Chapter 15. Adaptation Planning and Implementation

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References

Executive Summary

Adaptation planning is transitioning from a phase of awareness and promotion to the construction of concrete responses in societies (high agreement, robust evidence). [15.2] The combined efforts of a broad range of international organizations, scientific reports, and media coverage have raised the importance of adaptation to climate change. National-level plans and adaptation strategies for developed countries are dominated in the literature than for developing countries; whereas, more implementation cases are documented at the local level in developing countries. Attention to climate change impacts and disaster risk management, which are key elements of adaptation planning, appear to have a more prominent role in developed countries. In contrast, there is a trend to link adaptation planning to development needs and stresses in developing countries. This has had implications in terms of the resources and institutional needs to support adaptation planning and its implementation in developed and developing countries. Although the transition in adaptation planning represents a positive trend compared to the previous IPCC reports, it is not clear yet whether the observed adjustments and changes to perceived climate risks represent evidence of a societal shift towards a well-adapting society.

The social dimensions of adaptation have attracted more attention, including the relationship between adaptation, and development and disaster risk management (high agreement, robust evidence). [15.2.1] Climate change adaptation (CCA) takes place as a response to multiple stimuli, which highlights the need of connecting CCA with the development and disaster risk management (DRM). The importance of CCA is influenced by how the issue is framed, and to the extent that it is viewed as a public safety issue or a development issue, it may have greater resonance within national and local policies. Therefore, the linkages between adaptation, development

and DRM need to be more explicit targeting co-benefits among them. As knowledge of impacts and vulnerabilities solely is not sufficient to lead to the most effective and efficient adaptation policy decisions, due to the context specificity of adaptation, it is needed to build operational approaches of adaptation planning by recognizing the structural socio-economic conditions and agency of individuals and communities in low and middle-income countries.

The national level plays a key role in adaptation planning and implementation, while adaptation responses have diverse processes and outcomes at national, subnational and local levels (high agreement, high evidence). [15.2.2] National governments assume a coordinating role of adaptation actions in subnational and local levels of government, including the provision of information and policy frameworks, creating legal frameworks, actions to protect vulnerable groups, and financial support to other levels of government. Despite the embryonic state of the adaptation process, an assessment of the characteristics and effectiveness of the coordinating role of national adaptation strategies and plans is an urgent pending task. The number of adaptation responses has increased at the local level in developed and developing countries. However, there is a common trend that local governments are hindered by the absence of applicable guides to adaptation decision-making. Local councils and planners are often confronted by the complexity of adaptation, and even when information is available, they are left with a portfolio of options to prepare for future climatic changes and the potential unanticipated consequences of their decisions. Therefore, linkages with national and subnational levels of government, as well as the collaboration and participation of a broad range of stakeholders are important.

Adaptation efforts in some developing countries provide a 'win-win' adaptation strategy that strengthens resilience to climate change while improving economic stability and environmental quality. (high agreement, medium evidence). [15.3.1] Climate change adaptation efforts also improve ecosystem resilience by implementing sustainable forestry quotas, expanding floodplain setbacks, implementing coastal afforestation, coral reef propagation, restoring degraded lands, maintaining healthy vegetation on slopes, incentivizing development away from coastal areas and bluffs, and removing barriers to the migration of plants and animals. These linked approaches highlight the need for greater emphasis on nature-based protection strategies or buffers. Low cost behavioral actions can provide benefits within a short time.

There are many strategies and approaches to climate change adaptation, which include decreasing vulnerability, increasing resilience, increasing adaptive capacity, and/or decreasing the risk of impacts (high agreement, high evidence). [15.2.3] Decreasing risk, especially for developed countries, has been planned by a top-down approach including engineered infrastructure-based solutions such as dikes to prevent flooding and coastal inundation and dams to improve water supplies. Strategies adopted in developing countries, e.g., those in NAPAs, are almost identical with standard development projects. Bottom-up approaches are particularly useful in efforts seeking to reduce social vulnerability and addressing adaptation to climate change as a process. However, adaptation to climate change also requires complementary top-down strategies through different levels of governments to realize mainstreaming adaptation. Adaptation planning also highlights the importance of intergovernmental and multidisciplinary approaches integrating science and planning.

A no-regrets co-benefits approach of improving resilience through an emphasis on disaster risk reduction has become increasingly common. (high agreement, medium evidence). [15.2.3.2,] Disaster risk reduction (DRR) includes managing hazards from extreme weather events and helps communities to deal with the uncertainty of climate change. Climate change adaptation and disaster risk reduction are within separate agencies, although they share similar objectives and challenges, and there must be an effort towards better coordination. On the other hand, disaster risk management strategies by themselves often fail to account for a wide spectrum of threats and scales needed for climate change adaptation. The root causes of climate change vulnerability cannot be addressed through risk management alone. Due to the uncertainty, dynamic complexity, and short to long timeframes associated with climate change, robust adaptation efforts require iterative risk management strategies.

A variety of tools are being employed in adaptation planning and implementation depending on social and management context (high agreement, robust evidence). [15.2.4] Uncertainties in climate change coupled with the complexities of social-ecological systems requires adaptation planning and implementation are dynamic. Information and knowledge on climate change risks from various stakeholders and organizations are essential

resources for making adaptation planning. Multidisciplinary efforts have been engaged to develop, assess and communicate climate information and risk assessments across timescales. These efforts use a mixed portfolio of products from simple agroclimate calendars to computerized decision-support tools. Although a wide range of adaptations are possible with current technologies and management practices, development and diffusion of technologies can expand the range of adaptation possibilities by expanding opportunities or reducing costs. The status quo generally requires no new capital costs and may be more profitable in the short term than developing more climate-resilient technologies. Monitoring and early warning systems play an important role in helping to adjust adaptation implementation, especially on the local scale.

Adaptation planning and implementation is considered as a social learning process to formulate efficient plans, which allows periodical adjustments in order to reduce the uncertainty of the impacts of climate change and societal needs to cope with them (high agreement, medium evidence). [15.3.3] Social learning is a relevant but under-investigated feature of planning and a critical part in the innovations for adaptation. Understanding of why and how learning takes place is needed to improve the impact and efficiency of the plan, improve the transferability of best practices, increase public support, and translate the learning into new plans. Monitoring and evaluation are two important learning tools in promoting this process. Although the importance of evaluation in adaptation is recognized, this topic is under-researched and requires significant work.

Adaptation governance plays a key role to promote the transition from planning to implementation of adaptation. (high agreement, medium evidence). [15.4] The role of governance is highlighted in building adaptive capacity to climate change, providing the connections between individuals, communities, organizations, agencies, and institutions at multiple levels and in articulating top-down or bottom-up perspectives. As a multidimensional issue involving many state and non-state actors functioning on varying scales of global, national and local levels, a coordination of roles and responsibilities enhances institutional networking for effective implementation of climate change adaptation. Multilevel governance offers the chance to identify options for switching from reactive to proactive adaptation processes which are essential in safeguarding investments and infrastructures especially in urban adaptation. The creation of larger governance networks through coordination is reported to expand the adaptive capacity of local actors, as well as enhancing learning opportunities for policy formulations.

15.1. Introduction

As impacts of climate change have become apparent around the world, adaptation has attracted increasing attention. The impacts are expected to be particularly severe in the developing world and among marginalized communities because their adaptive capacity is limited. Until the mid-1990s, research on climate change focused almost exclusively on understanding of climate system dynamics and modeling of future climate. More recently, several programmes have been developed that give more prominence to studies of vulnerability and adaptive capacity and associated adaptation options, measures and strategies, including local, regional, and sectoral studies.

Chapter 17 of the IPCC Fourth Assessment Report (AR4) (Adger et al., 2007) presented the following major findings on adaptation practice:

- Adaptation to climate change is already taking place, but on a limited basis.
- Adaptation measures are seldom undertaken in response to climate change alone.
- Many adaptations can be implemented at low cost, but comprehensive estimates of adaptation costs and benefits are currently lacking.
- Adaptive capacity is uneven across and within societies.
- There are substantial limits and barriers to adaptation

There are many definitions and characteristics of adaptation strategies and varieties of implementation (Carter et al., 1994; Burton et al., 2005, Biesbroek et al., 2010). For the purpose of this chapter, adaptation strategies in general are defined as a general plan of action for addressing the impacts of climate change, including climate variability and extremes. It will include a mix of policies and measures with the overarching objective of reducing the country's vulnerability. This chapter will review the literature on climate change adaptation to assess the progress and limitations of adaptation planning and implementation. As the Fifth Assessment Report of the IPCC Working Group

II has four inter-related chapters for adaptation, this chapter focuses on the assessment of cases at different levels, from international to local in various sectors to assess:

- The resent status of climate change adaptation planning and implementation across the globe. The practices of adaptation planning and implementation have extended from international and national to local levels, and different sectors (e.g., disaster risk reduction, water resource planning, agriculture, urban planning) treat adaptation within their traditional context of planning to various degrees.
- Characteristics of adaptation in different settings. Adaptation planning characterizes decision-making under the uncertainty of climate change projections, other climatic factors, as well as societal changes in the long term. Countries take different strategies and approaches such as low-regret policy, climate proofing approach, science-driven and community-based approaches. Flexible and adaptive approaches are also emphasized. To understand the characteristics of the strategies and approaches to adaptation is also a challenge of this chapter.
- Barriers and opportunities for adaptation. It has been indicated that there are substantial limits and barriers to perform adaptation planning and implementation whereas the opportunities are also recognized. This chapter tries to identify the barriers to and opportunities for adaptation in developing and developed countries.
- Capacities for adaptation and how are they built? Capacities for adaptation planning and implementation are wide including institutional and financial abilities, capacities to access and use scientific information, technologies, decision-making measures, human resources and social awareness.
- Governance of adaptation. As adaptation has a wide range of stakeholders, its success or failure depends on governance, which is quite complicated because of many reasons. How climate change adaptation is being coordinated across different levels of governance is a key question regarding this subject.

Following national and region-specific syntheses (Biesbroek et al., 2010; Bierbaum et al., 2013), the Chapter highlights factors motivating and facilitating the development of adaptation strategies; the scientific and technical information, support and collaborative mechanisms being used for the development and implementation; promotion of climate change awareness and strategies through communication; present and evolving forms of multi-level governance and responsibilities to implement the proposed actions, mechanisms and arrangements for incorporating adaptation into integrated management and sectoral actions; and how the strategies and their implementation are being evaluated.

Figure 15-1 shows a general cycle of adaptation and the environment it occurs. It has major components of adaptation planning and implementation and this chapter will discuss them in the following sections.

[INSERT FIGURE 15-1 HERE
Figure 15-1: Four main phases of adaptation planning and implementation: needs, planning, implementation, and evaluation. This is a cyclic, iterative process. Building capacity to respond to change, whether expected or unexpected, creates resilience in societies to cope in the face of uncertainties in climate change projections. Efforts in adaptation need to be linked with development or disaster risk management. This is particularly true and important in developing countries. Adaptation governance underlies the capacity and governance takes place at multiple scales: international, national, sub-national, and local.]

15.2. Status of Adaptation Planning and Implementation

The combined efforts of a broad range of international organizations, scientific reports, and media coverage have raised the importance of adaptation to climate change. These efforts have fostered a growing number of adaptation responses in developed and developing countries. The assessment of literature indicates adaptation planning is transitioning from a phase of awareness and promotion to the development and construction of adaptation responses. This transition represents a positive trend compared to earlier IPCC reports, it is not clear yet how effective these responses currently are and will be in the future. Despite the current dynamics of adaptation planning, there are still limited evidence of its implementation that is readily identifiable from development and disaster risk reduction plans.

The review of the international literature identifies a high heterogeneity of adaptation planning. The heterogeneity is related to the context specific nature of adaptation, but also to the differences in resources, values, needs, and perceptions among and within societies. The diversity of adaptation strategies, plans and actions at the national, subnational, and local level indicates differences in approaches between developed and developing countries. Although attention to climate change impacts and disaster risk management are key elements of adaptation planning, they appear to have a more prominent role in developed countries. In contrast, the literature reflects a trend to link adaptation planning to development needs and stresses in developing countries. This has had implications in terms of the resources and institutional needs to support adaptation planning and its implementation in developed and developing countries.

Although more attention is being paid to the institutional dimension of adaptation, it remains an underdeveloped area. Embryonic discussions of the transformations needed in the structure and operational culture of institutions to address adaptation to climate change are occurring in both developed and developing countries. Researchers have been reporting on the limitations of current institutional arrangements to support the implementation process of adaptation, critically so at the local level. Other unintended consequences include the difficulty to mainstream adaptation planning and delays in its implementation as a result of the mismatch of organizations and responsibilities.

Central to this discussion and one of the critical aspects identified in the review of the international literature is the trend to consider adaptation planning as a problem-free process capable of delivering positive outcomes. There is the risk of underestimating the complexity of adaptation planning as a social process. This can lead to creating unrealistic expectations in societies, and overestimating the capacity of planning to deliver the intended outcome of preparing societies to adapt to the negative impacts of climate change. This highlights the importance of monitoring, evaluating and reviewing adaptation planning and implementation.

15.2.1. Responding to Present and Future Climate Impacts

The international literature reports the dynamic creation of plans, strategies, legislation and projects at national, subnational, and local levels (Bulkeley, 2006; Biesbroek, 2009; Romero-Lankao and Dodman, 2011). The number of adaptation plans and strategies has grown at the national and subnational level in high-income countries, but at a lower pace in low and middle-income countries. Berrang-Ford et al. (2011) document a sharp increase in the peer-reviewed literature addressing adaptation to climate change (1741 articles published between 2006 and 2009). Preston et al. (2009) identify at least 62 different adaptation plans publicly released in the United States, Canada, United Kingdom and Australia, and they expected that number would double by the end of 2009. Tompkins et al. (2010) document over 300 adaptation actions in the UK in 2005. The non-peer reviewed literature reports a dynamic growth of adaptation plans and strategies at the national, subnational, and local level. A significant number of those publications are descriptive and provide limited information on the progress made so far in adaptation planning and its implementation.

The international literature has begun to pay attention to the need for improving the understanding of adaptation processes. Berrang-Ford et al. (2011) highlights the limited understanding of these processes and how adaptation planning is actually taking place. The majority of studies on adaptation to climate change report on the assessment of potential vulnerability of the social and natural systems to the negative impacts of climate change. They note that most publications describe an intention to act rather than concrete adaptation actions. In a review of adaptation articles in the journal Climatic Change Arnell (2010) as well concludes that very few published examples of case studies of how adaptation to climate change is actually being delivered, or on the barriers that will influence how adaptation takes place. Tompkins et al. (2010) question whether the observed adjustments and changes to perceived climate risks represent evidence of a societal shift towards a well-adapting society, or are merely unconnected actions of individuals motivated by different stimuli. Other studies report little research has been carried out on climate change adaptation actions to date as distinguished from determinants of adaptation capacity (National Research Council, 2011).

Some literature has focused on the social dimension of adaptation and adaptation planning. Orlove (2009), Ribot (2010), Boyd and Juhola, (2009) and others observe that adaptation analysis and many recommended measures tend to focus on the physical hazards rather on than on the underlying stressors creating them thus neglecting the drivers of vulnerability, and thus, limiting the effectiveness for interventions. Hardee and Mutunga (2010), Lemos et al. (2007), and Sietza et al. (2011) indicate that the disproportionate focus on the impacts of climate change could obscure opportunities for connecting development pressures, poverty, social inequality and climate change, particularly for the reduction of social vulnerability. Hulme et al. (2009), Barnett and Campbell (2009) suggest knowledge of impacts and vulnerabilities does not necessarily lead to the most cost-effective and efficient adaptation policy decisions, partly due to the context specificity of adaptation. Thus Sanchez-Rodriguez (2012) highlights the need to build operational approaches of adaptation planning by recognizing the structural socio-economic conditions and agency of individuals and communities in low and middle-income countries. These studies follow on decades of research and practice in the disaster risk reduction field (Blaikie et al., 1997; IPCC, 2012) and shows positive examples of the adaptation research community beginning to learn from other long-standing disciplines.

