the stresses in both locations. In many Arab countries men and boys migrate leading to further crowding and competition for jobs in the cities, while women are left to manage the farms often without rights of access to markets, rights to water *etc*. that were vested in the men (Verner, 2012: Chpts 1 and 7). This emphasizes the importance to households of social safety nets to avoid poverty traps (Morduch and Sharma, 2002; De Janvry *et al*. 2006; Hess *et al*., 2006).

14.4.7. Indigenous Peoples

Indigenous actors are in a particular position in relation to climate change. Many live in locations that are particularly exposed to climate change with resource-based livelihoods, and often with limited external resources and support to respond to a changing climate. As such they are often politically and economically marginalized and face substantial risks to livelihoods and culture from climate change (12.3). They are also the owners of knowledge systems that have served them through generations of climate variability, that provide local relevance, and that are attuned to their culture values and attitudes. (Nakashima, 2012). This knowledge is threatened through loss of context, concern about its continuing relevance and neglect (12.3.3). The respectful blending of this knowledge with that from scientific knowledge systems, which could inform both science and Indigenous Peoples, is still far from complete (Alexander *et al*., 2011, Thornton & Scheer, 2012). But progress is being made, including sharing of climate information and knowledge (Ziervogel et al. 2010) and in local information collection and monitoring (King et al., 2008; Anguelovski and Carmin, 2011). 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). Most progress is made in these exchanges if they are seen as a source of new insights for all those engaged rather than "contesting validities" (King and Goff, 2010).

14.4.8. 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 Chapter 15). However, the delivery of adaptation actions ranges more widely and spans different types of private enterprise, from small farmers, to SMEs (Small to Medium Enterprises) to multinational companies. KPMG (2008) used published reports and interviews to identify the sectors where businesses face the greatest risks. In order of perceived importance the core risks were regulatory, physical, reputational and litigation risks. The sectors identified as most at risk included an expected cluster around oil & gas and aviation, and also a group less commonly perceived to be at risk, including health care, the financial sector, tourism and transport.

As shown in 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 of supply and markets. The second form of involvement recognizes that business is a stakeholder and therefore needs to participate in public sector and civil society initiatives, such as, The New York City Panel on Climate Change, which consists of diverse stakeholders, including representatives from the private sector (Rosenzweig *et al*., 2011). Third, climate adaptation also provides a wide range of new opportunities to the business community. Even in developing countries Khattri *et al*., (2010) identified opportunities for working in the healthcare, waste and water management, sanitation, housing, energy, and information sectors through fostering cooperation across government departments and NGO and promoting public-private partnerships.

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

Despite broad-scale recognition of the need to adapt, such as the World Economic Forum's (2012) ranking of the failure to adapt as one of the highest global risks and on a par with terrorism, and despite some examples of private sector engagement in adaptation, most assessments conclude that action in each of the potential arenas has been slow to emerge (Khattri *et al*., 2010, Agrawala *et al*., 2011). KPMG (2008) concluded that while companies are well used to managing business risk they are yet to integrate the long-term risks of climate change into these systems. Nor are they preparing to grasp the competitive advantages that will accrue to those taking early action. 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 (Persson *et al*., 2009; IFC, 2010, Agrawala *et al*., 2011) although this is being piloted through the Pilot Program for Climate Resilience (World Bank, 2008; IFC and Asian Tiger Capital Partners, 2010). Private sector engagement and investment in adaptation is expected to make a substantial contribution to reducing climate risk, but the distribution of its investments will be selective and will be unlikely to match government and civil priorities (Atteridge, 2011).

14.5. Adaptation Assessments

14.5.1. Purpose of Assessments

Identifying adaptation needs requires an assessment of the factors that determine the nature of, and vulnerability to, climate risks (climate impacts and vulnerability assessments) and an assessment of adaptation options to mitigate risks (adaptation assessment).

Assessments help decision makers understand the impacts, vulnerability and adaptation options in a region, country, community or sector. They are often characterized into ‘top-down’ and ‘bottom-up’ assessments. Top-down assessments are used to measure the potential impacts of climate change using a scenario and modeling driven approach. Bottom-up assessments begin at the local scale, address socio-economic responses to climate, and tend to be location-specific (Dessai and Hulme, 2004). They are often used to determine the vulnerability of different groups to current and/or future climate change and their adaptation options, using stakeholder intervention and analyzing socio-economic conditions and livelihoods (UNFCCC, 2010). There are also policy-based assessments, which assess current policy and plans for their effectiveness under climate change within a risk-management framework (UNDP APF; UNDP, 2005). In practice assessments have become increasingly complex, often combining elements of top-down and bottom-up approaches (e.g., Dessai et al., 2005). Decision-makers use both in the policy process (Kates and Wilbanks, 2003; McKenzie Hedger et al., 2006).

