Chapter 15. Adaptation Planning and Implementation

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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, 15.2.2] The combined efforts of a broad range of international organizations, scientific reports, and media coverage have raised the importance of adaptation to climate change. More national-level plans and adaptation strategies for developed countries are mentioned in the literature than for developing countries; whereas, more implementation cases are documented at the local level in developing countries. Different sectors (e.g., disaster risk reduction, water resource planning, agriculture, urban planning) treat adaptation within their traditional context of planning to various degrees. Although the transition in adaptation planning represents a positive trend compared to 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 (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 process such as existing policies and agendas, knowledge, risks, and issues the society already faces. The linkages between adaptation and development need to be more explicit to link adaptation planning with co-benefits for development. Separating investments that have been applied solely to adaptation as opposed to development is difficult in many cases.

The national level plays a key role in adaptation planning and implementation, while national adaptation responses have diverse processes and outcomes in developed and developing countries (high agreement, medium evidence). [15.2.2] 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. Adaptation planning also highlights the importance of intergovernmental and multidisciplinary approaches integrating science and planning.

Despite the resource limitations, some developing countries are in the forefront on adaptation (high agreement, robust evidence). [15.3.1] 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. 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. One such example, the Humbo Project, assists communities affected by ecosystem degradation with an opportunity to benefit from carbon markets.

A growing number of adaptation plans are reported, and urban areas are the focus of a number of local planning initiatives (medium agreement, medium evidence). [15.2.2] The majority of urban adaptation plans is focused on infrastructure reinforcement and is occurring within selected urban environments. 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 and know-how to institutionalize adaptation to climate change. The mismatch between the current structure and operational culture of municipal planning institutions and the need for multidimensional collaboration in adaptation is also reported in developed countries.

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). [15.3.1] 'Win-win' strategies couple the need for adaptation with developmental needs or improvements in disaster risk reduction. 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. However, adaptation finance channelled through national governments is not likely to reach the lowest income and most vulnerable people. In addition to the funding for infrastructure-related plans, implementation of top-down approaches can require numerous legislative and executive actions. In contrast to top-down strategies, community-based adaptation is becoming a popular approach in developing countries, because impacts to climate change occur at the local level.

A no-regrets approach of improving resilience through an emphasis on disaster risk management has become increasingly common (high agreement, medium evidence). [15.3.1] 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. Four types of methodologies or approaches linking DRR and climate change adaptation (CCA) are increasingly being employed: Early warning systems, new legislation, risk transfer in developing countries and education, training and public awareness initiatives. Current disaster risk management and CCA policies and measures have not been sufficient to avoid, fully prepare for and respond to extreme weather and climate events. Due to the uncertainty, dynamic complexity, and short to long timeframes associated with climate change, robust adaptation efforts require iterative risk management strategies.

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). [15.2.1, 15.4.1] 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.

A variety of tools are being employed in adaptation planning and implementation depending on social and management context (high agreement, robust evidence). [15.3.2] Indicators, qualitative information and probabilistic metrics are important measures and techniques for vulnerability and risk analysis. 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 the tool for environmental assessment and management. Risk management within the broader risk governance framework, for integrating adaptation to climate change and disaster risk reduction and transfer, is increasingly advocated within plans. These tools vary from formalized probabilistic risk analysis to local level, participatory risk and context analysis methodologies. Multi-criteria analysis, scenario planning and flexible decision-paths offer options for taking action when faced with large uncertainties or incomplete information. 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 among practitioners in this community, as well as local government and the public.

Development and diffusion of new technologies and management practices will be critical to many adaptation efforts (medium agreement, medium evidence). [15.4.2] 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.

Effectively communicating risk involves multiple pathway exchanges between decision- makers and local citizens (medium agreement, robust evidence). [15.2.2] 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. Without broader stakeholder agreement at the local level, successful implementation was not possible. However, in the case of other 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. Viewing risk communication as a social process allows for effective participatory approaches, relationship building and the production of visual, compelling and engaging information for use by local stakeholders.

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 and future coordination of implementation (high agreement, medium evidence). [15.4.2] 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. Therefore, there is a strong need to develop and strengthen capacities effective for adaptation planning and implementation. To respond to the urgent needs, least developed countries (LDCs) have developed National Adaptation Programmes of Action (NAPAs). The NAPA focus on existing coping strategies and actions at the grassroots level, 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.

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

- 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

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. Through the literature review, this section tries to assess the following key subjects.