Attention to the social dimensions of adaptation, including rates of change in social conditions, in part of the international literature coincides with the interest of international organization and scholars in the relationship between adaptation and development. The literature supports the long-standing contention that adaptation takes place as a response to multiple stimuli - not just climate (IPCC, 2007; Tompkins et al., 2010). The importance of climate adaptation is also influenced by how the issue is framed. For example, to the extent that it is viewed as a public safety issue or a development issue, it may have greater resonance within local government (Measham et al., 2010). Other authors consider integrating local knowledge and experience, including households, into multidimensional and multi-scale approaches to guide the construction of adaptation responses to climate change, and integrate them with development strategies (Ewing et al., 2008; Moser and Satterthwaite, 2008; Hodson and Marvin, 2009). Stringer et al. (2009) consider that the linkages between adaptation and development should be made more explicit. Dovers (2009) stresses the need of connecting climate adaptation more closely to existing policy and existing agendas, knowledge, risks, and issues communities already face.

Important steps for mainstreaming adaptation have been identified but the challenges remain in their operationalization within the current structures or operational cultures of national, subnational and local agencies. Multilateral Development Agencies encourage efforts in this direction through a number of guidelines, publication and development assistance (UNDP, 2005; USAID, 2007; OECD, 2009; UNEP, 2010; World Bank, 2010; UN-HABITAT, 2011). Central to these efforts is the role of planning that connects adaptation and development needs and challenges (Blanco and Alberti, 2009; Dovers, 2009; Juhola and Westerhoff, 2011). Urban, regional, and development planning have struggled to create interdisciplinary perspectives to address the multidimensional reality they seek to modify. This issue will be addressed in more detail in section 15.3.1.2 within the context of institutional arrangements.

15.2.2. International, National, and Local Assessment

15.2.2.1. International Mechanisms for Supporting Adaptation Planning

There has been a large growth of adaptation planning initiatives at the international, national, subnational, and local level since the last IPCC report (UK, Germany, Australia, Canada, the Caribbean among others). The assessment of the literature illustrates a diversity of approaches that have evolved in adaptation planning across and within countries, the challenges to create multilevel governance to support dynamic adaptation planning and implementation, the central role of climate change impacts and risk management in adaptation strategies and plans, and different perceptions, resources, and approaches in these strategies and plans between developed and developing countries. Many of these adaptation initiatives are at an embryonic state and it is difficult to extract conclusions of their effectiveness, efficiency, and equity at this point. The dynamic pace of the creation of adaptation strategies and plans stresses the importance of monitoring and evaluation. While the Adaptation Fund and Pilot Program in Climate Resilience have outlined monitoring and evaluation criteria, little is found in the literature to support effective and sustained implementation of these two dimensions (Adger et al., 2009b; Preston et al., 2009; Tompkins et al., 2010; Wolf et al., 2010).

15.2.2.1. International Mechanisms for Supporting Adaptation Planning

International mechanisms for supporting regional adaptation planning are an important resource for the creation of adaptation responses. The directives and initiatives of the European Commission (EC) have fostered the creation of a significant number of National Adaptation Strategies and Plans in EU member countries since the last IPCC report. Adaptation planning responses at the local level have also multiplied in these countries in response to these directives. Other relevant regional initiatives are the South Pacific Regional Environmental Programme (SPREP) supported by a number of international agencies, and in the Caribbean through the Caribbean Catastrophic Risk Insurance Facility (Pulwarty et al., 2010).

The international literature reports a growing number of mechanisms developed by Multilateral Development Organizations, development cooperation agencies from Developed countries (UK, USA, Canada, Sweden, Denmark, Norway, Japan, Spain, the Netherlands among others), United Nations programs (UNDP, UNEP, UN-HABITAT, WMO, FAO and other agencies), and International Non-Governmental Organizations (OXFAM, CARE, IFRC, ICLEI and others). These organizations focus on their particular geographic and thematic areas of interest. An example in the case of development agencies is the collaboration between the UK and Canada (IDFG and IDRC) to create the Climate Change Adaptation in Africa (CCAA). This initiative supported 46 projects mostly in rural areas of several countries. The initiative focused on three areas: participatory action research, communication and networking, and networking education and training. Development agencies have also supported adaptation planning in a number of developing countries in Africa, Asia, and Latin America, the South Pacific, and the Caribbean.

Multilateral Development Agencies (MDA) have developed mechanisms to mainstream climate change in their project planning. They have created guidelines and provided support for adaptation planning in developing countries. Some MDA focus on guidelines for the creation of adaptation projects (USAID, 2007), other highlights the importance of integrating adaptation planning with development co-operation (OECD, 2009). The World Bank has led the systematic examination or 'portfolio screening', of its set of policies, programs or projects, with the aim of identifying how concerns about climate change can be combined with an agency's development priorities, such as poverty reduction, institutional development and capacity building (Klein et al., 2007; World Bank, 2010).

The United Nations Development Programme (UNDP) has a broad range of mechanisms supporting adaptation planning, including guidelines (UNDP, 2005), information resources, support to national adaptation planning, and as an implementation organization in some of the early projects approved by the Adaptation Fund. Together with the United Nations of Environmental Programme (UNEP) provide support to Sub-Sahara countries in Africa through the Climate Change Development Initiative (CCDARE). Other UN agencies have created information mechanisms supporting adaptation planning. Particularly relevant are the activities United Nations Framework Convention on Climate Change for least developing countries through the National Adaptation Programmes of Action (NAPAs) and for less developed countries through the National Adaptation Plans (NAPs) discussed in the next section.

Relevant funding mechanisms are associated with the Global Environmental Facility (GEF) adaptation funds (LDCF and SCCF), support for the Pilot Program for Climate Resilience (PPCR), and special purpose adaptation funds for UN Agencies. The Adaptation Fund (AF) set up under the Kyoto Protocol is of particular importance to developing countries as it is pioneering the direct access mechanisms, which allows countries to access funds without having to work through a multi-lateral development agency. The AF indicators suggest a focus on addressing the adaptation deficit and climate -proofing development for incremental changes in existing risks while the PPCR framework has a stronger focus on the mechanisms through which adaptation is integrated into development planning and practice.

International non-governmental organizations has growing presence fostering adaptation planning in developing countries. Large organizations have created diverse mechanisms to support adaptation at the local level. For example, Oxfam America has developed a risk management framework with enable poor farmers in Ethiopia to strengthen their food and income security through a combination of improved resource management (risk reduction), microcredit ("smart" risk taking), risk transfer (insurance), and risk reserves (savings). Oxfam has also published guidelines to support local adaptation planning (Crane, 2013). The International Federation of Red Cross (IFRC)

have extensive mechanisms focusing on disaster risk management and vulnerability reduction and its integration with climate change adaptation (IFRC, 2009; Braman et al., 2010). CARE has also extensive mechanisms addressing climate change adaptation and community resilience (Action Aid, CARE, WWF, 2012). It is worth mentioning a number of other International NGOs have created mechanisms to support adaptation planning at the local level in developed countries (ICLEI, 2008; Pew Center, 2009).

Information centers have also arisen with guidelines, information, case studies, and other support tools to facilitate adaptation planning by MDA, UN agencies, and international NGOs. Some of these center are: IFRC's Climate Center, CARE's Climate Change information Center, World Bank Adapt, UNDP Adaptation Learning Mechanism, and weAdapt of the Stockholm Environmental Institute.

The fast growth of international mechanisms for supporting adaptation planning has assisted the creation of adaptation strategies, plans, and actions at the national, subnational and local level. The international literature documents a growing number of projects sponsored through these mechanisms. Their monitoring and evaluation can help sponsoring organizations, stakeholders, and government agencies to extract learning lessons to increase and improve the efficiency of adaptation planning and implementation. It is worth noting that so far little attention has been provided to critical reflections during the adaptation process.

15.2.2.2. National Adaptation Plans

The IPCC Fourth Assessment Report documented the international recognition of the importance of adaptation to climate change. This is reflected in the growing number of national governments creating national adaptation strategies, policies, and plans. The international literature illustrates the diversity of approaches used in these national initiatives, from National Adaptation Programmes for Action (NAPAs) in least developed countries targeting key sectors (Ciplet at el., *in press*), to the efforts to create national holistic plans in response to regional directives in some European countries (Biesbroek et al., 2009, 2010). The NAPA focus on existing coping strategies and actions at the grassroots level in Least Developed Countries (LDCs) , and build upon that to identify priority activities, recognizing that local communities are the main stakeholders. At the same time, the movement to introduce climate change adaptation policies into national policies has accelerated in the developed countries as well. National adaptation initiatives and their heterogeneity reflect the idiosyncrasies of the domestic political structures, socio-economic conditions, values and perceptions, and development stresses and opportunities.

The analysis of the international literature identifies national governments assume a coordinating role of adaptation actions in subnational and local levels of government. Early evidences suggest that some of the coordination roles of national governments include: the provision of information of potential impacts risks to strengthen actions of state and local governments, providing policy frameworks to guide decisions at subnational level, driving and coordinating the creation of legal frameworks, direct action in case of sectors and resources key for national development (agriculture, fisheries, health, ecosystem protection, among others), actions to protect vulnerable groups, and financial support to other levels of government. In some cases, national governments are key actors securing international funding for subnational and local levels of government. Despite the embryonic state of the adaptation process, an assessment of the characteristics and effectiveness of the coordinating role of national adaptation strategies and plans is an urgent pending task.

National adaptation is an evolving process. Thirteen European countries have created National Adaptation Strategies—Austria, Belgium, Denmark, Finland, France, Germany, Hungary, the Netherlands, Norway, Portugal, Sweden, Spain, United Kingdom (only two of them were created before the last IPCC report, Finland and Spain) (Prutsch et al., 2010). Some of these strategies have evolved to a National Adaptation Plan (France, Germany, UK). While these may represent a new political commitment to adaptation at national political levels (Biesbroek et al., 2010) , many institutional challenges and barriers to future policy implementation remain. Many projects do not have defined an implementation agency (Swart et al., 2003). Australia's federal government has invested in research through CSIRO Climate Adaptation National Research Flagship and the National Adaptation Research Facility and supports local government's climate change adaptation role (Local Adaptation Pathways Program). However, a governance system integrating adaptation planning across all levels of government is still pending (Doran, 2011).

Some countries recognize the learning process of adaptation and have programmed the evaluation of their national adaptation strategies and plans (UK, Germany, Australia among others). The federal government in Mexico has taken steps to update its National Adaptation Strategy from 2007 (Gobierno Federal, 2012). Although these steps update and upgrades adaptation planning, there remain obstacles for their implementation. Within the U.S., as in other areas, although substantial adaptation planning is occurring in various sectors, levels of government, and the private sector, few measures have as yet to be implemented and fewer have been evaluated (Bierbaum et al., 2013).

The experience resonates with the perspective that most strategies can be regarded as just the start of a policy process rather than its culmination emphasizes the importance of considering evaluation planning and its implementation a learning process (Hulme et al., 2009; Biesbroek et al., 2011; Pulwarty et al., 2012).

Institutional obstacles affect differently the coordinating roles of national adaptation strategies and plans. Particularly affected are the creation of policy frameworks to guide decisions at subnational and local level and the integration of adaptation in sectorial policies. Evidence of this problem begins to be addressed in some studies. The ADAM project in Europe considers most barriers to actual adaptation to be related to policy co-ordination and implementation (Hulme et al., 2009). Particularly challenging is multi-level coordination within with other levels of government and between the government and other sectors in society. Multi-level governance is a challenge in developed and developing countries (Storbjork, 2007; Unwin and Jordan, 2008; Gupta et al., 2010; Gero et al., 2012; Rodima-Taylor et al., 2012). Early identification of these barriers and actions to address them are part of the pending task in national adaptation strategies and plans. Governance structures have seldom efficient multi-level practices despite decades of development planning. This remains a major obstacle to achieve efficient adaptation planning and implementation. Sections 15.3.1.1 and 15.3.1.2 address this issue further.

National Adaptation Programmes of Action (NAPAs)

National adaptation responses have a particular condition in the case of the Least Developed Countries through the experience of UNFCCC's NAPAs (National Adaptation Programmes of Action). Established in 2001, NAPA is an organized planning process for adaptation sponsored by the United Nations Framework Convention for Climate Change (UNFCCC) (Ciplet *et al*., in press). As of November 2010, the UNFCCC Secretariat received forty-seven NAPAs.

The international literature stresses the reliance on this program (Agrawal, 2008; Agrawal and Perrin, 2008; Stringer et al., 2009). The NAPAs have emphasized the connecting local level adaptation and development. More than 50% of the projects under this program are concentrated in three key sectors for development and livelihoods: food security, terrestrial ecosystems and water resources. One study of NAPAs in four African countries illustrates that they are attracting the support of a greater range of actors but linkages between development and adaptation need to be made more explicit (Stringer et al., 2009).. They find the enthusiasm for broader participation in the rhetoric of international politics does not yet match the realities of its enactment on the ground. Another study identified only 20% of projects described in the NAPA documents that incorporate local institutions as the focus of adaptation projects and identified even fewer that incorporate local institutions as agents or partners in facilitating adaptation. The researchers, Agrawal and Perrin (2008) suggest that projects tend to build the capacity of national governments and agencies rather than local actors and local institutions still seems to be valid. Other authors document financial difficulties in NAPA projects leading to cumulative delays and the outdatedness of many of the needs first assessed (Ciplet at el., *in press*). Sustained monitoring , evaluation and feedback to learning of the NAPAs process are needed to help these countries transcend from a project by project basis to an adaptation process within the context of domestic and local development efforts.

15.2.2.3. Sub-National Adaptation Plans

The international literature has paid less attention to adaptation planning and implementation at the subnational level. There are major differences on the role subnational governments play in the governance structure of countries, from those with strong concentration of political and economic power to a very minor role in governance and decision-

making. The role of subnational governments in adaptation planning reflects the governance structure of each country.

The review of the international literature identifies subnational governments have often a complementary role to national governments in adaptation planning according to the governance structure in each country (Moser, 2005; West and Gawith, 2005; Lemmen et al., 2008; Pew Centre, 2009; USGCRP, 2009). Although the development of adaptation governance has not created guiding frameworks for subnational governments in most countries, the literature reflects an active participation of states and provinces in some countries. For instance, Gero et al. (2012) report all states and territories in Australia have begun creating or amending laws, policies, and action plans to account for climate change adaptation. The provincial governments in Canada have also an active role in the creation of adaptation planning. 24 out of 32 states in Mexico have created Climate Action Plans in the last 6 years with technical support from the federal government of Mexico and some financial support from international sources (Gobierno Federal, 2012). A growing number of states have created also climate actions plans that include adaptation actions in the United States.

In addition to state by state efforts, supra-state organizations are also recognizing, supporting, and fostering attention on adaptation, though concrete action to date is limited (Pew Centre, 2009). In some instances, states are collaborating on sector specific issues that concern them regionally (Bierbaum et al., 2013). For example, in the American West, water managers are collaborating and sharing information regionally (Brekke et al., 2009; Barsugli et al., 2012). Similarly, in the Great Lakes region, Midwestern states and Canadian provinces have expressed concern over the impact of climate change on their joint water basin (though concrete adaptive management actions have not yet been specified) (Dinse et al., 2009). Canada's Regional Adaptation Collaborative Program is also an example of regional collaboration of subnational governments. Further examples have appeared also across borders (for example, the Western Climate Initiative that includes 7 states in the U.S. and 4 provinces in Canada). Regional adaptation plans have also been created in European countries such as the Climate Change Adaptation Plan in East England (Staples, 2011). The embryonic state of these regional collaborations does not allow drawing conclusion of their operation and outcomes for this report. However, it is a process worth monitoring during the coming years.

15.2.2.4. Local Adaptation Plans

The international literature shows a significant increase in the number of planned adaptation responses at the local level in rural and urban communities of developed and developing countries since the last IPCC report. Climate adaptation is context dependent and it is uniquely linked to location, making it predominantly a local government and community level of action. However, limited economic, human, technical resources at the local level highlight the importance of national and subnational levels of government, as well as the collaboration and participation of a broad range of stakeholders. Despite the obligation to act, local governments are hindered by the absence of applicable guides to adaptation decision-making, especially adaptation to extreme events (Corfee-Morlot et al., 2009; Glaas et al., 2010; Gero et al., 2012). Local councils and planners are often confronted by the complexity of adaptation without adequate access to guiding information, data on local vulnerability and the potential impacts of climate change. Even when information is available, they are left with a portfolio of options to prepare for future climatic changes but without effective guidance on decision-making and the potential unanticipated consequences of those decisions (Mathew et al., 2012).