14.5.2. Trends in Assessments

A variety of frameworks have been developed for the assessment of climate impacts, vulnerability and adaptation. ‘Impacts-based’ approaches focus primarily on the biophysical climate change impacts to which people and systems need to adapt. ‘Adaptation-based’ approaches examine the adaptive capacity and adaptation measures required to improve the resilience or robustness of a system exposed to climate change (Smit and Wandel, 2006). ‘Vulnerability-based’ approaches focus on the risks themselves by concentrating on the propensity to be harmed, then seeking to maximize potential benefits and minimize or reverse potential losses (Adger, 2006; IPCC, 2007). In practice these approaches are interrelated, especially with regard to adaptive capacity (O’Brien et al., 2006),

The ‘standard approach’ to assessment has been the climate scenario-driven impacts-based approach, which developed from the seven-step assessment framework of the IPCC (Carter et al., 1994; Parry and Carter, 1998):

1) Define problem (including study area and sectors to be examined)
2) Select method of problem assessment
3) Test methods/conduct sensitivity analyses
4) Select and apply climate change scenarios
5) Assess biophysical and socio-economic impacts
6) Assess autonomous adjustments
7) Evaluate adaptation strategies.

This approach dominated the assessment sections of the first three IPCC reports, and aims to evaluate the likely impacts of climate change under a given scenario and to assess the need for adaptation and/or mitigation to reduce any resulting vulnerability to climate risks (IPCC 2007). These frameworks are described as 'first generation' or 'type 1' assessment studies (Burton et al., 2002). The standard impact approach is often described as top-down because it combines scenarios downscaled from global climate models to the local scale with a sequence of analytical steps that begin with the climate system and move through biophysical impacts towards socio-economic assessment (IPCC, 2007).

The 'second generation' assessments (Burton et al., 2002) are characterized by vulnerability and adaptation assessments, which pay greater attention to information around vulnerability to inform decisions on adaptation. They focus on the participation of vulnerable groups in decision-making around adaptation options (LEG 2002).

Adaptation assessments continue to evolve, but most synthesis now include 'top-down' and 'bottom-up' approaches, and include the assessment of both biophysical climate change risks and the factors that make people vulnerable to those risks. There is a shift towards integrating community-based planning into national adaptation plans. The Government of Nepal proposes 'LAPA assessments' (Local Adaptation Plans of Action) that seek to integrate top-down and bottom-up models (Government of Nepal, 2011). There is also increasing attention to institutional capacity assessments and policy environments as key factors that can both drive vulnerability, and also determine the type and success of different adaptation options. The generic elements of adaptation and vulnerability assessment are reflected in the UKCIP guidelines presented in Figure 14-2.

[INSERT FIGURE 14-2 HERE
Figure 14-2: A generic framework for vulnerability and adaptation assessments (UKCIP, 2011).]

14.5.3. Issues and Tensions in the Use of Assessments

Adaptation and risk assessments give rise to various tensions, three of which are discussed in this section. The first is the 'adaptation paradox' which recognizes that climate change is a global problem, whilst vulnerability is locally experienced (Ayers, 2011). Top-down assessments of climate scenarios are deemed necessary in order to understand the climate change scenarios that render climate risk. However, the factors that make people vulnerable to climate risks are locally generated, so require locally driven bottom-up analysis. Bottom-up analysis tends to prioritise groups based on factors related to poverty and development that drive vulnerability. Top-down assessments tend to prioritise those most exposed to climate risks. Analysis in Nepal that assessed both under-development and climate change impacts showed that, at the household scale, there was a strong correlation between local measures of poverty and vulnerability to climate change (Ghimire et al. 2010). However, when indicators were aggregated at district scale, the correlation was weaker - even when the vulnerability index used included poverty as a proxy for adaptive capacity alongside climate hazard risk and exposure (Ghimire et al. 2010).

There are also tensions around ownership and participation. Assessments managed under global climate change governance structure of the UNFCCC are developed under an 'impacts-based' paradigm (Burton et al 2002). This impacts-based approach requires external scientific and technological expertise for defining climate change problems, and formulating technological adaptation solutions, based on specific knowledge of future climate conditions. Such assessments are necessarily 'top-down' because this expertise exists at the global and national level. At the local level, the capacity to adapt is based on the underlying securities that determine vulnerability to these impacts in the first place (Adger et al., 2003). Accessing this information requires 'bottom-up' and participatory assessments that engage local vulnerable people. These vulnerable groups and institutions do not have access to the climate impacts science necessary to fulfill the requirements of top-down impacts-based assessments. So there is a tension between enabling local participation under assessments driven by a global climate impacts remit.

The numerous assessments that have been carried out have led to a general awareness among decision makers and stakeholders of climate risks and adaptation needs and options. But this awareness is often not translated into the implementation of even simple adaptation measures within ongoing activities or within risk management planning. To overcome this 'adaptation bottleneck' assessments may need to be linked more directly to particular decisions and the information tailored to facilitate the decision making process (Preston and Stafford Smith, 2009; Brown *et al*., 2011). Specific techniques such as decision scaling, which seeks to understand which climate conditions would result in hazardous conditions of concern for particular stakeholder groups are a step in this direction (Moody and Brown, 2012; Brown *et al*., 2012).