- Present 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. This chapter will assess these activities to understand the whole picture of the present status.
- Characteristics of adaptation in different settings. Adaptation planning is a decision-making under the uncertainty of climate change projection 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 to 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. In many situations, it is particularly difficult for adaptation plans to be implemented. To assess the barriers between planning and implementation is a focus of the assessment.
- 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. As climate change adaptation is a relatively new approach to addressing phenomena with long-term consequences, and adaptation operates on difference spatial and societal scales, evaluation of the needed capacities is further complicated. This chapter tries to give an assessment of the present status of the development of the capacities.
- 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.

15.2. Adaptation Planning

Assessment of the international peer-reviewed and gray literature indicates adaptation planning may be 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 have raised the importance of adaptation to climate change, particularly in light of the difficulties to reach international consensus in the control of green houses emissions. These efforts have fostered a growing number of adaptation responses in a growing number of countries. Although the transition in adaptation planning represents a positive trend compared to previous IPCC reports, it is not clear yet how effective those responses currently are and will be in the near future. A large part of the international literature reports the creation of adaptation responses often with a rather descriptive approach with little critical assessment. This is a trend expected in the gray literature but also not uncommon in part of the peer-reviewed literature. Another part of the peer-reviewed literature has provided a more analytical approach of adaptation responses. It highlights that those responses are not free of problems and risks, and requires frequent

monitoring and evaluation to deliver the intended positive outcomes. One of the critical elements 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 cope and address the negative impacts of climate change.

15.2.1. Responding to Present and Future Climate Impacts

The review of the international literature can be summarized as follows. On one hand, the international literature reports the dynamic creation of plans, strategies, legislation and projects at a national and subnational level. 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 gray literature reports a growing number of adaptation plans and strategies at the national and subnational level in developed countries, and at a lower pace in developing countries. However, a significant number of those publications are descriptive and provide limited information on adaptation planning. Part of the literature in this group (peer-reviewed and gray) continues to emphasize the need for adaptation. These publications emphasize the importance of mainstreaming adaptation policy into existing and new policy strategies to make more efficient and effective use of financial and human resources (Bulkeley 2006, Biersbork et al. 2009, Romero Lankau and Dodman 2011).

On the other hand, part of the peer-reviewed literature reports concerns about the contributions to a better understanding of adaptation. Berrang-Ford et al.(2011) highlights the limited understanding of if and how adaptation planning is actually taking place. For them, 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. Arnell (2010) characterizes what we know about adaptation by reviewing all adaptation-related articles in the journal Climatic Change. His conclusions indicate there are 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. They suggest that in the context of adaptation planning, there is no evidence to show that adaptation planners are working towards transitions. 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 focuses on the social dimension of adaptation and explores the potential role of adaptation planning. Orlove (2009) expresses concern that adaptation analysis tends to focus on hazards rather on the stressors creating them. For him, adaptation planning can neglect to address the drivers of vulnerability, thus, limiting its effectiveness. Hardee and Mutunga (2010), Lemos et al. (2007), and Sietz et al. (2011) are concerned 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. Moreover, Boyde and Juhola (2009) express concern over how the debate of climate change is dominated by impact-led approaches that focus on climate risks rather than on human vulnerability. Hulme et al. (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 which makes detailed planning at a national level challenging. By the same token, Ribot (2010) notes that adaptation measures often ignore causality by focusing on responses and reducing attention to the underlying social causes of risk. He highlights the importance of understanding multi-scale causes of vulnerability to better identify the adequate dimensions of adaptation actions and planning. Sanchez-Rodriguez (2012) highlights the need to build operational approaches of adaptation planning by recognizing the

structural socio-economic conditions in low and middle-income countries. Adger and Barnett (2009) argue that the social context in which adaptation takes place is a key element to measure the success of adaptation and the trade-offs that may be involved. Along these lines, Barnett and Campbell (2009) believe community values must be taken into account if adaptation planning is to be effective, efficient, legitimate, and equitable.

Attention to the social dimensions of adaptation in part of the international literature coincides with the interest of international organization and scholars in the relationship between adaptation and development. Important international organizations emphasize the need to consider adaptation within the context of development (OECD 2009, UN-HABITAT 2011, UNEP 2010, UNDP 2005, World Bank 2010). Scholars have also highlighted this important relationship. Stringer et al. (2009) consider that the linkages between adaptation and development should be made more explicit. Dover (2009) stresses the need of connecting climate adaptation more closely to existing policy and existing agendas, knowledge, risks, and issues communities already face. He emphasizes the important role of planning that connects adaptation and development needs and challenges. The literature supports the contention that adaptation takes place as a response to multiple stimuli - not just climate (Adger et al. 2009, Tompkins et al. 2010). This highlights the need of connecting adaptation with the development process of societies. 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 into multidimensional and multi-scale approaches as a critical task that can better guide the construction of adaptation responses to climate change, and integrate 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.