The central role of local governments addressing the challenges of adaptation planning and implementation is reflected in the literature (Blanco and Alberti, 2009; Sanchez-Rodriguez, 2009; Rosenzweig and Solecki, 2010; Simon, 2010; Matthews, 2012;), but scholars stress also the importance of partnerships between public, civic, and private in the adaptation process (Agrawal, 2010; Tompkins and Ealkin, 2012). The complexity and uniqueness of each locality is often not recognized by policy planners because of the lack of understanding and consultation with the local community (Geiser and Rist, 2009; Ribot, 2010). Inclusive and participatory approaches in adaptation planning are encouraged by international organizations (UNDP, 2005, 2010; World Bank, 2010; UN-HABITAT, 2011) and scholars (Moser, 2008; Moser and Satterthwaite, 2008).

15.2.2.4.1. Rural and community adaptation planning

Community-based adaptation, an example of local level planning and implementation, is a course of action that allows local stakeholders to bring skills and knowledge into the planning process. Because climate change impacts occur locally, the scale of community engagement and the approaches used have been critical to the success or failure of adaptation programs where they occur (Picketts et al., 2012).

Ford et al. (2011) examined adaptation plans that were implemented in developed nations from 2006 to 2009, and found that stakeholder participation was commonly mentioned as part of the planning process. Patt and Schröter (2008) document barriers to implementing climate change adaptation strategies in Mozambique that resulted from differing perceptions of climate risk between farmers and policy makers, and the perceived potential for negative consequences of the proposed adaptation plans. These studies suggest that without broader stakeholder agreement at the local level, successful implementation of adaptation is not possible. However, in other case studies of community-based participatory adaptation projects, local farmers such as those in Sri Lanka needed no additional incentives to participate in adaptation programs that they recognized as an opportunity to improve their harvests and income. The creation of community organizations can provide an avenue for local participation, and provides a mechanism that helps to sustain adaptation efforts. Community-based adaptation in Bangladesh has included participatory action plan development, an approach that combines consensus-building and participatory rural appraisal. The needs, skills and assets of the communities were assessed by conducting household surveys and consultation meetings (Ensor and Berger, 2009).

Indigenous and rural peoples, however, are not only potential victims of climate change. Attentiveness to environmental variability, shifts and trends is an integral part of their ways of life. Community-based and local knowledge continue to offer valuable insights into environmental change due to climate change, and complement broader-scale scientific research with local precision and nuance. Indigenous societies have elaborated coping strategies to deal with unstable environments, and in some cases, are already actively adapting to early climate change impacts (Nakashima et al., 2012). Indigenous Arctic communities are providing systematic observations of climate change impacts, which complement scientific data and frame local efforts to adapt.

Other authors have studied the role of the business community in adaptation planning. Howe (2011) notes the adaptive capacity of businesses vary with the types of business, location, and socio-cognitive characteristics of business owners. Other perspectives (Berkholt et al., 2006; Tompkins et al., 2010) suggest that market forces are unlikely by themselves to lead to efficient adaptation requiring public ploicy interventions. Other studies suggest business responses can be motivated by other forces. For example, the study of climate adaptation in the UK mentioned above found that responses to regulation, industry standards such as ISO14001, and corporate social responsibility obligations have at least as great an influence on adaptive behavior in the business community as direct climate-related risks and can produce public benefits (Tompkins et al., 2010)

15.2.2.4.2. Urban areas

A growing number of urban areas have created disaster management plans at the local level, often in response to climate-related disasters (OECD, 2010; Dodman, 2012; EEA, 2012). Few of these plans have incorporated climate change adaptation so far. The peer and non-peer reviewed literature reports a growing number of adaptation plans at the local level. Urban areas are the locus of a number of those planning initiatives (Roberts, 2008; Blanco and Alberti, 2009; Hamin and Gurran, 2009; Lowe et al., 2009; Parzen, 2009; Sanchez-Rodriguez, 2009; Corfee et al., 2010; Rosenzweig and Solecki, 2010; Rosenzweig et al., 2011; Matthews, 2012; New York, 2012; ; Rotterdam, 2012). This includes special issues in some academic journals (for example, papers included in the special issue Habitat International vol. 33, 2009 and Current Opinion in Environmental Sustainability vol. 2, 2010 and vol. 3, 2011). The non-peer reviewed literature also documents a growing number of adaptation plans to climate change in large cities (New York (2012), Chicago (2012), London (2010), Toronto (2008), Mexico City (2008), Sao Paulo, Rotterdam (2012)), but increasingly in medium-size cities (King County in Washington State, Santa Cruz in the US, Cartagena in Colombia (2005), Durban (2012) and Cape Town in South Africa (2006)) (note that this list of urban

areas is intended for illustrative purposes). The experiences in these cities provide early lessons potentially useful to other cities.

Chapter 8 discuses in detail the impacts, vulnerability and adaptation of climate change in urban areas. A review of the literature allow identification of the difference in the adaptive plans of urban areas (Romero-Lankao and Dodman, 2011; Rosenzweig et al., 2011; Carmin et al., 2012). These differences are particularly evident between urban areas in developed and in developing countries and they reflect diverse conditions, resources, perceptions, and governance structures among cities (Agrawala and van Aalst, 2008; Ayers, 2008; Bartlett, 2008; Caney, 2008; Moser and Satterthwaite, 2008; Revi, 2008; Roberts, 2008; Simon, 2010; Stren, 2008; Tanner et al., 2008; Hardoy and Pandiella, 2009; O'Demsey, 2009; Hardoy and Romero-Lankao, 2011;). The literature suggests that responding to current climate extremes and potential future impacts of climate change are primary determinants in the creation of adaptation plans (Rosenzweig and Solecki, 2010; Rosenzweig et al., 2011; Carmin et al., 2012). For instance, adaptation plans in London, Toronto, New York City, Chicago, Rotterdam focus on responses to the impacts of climate change and sea level rise with a strong emphasis on protective infrastructure.

As yet the extent to which adaptation plans in cities of developing countries will follow a similar approach or if they will consider the guidelines suggested by MDA and other international organizations to mainstreaming adaptation into municipal and development planning remains unclear (UNDP, 2005, 2010; USAID, 2007; World Bank, 2010). The difference in approaches to adaptation planning has implications for adaptation governance, institutional arrangements, resources, and stakeholders involvement in the adaptation planning process and its implementation. This is an issue that merits further analysis in the near future. Related to this discussion is the gap between disaster risk management and climate change adaptation in urban areas. Enforcing parallel agendas for disaster risk management and climate change adaptation runs the risk of duplicating efforts and resources, creating competing actions and potential conflicts with unintended negative consequences, including maladaptation. Anguelovski and Carmin (2011) suggest that few urban areas have the resources and know-how to institutionalize adaptation planning in developing countries. Section 15.3.1.1 addresses this issue further.

15.2.3. Strategies and Approaches

15.2.3.1. An Overview

Strategies include decreasing vulnerability, increasing resilience, increasing adaptive capacity, and/or decreasing the risk of impacts (Few et al., 2007; IPCC, 2012). Decreasing risk, especially for high-income nations, has furthered through with engineered infrastructure-based solutions such as dikes to prevent coastal inundation from sea-level rise, new dams to improve water supplies, and other designs to reduce flooding. These approaches have been implemented in European countries such as the UK, Germany, especially the Baltic Sea region, and in U.S. coastal cities such as San Francisco and New York (Hofstede, 2008; Garrelts and Lange, 2011; Rumbach and Kudva, 2011; Rosenzweig et al., 2011). In some case, such as flood risk planning, government policies have made implementing a diverse set of adaptation planning options more difficult because of the institutional preference for construction of large-scale protection designs (Harries and Penning-Rowsell, 2011). However, adaptation finance channelled through national governments is not likely to reach the lowest income and most vulnerable people, and infrastructure-based approaches to climate change adaptation often fail to include local residents in the adaptation planning process (Sabates-Wheeler et al., 2008; Rumbach and Kudva, 2011). In addition to the need to secure funding for infrastructure-related plans, implementation of top-down approaches can require numerous legislative and executive actions (Wheeler, 2008, 2011; Harries and Penning-Rowsell, 2011; Marino, 2011). In a review of adaptation planning for cities of the United States, planning for the effects of excessive heat in urban areas primarily consisted of future infrastructure changes, such as cool paving materials; but in actual heat-related emergencies, public health campaigns and community mobilization were necessary (Ebi and Schmier, 2005; O'Neill et al., 2010). During a 1999 heat wave in Milwaukee Wisconsin, USA, the coordination of 20 different agencies was involved, demonstrating the need for additional adaptation strategies in addition to infrastructure planning (O'Neill et al., 2010).

In contrast to top-down strategies to fortify infrastructure, there are local organizational and community-based approaches (Ensor and Berger, 2009; Pelling, 2011). Community participation in adaptation planning appears to be more common in developing countries where community level planning is more common (Ford et al., 2011). Public awareness campaigns have aided the adaptation process. In the case of farming households in the Nile basin of Ethiopia, Di Falco and Veronesi (2011) demonstrated that farmers that were better informed were more proactive, and more likely to adopt new technologies useful in reducing drought-related crop failure.

15.2.3.2. Disaster Risk Management and Adaptation

A no-regrets co-benefits approach of improving resilience through an emphasis on disaster risk reduction has become increasingly common. Disaster risk reduction (DRR) includes managing hazards from extreme weather events and helps communities to deal with the uncertainty of climate change (Mitchell et al., 2010; IPCC, 2012) Proponents of merging DRR with climate change adaptation also note that currently, climate change adaptation and disaster risk reduction are within separate agencies, although they share similar objectives and challenges. Current regional and international institutions that have merged DRR and climate change adaptation include CARICOM (Caribbean Community Comprehensive Disaster Strategy) and CHARM (Comprehensive Hazard and Risk Management) in the South Pacific (Mitchell et al., 2010). In Bolivia, the Intercooperation project, utilizes traditional knowledge to improve agricultural production and to provide better decision making in risk-management (Mitchell et al. 2010). On the other hand, disaster risk management strategies by themselves often fail to account for the differing spectrum of threats and scales needed for climate change adaptation. A critique of climate change and disaster risk efforts in Canada by Etkin et al. (2012) showed that the root causes of climate change vulnerability cannot be addressed through risk management alone.

The need for better coordination between risk management agencies and climate change adaptation efforts is exemplified by the current dilemma faced by the Inupiat village of Shishmaref, Alaska. Village inhabitants are descendants of indigenous nomadic people that established a post-colonial sedentary community in response to government modernization, infrastructure development, and the need to send their children to school. Currently, the village and island where it is situated are experiencing increased flooding and high rates of coastal erosion (United States General Accounting Office (USGAO), 2009). The village has failed to find the funding needed to relocate, even though the community has rights to land off the island in a safer location. Planners, researchers and advocates have worked unsuccessfully with multiple government agencies in order to plan and organize relocation (Marino, 2011), because recovery funds are tied to rebuilding infrastructure in the same location without upgrades.

A recent Foresight project report on migration and environmental change (2011) examined the drivers of migration in 30 countries, and although the reasons for migration were multi-faceted, the primary driver of migration was economic adversity (Foresight Government Office for Science, 2011). Although economic changes can be produced by climate change impacts, the two are not always coupled. Tidal flooding in Semarang, Indonesia has not resulted in migration, even though communities affected by flooding are middle-income, and assumed to have the financial capacity to move. Some families, who own their land, are not abandoning their homes even when flooding becomes an everyday occurrence (Harwitasari and van Ast, 2011).

15.2.3.3. Adaptation, Development, and Ecosystems

International organizations are increasingly emphasizing the important relation between adaptation to climate change and development (UNDP, 2005; OECD, 2009; UNEP, 2010; World Bank, 2010; UN-HABITAT, 2011). IPCC (2012), Boyd and Juhola (2009) and others illustrate that the debate of climate change is dominated at present by impacts-led approaches that focus on climate risks rather than on human vulnerability. Knowledge of impacts and vulnerabilities does not necessarily lead to the most cost-effective and efficient adaptation policy decisions, partly due to the context specificity of adaptation which makes detailed planning at the national level challenging (Hulme et al., 2009). Dovers (2009) highlights the importance of connecting climate adaptation more closely to existing policy and management in communities, professions, and agencies, and to their existing agendas, knowledge, risks, and issues they already face.

Adaptation to climate change can be viewed as a continuous learning process (not a single outcome) likely to require regular revisiting of development policies, plans and projects as climate and socioeconomic conditions change (Hinkel et al., 2009; Hofmann et al., 2011). Most strategies can be regarded as just the start of a policy process rather than its culmination (Hulme et al., 2009). Projects in Asia implemented by the Global Environment-Least Developed Country Fund have linked adaptation efforts with development, and allowed for a holistic approach that builds institutional resilience, flexible technologies, and enhanced community capacity (Sovacool et al., 2012).

Research has long shown that coupling adaptive improvements in infrastructure with governance and community welfare, improved community resilience by enhancing local ownership, and created organizations increases adaptive capacity (IPCC, 2012). Climate change adaptation efforts also improve ecosystem resilience by implementing sustainable forestry quotas, expanding floodplain setbacks, implementing coastal afforestation, coral reef propagation, restoring degraded lands, maintaining healthy vegetation on slopes, incentivizing development away from coastal areas and bluffs, and removing barriers to the migration of plants and animals, (Sovacool et al., 2012). Increasingly, the good practices of planning and implementing integrated coastal and watershed management measures have been shown to apply equally to climate change adaptation (Tobey et al., 2010). These linked approaches highlight the need for greater emphasis on nature-based protection strategies or buffers. Adaptation efforts in Bangladesh, Cambodia, Bhutan, and the Maldives that are embedded in the development context are providing a 'win-win' adaptation strategy that improves resilience to climate change while improving economic stability and environmental quality. Even though the funds invested in adaptation linked to development is relatively small ($40 million in 2007), the Asian Development Bank estimates that every dollar invested could yield as much as $40 in economic benefits in twenty years (Sovacool et al., 2012).

Examples of such measures include: developing early warning information systems, health/heat action plans, vaccination, health system planning, flood risk planning, drought and water scarcity risk management, water demand management, coastal and flood defenses, economic diversification, natural hazard monitoring, reinforcing the built and green infrastructure environments (e.g. roads, bridges, electric wires, wetlands, land-use (IPCC, 2012).

In spite of the many positive attributes of community-based and development-based adaptation efforts, there are concerns that a disproportionate focus on the impacts of climate change could obscure opportunities for connecting development pressures, poverty, social inequality and climate change, particularly for the reduction of social vulnerability (Lemos et al., 2007; Hardee and Mutunga, 2010; Sietza et al., 2011). Other authors consider it critical to wholly integrate knowledge and experience into multidimensional and multi-scale approaches in order to guide the formation of adaptation responses, and effectively combine them with development strategies (Ewing et al., 2008; Hodson and Marvin, 2009). Moser and Satterthwaite (2008) propose considering the roles of not only different levels of government but also individuals, households, and civil society organizations. They suggest a framework of pro-poor asset adaptation for climate change as a conceptual and operational framework. Moser (2008) proposes a second-generation asset-based policy as an effort to sustain current poverty reduction policies focusing on the provision of housing, urban services and infrastructure, health, education and microfinance.

15.2.3.4. Stakeholder Participatory Approaches

Both procedural and distributional equity in adaptation requires considering the spread of adaptation benefits, costs, and residual climate impacts across regions, sectors, and population groups and peoples access and capability to take advantage of those benefits. Thomas and Twyman (2005) highlight the fact that climate change does not occur independently of other social processes. Despite the fact that social change is a central element of development, there is inadequate not attention paid to livelihoods in development studies to connect adaptation, vulnerability, and development (Paavola, 2008b; Sanchez-Rodriguez, 2009).

To address vulnerabilities to climate change, stakeholder participation is essential so that local impacts can be addressed and coping mechanisms including social and cultural capabilities are recognized and employed. Lyytimäki (2011) examined the role of national-level media coverage in Finland in relation to disseminating climate policies. Their work showed that the majority of news that mentioned climate change actually focused on additional

issues of culture, economy, and lifestyle issues. Marshall et al. (2010) examined the reasons behind sub-optimal adoption of seasonal forecasts by livestock owners in Queensland, Australia, and found that environmental awareness as well as social factors significantly influenced their willingness to adopt new grazing practices.