14.5.4. National Assessments

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 (described above). Annex 1 countries are due to submit their 6th Communications by 2014 and most non-Annex I countries are due to have submitted at least one Communication and some their second. As such, National Communications have formed the first avenue for assessing and reporting on climate risk and vulnerability assessments at the national level.

National Adaptation Programmes of Action are designed as a vehicle for Least Developed Countries (LDCs) to communicate their most "urgent and immediate adaptation needs" to the UNFCCC for funding from the LDC Fund. "Urgent and immediate needs" are defined as those for which further delay in implementation would increase vulnerability or increase adaptation costs at a later stage (LEG, 2002:1). The approach adopted to vulnerability assessment under NAPAs vary. Although the guidelines allow for more participatory and 'bottom-up' mechanisms to be adopted, time and funding limitations has meant that often the NAPA process remains largely top-down, focused on impacts and only consulting the communities to verify this information (Ayers, 2001; Huq and Khan, 2006).

Under the Cancun Adaptation Framework (CAF), a process was established to enable least developed country Parties (LDCs) to formulate and implement National Adaptation Plans (NAPs). NAPs are intended to build on NAPAs but shift the focus towards identifying medium- and long-term adaptation needs and developing and implementing strategies and programmes to address those needs. Other developing country Parties are also invited to employ the modalities formulated to support the national adaptation plans in the elaboration of their planning efforts. Early guidelines (LDC Expert Group, 2002) propose a country-specific approach is adopted tailored to national circumstances, mixing top-down policy-first assessments with bottom-up approaches.

14.6. Measuring Adaptation

Adaptation has tended to lag behind mitigation efforts in both in research and in the climate negotiations. In part this because adaptation and development specialists, governments, NGOs and international agencies have found it difficult to clearly define and identify precisely what constitutes adaptation, how to track its implementation and effectiveness, and how to distinguish it from effective development (Burton *et al*., 2002; Arnell, 2009; Doria, *et al*. 2009). A contributing reason is that adaptation has no common reference metrics in the same way that tonnes of greenhouse gases or radiative forcing values are for mitigation. This section seeks to explore the feasibility of finding metrics for measuring adaptation effectiveness.

The search for metrics[2] for adaptation will remain contentious with many alternatives competing for attention. This is inevitable as there are multiple purposes and viewpoints in approaching the measurement of adaptation (Hulme, 2009). Brooks et al (2011) asked 'what constitutes successful adaptation' and suggested that the criteria by which success might be assessed include, feasibility, efficacy/effectiveness, efficiency, acceptability/legitimacy, and equity (derived from Yohe and Tol, 2002; Adger, 2005; Stern, 2006), to which they added sustainability (see also Fankhauser and Burton, 2011). Also institutions, communities and individuals value things differently and many of those values cannot be captured in a comparable way by metrics (Adger and Barnett, 2009).

[FOOTNOTE 2: Here a 'metric' is defined as any type of measurement used to gauge some quantifiable component of performance; it is largely synonymous with the term 'indicator'. 'Metric' is used here to reduce confusion with the wider uses of the terms 'measure' and 'indicate'.]

At least three uses of measurements are relevant to adaptation each requiring different characteristics of its metrics. The first use seeks metrics to help determine the need for adaptation. These metrics usually focus on measuring vulnerability, but that term is not well defined as is discussed below. Further, even within this application 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 (Smit and Wandel, 2006). Hinkel (2010) identifies six uses that vulnerability indicators are sometimes expected to serve and concludes that they can truly serve only their core purpose; i.e. to identify vulnerable people, communities and regions. The second use of metrics relates to measuring and tracking the process of implementing adaptive actions, such as spending on coastal protection, the number of early warning plans implemented as part of a program, or the number of agricultural specialists with appropriate training in climate risks. Here the selection of appropriate metrics is usually less contentious but although there is disagreement as to how much they represent adaptation versus normal development. The third use relates to measuring the effectiveness of adaptation. This set is essential to help measure progress and provide feedback on the effectiveness of actions, but are among the most difficult to identify as adaption outcomes take time to become identifiable.

14.6.1. What Needs to be Measured?

The measurement of vulnerability is central to many adaptation metrics and initially it was approached 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, Chapter 17). This approach continues to be used as the basis of many assessments and adaptation prioritization efforts. Recently the emphasis has moved from better defining exposure and potential impacts to a better understanding of the factors that affect societies' sensitivity to those impacts and their capacity to adapt. This reflects the increasing recognition of the importance of considering social vulnerability alongside biophysical vulnerability. Various terms have been used to describe these different emphases including biophysical versus social vulnerability, outcome versus contextual vulnerability (Sections 14.2.1.1.1 and 14.2.1.1.2; Eakin and Luers, 2006; Füssel and Klein, 2006; Eriksen and Kelly, 2007; Füssel, 2007; Füssel, 2010) 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 broader geopolitical and economic contexts.