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. These issues underscore the need for interdisciplinary approaches to planning in adaptation addressed by other scholars. Blanco and Alberti (2009) suggest adaptation planning for climate change will need to rely on an emerging interdisciplinary scientific field, which couples human and natural systems and their interactions. Sanchez-Rodriguez (2012) discusses 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 of the 21st century. This is an important question given the expectations mentioned above 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.

The mismatch between the current structure and operational culture of municipal planning institutions and the need for multidimensional collaboration in adaptation is also reported in high-income countries. Vammen Larsen et al. (2012) study municipal responses to climate change in Denmark (mitigation and adaptation) through Municipal Strategic Environmental Reports. They find the municipal organizational structure is based on professional silos that hinder horizontal coordination across professional sectors. They recognize the interdisciplinary nature of climate change affecting most municipal sectors, and the scant experience in municipalities to assume the coordinated role required. For the authors, this dilemma complicates the integration of the interdisciplinary element of climate change into the bureaucratic organization.

By the same token, 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 they lack a formal institutional framework necessary to shape and execute adaptation measures on an urgent basis. Their study shows that despite the recognition of the importance of climate change impacts, very few experts and decision-

makers report that their respective agencies have developed formal adaptation plans. 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). However, Biersbork et al. (2009) consider climate change could also lead to changes in the traditional administrative structures that spatial planners are accustomed to.

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 (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. The discussion of planning as a social learning process is relevant to formulate efficient adaptation planning. Although there is little attention in the literature to the potential benefits of planning as a social learning process for adaptation, some literature on planning has addressed the issue. Holden (2008) suggests social learning is a relevant but under-investigated feature of planning and a critical part in the adaptation of innovations. For her, the understanding of why and how learning takes place is needed in the theory and practice of planning 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. However, Holden (2008) remarks that 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 with the impacts (Frommer 2009). But it will require broader attention by scholars and practitioners to develop a better understanding of this process.

Two important learning tools in adaptation planning are monitoring and evaluation. 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, policies and measures are still in their developmental infancy. For them, evaluation and monitoring 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 at. (2010) consider that in order to assess the effectiveness of adaptation strategies, frameworks should not start from the modeling perspective, but from the stakeholders' perspective. They suggest three steps: (1) assess current vulnerability to climatic variability (including aspects that cannot be simulated with quantitative models), (2), assess climate risks (considering climate scenarios), and (3) develop adaptation strategies (based on integrated assessments and stakeholder involvement), either relevant at the farming system level or at the policy level.

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). By the same token, Arnell (2010) highlights the importance of context in the analysis and evaluation of adaptation. The case studies and the assessment of potential adaptation measures in his review show 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.

Studies of key concepts in adaptation that highlight adaptive capacity (Engle 2011) and vulnerability (Hinkel 2010) provide a further evaluation of the adaptation process. 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 identify mitigations targets of vulnerability, 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. These and other recent contributions in the literature (Adger et al. 2009, 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.

15.2.2. International, National, and Local Assessment

Despite significant growth in adaptation planning since the last IPCC report, there is concern about the lack of information available about its extent and effectiveness. The results of some studies suggest this is a legitimate concern. The situation in the UK, one of the countries with a larger experience of adaptation planning, illustrates this point. The UK has made an effort to create capacity for adaptation, particularly in public sector organizations during the last decade (Tompkins et al. 2010). However, from the evidence reviewed, capacity-building is not yet systematically translating into tangible action on the ground to reduce the UK's vulnerability to climate change (Biesbroek et al, 2010). By the same token, Tompkins et al. (2010) question weather 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. They suggest that in the context of adaptation planning, there is no evidence to show that adaptation planners are working towards transitions. It is also worth noting that despite the growth in adaptation plans and strategies at the national and subnational level in developed and developing countries, adaptation is still a pending task in many developing countries.

15.2.2.1. International Mechanisms for Supporting Adaptation Planning

The most significant international mechanisms to promote adaptation planning in developing countries is the National Adaptation programmes of Action (NAPA). It was created in the seventh Conference of the Parties to the UNFCCC (COP 7) in 2001. To date, 47 countries submitted NAPs. COP 7 also established specific funds for assisting the Least Developed Countries in managing the impacts of climate change (the LDC Fund), and the first step of this assistance was the funding of NAPA. Guidance for NAPA preparation was developed by the Least Developed Countries Expert Group (LEG). The roles of and key lessons from NAPA are presented in Chapter 14 and the following sections of this chapter.