Stakeholder participation takes many forms, including integration of climate change impact scenarios in local decision making processes (Romanenko et al., 2007; Schmidt-Thomé and Kaulbarsz, 2008; Gawith et al., 2009). One example, in the Baltic Sea Region, includes two projects referred to as Sea level change affecting the spatial development of the Baltic Sea Region (SEAREG), and Developing policies and adaptation strategies for climate change in the Baltic Sea Region(ASTRA) that focused on integration of potential climate change impacts in local decision making. The resulting communication process produced a set of tools referred to as Decision Support Frame (DSF). The DSF addresses uncertainty in climate change model results, but also includes a vulnerability assessment and a discussion platform to help identify stakeholders, and to clarify climate change impacts and downscaled model uncertainty (Schmidt-Thomé and Kaulbarsz, 2008). Challenges addressed in the project included the explanation of the creation, application and uncertainty of complex climate models, as well as the inclusion of social scientists into applicable communication and application frameworks for climate change adaptation strategies. The ASTRA project followed the winter storm of January 2005, and was tasked with identifying what stakeholders perceive as the biggest potential impacts from climate change. The task of ASTRA is the sustained result of SEAREG by continuing awareness-raising efforts, and the development of adaptation strategies based on SEAREG scenarios (Schmidt-Thomé and Kaulbarsz, 2008).

15.2.4. Adaptation Tools and Decision Support Processes

15.2.4.1. An Overview

Uncertainties in climate change coupled with the complexities of social-ecological systems require adaptation planning and implementation are dynamic. Information and knowledge on climate change risks from various stakeholders and organizations are essential resources for making adaptation planning. Several multidisciplinary efforts, some of which are discussed below, have been engaged to develop, assess and communicate climate information and risk assessments across timescales. These efforts use a mixed portfolio of products from simple agroclimate calendars to computerized decision-support tools.

15.2.4.2. Science Supporting Adaptation Planning and Implementation

Adaptation planning and implementation takes place in a dynamic form on local, regional or global scales with complex management and governance processes, need to be implemented (Moser, 2009). The degree and type of feedback of a social-ecological system to climate change for planned adaptation measures are the major indicators of concern. (e.g. Berkhout et al., 2006). It has also long been recognized that adaptation is embedded within a process of social learning (IPCC, 2007, Ch 17) requiring the integration of science and policy in a fundamental and structured way.

Some of the earliest evidence of U.S. states beginning to address and plan for the impacts of anthropogenic climate change comes from states which had received federal financial and/or technical assistance to assess impacts and vulnerabilities and from existing concerns with climate variability or in response to experiencing severe climate-related disasters such as from ENSO (Miles et al., 2000; Moser, 2005; Pulwarty et al., 2009). In the U.S. the Regional Integrated Sciences and Assessment for academically led, Federal funded mechanisms to The Regional Integrated Sciences and Assessments (RISAs) have developed as decentralized scientific applications and policy experiments (Brunner, 1996) centered at Universities basis for a collaborative framework between monitoring, research, and management networked at regional and local levels (Pulwarty et al., 2009; Bierbaum et al., 2013). RISAs are somewhat different from other such knowledge management and applications efforts having been initiated out of a need to provide information on climate extremes and variability before moving out to climate change. Evolutionary or learning-based approaches to “assessment” such as designed and developed by RISA-type programs have proven effective at entering into national, regional and local plans of action for responding to

complex environmental problems than traditional, discrete integrated knowledge assessments (Pulwarty et al., 2009).

In UK, a national program was developed to access climate impacts across the country and to incentivize adaptive behavior since 2005 (Pringle, 2011). In Australia an interdisciplinary program was developed by the federal government to carry out adaptation activities through the NCCARF – National Climate Change Adaptation Research Facility. Government of Canada Regional Adaptation Collaboratives program, which supported science research for creation of adaptation plans (http://www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/regional-collaborative/48). This program was instrumental in catalyzing further advancement and generated some comprehensive adaptation plans for regions across Canada. In Canada the OURANOS Consortium produces projections of regional climate trends and offer expertise in climatology and climate simulation.

The Caribbean Community and Common Market (CARICOM) with collaboration from the Organization of American States established the Caribbean Community Climate Change Centre (5Cs) in 2005 to guide the development of regional adaptation planning and implementation in the Caribbean. The 5Cs coordinates funding and provides guidance to regional impacts assessment and adaptation efforts. These include supporting critical capacity in regional climate modeling and sea-level monitoring, embedding climate risk information into environmental impacts statements, conducting and mainstreaming vulnerability and capacity assessments into national and local planning, facilitating within-country networks and to a Masters Degree program with a specialization in climate policy and impacts assessment. Climate adaptation has also been top issues in Mountainous areas and a series of relevant activities have been carried out (http://www.icimod.org/ and http://mri.scnatweb.ch/).

Local communities and NGOs are demanding an increasingly active role of public institutions in the delivery of technological options to cope with emerging climate challenges (Prowse and Scott, 2008; Rodima-Taylor et al., 2012). Aside from their traditional roles, some NGOs serve important information clearinghouse roles regarding adaptation (e.g., the Pew Center for Global Climate Change or the virtual Adaptation Network [http://adaptationnetwork.org]). Others have emerged as active partners in adaptation, such as the Center for Clean Air Policy (CCAP), CAKE and ICLEI Local Governments for Sustainability. CCAP is working with nine U.S. cities (and one Canadian city, Toronto) in its Urban Leaders Adaptation Initiative to help operationalize key steps in the local adaptation process (Lowe et al., 2009). ICLEI, a non-profit network of local government members, provides web-based information in support of local sustainability efforts using customized tools and case studies on assessing climate resilience and climate change adaptation. With a collaboration with King County, WA, ICLEI developed a procedural guidebook for local, regional, and state governments on how to begin preparing for the impacts of climate change (Center for Science in the Earth System and King County, 2007).

Most of these adaptation plans initially focus on few high risk areas and are then conducted in collaboration with locally based university researchers and consulting teams. Researchers have helped identify some of the physical and social characteristics that allow for the adoption of effective partnerships and implementation practices during events (Birkland, 1997; Pulwarty et al., 2009; IPCC, 2012; Mimura, 2012; Rodima-Taylor et al., 2012). These include the occurrence of previous strong focusing events (such as catastrophic extreme events) that generate significant public interest and the personal attention of key leaders, a social basis for cooperation including close intersectoral partnerships, and the existence of a supported collaborative framework between research and management such as RISAs, OURANOS, UKCIP, 5Cs. The successful boundary organizations:

- Perform basic and applied research on local climate dynamics impacts, and information prototypes relevant to stakeholder interests
- Support the integrated research base for operational informational and transition of new climate applications products
- Develop and maintain multi-way risk communication among research teams, member agencies, and stakeholders for developing information relevant for planning and decision making

While often initiated by interest in climate variability, these are advancing into climate change and adaptation planning support integrating the multiple timescales of climate risks (across extremes variability and trends). As has been noted, these efforts – while valuable and expanding – are as yet at too small level to meet the rapidly growing demand (USGCRP, 2009; Bierbaum et al., 2013). One recurring theme and lesson is the value of investments in

knowledge and information, including monitoring systems and early warning information systems that include clearer understanding of resources, health and livelihood impacts (Pulwarty et al., 2012).

Support for vulnerability and adaptation research, establishing adequate decision support institutions, as well as the building of the necessary capacity in science, the consulting world, and in government agencies, is still lags behind a rapidly growing need. With this in mind the development of climate extension services is leading to the development of the UN Global Framework on Climate Services.

15.2.4.3. Monitoring, Modeling, and Spatially Integrated Tools

The use of a decision support system (DSS) is a very effective means for a policy analyst or planner to compare different possible interventions. Through creating information products (reports, maps, diagrams, figures, visualizations, etc.), decision support systems provide knowledge of better choices about how socio-ecological coupled systems can achieve efficient, effective and equitable adaptation to global climate change. The complex, multi-scale, interdisciplinary nature of climate change impact on socio-ecological coupled systems has made the computer-based modeling approach a robust tool for understanding the evolving processes and the future conditions of the systems (Alter, 2004; Pyke et al., 2007). Typically with the widespread application of cellular automata and the multi-agent techniques since the 1980s, modeling of the behavior of physical, socio-economic or coupled systems has gained a new dynamic pace, and the role of the modeling approach in decision support tools has been enhanced (e.g., Epstein and Axtell, 1996; Wolfram, 2002).

Recent years have seen integration of monitoring systems and/or modeling systems with the techniques of geographical information systems, remote sensing and global positioning systems and “discussion support” or a dynamic dialogue between researchers and practitioners. As a result, much more powerful, process-visual and spatially implicit decision support systems have been developed. One example of this kind is the development of the Invasive Species Forecasting System (ISFS) (Stohlgren et al., 2005), which, through combining USGS science and NASA Earth observations with software engineering and high-performance computing expertise, is capable of providing regional-scale assessments of invasive species patterns and vulnerable habitats. In the Yellow River, the second largest drainage basin of China, the drying up of the channel near the mouth of the river in low-flow seasons forced governments to develop a basin-scale decision support system (Li and Li, 2009). Numerous such applications have also been made in the management of water quality, air quality, land use, crop production, and more (e.g., Jamiesona and Fedra, 1996a,b; Huang et al., 1998; Gimblett, 2002; Qin et al., 2008).

15.2.4.4. Decision Making Tools

Adaptation decision making can be kept informed by various tools, which are developed generally in ‘top-down’ and ‘bottom-up’ forms. The *top-down* tools normally downscale simulated climate scenarios to a regional level and then adopt expert opinions, apply multi-criteria optimization methods, or perform cost-effectiveness or cost-benefit analyses to assess impacts so as to identify most feasible adaptation measures (Carter et al., 1994; IPCC-TGICA, 2007; Adger et al., 2009a,b).

In the *bottom-up* approach, affected actors make their own impacts transparent and decisions at different levels on adaptive options, and the society consisting of all the stakeholders itself organizes social and institutional activities in the light of actions and interactions among all the stakeholders. Advances in stakeholder participatory methods, cellular automata and multi-agent modeling techniques have significantly enhanced the development of this type of decision making tool in recent years (Epstein and Axtell, 1996; Wolfram, 2002; Kaner et al., 2007).

The central difference between the top-down and bottom-up based tools lies in the fact that the former focuses largely on the behavior of a system as an entity, while the latter concerns mainly the roles of actors in the system. As a result, top-down based tools may yield adaptation options that may or cannot be accepted by most individuals, while bottom-up based tools may select adaptation options acceptable to most individuals but not-effective for significantly minimizing the impacts to the whole system. There is no single tool that suits all circumstances of

adaptation decision making, although information development tools such as CRiSTAL help to coordinate diver information on vulnerability and risk, and the specification of the problem and the available 'inputs' to the decision process may provide a choice of a suitable tool (Gimblett, 2002). IPCC (2012) notes the distinct differences in problem orientation and solution space depending on whether an adaptation plan commences with a climate modeling outputs-based versus that of a risk and vulnerability-based framework.

15.2.4.5. Communication Tools

Communication is a major component of social learning process and effectively exchanging and sharing information about climate change related risks and effects of adaptation measures is crucial to the identification of a right adaptation pathway out of multiple possibilities. A wide range of communication tools are being employed to carry out multi-way participatory dialogues among information developers (e.g. scientists, trainers, project implementers, government agencies, etc.) and the receivers who in turn also influence the nature of information being produced. (e.g. community members, household heads, school children, groups at risks, government regulators, etc.). They include brochures, bulletins, posters, magazines, policy briefs, desktop presentations, articles, drama, role-playing, music, group discussions, training of trainers, videos, TV and radio broadcasts, internet, and many more. While all these tools are effective in communicating risks, some of them are more cost-effective and complex than others, and some reach a wider audience than others. At the local level, interactive communication strategies such as theater, role-playing, music, and group discussions where community members are involved in debating climate risks and possible solutions to cope with climate change exert a positive effect on communities' behavior and practices, while reports, concept notes, brochures, magazines, presentations and workshops are more effective with policy makers at local and national levels. At country/regional level, nevertheless, broad dissemination channels such as TV, radio and internet broadcast, high-level summits, etc. have been effective in catering a wider range of stakeholders and creating widespread awareness as demonstrated in Advancing Capacity for Climate Change Adaptation (ACCCA) project (http://www.acccaproject.org/), UK Climate Impacts Program (UKCIP) (Pringle, 2011) and the special report of IPCC, 2012.

In addition to these commonly applied tools, innovative ways of communicating which can effectively inform the process of climate change adaptation planning and implementation are being employed. These include learning-by-doing, hands-on exercises, and training of trainers that use practical and creative cases. This is reflected particularly by the IPCC Fourth Assessment Report (IPCC, 2007), ACCCA project (http://www.acccaproject.org/), UKCIP (Pringle, 2011), the first U.S. National Assessment of the Potential Consequences of Climate Variability and Change, and the U.S. Climate Change Science Program Synthesis and 2013 National Climate Assessment products.

To assist the syntheses, a variety of rule- or matrix-based methods has been applied for screening adaptation options. For example, the Adaptation Decision Matrix uses subjective scoring to compare the relative cost-effectiveness of alternative adaptation measures (Benioff and Warren, 1996), while the RamCo (Rapid Assessment Module for Coastal Zones) system uses a series of structured questions for a decision matrix to illustrate adaptive opportunities for coastal zone management (Research Institute for Knowledge Systems, 2012). For generating visualizations and customized reports, greater emphasis on user interaction, sensitivity analysis and capabilities has been placed in recent years (Sarewitz et al., 2000; Sarewitz, 2004). Furthermore, multi-criterion and multi-actor participatory approaches that allow users to consider alternative adaptation strategies and evaluate tradeoffs have also been deployed, typically in the development of tools for environmental assessment and management (TEAM) (Julius and Scheraga, 2000).

15.2.4.6. Insurance and Social Safety

Insurance allows people and households to recover quickly and encourages adoption of new techniques so as to increase assets in a short period. These market-based arrangements have immense potential by allowing households and individuals to take advantage of the financial products offered by insurance companies and banks. Throughout the world, crop insurance and risk-pooling have allowed national economies, communities and individuals to develop the full potential of their agricultural sector by transferring weather-related risks away from the farmer.

Informal arrangements have existed for a long time, and still constitute the main source of risk management for the majority of the world's population. In the absence of (or with incomplete) market institutions and public support, individual households respond to risk by protecting themselves through informal and personal arrangements. Access to savings instruments and credit can also be facilitated. When these types of microfinance are properly provided, such as part of a well-managed and targeted intervention, it allows these households to increase their assets, improve their ability to alleviate risk and reduce their reliance on money lenders (Chu and Gupta, 1998; Holzmann and Jorgensen, 2000; Townsend, 2006).

Crop insurance will likely play a greater role in the developing world in absorbing shocks as climate-change related disasters become increasingly problematic for agricultural production. A project in Ethiopia provides a promising model. Oxfam America (http://www.oxfamamerica.org/)has developed a risk management framework to enable poor farmers in Ethiopia to strengthen their food and income security through a combination of improved resource management (risk reduction), microcredit ("smart" risk taking), risk transfer (insurance), and risk reserves (savings). This project—The Horn of Africa Risk Transfer for Adaptation (HARITA)—was initiated in 2007 and brings together Ethiopian farmers, local insurers and international re-insurers, relief societies, credit and savings institutions, local government agencies, and a local agricultural research organization. The project enables Ethiopia's poorest farmers to pay for insurance with their own labor. Meanwhile, the governments of Malawi and India have initiated pilot projects with national smallholder farmers associations that have pioneered rainfall insurance schemes to ensure payouts when rain falls below a crop-specific rainfall index. Such risk-pooling efforts, where premiums are low since they are collected only to insure immediate livelihood recovery rather than full asset losses, are also being tested at the regional-scale in the Caribbean. Index insurance has been recently introduced to overcome obstacles to traditional agricultural and disaster insurance markets. If the rainfall amount is below the threshold, then the insurance pays out. Of particular note is the Caribbean Catastrophe Risk Insurance Facility (CCRIF), the world's first index-based parametric insurance mechanism. It is a new partnership among 16 Caribbean countries and the World Bank with support from several countries, and will be tested over the coming years (CCRIF, 2012). Despite these advances, the expansion of weather-indexed crop insurance faces key challenges especially in targeting those engaged in non-commercial marginal agriculture.