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, although experience repeatedly cautions us to be cautious in doing so (Schröter *et al.*, 2005). Also, a system's vulnerability is not static but can respond rapidly to changes in economic, social, political and institutional conditions over time (Smit and Wandel 2006; Smit and Pilifosova, 2003).

It has also been suggested that a framework based on the concept of resilience 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 also 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 is particularly resistant to attempts to establish commonly accepted sets of indicators. Some (e.g. Klein *et al.*, 2003) have suggested that resilience has become an umbrella concept that has not been able to support effectively planning or management.

Recently Brooks et al. (2011) have outlined a framework tracking adaptation that combines the establishment of upstream metrics to assess how well risks are being managed by institutions, and downstream metrics to track whether the interventions are reducing the vulnerability of affected groups. The upstream metrics would focus on assessments of institutional capacity, managerial performance, integration of climate risk management into planning processes and tracking and feedback processes. The downstream metrics would focus on measures to track development performance and changes in vulnerability. Attribution of these changes to particular interventions would be desirable, but not essential to track progress.

But understanding vulnerability does not necessarily translate to effective adaptation. Smit *et al*. (2001), Osman-Elasha *et al*. (2009) and others have suggested that the focus should be on increasing adaptive capacity within the context of the full range of biophysical and socio-economic stressors. However, as the scope of the metrics is widened to include aspects of development and sustainability they often become less suitable for other purposes such as helping to identify "the full and additional costs of adaptation" (McGray *et al*., 2007).

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 criteria for selecting indicators, which have been concisely summarized by Perch-Nielsen (2010) in Table 14-4.

[INSERT TABLE 14-4 HERE
Table 14-4: Set of criteria for selection of indicators.]

14.6.2. Established Metrics

14.6.2.1. Vulnerability Metrics

Numerous metrics continue to be prepared for a variety of purposes and at scales ranging from estimating the vulnerability of communities to comparing countries. Several reviews, including Moss (2001, to appear) Srinivarsan and Prabhakar (2008), and Prabhakar and Srinivarsan (2011), discuss both the design and effectiveness of many of the existing proposals for adaptation metrics.

Eriksen and Kelly (2007) found strong divergence among five 'indices' for comparing national vulnerability published over the period 1995 to 2003. (Namely the Dimensions of vulnerability of Downing *et al*., 1995; the Index of Human Insecurity (IHI) of Lonergan *et al*. 1999; the Vulnerability-resilience indicators of Moss *et al*., 2001; the Environmental Sustainability Index of the World Economic Forum, 2002; and the Country-level risk measures, Brooks and Adger 2003.) Between them, 29 indicators were used with only five indicators appearing in more than one study. They were able to compare the 20 countries ranked as most vulnerable from three of the studies and found little overlap with only five countries ranked in the top 20 in more than one study. 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 rather than on 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; the Americas Index of Cardona, 2005; and an index for South Asia of Moench *et al*., 2009). Again there has been little effort to further analyse, validate or compare these indices.

14.6.2.2. Metrics and Resource Allocation

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 entities (countries, regions or other administrative groups, or different proponents of adaptation). For allocation we might expect that vulnerability and coping/adaptive capacity would remain a core consideration, but so also should the ability of the recipients to absorb the funding and implement policies and projects to actually achieve the projected benefits (UNFCCC, 2007; Wheeler, 2011).

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 allocations to the poorest developing countries with long-term, no interest (IDA) loans. The CPIA and the ultimate IDA allocation formulae are controversial, much debated (Alexander 2010), often fine-tuned (IEG, 2009) but still commonly used as 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 independent expert group to make recommendations as to which countries might be included as pilots within the c. USD1billion program (Climate Investment Funds, 2009). The expert group refrained from using a simple index, but instead country selection was done across 9 regions and each based on a suite of indices appropriate for the region and on expert judgment. It is interesting to note that on moving to the next step of deciding on allocation of financial resources to the selected 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 (Climate Investment Funds, 2009). Similarly, none of the other governing bodies of international adaptation funding mechanisms (e.g. the GEF, the Adaptation Fund) has chosen to use a defined set of metrics within their decision-making.

Wheeler (2011) has developed an index of vulnerability based on weather related disasters, sea-level rise and agricultural productivity. The index can be adjusted according to user preferences to develop allocation formulas based only on biophysical vulnerability, further adjusted for economic development and governance, and finally for project costs and probability of success. Klein and Möhner (2011) have discussed the options for the Green Climate Fund based on experience to date and conclude that science cannot be relied upon for a single objective ranking of vulnerability.