Another international mechanism is for funding to assist developing countries with their adaptation planning and implementation. As this issue is also assessed in Chapter 14, only a rough sketch of the assessment is presented here. Least Developed Countries were supported via the GEF resources to prepare NAPAs prioritizing their immediate and urgent adaptation needs. However, funding to take action on these needs was slow to come, and many governments were reluctant to move ahead without external support. The NAPAs were, in most countries, excellent opportunities to build technical capacity and institutional links, but with the long delays in moving to an implementation phase, many of these skills dissipated. However, recently there has been a significant increase in financial flows with replenishment of the GEF adaptation funds (LDCF & SCCF), support for the Pilot Program for Climate Resilience, and special purpose adaptation funds for UN Agencies, MDBs and major bi-lateral funds earmarked for adaptation. The Adaptation Fund set up under the Kyoto Protocol is of particular importance to developing countries as it is pioneering the direct access mechanism which allows countries to access funds without having to work though a multi-lateral development agency. This mechanism has again bought home the need to build and maintain capacity, not just in the technical aspects of adaptation assessment and project design, but also in financial management and due diligence. The Cancún Agreement in 2010 calls on developed countries to provide new and additional resources for climate actions, but with the share going to adaptation still undetermined. While efforts to integrate climate change adaptation will be led by developing country partners, international donors have a

critical role to play in supporting such efforts, as well as in integrating consideration of adaptation within their own plans and activities.

Regional and NGO coordination

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 very limited. For example, the Western Climate Initiative – a state-coalition including Arizona, New Mexico, Oregon, California, Utah, Washington, and Montana (as well as four Canadian provinces) to date has also agreed to work jointly to identify measures to adapt to climate change impacts (Pew Centre 2009). In some instances, states are collaborating on sector-specific issues that concern them regionally. For example, in the American West, water managers are collaborating and sharing information regionally. 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, Read, and Scavia 2009).

Multilateral agencies such as the World Bank have been developing mechanisms to integrate or mainstream climate change in their project planning (Burton and van Aalst, 2004). This has led to the systematic examination or 'portfolio screening', of an agency's set of policies, programmes 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).
Frameworks have been developed to evaluate adaptation in the context of development paths. The most comprehensive such frameworks currently available are those associated with the Pilot Programme for Climate Resilience (PPCR) and the Adaptation Fund (AF) (Brooks et al, 2011). 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, and is potentially more able to accommodate issues of transformational change. Both the PPCR and AF frameworks are built on previous programs to assess vulnerability and mainstreaming.

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). Since 2008, the number of adopters have increased from 200 households in the first year to 1,300 households in five villages and four crop varieties in 2010. 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 at the cross-national regional scale in the Caribbean through the Caribbean Catastrophic Risk Insurance Facility (Pulwarty et al, 2010).

15.2.2.2. National Adaptation Plans

National adaptation responses have diverse process and outcomes in developed and developing countries. The experience of UNFCCC's NAPAs (National Adaptation Programmes of Action) illustrates some of the adaptation responses in developing countries. Established in 2001, the National Adaptation Programme of Action (NAPA) is an organized planning process for adaptation (Ciplet *et al*., in press). By allowing Least Developed Countries to identify priority actions regarding adaptation to climate change, a 'new approach' is being created that would focus on enhancing adaptive capacity to climate variability. This would help address the adverse effects of climate change. As of November 2010, forty-five NAPAs were received by the UNFCCC Secretariat. In terms of sectorial priority, it appears that food security, terrestrial ecosystems and water resources are respectively the three sectors that gather the highest number of projects, amounting to a little more than 50% of them.

NAPAs are required to engage local stakeholders in the NAPA process, and take into account existing coping strategies at the local level, building upon them to identify priority activities for which further delay could increase vulnerability or lead to higher adaptation costs at later stages. The Stringer et al (2010) study of NAPAs in four African countries illustrates how they are attracting the support of a greater range of actors. But they find the

linkages between development and adaptation should be made more explicit. For them, adaptations like livelihood diversification to reduce vulnerability have long been taking place at local and policy levels in each of their case study countries. Their results show people do not adapt only to climate change but they aggregate the result of multiple drivers, needs and aspirations operating over myriads of time and spatial scales. They also find the enthusiasm for broader participation in the rhetoric of international politics does not yet match the realities of its enactment on the ground. The Agrawal (2008) study of NAPAs 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. Agrawal and Perrin (2008) suggest the idea 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*).