15.2.5. Bridging Planning to Implementation

For adaptation planning and implementation, a variety of tools are employed depending on the social and management context. Development and diffusion of new technologies and management practices ia another important area for adaptation efforts. Although a wide range of adaptations are possible with current technologies and management practices, development and diffusion of technologies can expand the range of adaptation possibilities by expanding opportunities or reducing costs. While effective communication is important, the research experience shows that broad societal processes that create dynamic pressures and unsafe conditions are not easy to change, yet are fundamental to human vulnerability. More challenging is an understanding the socialization of lessons learned by particular individuals and organizations through their own, direct trial and error experiences. The mismatch between the current structure and operational culture of municipal planning institutions and the need for multidimensional collaboration in adaptation is reported as a planning and implementation barriers in both developing and developed countries.

Several studies have identified the characteristics of pre-decisional practices in implementation that lead to effective practice over the long-term (Fischhoff, 2009, IPCC, 2012). These include: 1) understanding of the goals, objectives, and constraints of communities in the target system; 2) mapping practical pathways to different outcomes carried out as joint problem definition and fact-finding strategies among research, extension and farmer communities; 3) bringing the delivery persons (e.g. extension personnel, research community etc.) to an understanding of what has to be done to translate current information into usable information; 4) interacting with actual and potential users to better understand informational needs, desired formats of information, and timeliness of delivery; 5) assessing impediments and opportunities to the flow of information including issues of credibility, legitimacy, compatibility (appropriate scale, content, match with existing practice) and acceptability; and 6) relying on existing stakeholders' networks and organizations to disseminate and assess climate information and forecasts.

15.3. Capabilities for Adaptation Planning and Implementation

15.3.1. Institutional Arrangements: Public- and Private-Sector Stakeholders and Priorities

While there is growing recognition that adaptation planning is essential (Ayers and Huq, 2009; Wilbanks and Kates, 2010; Ford et al., 2011), attempts at implementation have increased appreciation of the magnitude of the institutional challenges of linking adaptation planning and implementation including the problems of multi-scale coordination and support among national, state (provincial), and municipal governments to foster adaptation planning at the local level. Several studies, including municipalities in Denmark (Vammen Larsen et al., 2012), local adaptation in Florida (Mozumder et al., 2011), local governments in Australia (Doran, 2011; Gero et al., 2012; Municipal Association of Victoria (MAV), 2011), and in Sweden (Glaas et al., 2010; Storbjörk, 2007) illustrate the difficulties in creating efficient interdisciplinary integrated approaches in adaptation planning and implementation. One of the most significant challenges lies in introduce changes to the national and subnational institutional landscape in order to foster adaptation planning. Institutions are comprised of formal rules and informal codes of behavior that shape expectations and guide interactions (Ostrom, 1990). Adaptation planning follows formal institutions associated with regulations, policies, and standards created and enforced by government actors but also requires the participation of informal institutions through interactions among stakeholders according to cultural, social, and political conditions in societies (Moser and Satterthwaite, 2008; Carmin et al., 2012). Chapter 14 describes the importance of these institutional frameworks for adaptation. This section assesses the extent to which the international literature has addressed the issue of institutional arrangements fostering adaptation planning, what role different organizations (public, private, and social) and stakeholders in those arrangements have played, and what lessons can be learned from these experiences.

15.3.1.1. Institutional Capacity of National and Local Governments

The review of the broad international literature suggests the development of institutional arrangements for adaptation planning is at an early stage both at the national and at the subnational level (Carmin et al., 2012; Gero, 2012; Glaas et al., 2010; Gupta et al., 2010; Rodima-Taylor et al., 2012; Tompkins et al., 2010). Huntjens et al. (2012) compare adaptation to climate change in the Netherlands, Australia, and South Africa in an effort to identify strategies that move from individual impacts to more holistic approaches increasing the adaptive capacity of the system. Tompkins et al. (2010) and other studies of climate change adaptation in the United Kingdom consider a broad range of adaptation actions, from small adjustments to creating deeper systematic change in public and private organizations. These authors argue that the transition to deeper systematic changes could eventually result from a set of simultaneous changes (changes in technology, user practices, regulation, industrial networks, infrastructure, symbolic meanings, and culture). Some of these elements are part of the institutional adjustments discussed above. As with other studies, in the context of adaptation planning, find there is no evidence to show that adaptation planners are deliberately working towards transitions and with little real evidence of climate change adaptation initiatives trickling down to local government level.

Climate adaptation is uniquely linked to location, and it is often a responsibility of local governments, stakeholders, and communities (Mattews et al., 2012). The importance of multilevel institutional arrangements is increasingly cited (Corfee-Morlot et al., 2009; Gero et al., 2012; Storbjork, 2007; Vammen Larsen et al., 2012; Wilson 2006). Carmin et al. (2012) describe the importance of developing regulations, policies, and codes to support the institutionalization of local climate actions. Roberts (2010) describes the difficulties of operationalizing development in Durban, where some departments were able to mainstream adaptation activities into their ongoing work while others did not have that capacity. Vammen Larsen et al.'s (2012) study in Denmark reports the rapid incorporation of climate change in the Strategic Environmental Assessments (SEA) of the new municipal plans prepared by local governments in that country in 2009. The study showed that the current structure of the municipal organization is made of different professional silos with their own internal norms, cultures and procedures that may hinder horizontal coordination across professional sectors and departments. The study showed also there are few national requirements or guidelines to help local governments integrate climate change into spatial planning. The lack of national guidelines is also reported in Norway (Amundsen et al., 2010) in Sweden (Glaas et al., 2011;

Storbjork, 2007) and in Australia (Gero et al., 2012; Municipal Association of Victoria (MAV), 2011). Vammen Larsen et al. (2012) stress that climate change does not posses clear institutional characteristics as a municipal professional area. Rather, it is viewed as a void with no clear rules and norms according to which politics is to be conducted and policy measures agreed upon. While the institutionalization of climate change integration has begun, it is unknown whether the municipalities will be successful in developing the governing capacity needed.

15.3.1.2. Role of Spatial Planning

The review of the literature above suggests that planning has been widely considered in adaptation, but perhaps not enough attention has been given to study the capacity of current planning institutions. This is required in order to move toward a balance of top-down and bottom-up strategies in adaptation. Planning is considered a societal tool to create order among activities and interests driving growth in societies, to reduce conflicts among them, and to seek the well-being of their inhabitants (Blair, 1973). Some of the literature is beginning to focus on the capacity of planning to address adaptation to climate change. Juhola and Westerhoff (2011) stress the transition of adaptation from being first considered a matter of relevance only to the environmental sector, to a development challenge that will require the participation and cooperation of a multitude of sectors to avoid potential conflicts. Sanchez-Sanchez-Rodriguez (2012) highlights the role and limitations of planning in the construction of operational approaches to adaptation, particularly in urban areas of low-income and middle-income countries. He questions if planning institutions have the vision, capacity, and flexibility to update themselves, and to guide future urban growth in order to meet the challenges facing to their future. This is an important question given the expectations that planning will be able to create order and balance in adaptation to climate change, and in light of the reticence of planning institutions to change their operations and structures.

Mozumder et al. (2011) study on the role of experts and decision-makers building adaptation to climate change in the Florida Keys reveals they are currently operating with limited information, and lack a formal institutional framework necessary to shape and execute adaptation measures. Other studies suggest there have been few changes in forecasts, plans, design criteria, investment decisions, budgets or staffing patterns in response to climate risks (Repetto, 2008; Berrang-Ford et al., 2011).

Biesbroek et al. (2009) considers that climate change could also lead to changes in the traditional administrative structures to which spatial planners are accustomed. Other literature emphasizes the role of spatial planning as a switchboard for adaptation and sustainable development change (Füssel, 2007; Hallegatte, 2009; Preston et al., 2011). Biesbroek et al. (2009) stress spatial planning coordinates the different relevant socio-economic objectives and desires, and shaping spatial developments in a long-term perspective. However, they recognize it is becoming more and more a pragmatic challenge for spatial planners to include climate change as an important consideration in the planning process, especially in the context of sustainable development. Bulkeley (2006) concludes that given the complexity, uncertainties and scale of the climate change issue, spatial planning might play a key role in facilitating the development of both adaptation and mitigation strategies with a spatial component. However, not enough attention has been provided yet to the institutional arrangements needed to enable adaptation through spatial planning.

The review of the international literature discussed above identifies two major trends: First there is the assumption that current of planning structures and operational cultures will be able to meet the needs of adaptation on different scales (regional, national, and subnational); and second, there are studies that document the shortcomings, challenges and opportunities of planning as a societal process that is needed to create and implement adaptation, bringing more attention to the institutional changes required to build efficient responses to climate change.

Some literature on adaptation has suggested the importance of considering adaptation planning as a learning process (Glaas et al., 2010; Hinkel et al., 2009; Hofmann et al., 2011) likely to require regular revisiting of development policies, plans and projects as climate and socioeconomic conditions change and adaptation plans need revision. Holden (2008) suggests that social learning is a relevant but under-investigated feature of planning and a critical part in the adaptation of innovations but there are few analytical tools to assess how and when learning is taking place, and amongst different professional and public communities. Considering adaptation planning a social learning

process would allow for periodical adjustments in order to reduce the uncertainty of the impacts of climate change and societal needs to cope with them. This is relevant in light of the need to develop new tools to cope and adapt with the impacts of climate change (Frommer, 2009). But it will require major efforts in multilevel and cross-sectoral collaboration, as well as a broader attention by scholars and practitioners to develop a better understanding of this process.

Important learning tools in adaptation planning are monitoring, evaluation and feedback. Although some recognize the importance of evaluation in adaptation, this topic is under-researched and requires significant work to go beyond the simple evaluation criteria that have been developed to date (Doria et al., 2009). Preston et al. (2009) suggest the institutional arrangements for the evaluation of adaptation processes are still in their developmental infancy. Monitoring and evaluation are often advocated within adaptation decision making frameworks, but methods for undertaking such work are rarely articulated, and adaptation plans frequently fail to acknowledge the importance of core design principles for adaptation policies and measures such as efficacy, efficiency and equity. Reidsma et al. (2010) and IPCC SREX (2012) argue that in order to assess the effectiveness of adaptation strategies, frameworks should not start from the modeling perspective, but from the stakeholders' perspective.

Adger and Barnett (2009) argue that metrics used to determine the goals of adaptation, the measures of its success and the trade-offs involved, can be understood only in terms of the social context in which adaptation takes place. Communities value things differently, and this must be taken into account if adaptation is to be effective, efficient, legitimate, and equitable (Barnett and Campbell, 2009). Arnell (2010) highlights the importance of context in the analysis and evaluation of adaptation. His review shows that local circumstances significantly affect what adaptation options are considered feasible, what information is likely to be used, what assessment techniques are adopted, and, crucially, how adaptation decisions are actually made. This work indicates that it could be difficult to make generalized assessments about the contribution of adaptation to managing the risks posed by climate change, and to construct generalized models of the adaptation process.

By the same token, Engle (2011) calls attention to the limited effort to evaluate adaptive capacity across vulnerability and resilience frameworks, and to improve the understanding of adaptive capacity dynamics. For him, it is important to identify what builds adaptive capacity and what functions as limits and barriers to adaptation. Hinkel (2010) questions the use of vulnerability as a concept to increasing awareness of the importance of adaptation, to guide the allocation of adaptation funds, monitoring of adaptation policy, and conducting scientific research. He finds it misleading to speak of measuring vulnerability as it raises false expectations.

Providing spatial planning a bigger role in institutionalizing adaptation planning at the local level requires the participation and cooperation of a multitude of sectors to avoid potential conflicts (Juhola and Westerhoff, 2011). Anguelovski and Carmin (2011) highlights the ways in which public, private, and civil society actors and institutions articulate climate goals, exercise influence and authority, and manage urban climate planning and implementation processes. They document that urban areas tend to formalize and institutionalize their work through the establishment of dedicated climate units, either within a relevant department or as a separate and cross-cutting office. However, they recognize few local governments have had the resources and know-how to institutionalize adaptation to climate change.

Koch et al. (2007) stress the gap in understanding and evaluating how institutional networks operate. Their research results in South Africa show that few institutions fully understand the implications of adaptation, and their roles and responsibilities have not yet been properly defined. They suggest constraints relating to capacity, lack of awareness and poor information flow need to be addressed. Adaptation challenges the hierarchical manner in which government works, and a more collaborative approach to climate change adaptation is needed. These and other recent contributions in the literature (Adger et al., 2009b; Preston et al., 2009; Tompkins et al., 2010; Wolf et al., 2010) move the discussion of adaptation planning to climate change to a better understanding of the elements needed to operationalize this concept, building responses to present and future climate impacts.

15.3.1.3. Institutional Arrangements and Disaster Risk Management

The divide between the Disaster Risk Management (DRM) and the Climate Change Adaptation (CCA) communities at the national, subnational, and local level is evident in a large number of countries (Birkmann and Teichman, 2010; Falaleeva et al., 2011; Schipper and Pelling, 2006; World Bank, 2010). International pressure to draft separate disaster and adaptation strategies and policies has now become enshrined in divergent laws, creating further obstacles to institutional integration of DRM and CCA. The convergence of adaptation planning and disaster risk management offers opportunities to more efficent use of resources and effective and coherent short and long-term responses to hidrometeorological events and climate change (IPCC, 2012). It can enhance attention to climate change adaptation and awarness of the need of short, medium, and long-term strategies to build resilient and sustainable communities. This convergence helps decision-makers build a better understanding of present and future risks and their consequences for development. One of the problems they face is the short-term horizons of local plans compared with the long-term implications of vulnerability and climate change.

The convergence of DRM and CCA need building capabilities in institutions to recognize and better understand vulnerabilities to hydrometeorological and climate change simultaneously (Agrawal and Perrin, 2008; Agrawal 2010). Some early examples in this direction are ecouraging. In a study of current and future city-wide flood risks to Ho Chi Minh City in Vietnam, Storch and Downes (2011) connects spatial planning scenarios linking urban growth and climate change (sea-level rise scenarios) in order to explore the main driving forces for future risks. There is a growing interest connecting initiatives for disaster risk management and climate change adaptation planning (Bierkman, 2010; Rosenzweig and Solecki, 2010; Carmin et al., 2012). The World Bank prepared guidelines to connect disaster risk management, poverty reduction and climate change adaptation and emphasize the role of planning and participatory approaches (World Bank, 2010). Mathew et al. (2012) describes the benefits of defining adaptation options in consultation with local authorities in a study on climatic hazards in Kochi, India. Frazier et al. (2010) explore stakeholder participation in the context of coastal hazards concluding that adaptation planning tends to be more difficult in areas that lack recent disaster experience.

Some countries expand the divide between DRM and CCA. For instance, Mexico published a new National Climate Change Law in 2012, but instead of integrating DRM as one of its key components, it published simustaneously a new Disaster Risk Management Law. In general little progress has been made integrating DRM and CCA at the national, subnational, and local level. The Birkmann and Teichman (2010) study on the U.K. Germany, and Fiji found that little action has been taken at the national level to establish working relationships between adaptation planning and DRM. The convergence of DRM and CCA require new institutional arrangements, particularly in terms of legislation, operational and management structures, working agendas, and time horizons (Birkmann and Teichman, 2010; Falaleeva et al., 2011; Schipper and Pelling, 2006).

15.3.1.4. Enhancing Institutional Capacity

Two key issues emerge in the literature as essential for enhacing the institutional capacity of adaptation: multilevel governance and cross-sectoral frameworks. Although these two issues interact dynamically in adaptation planning and implementation, they have different connotations and require specific actions to enhance and strengthen their practices.

15.3.2. Knowledge Development and Sharing

Scientists and managers across agencies and management systems would benefit from greater sharing of data, models, and experiences in climate change adaptation (West et al., 2009). Indigenous observations and interpretations of meteorological phenomena have guided seasonal and inter-annual activities of local communities for millennia. However the number of documents published about knowledge development and sharing is still limited. The available documents deal mainly with general principles rather than practical applications. The current section outlines the main relevant issues surrounding knowledge development and sharing in adaptation to climate change.

15.3.2.1. Science and Technologies for Observation, Monitoring, and Prediction

Development and diffusion of new technologies and management practices will be critical to many adaptation efforts. The role of technology is not so much to make adaptation possible-a wide range of adaptations are possible with current technologies and management practices-but to expand the range of adaptation possibilities by expanding opportunities or reducing costs (Smith et al., 2009). The status quo generally requires no new capital costs and may be more profitable in the short term than developing more climate-resilient technologies (Yang et al., 2007). Several researches indicated the autonomous adaptation to climate change of many animals and plants (Mastrandrea et al., 2010; Tingley et al., 2009).