14.6.2.3. Metrics for Monitoring and Evaluation

The IPCC's *Fourth Assessment Report* provided little discussion of the role of evaluation and monitoring of adaptation responses as a component of building adaptive capacity (Adger *et al*., 2007). Preston *et al*. (2011) identify three specific roles of evaluation: a) ensuring reduction in societal and ecological vulnerability; b) facilitating learning and adaptive management; and c) providing accountability for adaptation investments (see also GIZ 2011). A central challenge in developing robust monitoring and evaluation frameworks for adaptation is the existence of multiple, valid points-of-view that can be used to evaluate adaptation (Gagnon-Lebrun and Agrawala, 2006; Perkins *et al*., 2007; Füssel, 2008; Smith *et al*., 2009; Ford *et al*., 2011; Preston *et al*., 2011). This challenges the selection of appropriate metrics for the monitoring and evaluation of adaptation and its contribution to vulnerability reduction (Burton and May, 2004; Gagnon-Lebrun and Agrawala, 2007; Hedger *et al*., 2008; IGES, 2008; Ford *et al*., 2011).

One of the central unresolved tensions in progressing evaluation is the relative merit of targeting adaptation processes versus outcomes. Preston *et al*. (2011) suggest the evaluation of adaptation processes may be a more robust approach to evaluation, due to the difficulties in attributing future outcomes to adaptation strategies and the long-time lags that may be needed to assess the performance of a particular strategy (Berkhout, 2005; Dovers and Hezri, 2010; Ford *et al*., 2011). The OECD analyzed the monitoring and evaluation processes across 106 adaptation projects across six development agencies and found that Results Based Management and Logical Framework approaches dominated as they do in normal development projects (Lamhauge *et al*., 2011). They also drew attention to the need for appropriate baselines and complimentary sets of indicators that track not just process and implementation, but also the extent to which targeted changes are occurring. Monitoring programs themselves will need careful design to ensure that they remain in place over the long timeframes needed for the outcomes to be identified; that they contain incentives for beneficiaries to comply with conditions and that compliance itself does not impose undue burdens.

A number of national and international organizations have guides to monitoring and evaluating adaptation activities (McKenzie Hedger *et al*., 2008; UNDP, 2008; WRI, 2009; World Bank, 2010; GIZ, 2011). These guides tend to focus on the wider framework of identifying and managing adaptation-related activities and within that the criteria for the selection of metrics for monitoring and evaluating those activities. These issues are dealt with in Chapters 15 and 16.

14.6.3. Validation of Metrics

The practice of developing and applying metrics in adaptation has been subject much scrutiny. Eakin and Luers (2006) express serious concerns about national-scale vulnerability assessments ranging from the quality of the available data, the selection and creation of indicators, the assumptions used in weighting of variables and the mathematics of aggregation. Downing (to appear) has made a similar critique. 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, *et al*., 2004. They used the probability of national climate related mortality from the CRED data-base as a proxy for risk and selected a set of 46 social, governance, economic and biophysical measures as indicators of social vulnerability. They found that 11 were effective indicators of mortality rates and these were confirmed as useful by a small focus group of seven 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 an 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) developed an index to estimate the vulnerability of beach tourism using a systematic approach by establishing a framework to identify the types of measures needed and a systematic approach to identify measures that covered 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.

14.6.4. Assessment of Existing and Proposed Metrics for Adaptation

Srinivarsan and Prabhakar (2008) conducted a wide-ranging stakeholder survey to assess the attitudes to, and requirements for, indicators of 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, and data checking) are badly needed. Preston *et al*. (2009) has suggest that, rather than seeking particular metrics, researchers should focus on developing rigorous processes for selecting metrics that can be applied in a range of contexts.

But metrics for adaptation remain a necessity. Their derivation challenges the adaptation community to clarify its goals, conceptual models, definitions and applications. But as both theory and practice has shown 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. Downing (2003) noted that the climate change community 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.

14.7. Addressing Maladaptation

The adaptation literature is replete with advice to avoid maladaptation, but it is less clear precisely what is included as "maladaptation". In a general sense it refers to cases where actions to improve the welfare of target groups may result in adverse climate-related outcomes or increased vulnerability to climate change to either the target community at a later date, or more immediately to other communities. For example, the construction of well engineering of roads to withstand current and future climate extremes may foster new settlement into areas highly exposed to the impacts of future climates; or increased water harvesting upstream to cope with erratic rainfall may harm and reduce the opportunities for communities downstream to manage their own risks. The AR5 defines maladaptive actions as "those that may lead to increased risk of adverse climate-related outcomes or increased vulnerability to climate change now or in the future". Actions that are potentially maladaptive need not be inadvertent as in the IPCC AR3 and AR4 definition, nor "taken ostensibly to avoid or reduce vulnerability to climate change" (Barnett and O'Neill 2010) as the actions may be assessed as appropriate given the full range of climate and non-climate considerations and pressures that apply. There should be clarity as to what is maladaptive action, or lack of action, lest the avoidance of maladaptation becomes a barrier to effective implementation of adaptation. In the road example above, the immediate and multiple benefits to the community of a reliable road system (including as evacuation route in floods etc.) might be judged as outweighing the longer-term risk of inappropriate settlement patterns. The true maladaptation in this case would be the failure to implement appropriate incentives or regulations to avoid settlement in the highly exposed areas.