Despite the fast growth of the adaptation literature mentioned above, only few articles in the peer-reviewed literature have studied national adaptation strategies. At a regional level, only Europe has a regional effort to encourage adaptation to climate change. The European Commission provides a structure supporting the creation of national adaptation strategies (Commission of the European Communities 2009). The Biesbroek et al. (2010) study of 7 national adaptation strategies in Europe considers these strategies to represent a new political commitment to adaptation at national political levels. However, this study also recognizes many institutional challenges that can act as considerable barriers in future policy implementation. The review of national adaptation strategies in other countries in the gray literature (e.g., Australia, Brazil, Mexico) shows the national level enhances the importance of adaptation in the political agenda, and creates a coordination framework for subnational actions or by economic sectors (Council of Australian Governments 2007, Gobierno Federal 2010). It also shows different approaches in the national strategies. For example, the Australia Climate Change Adaptation Framework (2007) has two practical objectives: building understanding and adaptive capacity, and reducing vulnerability in key sectors and regions; abd supporting decision-makers during the next 5 to 7 years (Council of Australian Governments 2007). In contrast, Mexico seeks to create a comprehensive framework for subnational and sectorial actions (Gobierno Federal 2010).

There is a diversity of approaches to adaptation strategies, but it is not clear yet how far the current strategies foster and coordinate subnational adaptation planning and policies. Most strategies can be regarded as just the start of a policy process rather than its culmination (Hulme et al. 2009). This is a challenge for the planning process that needs to consider short-term and long-term goals, and multi-scale interdisciplinary approaches. Norman (2009) highlights the importance of intergovernmental and multidisciplinary approaches integrating science and spatial planning as an efficient approach to address conflicts within adaptation, and between adaptation and mitigation. Unfortunately, few studies in the literature document or analyze these issues. Among them, the ADAM project in Europe considers most barriers to actual adaptation appear to be related to policy co-ordination and implementation (Hulme et al. 2009). Particularly challenging is multi-level coordination within the public sector, between the public sector and other sectors in society, and multi-level governance in developed and developing countries.

15.2.2.3. Local Adaptation Plans

Adaptation at the subnational level described by the peer-reviewed and gray literature documents a growing number of plans at the state, provincial, urban and community level. There is, however, a similar situation as discussed above at the national level. Attention has focused on describing the need, creation, and content of adaptation plans, and less on analyzing their extent and efficiency.

Communities at a variety of scales have begun assessing their physical vulnerabilities with of sub-national planning on adaptation being undertaken (West and Gawith 2005; Moser, 2005). These include state studies in Australia; provinces/territories in Canada (e.g. Lemmen et al 2007) and; state studies in the US (Pew Centre 2009; USGCRP, 2009). In many cases these follow three categories of low-regret options that integrate across the research in disaster management and climate adaptation:

i) Measures that reduce current climate vulnerability.
ii) Measures with co-benefits or measures to manage non-climate risks.

iii) A portfolio of options that broaden the coping range/choice and flexibility to respond to emergent events and potentially critical transitions.

Local governments have proven to be especially critical for implementing adaptation given their responsibility for providing infrastructure, preparing and responding to disasters, developing and enforcing planning, and connecting national government programs with local communities (Huq et al , 2007; UNISDR, 2009).

Several U.S. states began to address and plan for the impacts of climate change through federal financial and technical assistance to assess impacts and vulnerabilities (see, e.g., Moser 2005; 2010 USGCRP, 2009). To date eleven US states have launched comprehensive assessment and planning efforts parallel to their mitigation activities – Alaska, California, Maryland, Oregon, Florida, Washington, Massachusetts and New Hampshire Most of these plans follow templates which include features such as: Identify risk; Identifying main climate change impacts to project/unit of analysis; apply future climate change scenarios; characterize adaptation options; evaluate options: e.g., benefit and cost analysis; and develop implementation plans, including timeframe (e.g. Rosenzweig et al. 2007). The climate change risks most frequently addressed in existing studies are associated with sea-level rise, health and water resources. Urban areas, where many adaptation implementation cases are occurring have focused more on expected biophysical impacts than on socio-economic impacts and have not had a strong focus on vulnerability and the associated susceptibility or coping capacity. Two cities—London and New York—are relatively advanced in the assessment of climate risks and adaptation (Hunt and Watkiss, 2011). The majority of efforts appear to be single-issue with sea level rise and heat waves being the most common.