15.3.2.2. Early Warning Information Systems

Monitoring and early warning systems (EWS) have long-played important roles in helping in adjustment, and adaptation especially on the local scale. The disaster research community has shown that successful warnings of impending events are those that are complemented by information on the risks actually posed by the hazards as well as the potential strategies and pathways to mitigate the damage in the particular context in which they arise (Drabek, 1999; UNISDR, 2006). While current science and technology do not resolve the uncertainties in modeling, and in the response of ecosystems to climate change and management interventions at levels needed for probabilistic early warning, the need for precise climate information is often overstated (Smith et al, 2009). Local level early warnings based on traditional knowledge (e.g. water turning a different color, winds shifting) are frequently used. The use of radios, megaphones, and cell phones are also used at the local level to warn. Countries that have not developed such systems, even in part, to develop and inform strategic response options often illustrate a broader lack of institutional flexibility and preparedness and thus higher vulnerability. Given the links between near term and long-term climate variability and change, the early warning construct is, of necessity, being applied to more extended timescales.

The impacts of climate change will be most strongly felt by resource insecure populations, who are more vulnerable to changes in the distribution and magnitude of extreme weather events, as these affect crops, disease outbreaks and soil and water quality. The use of climate data analyses and projections in early warning and information systems is an important and established mechanism to mitigate the effects of natural disasters (Pulwarty and Verdin, 2013). An early warning information system involves much more than developing and disseminating a forecast.

The long-standing experience with climate extremes and variability offers many usable lessons. The U.S. National Integrated Drought Information System offers an end to end system in which monitoring and forecasting, risk assessment and communication are integrated, but as importantly interagency cross-coordination is a goal and is are increasingly embedded with states and local communities (Pulwarty and Verdin, 2013; Bierbaum et al., 2013) The USAID's Famine Early Warning System Network (FEWSNet), for instance, integrates seasonal climate forecasts into 3- and 6-month food security outlooks, and it has developed 10-20 year climate projections for food insecure regions of Africa. FEWSNet has also created livelihood zone maps, profiles, and baselines for some of the most food insecure countries of Sub-Saharan Africa, Central Asia, Central America, and the Caribbean. These maps and profiles describe areas in terms of food production, income generation, and market opportunities, and they make distinctions between different wealth groups and their respective coping capacities for dealing with shocks, including drought. These are valuable tools that could help countries develop adaptation strategies to cope with the predicted increases in drought frequency and severity.

The EWSs are often utilized for disaster management by traditional media (radio, TV). However, to ensure the collection and dissemination of information and delivery of early warnings, the EWSs need new Information and Communication Technologies (ICT) for analysing and processing information, and providing automated alerts to vulnerable populations (Karanasios, 2011). Local coping strategies are an important element of planning for adaptation, and ICTs can be used in a number of productive ways, particularly by leveraging existing ICT successes in developing countries such as telecentres and mobile phones, as well as by introducing emergent ICTs in

conjunction with existing sectoral policies, planning and budgeting (UNFCCC, 2007).Insurance and and the basis for finacial services mechanisms are discussed in detail in Chaptet 10.

15.3.2.3. Science and Technologies for Vulnerability Assessment, and Adaptation Planning and Implementation

Effective collaboration and linkages between managers and scientists offer a variety of opportunities for adaptation implementation. First, resource scientists have monitoring data and research results that are often under-used. Second, monitoring efforts could be conducted with specific objectives in mind to increase usefulness for managers. Finally, scientists can support management by targeting their research. All of these are opportunities for interactions between scientists and managers that provide information relevant to major management challenges (Füssel, 2007).

Adaptation action, such as changes in crops and crop varieties, improved water management and irrigation systems, and changes in planting schedules and tillage practices, can limit negative effects and take advantage of beneficial changes in climate (Yang et al., 2007). The adaptation part of this is based on a science-policy collaborative exchange that has operated in various forms for about a decade, and has successfully co-produced scientific assessments (Corfee-Morlot et al., 2011).

ICTs can help strengthen the physical preparedness of livelihood systems for climate change-related events. These can contribute to design of defences and determination of their optimal location, and make the livelihood system more robust. As an example geographic information system (GIS) technology was applied to foster the ability of the community to deal with climate change hazards and trends in the Philippines (IAPAD, 2010) and form modelling processes of climate change adaptation which which supports regional stakeholders to develop better protection of key spaces in the landscape (Bardsley and Sweeney, 2010). Visualization of sea level rise and climate change damage in Delta, British Columbia, and subsequent illustrations of options for adaptation, has led to increased awareness of long-term risks and response challenges between practitioners in this community, as well as by local government and the public (Shaw et al. 2009).

By sharing observations and reflections through ICT tools, users foster new ways of assimilating or translating information, which can be shared through wider networks, and then influence action, enabling new experiments/practices to take place. This generation of new and broader learning cycles will in turn strengthen systematic resilience (Ospina and Heeks, 2010). Karanasios (2011) outlines the range of new and emergent ICTs (e.g. wireless broadband, sensor networks, GIS and Web-based tools) being applied to climate change issues, and investigates their use in developing countries.

15.3.2.4. Science and Technologies for Individual Sectors

The adoption of advanced technologies greatly facilitated agricultural development. New varieties and new fertilizers, pesticides, and agricultural techniques have been actively adopted (Yang et al., 2007). In the sector of logistics, on a global scale, most sea ports are in the beginning stages of considering adaptation to climate change. There is an opportunity for the scientific community to engage with this sector to create the knowledge base needed to understand and improve resilience and efficiency in the coming century (Becker et al., 2011). The European Spatial Planning Adapting to Climate Events Project (ESPACE) asserts that while adaptation presents a variety of new issues for urban planning, it can be an opportunity for good planning to thrive. It is further argued that good planning can positively contribute to adaptive efforts if it works within its means, and correctly uses the tools available to it such as adaptation through infrastructure and design (porous surfacing, green roofs, etc.) (ESPACE, 2008). The linkage between disaster risk reduction (DRR) and adaptation can help communities to build resilience and live with change.

15.3.2.5. Technology Development, Transfer, and Diffusion

Technology is essential for adaptation to climate change, and access to technologies is an important component of a society's adaptive capacity. In some settings, adaptation could be made more effective and efficient by technologies such as new crop varieties tolerant of changed conditions and more efficient water treatment. However, successful deployment of technology is dependent on local social and institutional contexts. Technologies will therefore be more effective when used within multiple adaptation measures that integrate different sectors and social, institutional, and infrastructural dimensions (Rawlani and Sovacool, 2011).

Technologies related to information collection and diffusion are particularly important for adaptation, including technologies for data collection and information dissemination during extreme events and emergencies. Despite remaining uncertainties, technologies to project climate changes, and identify potential impacts and vulnerabilities are frequently seen as precursors to successful adaptation planning. Developing countries require enhanced access to improved climate models, but also adaptation planning tools that focus on robustness in the face of uncertainty (Dessai et al., 2009).

Technology choices can both reduce and exacerbate risk (Jonkman et al., 2010). For example, technologies can strengthen physical infrastructure, such as bridges and buildings, so that they can withstand more extreme hazards. However, relatively centralized high-technology systems can increase efficiency under normal conditions but risk cascading malfunctions in the event of emergencies. In some circumstances, technologies to reduce short-term risk and vulnerability can contribute to increased future vulnerability to larger extreme events (Etkin, 1999; Moser, 2010). This was seen in the impacts of Hurricane Katrina on New Orleans, where a flood defense system enabling construction in a floodplain was subject to catastrophic failure in the face of a particularly large extreme event (Freudenburg et al., 2008; Link, 2010).

Planning for physical infrastructure intended to last decades should account for potential changes in associated social conditions, such as land use, transport, and water and sanitation requirements, in order to avoid maladaptation. Technology development and transfer should promote flexible solutions, for example multiple, smaller dams that can resolve local as well as more distant needs. This has been expressed in Thailand's Sufficiency Economy approach, where local development is judged against contributions to local, national and international wealth generation (UNDP, 2007).

International efforts for technology transfer have been concentrated in the UNFCCC framework's five themes: technology needs and needs assessments, technology information, enabling environments, capacity building, and mechanisms for technology transfer. A key project is developing a technology transfer clearinghouse called TT:CLEAR, and establishing a Technology Centre and Network (UNFCCC, 2012). However, successful technology transfer requires not only exchange of technological solutions, but also strengthening policy and regulatory environments, and capacities to absorb, employ and improve appropriate technologies. In both developed and developing countries, multilateral institutions can support collaboration which engages private interests in regulatory planning and possibly activities, particularly if ongoing funding is expected (Tessa and Kurukulasuriya, 2010).

15.3.2.6. Education and Training

Developing general guidance on potential climate change impacts, vulnerability, and adaptation helps the promotion of flexible approaches to adaptation planning and implementation. It means investing in climate science extension personnel including translators, who could work in partnership with managers and planners to translate the projections of climate models, understand potential impacts, and help design adaptation responses. These individuals would also function as outreach staff who could explain to the public what climate change might mean to long-standing opportunities or management goals (West et al., 2009).

The farmers in Northeast China learn to adapt to climate change through experience and self-judgment, but also, and importantly, from neighbors' practices and scientific demonstrations. Scientists played a supporting role by discerning long-term climate trends, predicting future scenarios, and recommending development blueprints and

technologies (Yang et al., 2007). In the built environment sector of Australia, (Lyth et al., 2007) recommend that education about and for climate change adaptation in accredited courses be addressed in an integrated way with education about and for climate change mitigation in Australia. Programs for Master and Ph.D degreees with specific applications for climate change impacts, vulnerability, adaptation, and capacity assessment have been established in many universities such as United Nations Univerwsity and The University of the West Indies.

15.3.2.7. Local and Traditional Knowledge

Local and traditional knowledge is gained by longtime recognition and adjustment to adverse events. The value of local knowledge was given primacy, be it to complement scientific climate data, to provide insights about and for climate change adaptation, or as a source of community-based environmental monitoring (Newsham and Thomas, 2011; Nakashima et al, 2012).

Rural populations have an considerable capacity to adapt to a range of climatic and non-climatic risks. However, this capacity does have limits that can be exceeded, especially when climate-related stresses are superimposed on other forces that give rise to vulnerability. Whether that threshold is exceeded is strongly influenced by the role that higher-level actors such as governments choose to play in providing adaptation assistance and capacity-building (McLeman et al., 2008). Local agro-ecological knowledge in North Central Namibia has provided farmers with resilience in the face of a highly variable, and hence uncertain, climate for perhaps hundreds of years (Newsham and Thomas, 2011). Most of the farmers in the Mekong river delta had applied them personally during major flood events in the past such as lifting the ground floor level, moving important items to upper floors, sending the children to day care centers, and selling livestock in case of very large floods (Birkmann, 2011). A summary of the integration of indigenous peoples' knowledge and observations of environmental processes in developing collective responses to climate change in Africa, Australia, small islands in the Asia-Pacific region, and the Arctic Ocean concludes that knowledge co-development helps to realize the purpose of developing climate change mitigation, adaptation strategies and actions (Green and Raygorodetsky, 2010).

Adaptation plans in developing countries tend to be stakeholder-driven, and implemented at the local level, where there is ample opportunity to include capacity-building as part of the adaptation plan (Berrang-Ford et al., 2011; Ford et al., 2011). Some recent climate community-scale adaptation plans as well as local adaptation methods have increased adaptive capacity by re-introducing indigenous varieties of crops that are selected by local farmers to be more resilient to changing conditions, and by initiating subsistence farming of a broad variety of vegetables in regions where local economies are dependent on the success of a few to sometimes one cereal crop (Deressa et al., 2009; Ensor and Berger, 2009).

15.3.3. Learning and Capacity-Building

15.3.3.1. Perception of Climate Change and Adaptation

In regions where there is awareness of climate change, people tend to have greater adaptive capacity and are more proactive in adaptation responses (Di Falco and Veronesi, 2011). However, there are still cases where there are gaps in knowledge between projected and perceived risks, as well as the degree of uncertainty. Individuals in flood-prone areas, in educated, affluent regions as well as developing countries, commonly miscalculate the degree of flood risk (Lata and Nunn, 2012; Ludy and Kondolf, 2012; Bell and Tobin, 2007). In some cases, people are aware of the dangers from flooding, riverbank erosion, etc., but do not necessarily attribute these risks to possible manifestations of climate change or the need to adapt to changing hazard frequency (Lata and Nunn, 2012). Additionally, there have been very few documented changes in forecasts, plans, design criteria, investment decisions, budgets or staffing patterns in response to climate risks (Berrang-Ford et al., 2011; Repetto, 2008). Because there is uncertainty about the future climate, new decision making tools need to be developed to cope with the impacts (Frommer, 2009). Adaptation in addition to mitigation is growing in mainstream policy efforts in response to climate change (Preston et al., 2009). However, there is a significant gap between adaptation recommendations and planning, and actual implementation efforts (Berrang-Ford et al., 2011; Repetto, 2008).

Building capacity to respond to change, whether expected or unexpected, creates resilience in communities to cope in the face of uncertainties in climate change projections. Because in both developed and developing countries, climate change adaptation is not viewed as a high priority because of more immediate needs that are based on short-term economic welfare (Coles and Scott, 2009). In developing countries there are also additional challenges in obtaining basic human requirements and to address human health. People in developing countries are particularly vulnerable to climate change and more directly impacted by climatic hazards, in part because their economies tend to be more natural resource-dependent (Nath and Behera, 2010; Reid et al, 2010; Handmer, 2009). Greater exposure is often accompanied by a deficit of adaptive capacity, because poorer, less educated populations tend to have less access to information about climate risks, and fewer economic and technical resources available (Sissoko et al., 2011; Reid et al., 2010).

15.3.3.2. Balancing Mitigation and Adaptation Responses to Climate Change

Three major themes where adaptation and mitigation issues are expected to coincide are agriculture, built environment and carbon sequestration through re-vegetation. In north central Victoria, Australia, Jones et al. (2007) describe adaptation and mitigation efforts that are jointly managed by a greenhouse consortium and a catchment management authority. They conclude that when managing climate change risks, adaptation and mitigation can be integrated at the operational level. However, significant gaps in understanding the benefits of adaptation and mitigation on the local and global scales remain. Links between adaptation and mitigation can be strengthened by reduction of emissions from deforestation and forest degradation, as they contribute to conserving and restoring ecosystem service (Van Aalst et al., 2008). The Klima-Werkstatt project (Germany) has invested in climate change mitigation and adaptation by communicating the added value of climate-friendly products and services. It provides demand-oriented knowledge transfer, and develops opportunities for stakeholder participation. A long-term goal is to develop a stakeholder network that is a self-supporting structure (Frommer, 2009).

15.3.3.3. Opportunities to Improve the Communication between Science and Practice in the Creation of Decisionmaking Support Information and Tools

Decision analysis tools have been valuable as a means of informing decision-makers. Whether it is multicriteria analysis, benefit-cost analysis, or any number of other tools, part of the analytical process will always be difficult and challenging primarily because of underlying uncertainties and differing local conditions (Smith et al., 2009). Decision support systems for climate adaptation have been set up for various sectors such as water (Stakhiv and Stewart, 2010), ecosystem (Munang et al, 2010), and tourism (Scott and Lemieux, 2010). Several efforts at defining frameworks to guide decision-makers dealing explicitly with climate adaptation are a valuable start, but more practice-oriented evaluation of such tools is merited (Smith et al., 2009). Networks are useful tools to develop individual adaptation options on the local and regional scales, e.g., the KLARA-Net builds on four fields of action, as follows: ‘spatial planning + building industry + water resources management’, ‘agriculture, viniculture + forestry’, ‘tourism’, and ‘health’. Each of these fields of action is operationalized by a working group (Frommer, 2009).

15.3.3.4. Developing Localized Information for Adaptation Planning and Implementation

Community-based climate change adaptation plans have included strategies for disseminating information on climate change and raising awareness using novel and creative methods, including art and essay writing contests, public information posters, and signs on rickshaws. Community engagement offers additional opportunities to discuss climate change impacts in plans by including baseline surveys of community members, public discussions at existing village level social platforms, demonstration projects, and festivals (Mekong River Commission, 2010; Ensor and Berger, 2009). It also allows incorporation of local or traditional knowledge into climate change adaptation plans.