The complexity of the concept and terminology is further demonstrated by the recent introduction by Thomsen et al. (2012) of the term "manipulation" that has some similarities to the concept of maladaptation. They see adaptation as "behaviors that are respectful of the intrinsic integrity of social-ecological systems and change is directed toward internal or self-regulating modification", whereas manipulation consists of behaviors that disregard this integrity and seek to override self-regulation. Their example is the management of Noosa beach in northern Australia. This coastline is characterized by cycles of erosion and depletion of beach sands, but rather than enhance the self-regulatory processes and adapting by managed retreat and expansion according to the cycle, management has sought to maintain a static beach profile through hard constructions and beach nourishment. This may seem synonymous with maladaptation, but they differ because with manipulation there is a decision not to adapt. Niemeyer et al. (2005) also describe the state of individual beliefs about climate change that might lead to adaptive, maladaptive or non-adaptive behaviors, while Eriksen et al. (2011) and Brown (2011) discuss avoiding outcomes that are essentially maladaptive under a title of 'sustainable adaptation'.

14.7.1. Causes of Maladaptation

Maladaptation arises in many forms but several broad causes can be identified. One is development policies and measures that deliver short-term benefits or economic gains but lead to greater vulnerability in the medium to long-term, such as the construction of 'hard' infrastructure that may reduce flexibility and the range of future adaptation options (Adger *et al.*, 2003; Eriksen and Kelly, 2007, OECD**,** 2009), or the failure to encompass the full range of risks, such as the effects of increasing storm surge in the design of a coastal defense system (UNFCC, 2007d). Adaptation efforts aimed at armoring the coastline may result in coastal erosion elsewhere while building levees along a flood-prone area might encourage unwanted development within that area often accentuated by a false sense of safety (Grothmann and Patt, 2005; Repetto, 2009; National Research Council, 2007) and the levees may increase damage when they fail as in Bangladesh in 1999 and New Orleans in 2003 (IDS, 2006). Similarly, agricultural policies that promote the growing of a high yielding crop varieties through subsidies with the objective of boosting production and increasing revenues may reduce agro-biodiversity and increase exposure and vulnerability of mono-crops to climate change and finally undermine the adaptive capacity of farmers (World Bank, 2010).

Another cause is the failure to account for multiple interactions and feedbacks between systems and sectors leading to inadequate or inaccurate information for developing adaptive responses and strategies that are maladaptive (Scheraga *et al*. 2003, Satterthwaite *et al*, 2009, Pittock, 2011). An assessment of the downstream impacts of upstream rainwater harvesting in a semi-arid basin in Southern India showed that, once the full range of externalities were accounted for, the net benefits were insufficient to pay back investment costs (Bouma *et al*., 2011). Similarly, the conversion of coastal mangroves into shrimp farms that may increase economic productivity, but also lead to increased vulnerability to flooding and storm surges (Klein, 2010).

14.7.2. Screening for Maladaptation

Five dimensions of maladaptation were identified by Barnett and O'Neill (2010) including actions that, relative to alternatives: (i) increase emissions of greenhouse gases; (ii) disproportionately burden the most vulnerable; (iii) have high opportunity costs; (iv) reduce incentives and capacity to adapt; and (v) set paths that limit future choices. These dimensions are useful pointers to the potential for maladaptation but their application tends to be subjective. The first assumes a fungibility between mitigation and vulnerability; the second turns on the interpretation of "disproportionately", and the third on "high" and on how opportunity costs are compared with current benefits. The dimensions were used by Barnett & O'Neill (2010) to describe maladaptive potential of the Wonthaggi desalinization plant to improve water supply to Melbourne, Australia. They conclude the plant will (i) increase GHG emissions (unless the promised wind power energy source is completed), (ii) lead to higher water costs that will disproportionally affect the poorer households; (iii) divert money and attention from more cost effective recycling and rainwater harvesting, (iv) reduce incentives to adapt through water conservation approaches, and (v) as a large sunk cost has locked out other options. The plant also affected significant cultural sites of the Bunurong Aboriginal community (Lee and Chung, 2007).

14.7.3. Experiences with Maladaptation

Maladaptation is a cause of increasing concern to adaptation planners, where intervention in one sector could increase vulnerability of another sector or increase the vulnerability of a group to future climate change. An example is the situation experienced by subsistence and smallholder agriculturalists in Palca, Bolivia who, in the face of stressors relating to land access, small holdings etc., moved away from their long established practices of diversification of crop varieties and planting locations to more intensive farming practices and cash cropping. They are now seeing evidence of climate change and the new practices make them more vulnerable to these changes leading to a risk of insufficient adaptation and maladaptation (McDowell and Hess, 2012). But there can also be tensions between development goals and climate change goals, where people may be aware of a climate related risk but are willing to take that risk (or they may have limited choice) given their current circumstances (IPCC SREX 2012, section 4.2.2).