For most countries and subnational administrative units (e.g. states, provinces, communities) involved in implementation, development and adaptation are inseparable. Aligning adaptation with sustainable development goals, including disaster risk reduction has been identified as increasingly critical (UNDISR, 2011; IPCC, 2012). For instance despite the intention that city adaptation responses aim at an integrated approach, they tend to have sectoral responses, with limited integration of local voices. Despite these limitations, some less developed countries are in the forefront on adaptation. Bangladesh, which is especially vulnerable to sea level rise and tropical cyclone activity, has committed the equivalent of tens of millions of U.S. dollars toward development of a national adaptation strategy. In the rebuilding efforts along the Gulf of Mexico after hurricanes Rita and Katrina, extreme weather events, climate variability and climate change have risen in people's awareness. To some extent, important bridges and highways damaged in Katrina are being rebuilt at significantly higher elevations (though whether climate change and accelerated sea-level rise or the hurricane was the primary driver behind that decision is unclear, Savonis, Burkett and Potter (2008, p. 5-9).

Although many states have yet to formally address climate change preparedness within state government, a number of these states have existing water, energy agricultural, environmental and other policies or programs, such as water conservation or efficiency, that if recognized within the context of climate change, have shown to be beneficial. In many cases even where there is a good understanding of the impacts, the implementation of policy and outcomes on the ground appear limited (Bulkeley, 2006; Burch and Robinson, 2007). The Alaskan case has been well documented in the literature including and since the AR4. The experience in Alaska to date suggests that, even when adaptation is urgently required to protect life and property, the needed action is agreed upon, and initial funding is available, current institutions may be ill-equipped to implement adaption responses. Instead, current efforts are directed toward continued planning and protection of existing infrastructure until the relocation can be initiated.

Within countries primary and large cities exert individual independence, while smaller municipalities depend more on higher levels of the government units, and often form associations to pool their resources (Lundqvist and Borgstede, 2008). In the latter case, state mandated programs and state-generated grants are the main incentives to formulate mitigation policies (Aall et al. , 2007). It is also becoming more important within planning to highlight the interdependencies that exist between the inhabitants of the city, its immediate hinterland, and the wider, global, economic and social context. Thus, for example, cities such as London or New York are reliant on food imported and transportation networks from surrounding rural areas and even from other countries.

Aligning local climate adaptation policies with the state/provincial and national/federal units and having national plans informed by local priorities are significant challenges for local governments (Roberts, 2008; van Aalst et al. 2008; UNSIDR, 2011). The history and process of governance especially regarding centralized and decentralized

needs have been to shown to be significant in ensuring capacity of the local government to formulate and implement adaptation policies. While government actors play a key role, it is evident that partnerships between public, civic, and private actors are crucial in addressing climate hazards-related adaptation (Agrawal, 2010). Challenges of adaptation decentralization stem from the complexity and uniqueness of each locality that policy planners often fail to take into account because of the lack of understanding and consultation with the local community (Geiser and Rist, 2009; Ribot, 2010). Problems of absolute local controls involve uneven standards and evaluation metrics and the potential control of processes by local elites further marginalizing some groups (IPCC 2012; Moynihan 2009) and others illustrate even hierarchical disaster management structures, such as the incident command system in the U.S., operate on the network principles of negotiation, trust, and reciprocity illustrating the importance of networked collaboration and providing sufficient time for the process to take hold.

Urban areas

The peer-reviewed and gray literature reports a growing number of adaptation plans at the local level. Urban areas are the locus of a number of those planning initiatives (Blanco and Alberti 2009, Corfee et al. 2010, Hamin and Gurran 2009, Lowe et al. 2009, Parzen 2009, Roberts 2008, Sanchez-Rodriguez et al 2009). This includes special issues in some academic journals (Habitat International vol. 33 2009, Current Opinion in Environmental Sustainability vol. 2 2010 and vol. 3 2011). The gray literature also documents a growing number of adaptation plans to climate change (New York, 2012; Chicago, 2012; King County in Washington State, 2012; London, 2010; Toronto Environment Office, 2008; Rotterdam, 2012; Mexico City, 2008; Zambrano-Barragán et al., 2010; Cartagena and San Andres de Tumaco in Colombia, 2005; Durban, 2012; Cape Town, 2006). They provide interesting early lessons potentially useful to other cities. Note that this list of urban areas is intended for illustrative purposes in this review. It is difficult to determine how many urban areas have created climate change adaptation plans.