Conservation management of important and threatened resources can be strengthened by using local knowledge. In Kenya, local ecological knowledge about the harvesting of papyrus and the recovery time between harvests has been critical to developing sound conservation strategies (Terer et al., 2012). The local plant knowledge shared among tribal elders of the Standing Rock Lakota tribe has served as an adaptive asset that may be important for the survival of cultural practices under changing climatic conditions (Ruelle and Kassam, 2011). Additionally, indigenous knowledge has been used to predict weather and climate for generations in Malawi. Local farmers in this Sub-Saharan region of Africa rely on indigenous knowledge, and have not found conventional scientific weather predictions as useful at the local level (Kalanda-Joshua et al., 2011)

15.3.4. Preparing for Surprises: Role of Buffers

Disaster risk reduction is an important but often unrecognised and undervalued service provided by healthy ecosystems (UNISDR, 2011). The above cases suggest that under transitional climate change, due to climate variability and extreme events appear thresholds may be breached more frequently. In the face of mounting evidence of the biological and ecological consequences of climate change, and of the possibility that changes to ecosystems may in fact be rapid, large, and sometimes irreversible (i.e. there may be thresholds that, once crossed, will exacerbate coping challenges to humans), policy makers and resource managers are confronted with the need to develop ways to proceed with decision-making in the realms of both mitigation and adaptation, despite the many uncertainties associated with thresholds (Scheffer, 2009).

For instance, forest protected areas help conserve ecosystems that provide habitat, shelter, food, raw materials, genetic materials, a barrier against disasters, a stable source of resources and many other ecosystem goods and services – and thus can have an important role in helping species, people and countries adapt to climate change. Such systems continue to serve as a natural storehouse of goods and services into the future (Dudley, 2008). As part of its Climate Change Framework Strategy (World Bank, 2008), the World Bank is advocating that ecosystem-based adaptation to maintain ecosystem services and sustainable income-generating activities in the face of climate change. The Reduced Emissions from Deforestation and forest Degradation (REDD) is a major effort to produce co-benefits of reducing GHGs and ensuring livelihoods (Ezzine-de-Blas et al, 2011). Protected areas have been recognized for several decades as an essential tool for conserving biodiversity.

Guatemala's Mayan Biosphere Reserve provides employment for over 7 000 people and generates an annual income of approximately US$47 million (Poverty and Conservation Learning Group (PCLG), 2002). In Madagascar, a study of 41 reserves found that the economic rate of return of the protected area system was 54 percent, essentially from watershed protection and to a lesser extent from ecotourism (Naughton-Treveset al., 2005). Thus, protected areas provide a safety net which can be valuable in times of stress, such as extreme climate events.

In Kimbe Bay, Papua New Guinea, a network of marine protected areas were developed based on coral reef protection to help the Bay's ecosystems withstand the impacts of a warming ocean and continue to provide food and other resources to local communities (Green et al., 2009). In Samoa, mangroves are being planted as part of a larger restoration project to enhance food security and protect local communities from storm surges anticipated to increase as a result of climate change. In Myanmar, communities are replanting mangroves in the Irawaddy Delta following the destructive impact of Cyclone Nargis, which devastated life and property in the absence of mangrove forests, cleared over time for paddy cultivation (Tripartite Core Group, 2008). Mangrove restoration in Vietnam has been shown to attenuate wave height and thus reduce wave damage and erosion (Mazda et al., 1997). Sri Lanka's Muthurajawela marsh, a coastal peat bog covering some 3,100 hectares, is an important part of local flood control. Low cost behavioral actions can provide benefits within a short time. One such example, the Humbo Project, assists communities affected by ecosystem degradation including loss of biodiversity, erosion, and flooding with an opportunity to benefit from carbon markets. Farmer-managed natural regeneration has been involved in the regeneration of 2728 ha of degraded native forests in Humbo, Ethiopia (Brown et al., 2010). Benefits have included fodder and firewood in the first year, and fruit and non-timber products within three years. Indigenous communities have been using such low cost actions for generations. Highly rated adaptation options that are being implemented add climate change to already existing activities for managing climate-related and other risks. These include

integrated ecosystem and water management, integrated coastal zone management, risk-based allocation policy, risk management as basic strategy, and new institutional alliances (Füssel, 2007).

The impacts of climate change now give these approaches a renewed role as adaptation tools for a changing climate. Their importance in this respect is threefold (see Box CC-EA):

1) In supporting species to adapt to changing climate patterns and sudden climate events by providing refuges and migration corridors
2) In protecting people from sudden climatic events and reducing vulnerability to floods, droughts and other weather-induced problems
3) Indirectly, in supporting economies to adapt to climate change by reducing the costs of climate-related negative impacts.

15.4. Governing Adaptation

An assessment of the literature draws attention to the point that adaptation to climate change poses governance challenges such that arrangements inconsistent with governance principles. The role of governance is highlighted in building adaptive capacity to climate change (Engle and Lemos, 2010) and providing the connections between individuals, communities, organisations, agencies, and institutions at multiple organizational levels (Folke et al., 2005) and in articulating top-down or bottom-up perspectives which are both critical in policy formulation (Unwin and Jordan, 2008). Such organisations often draws from various knowledge systems and experiences in developing a common understanding and policies on an issue critical for cross-institutional coordination and multi-stakeholders actions. For example, mechanisms to facilitate learning processes are considered to support the management of complexity especially in cross-boundary and large scale resource systems. (Huntjens et al., 2012).

15.4.1. Factors for Adaptation Governance - Institutional, Financial, Incentives, Information Management

An assessment of the literature points out that adaptation is influenced by social factors which require having learning, cooperation and communication as part of the planning especially at the local level where the action takes place (Resilient Cities, 2011). Accountability is considered a factor which highlights a participatory process (Akompab et al., 2012). Similarly, knowledge is important for adaptation governance following the opportunity it offers for learning especially in supporting a feedback mechanism for improvement (Nilsson et al., 2012) and providing the context for adaptive governance (Bruner, 2010) in contribution to overall adaptive capacity to climate change (Preston et al., 2011). Incentives for economic growth and profitability in coping with climate change are also considered as an important factor of governance (Manuel-Navarrete et al., 2009).

Institutional dynamics is a factor of adaptation governance especially in fostering transboundary collaboration (Wilder et al., 2010). This is important in overcoming some of the adaptation barriers posed by hierarchical government structure by shifting towards a more collaborative approach following the multi-dimension and numerous state and non-state actors involved in adaptation (Koch et. al., 2007). Decentralised decision-making, open information sources, and plurality of user interests are important factors of governance emphasized in the literature for promoting multilevel institutions that are robust and able to learn (Bisaro et al., 2010; Rao, 2012). Case studies of fishing communities in northern Norway and north-west Russia showed that the adaptive capacity of local actors to respond to climate change is influenced politically beyond their immediate locality, within broader governance system (Keskitalo and Kulyasova, 2009). An instructive lesson on cost-effectiveness, sustainability, citizenship and social cohesion is taken from the UNISDR (2011) Global Assessment Report on Disaster Rick Reduction. The report notes that the central government level responsibility for disaster risk management needs to be located in a ministry or department, preferably with planning oversight and some fiscal responsibility that can provide political authority and policy coherence across sectors. Emergency management organizations can rarely play that role. The decentralization of responsibilities to local governments needs to be accompanied by a decentralization of capacities and resources – otherwise it may become an obstacle to effective DRM. Decentralization should be incremental and approaches such as twinning may facilitate capacity development, and will only be effective when it is carried out in real partnership with disaster prone households and communities and

their organizations. There are a growing number of positive examples of such partnerships. In many countries this however implies a change in the culture of public administration and the critical role of key individuals or policy entrepreneurs at every level cannot be underestimated.

15.4.2. Cross-Sector Coordination

Norman (2009) highlights the importance of intergovernmental and multidisciplinary approaches integrating science and spatial planning as an efficient approach to address those conflicts between adaptation and mitigation as discussed in 15.2.2.2. Bottom-up approaches can be particularly useful in efforts seeking to reduce social and urban vulnerability, and addressing adaptation to climate change as a process. However, adaptation to climate change requires also complementary top-down strategies through urban and state institutions (Raschky, 2008).

Linking climate change risks to systems and sectors, and the corresponding response planning and implementation actions occurring at different spatial and temporal scales, requires cross-coordination. Jurisdictional scales and mandates across sectors, and local, national and sub-national policies, constrict the potential benefits of close dependencies between institutions, institutional systems and organizational units in planning and implementation of adaptation (Dovers and Hezri, 2010). The lack of coordination in the scale of governance together with unclear division of tasks and responsibilities of actors, especially under conflicting timescales of interventions, are significant barriers to adaptation (Biesbroek et al., 2011) and future coordination of implementation in the same framework with other policy domains (Biesbroek et al., 2010). As a multidimensional issue involving many state and non-state actors functioning on varying scales of global, national and local levels, a coordination of roles and responsibilities enhances institutional networking for effective implementation of climate change adaptation (Koch et al., 2007; Amundsen et al., 2010). The creation of larger governance networks through coordination is reported to expand the adaptive capacity of local actors (Keskitalo and Kulyasova, 2009), as well as enhancing learning opportunities for policy formulations (Owen, 2010).

As systems evolve to handle problems that surpass contemporary political/administrative systems and boundaries, governance serves as an adaptive tool in generating thrust and empowering communities in a collective vision to effectively and coherently respond to emerging issues of climate change in mitigation and adaptation (Meadowcroft, 2009), using justifiable manners in the attribution of benefits and responsibilities under differentiated capabilities (Paavola and Adger, 2006). The quality of governance of adaptation is increasingly relevant under different strategies of responding to climate change and reducing greenhouse gas emissions in ways that foster complementarity rather than counteraction, building synergies, and reducing trade-offs (Laukkonen et al., 2009). With a centralized national planning that has dominated climate change adaptation strategies such as NAPAs, NAPs etc., governance plays a central role in setting priorities among competing interests, managing inclusion or exclusion, and mediating power relations between various actors that often influences fairness or skewedness in the distribution of benefits. Capturing various perspectives of multiple stakeholders and actors holding different views, power and influence, is pivotal in mutually achieving short-term coping needs and long-term adaptation to climate change (O'Brien et al., 2008).

Governance of adaptation thus creates the space and conditions for achieving specific goals or collective outputs by aligning principles and norms for regulations, decision making procedures and organizations in providing an overarching system to comprehensively address a challenge (Biermann et al., 2009). As a dynamic process, changes in resource regimes under human-environment interactions exposed to climate impacts must be matched with timely institutional reforms in exploiting the windows of opportunities for planned interventions (Young, 2010; DeWulf et al., 2011). Against uncertainties of system response to climate impacts, coordination in resource extraction such as fishery, forestry, watersheds, etc., in deciding on flexibility in management regimes, capacity adjustment schemes and the regulations implemented are important adaptation measures (Mcllgorm et al., 2010). This thus draws on either a centralized guidance of collective action or using subunits in a decentralized system which are both effective based on the circumstances of application (OECD, 2004; Underdal, 2010).

The perturbations triggered by the changing climate to both human and natural systems equally affect current institutions prompting institutional changes in adapting to the changes (Dovers and Hezri, 2010). Except for

prioritizing interventions in national plans and strategies in favor of most vulnerable communities or sectors, there is no evidence of a risk-sharing framework underlying any adaptation planning process. This remains a contentious issue as inter-generational and intra-generational equity and ethical responsibility take hold on the governance process of climate change (Beckman 2008; Page 2008), which undermines the legitimacy and effectiveness of some of the decisions and measures put in place (Paavola, 2008a).

15.4.3. Sustaining Adaptation Implementation

Public-private partnerships are considered to favor sustainable outcomes of the implemented actions for adaptation but are not without their challenges. There are also opportunities such as injecting competitive networks capable of spurring innovative and dynamic governance of sustainability (Smith and Fischlein, 2010). The sustainability of private-public partnership is built on the effectiveness of the governance scheme driving the partnership as is the case of a tropical forest, whereby actions at local levels could have direct implications at the global level, and vice versa, e.g., in REDD+, following the nuances of the uniqueness of time and place (Van Laerhoven, 2010). Characterized by multiple users and uses of tropical forest goods and services under different access rights and ownership patterns, governance could minimize trade-offs under asymmetric power configurations and sustaining implemented adaptation actions (Agrawal et al., 2008). In avoiding a disproportionate risk burden in shared natural resource systems by poorly dependent communities such as in water basins, the devolution of management rights to local communities is considered as a measure for sustainably internalizing risks, enhancing the resilience and adaptive capacity of local communities (Engle and Lemos, 2010), and providing equity and justice (Thomas and Twyman, 2005) especially when captured in planning adaptation.

15.4.4. Feedback and Adjustment Mechanism

Effective governance thus provides safeguards to social-ecological thresholds surrounded by uncertainties, surprises and complex causalities capable of tipping the system. Migration, for example, carries the flip sides of a tested adaptive response (Barnett and Webber, 2010), as well as a risk source of vulnerability to natural resource system thresholds some of which are characterized by slow-onsets (Warner, 2010) which could be addressed with policy and institutional governance (Paavola, 2008b). There is historical evidence of mobility and population distribution as adaptive responses to environmental challenges especially among African herdsmen (Tacoli, 2009; Nakashima et al., 2012). However, the effectiveness of such a technique for adaptation is viewed as generating new risks and security concerns (Brown et al., 2007). Characterized by uncertainties and surprise events, the approaches for adaptation in adjustment to future climate change are considered in the literature to have inescapable feedback trade-offs, such as efficiency over equity or equity over cost and legitimacy, etc. (Adger et al., 2009a).

Joint planning, co-management or co-implementation are considered as cost-effective measures in addressing common risks, especially common pooled resource risks, using collective action such as transboundary water river basins (Wiering et al., 2010). This has resulted in regional initiatives such as in Europe through the EU for example, and other bilateral cross-border co-operation drawing on interdependencies and transnational actors sometimes operating in a political sphere, and steering a process outside of national jurisdictions but contributing to national interests (Andonova et al., 2009).

15.5. Research Needs for Maximizing Opportunities

This chapter reviewed the literature on climate change adaptation (CCA) to assess the progress and limitations of adaptation planning and implementation being undertaken at present. The focus of this chapter is on assessing cases at different levels, from international to local in various sectors from different aspects such as present status and characteristics of CCA planning and implementation, barriers and opportunities to adaptation, capacity for adaptation and capacity-building, and governance of adaptation. Research has identified major issues in moving from planning to implementation which concern reconciling short-term and long-term goals for vulnerability

reduction, overcoming the disconnect between local risk management practices and national institutional and legal frameworks, including mandates policy and planning.

The literature is clear that adaptation planning is transitioning from a phase of awareness and promotion to the construction of concrete responses in societies. The combined efforts of a broad range of international organizations, scientific reports, and media coverage and the very important, occurrence of ongoing extremes event impacts such as Hurricane Sandy and the Drought of 2012 in the US, have raised the importance of adaptation to climate change. In agreement with Biesbroek et al. (2010) and this Chapter, several strategies cite the possible economic damage of unavoidable climate change as a major motivating factor for action, however, few, if any, strategies actually analyze the costs of adaptation. New non-traditional areas of international concern are emerging in the area of national security and economy and trade and receiving increasing attention but are not yet amenable to assessment.

In the literature, more national-level plans and adaptation strategies for developed countries are mentioned than for developing countries; whereas, more implementation cases are documented at the local level in developing countries. Most national strategies appear to be based on potential impacts derived from international and national assessments without consistent and systematic use of regional climate scenarios (Biesbroek et al., 2010; Pulwarty et al. 2012; Chapter Regional Context). At the same time, as the social dimensions of adaptation have attracted more attention, it is emphasized to make the linkages between adaptation and development more explicit to link adaptation planning with co-benefits for development. Different sectors (e.g., disaster risk reduction, water resource planning, agriculture, urban planning) treat adaptation within their traditional context of planning to various degrees and a few are attempting to reconcile various model projects for risk analysis (e.g. Barsugli et al., 2012).