Some studies warn against the simplistic use of maladaptation to communicate the state of high exposure to risks resulting from certain type of livelihoods. For example, the periodic movement of the nomadic pastoralists following the grass and water is a traditional and effective way of dealing with climate variability (Agrawal and Perrin, 2008), but is increasingly being described by some as maladaptive. More focused studies such as Young et al. (2009) put the breakdown of traditional pastoralism in the Sudan into the wider social and political context that led to restrictions on movement, asset stripping and escalating violence and undermined by policies not conducive to mobility.

14.7.4. Relationship between the Adaptation Deficit and Maladaptation

Adaptation deficit is a related but different concept from maladaptation and is defined as the gap between the current state of a system and a state that minimizes adverse impacts from existing climate conditions and variability. It can also be described as the inadequate adaptation to the current climate conditions (Burton *et al*., 2002; Burton, 2004; Parry, 2009; Chapter 17.xxx). The deficit may arise from past inaction, the mismanagement and depletion of natural resources, or maladaptive decisions in the past. The adaptation deficit may also result from a low level of development and the consequential reduced capacity to cope with climate variability. Thus, the adaptation deficit may be considered part of a larger 'development deficit' (World Bank, 2010). In the process of building future adaptive capacity it is important to reduce the current adaptation deficit along with designing effective risk management and climate change adaptation measures (Hallegatte *et al*., 2011).

14.8. Research Gaps and Data Gaps

[To be developed along with other chapters in next draft – a single section in a chosen chapter]

Frequently Asked Questions

FAQ 14.1: Are there different definitions of adaptation, and if so why, and are they important?

The most commonly used definitions of adaptation remain based on the IPCC AR3 (2001) definition ("adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities"), but with some important elaborations being introduced. The IPCC SREX (2012) and AR5 have modified the definition to deal separately with human and natural systems and included an element of purposefulness in human adaptation actions (i.e. "which seeks to moderate harm ...")[3]. Earlier IPCC Reports also defined the terms 'anticipatory', 'autonomous' and 'planned' adaptation, but the use of these terms in the IPCC and the literature has been inconsistent. The focus now is more on identifying terms in use in the UNFCCC negotiations such as 'concrete adaptation' measures [14.3.1] and incremental versus transformative adaptation [14.3.4].

Similarly, questions arise as to whether adaptation to climate change can, or should, be distinguished from normal development actions [15.x]. Adaptation and development are inextricably linked. Development that brings improvements in livelihoods, greater access to resources and more resilience to the wide variety of volatilities faced by household and communities, will usually also achieve adaptive outcomes. However, pursuing development priorities without looking ahead to a world with a changed climate could undermine development efforts either by failing to adjust to the possibility of changed climate [14.2; 15.x] or through actions that cut off options to deal with changed climates, i.e. maladaptation [14.6]. Increasing focus on the costs of adaptation and on evaluating adaptation practices has led to more attention to what constitutes *successful* adaptation. Some definitions of success emphasize reducing risks to a predetermined level while other focus on achieving predetermined levels of social and or economic well being [17.x].

[FOOTNOTE 3: IPCC AR5 definition of adaptation is "In human systems, the process of adjustment to actual or expected climate and its effects, which seeks to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate."]

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Table 14-1: Categories and examples of adaptation needs.

Categories	Examples of needs
Institutional	Inadequate laws, policies, incentives, plans, and procedures, as well as a lack of informal norms, to promote and support adaptation.
Social	Public and private needs arising from social conditions, such as poverty, health status, ethnicity, and age that increase vulnerability and risks.
Biophysical and Environmental	Need for actors and actions to maintain or improve ecosystem health, ecological productivity, and agricultural productivity while also addressing increasing the vulnerabilities of peoples who depend on these ecosystem services.
Resource	Insufficient financial, human, technological, informational, and social resources required for planning and implementing adaptation.

Table 14-2: Categories and examples of adaptation options.

Category	Examples of Options
Structural/Concrete	
Engineered	Sea wall; Water storage; Improved drainage; Beach nourishment; Flood shelters
Technological	New crop & animal varieties; Efficient irrigation and water use; Hazard mapping and monitoring; Early warning systems; Home insulation
Ecosystem-based	Wetland re-establishment; Re-establish floodplains; Bushfire fuel-reduction actions
Services	Social safety nets; Food banks; Vaccination programs, Municipal services
Institutional	
Economic	Financial incentives; Insurance & other risk spreading
Laws and Regulations	Land zoning laws; Building standards; Easements
Government Policies and Programs	National & local adaptation plans; Urban upgrading programs; Municipal water conservation programs; Disaster planning and preparedness
Social	
Educational	Awareness raising; Extension services
Informational	Hazard mapping and monitoring; Early warning; Community support groups
Behavioral	Household preparation; Evacuation planning; Retreat and migration; Water conservation; Storm drain clearance.