One of the most interesting aspects of recent contributions of adaptation to climate change in urban areas is the growing attention to the situation of middle and low-income countries (Blanco 2007, UN-HABITAT 2011, Agrawala and van Aalst 2008, Ayers 2008, Bartlett 2008, Caney 2008, Moser and Satterthwaite 2008, Revi 2008, Roberts 2008, Stren 2008, Tanner et al. 2008, O'Demsey 2009, Hardoy and Pandiella 2009). Urban areas of developed countries have been pro-active in creating adaptation plans during the last decade, but urban areas in developing countries have only recently begun to address adaptation to climate change. There are only a limited number of urban areas in developing countries with adaptation plans so far.

Literature on adaptation planning in urban areas has begun to document difficulties in adaptation planning and implementation. The Vammen Larsen et al. (2012) study on the municipalities in Denmark and Mozumder et al. (2011) study on local adaptation in Florida illustrate the difficulties to create efficient interdisciplinary planning approaches in developed countries. Anguelovski and Carmin (2011) suggest few urban areas have the resources and know-how to institutionalize adaptation planning in developing countries. There is also the problem of multi-scale coordination and support among national, state (provincial), and municipal governments to foster adaptation planning at the local level. These problems appear to be more prominent in small and medium size urban areas. The review of the literature also suggests a divide between resources and adaptation plans in major urban areas and those in smaller urban areas. Major urban areas like New York, London, Rotterdam, and Chicago have created multidimensional adaptation plans in cooperation with local academic institutions (Parzen 2009, Lowe et al. 2009). Few smaller urban areas in developed and particularly in developing countries have been able to create similar adaptation plans (Ayers 2008, Roberts 2008, Tanner 2008). It is also worth noting the large number of urban areas that have not considered adaptation planning yet.

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. Ford et al (2011) examined reports of 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. 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 (Picketts et al. 2012). 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. Without broader stakeholder agreement at the local level, successful implementation was 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. Using this approach, 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 2011). Indigenous Arctic communities are providing systematic observations of climate change impacts, which complement scientific data and frame local efforts to adapt.

15.3. Adaptation Implementation

15.3.1. Strategies and Approaches

15.3.1.1. An Overview

There are many strategies and approaches to climate change adaptation. Strategies include decreasing vulnerability (to lessen exposure to impacts), increasing resilience (the ability to absorb or ride out impacts), increasing adaptive capacity, and/or decreasing the risk of impacts (decreasing the probability of occurrence) (Few et al. 2007). So-called 'win-win strategies' couple the need for adaptation with developmental needs or improvements in disaster risk reduction. Decreasing risk, especially for high-income nations, has been planned 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, Rosenzwieg et al. 2011). In the case of flood risk planning in the UK, government policies have made 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 find funding for infrastructure-related plans, implementation of top-down approaches can require numerous legislative and executive actions (Wheeler 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 was 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 (Pelling, 2011). Because impacts to climate change occur at the local level, and because infrastructure-

based adaptation plans are costly and may be hampered by institutional inertia, community-based adaptation is becoming a popular approach to implementing climate change adaptation (Ensor and Berger, 2009). Community participation in adaptation planning appears to be more common in developing countries where community level planning is more common (Ford et al., 2011). Because climate change impacts occur locally, the scale of community engagement has been critical to the success or failure of adaptation programs. Without broader stakeholder agreement at the local level, successful implementation was not possible as mentioned in 15.2.2.3. Although some community adaptation plans are only small steps toward addressing climate change impacts, even 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.

15.3.1.2. Disaster Risk Management and Adaptation

A no-regrets 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). 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 that can duplicate efforts, and there must be an effort towards better coordination. 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, a different strategy of including DRR, through 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 often fail to account for the differing spectrum of threats, and time and spatial 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 are not addressed by risk management.

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. Before modern times, the inhabitants were semi-nomadic, a successful adaptation strategy for living within the variable environmental conditions of the arctic regions. Currently, the village and island where it is situated are experiencing increased flooding and high rates of coastal erosion that is linked to climate change (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 a relocation (Marino 2011). Disaster prevention and recovery aid from the U.S. government cannot provide assistance for the migration needed, because recovery funds are tied to rebuilding infrastructure in the same location where a disaster has occurred. Because the current objective of FEMA (US Federal Emergency Management Agency) is to rebuild in place without upgrades in infrastructure, it cannot adequately address disasters that are linked to climate change (Marino 2011).

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. Semarang coastal communities in areas of flooding have received government financial assistance to make their homes more resistant to flooding impacts. Some families, who own their land, are not abandoning their homes even when flooding becomes an everyday occurrence (Harwitasari and van Ast 2011).