Separating investments that have been applied solely “adaptation” as opposed to “development” has proven difficult in many cases, particularly in defining or attributing the specific component that contributes to climate change adaptation funding beyond benefits to development per se. Studies comparing both formal adaptation plans and less formal adaptation studies several cities demonstrates that the focus is mostly on risk reduction and the protection of citizens and infrastructure, with very few such as Rotterdam seeing adaptation as opportunity for transformation (Heinrichs et al., 2011). Other sectors such as energy, transport, and built infrastructure remain less engaged.

Major investments in infrastructure projects designed to adapt to weather related hazards are being undertaken without awareness of the impacts of climate change on long-term sustainable development (Lasco et al., 2009). The reasons for the initial of attention have been identified as limited public awareness regarding practical links between poverty reduction and adaptation to climate change, and a perception of climate change adaptation as being, “expert driven” and limited to technological responses to identified changes in climate variables (Crabbé and Robin, 2006; Klein et al., 2007) although this is gradually changing (UNISDR, 2011; IPCC, 2012). Barriers to implementing climate change adaptation strategies in Mozambique resulted from differing perceptions of climate risk between farmers and policy-makers, and the perceived potential for negative consequences of the proposed adaptation plans.

Many climate-sensitive sectors in developing countries and marginalized communities in developed countries are currently not well adapted to the risks from current climate. For example, an area may have no or inadequate protection from current climate risks such as floods and drought. This has been termed the adaptation deficit (Burton and May, 2004). Most planning assessments do not include additional costs of reducing present vulnerability to a desired level. Most significantly lack of resources and analytical capabilities to deal with present risks has led to outsourcing of local adaptation plan development. These can generate acontextual recommendations, lacking both the social and historical contexts of a communities experience with climatic risks and more reliance on technological fixes (Crabbé and Robin, 2006; UNISDR, 2011; Pulwarty and Verdin, 2013). For example, despite the intention that city adaptation responses aim at an integrated approach, they tend to have sectoral responses, with limited integration of local voices.

Although national adaptation responses have diverse processes and outcomes in both developed and developing countries, the national level plays a key role in adaptation planning and implementation. NAPAs of developing countries are favorably viewed as being country-driven in their development. Many NAPAs propose adaptation strategies that are almost identical with standard development projects. Bottom-up approaches are particularly useful in efforts seeking to reduce social vulnerability and addressing adaptation to climate change as a process. However,

adaptation to climate change also requires complementary top-down strategies through different levels of governments. Another feature is that good practices have emerged in developing countries. Adaptation efforts in some countries, such as Bangladesh, Cambodia, Bhutan, and the Maldives, which are linked to development funding, provide a 'win-win' adaptation strategy that strengthens resilience to climate change while improving economic stability and environmental quality. However, securing the long-term financing for ongoing adaptation is rarely addressed beyond the project phase.

Urban areas are showing progress of CCA planning and implementation. A growing number of adaptation plans are reported, and urban areas are the focus of a number of local planning initiatives. Urban areas tend to formalize and institutionalize their work through the establishment of dedicated climate units, either within a relevant department or as a separate and cross-cutting office. However, with some exceptions, few local governments have had the resources, capability, and coordination to institutionalize adaptation to climate change.

Monitoring and early warning systems designed to inform social learning play important roles in helping to adjust adaptation implementation, especially on the local scale. Viewing risk communication as a social process allows for effective participatory approaches, network- building and the production of visual, compelling and engaging information for use by local stakeholders. The lack of coordination in the scale of governance together with unclear division of tasks and responsibilities of actors, especially under conflicting timescales of interventions e.g. emergency versus adaptive, are significant barriers to adaptation and future coordination of implementation.

A no-regrets approach based on co-benefits to emphasize on disaster risk management are increasingly advocated. However, climate change adaptation and disaster risk reduction are, at present, handled by separate agencies, although they share similar objectives and challenges. The experience on adaptation to date illustrates the need for better coordination and the development of collaborative networks. Developing frameworks and metrics for evaluating adaptation, that is cognizant of the experience in disaster risk, integrated watershed, coastal zone and the natural and social capita experience and literatures remain a central need. The potential for ecosystem-based approaches is also increasingly being realized (e.g. Munroe et al., 2011) offering opportunities that integrate with or even substitute for the use of engineered infrastructure or other technological approaches. Examples include sustainable water and habitat management, where river basins, aquifers, flood plains, and their associated vegetation are managed or restored to provide resilient water storage and enhanced base-flows, flood regulation services, reduction of erosion/siltation rates, and more ecosystem goods (e.g., Midgley et al., 2012; Opperman et al., 2009). The most significant contributions of ecosystem-based approaches may lie in allowing for flexibility as rapid transitions and thresholds are met, and in lowering the risk of maladaptation by substituting for or delaying the need for engineering solutions. Although the importance of evaluation of this area in adaptation is recognized, it is under-researched.

Most critical is the need for research to inform practice on the governance, including the leadership of and public engagement in adaptation. As a multidimensional concern involving many state and non-state actors and decisions, functioning on varying scales of global, national and local levels, improved multilevel governance offers the chance to identify options for moving from reactive to proactive adaptation processes.

Frequently Asked Questions

FAQ 15.1: What is the present status of climate change adaptation planning and implementation across the globe?

Climate change adaptation has been brought to people's attention due to the recent media coverage and various reports, leading to a growing number of adaptation plans both in developed and developing countries. The assessment of literature indicates adaptation planning is transitioning from a phase of awareness and promotion to the construction of concrete responses in societies. There is a wide range of adaptation plans reflecting the specific context, needs, values, and perceptions of societies. More national-level plans and adaptation strategies have been established in developed countries than in developing countries; whereas, more implementation cases are reported at the local level in developing countries. The plans developed by developing countries appear to focus more on climate change impacts and disaster risk management, where urban areas have become the focal point in local

planning initiatives. However, except for large cities, few local governments have the resources, capability, and coordination ability to institutionalize adaptation to climate change. In spite of these limitations, early discussions of the transformations needed in the structure and operational culture of institutions to address adaptation to climate change are occurring in both developed and developing countries. Monitoring, evaluating, and reviewing adaptation planning and implementation are critical aspects of complex adaptation planning as a social process.

FAQ 15.2: How are climate change policies operationalized at different scales (e.g., international, national, and local)?

National and subnational plans are developed by many developed countries and more and more plans are being produced by developing countries through the National Adaptation Programmes of Action (NAPA) and the National Adaptation Plans (NAPs). What lacks is the mechanism and institutional capacity to bridge between the national/sub-national level and the local level adaptation planning. NAPAs of developing countries are favorably viewed as being country-driven in their development. Many NAPAs propose adaptation strategies that are almost identical with standard development projects. Bottom-up approaches are particularly useful for reducing social vulnerability and addressing adaptation to climate change as a process. However, adaptation to climate change also requires complementary top-down strategies through different levels of governments to realize mainstreaming adaptation. Sustainable development and disaster risk management are two approaches to incorporate adaptation planning into these various levels, and these themes are particularly important and relevant at the local community in developing countries. In general, progress has been slow with regard to integrating disaster risk management and climate change adaptation at the national, subnational, and local level. To overcome such gaps, better coordination between risk management agencies and climate change adaptation efforts is needed.

FAQ 15.3: What capacities currently exist for implementing climate change adaptation?

In general there are two sources of adaptive capacity: institutional and organizational support, and science and technology. Adaptation capacity is supported by adaptation governance which occurs at multiple scales: international, national, sub-national, and local. Integrating and coordinating adaptation planning and implementation across these vertical levels of governance provides one big challenge while doing the same across different sectors (e.g., disaster risk reduction, water resource planning, agriculture, urban planning) and different sections or departments of a government provides yet another challenge. For successful implementation of adaptation plans, it is needed to promote both vertical and horizontal integration and coordination of adaptation planning across different governance levels and sectors. Science and technology provide another source of capacity. Development and diffusion of new technologies and management practices expands the range of adaptation possibilities by increasing opportunities or reducing costs. Knowledge development and sharing includes the development of science and new technologies, early warning systems, technology transfer and diffusion, education and training, and the use of local and traditional knowledge.

Cross-Chapter Box

Box CC-EA. Ecosystem Based Approaches to Adaptation - Emerging Opportunities

[Rebecca Shaw (USA), Jonathan Overpeck (USA), Guy Midgley (South Africa)]

Ecosystem-based approaches to adaptation (also termed Ecosystem-based Adaptation, EBA) integrate the use of biodiversity and ecosystem services into climate change adaptation strategies (e.g., CBD, 2009; Munroe *et al.*, 2011; Munroe *et al.*, 2011). EBA is implemented through the sustainable management of natural resources, as well as conservation and restoration of ecosystems, to provide and sustain services that facilitate adaptation both to climate variability and change (Colls *et al.*, 2009). The CBD COP 10 Decision X/33 on Climate Change and Biodiversity states further that effective EBA also "takes into account the multiple social, economic and cultural co-benefits for local communities".

The potential for EBA is increasingly being realized (e.g., Munroe *et al.*, 2011), offering opportunities that integrate with or even substitute for the use of engineered infrastructure or other technological approaches. Engineered defenses such as dams, sea walls and levees, may adversely affect biodiversity, resulting in maladaptation due to damage to ecosystem regulating services (Campbell *et al.*, 2009, Munroe *et al.*, 2011). There is some evidence that

the restoration and use of ecosystem services may reduce or delay the need for these engineering solutions (CBD, 2009). Well-integrated EBA is also more cost effective and sustainable than non-integrated physical engineering approaches, and may contribute to achieving sustainable development goals (e.g., poverty reduction, sustainable environmental management, and even mitigation objectives), especially when they are integrated with sound ecosystem management approaches. EBA also offers lower risk of maladaptation than engineering solutions in that their application is more flexible and responsive to unanticipated environmental changes.

EBA provides opportunities particularly in developing countries where economies depend more directly on the provision of ecosystem services (Vignola *et al.*, 2009), to reduce risks to climate change impacts and ensure that development proceeds on a pathways that are resilient to climate change (Munang *et al.*,). In these settings, ecosystem-based adaptation projects may be readily developed by enhancing existing initiatives, such as community-based adaptation and natural resource management approaches (e.g., Khan *et al.*, 2012, Midgley *et al.*, 2012; Roberts *et al.*, 2012)

Examples of ecosystem based approaches to adaptation include:

- Sustainable water management, where river basins, aquifers, flood plains, and their associated vegetation are managed or restored to provide resilient water storage and enhanced baseflows, flood regulation services, reduction of erosion/siltation rates, and more ecosystem goods (e.g., Midgley *et al.*, 2012, Opperman *et al.*, 2009).
- Disaster risk reduction through the restoration of coastal habitats (e.g., mangroves, wetlands and deltas) to provide effective measure against storm-surges, saline intrusion and coastal erosion;
- Sustainable management of grasslands and rangelands to enhance pastoral livelihoods and increase resilience to drought and flooding;
- Establishment of diverse and resilient agricultural systems, and adapting crop and livestock variety mixes to secure food provision. Traditional knowledge may contribute in this area through, for example, identifying indigenous crop and livestock genetic diversity, and water conservation techniques;
- Management of fire-prone ecosystems to achieve safer fire regimes while ensuring the maintenance of natural processes.

It is important to assess the appropriate and effective application of EBA as a developing concept through learning from work underway, and to build understanding of the social and physical conditions that may limit its effectiveness. Application of EBA, like other approaches, is not without risk, and risk/benefit assessments will allow better assessment of opportunities offered by the approach.

[INSERT FIGURE EA-1 HERE
Figure EA-1: Adapted from Munang *et al*. (2013). Ecosystem based adaptation approaches to adaptation can utilize the capacity of nature to buffer human systems from the adverse impacts of climate change through sustainable delivery of ecosystems services. A) Business as Usual Scenario in which climate impacts degrade ecosystems, ecosystem service delivery and human well-being B) Ecosystem-based Adaptation Scenario which utilizes natural capital and ecosystem services to reduce climate-related risks to human communities.]

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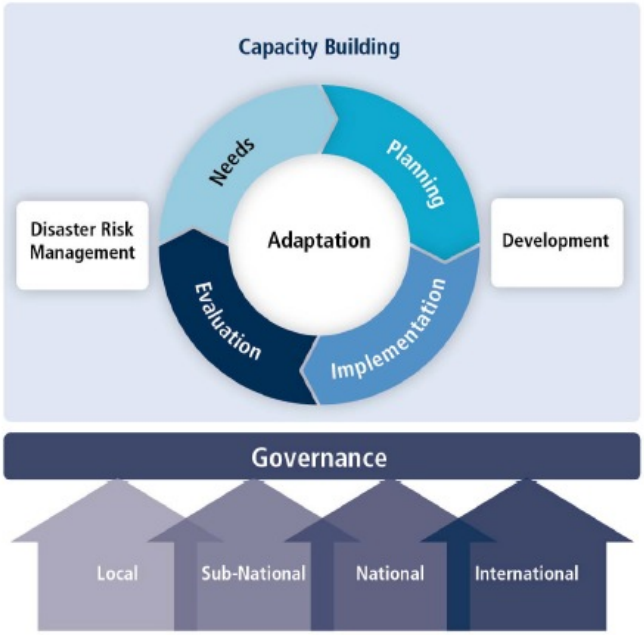

Figure 15-1: Four main phases of adaptation planning and implementation: needs, planning, implementation, and evaluation. This is a cyclic, iterative process. Building capacity to respond to change, whether expected or unexpected, creates resilience in societies to cope in the face of uncertainties in climate change projections. Efforts in adaptation need to be linked with development or disaster risk management. This is particularly true and important in developing countries. Adaptation governance underlies the capacity and governance takes place at multiple scales: international, national, sub-national, and local.

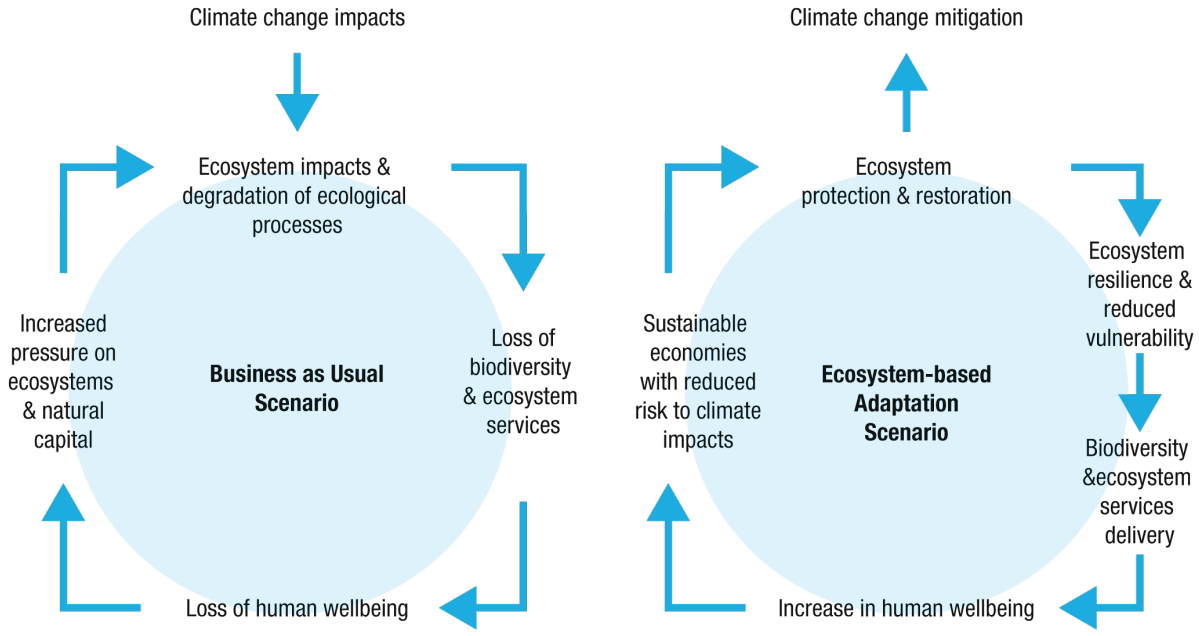

Figure EA-1: Adapted from Munang *et al*. (2013). Ecosystem based adaptation approaches to adaptation can utilize the capacity of nature to buffer human systems from the adverse impacts of climate change through sustainable delivery of ecosystems services. A) Business as Usual Scenario in which climate impacts degrade ecosystems, ecosystem service delivery and human well-being B) Ecosystem-based Adaptation Scenario which utilizes natural capital and ecosystem services to reduce climate-related risks to human communities.