Based on: Carmin et al, 2013.

Table 14-3: Considerations when selecting adaptation options.

- Minimizing cost
- Maximizing benefit
- Mainstreaming with goals, programs, activities
- Flexibility
- Safety margins
- Resource availability
- Potential for incremental implementation
- Equity
- Stakeholder input

Table14-4: 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.

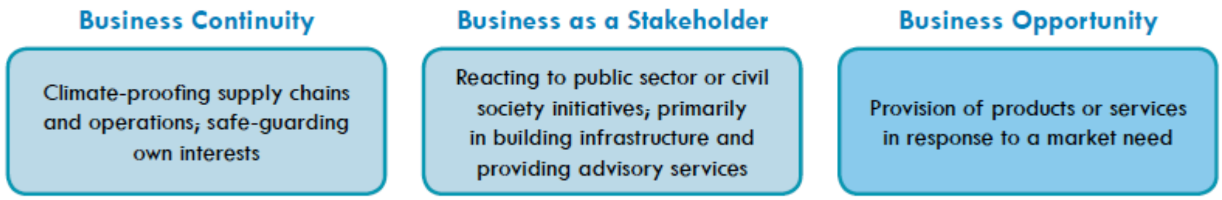

Figure 14-1: A typology of private sector engagement in adaptation (Khattri et al., 2010).

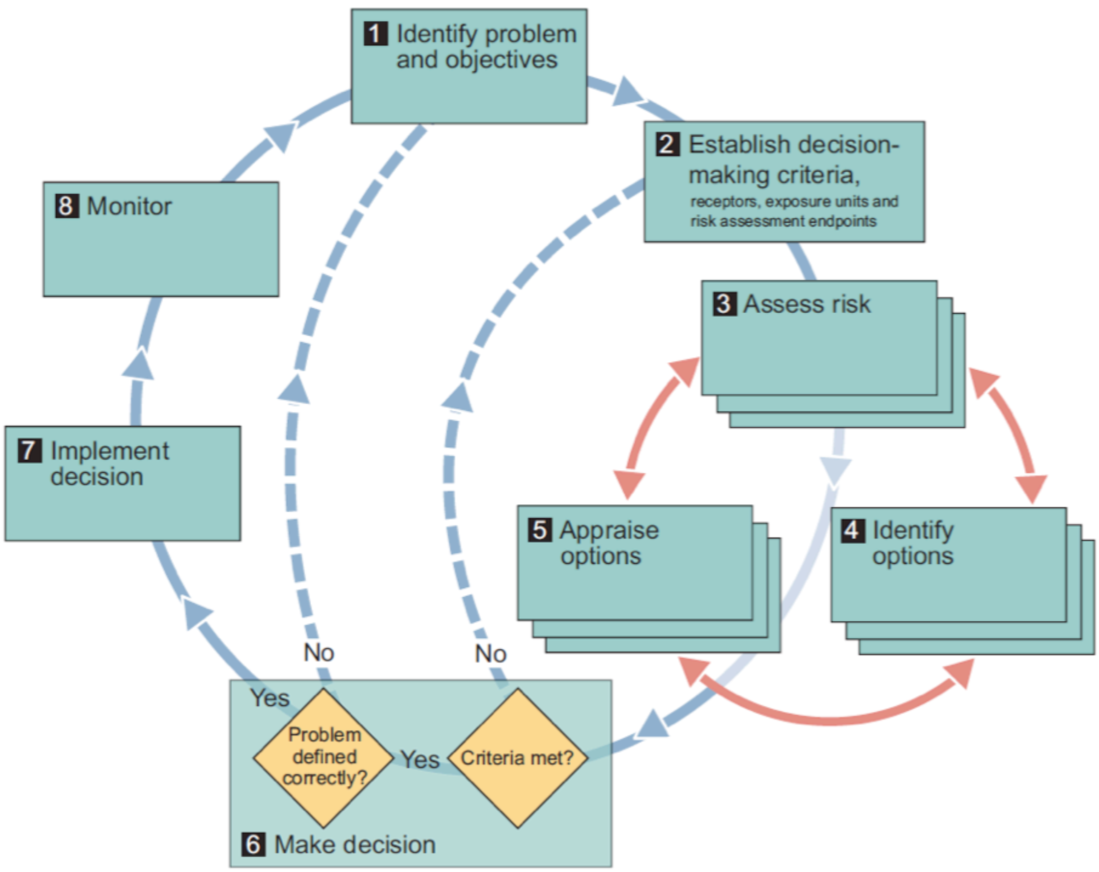

Figure 14-2: A generic framework for vulnerability and adaptation assessments (UKCIP, 2011).