15.3.1.3. Adaptation, Development, and Ecosystems

International organizations emphasize the important relation between adaptation to climate change and development in that process (OECD 2009, UN-HABITAT 2011, UNEP 2010, UNDP 2005, World Bank 2010). Boyde and Juhola (2009) also express concern over how the debate of climate change is dominated 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). Linking development and adaptation reduces the risk of unintended consequences of adaptation, and facilitates its acceptance by decision-makers at the subnational and national level. 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 (Sovacol et al. 2012).

Adaptation efforts in Bangladesh, Cambodia, Bhutan, and the Maldives that are linked to development funding provide a 'win-win' adaptation strategy that improves resilience to climate change while improving economic stability and environmental quality. Even though the amount of money 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 (Sovacol et al. 2012). The holistic approach afforded by linking adaptation to development, by coupling adaptive improvements in infrastructure with governance and community welfare, improved community resilience by enhancing local ownership, and created organizations able to respond to climate change issues through increased adaptive capacity. Related climate change adaptation efforts also improve ecosystem resilience by implementing sustainable forestry quotas, expanding floodplain setbacks, implementing coastal aforestation, 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, all of which are necessary for the resilience of communities facing climate change impacts (Sovacol et al. 2012). Increasingly, the good practices of planning and implementing 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.

Integration of climate change into other policy areas aims at protecting citizens and nature, and making economic activities less vulnerable by appropriate and proportionate adaptation measures. 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 environment (e.g. roads, bridges, electric wires), land-use management, and greening of cities (Refs).

Low cost behavioural 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 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 institutions (Raschky 2008). Blanco and Alberti (2009) suggest adaptation planning for climate change will need to rely on an emerging interdisciplinary scientific field, which couples human and natural systems and their interactions. 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.

Market-based arrangements have shown 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 has allowed national economies 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.

Index insurance is one mechanism that 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).

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 (Hardee and Mutunga 2010, Lemos et al. 2007, Sietz 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.

15.3.1.4. Stakeholder Participatory Approaches

Fairness in adaptation requires considering the distribution of adaptation benefits, costs, and residual climate impacts across regions, sectors, and population groups (Adger et al., 2006). Thomas and Twyman (2005) highlight the fact that climate change does not occur independently of other social processes. They call attention to how the interface between climate change and development processes can exacerbate existing inequalities. It is worth noting that despite the fact that social change is a central element of development, there is perhaps not enough 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 identified. Stakeholder participation is also an important tool for recognizing social and cultural barriers to adaptation. 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 downscaled climate change scenarios based on IPCC projections that have been used to integrate climate change impact scenarios in local decision making processes (Schmidt-Thomé and Kaulbarsz, 2008; Gawith et al., 2009; Romanenko et al., 2007). One such example, in the Baltic Sea Region, included two projects referred to as the '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 SEAREG project team consisted of natural scientists (geologists and meteorologists) social scientists and planners. The resulting communication process produced a set of tools referred to as the '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). Initially, it was difficult for the project to make meaningful contacts with stakeholders from the target area, in part because of the long time-range of climate change scenarios. However, when a winter storm struck the Baltic Sea Region in January 2005 that led to record sea-level and storm-surge heights, stakeholder participation increased significantly. 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, 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).

15.3.2. Adaptation Tools and Decision Support

15.3.2.1. Science Supporting Adaptation Planning and Implementation

Global climate change imposes new stresses on natural and socio-economic systems. It occurs both temporally and spatially, and there is a considerable degree of uncertainty in the dynamic process (IPCC, 2007). This requires adaptation planning and implementation to take place in a dynamic form on local, regional or global scales. In order to make adaptation follow the right pathway in complex human-natural world coupled systems, a chain of appraisal and adjustment, and complex management and governance processes, need to be implemented (Moser, 2009). The degree of feedback of a human-natural world system to climate change for planned adaptation measures is the major indicator of concern. If the feedback is direct and strong, significant adjustments in adaptation measures need to be made. In contrast, indirect and weak feedback provides a justification for the measures planned (e.g. Berkhout et al., 2006). By doing so from time to time, desired adaptation measures for complex human-natural world coupled systems can be selected.

It has long been recognized that adaptation is embedded within a process of social learning process (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 in the US 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 Australia a national fund was established to incentivise adaptive behavior and innovation within states. In addition, the Australian version of the National Science Foundation was reorganized as an interdisciplinary program to support research on system solutions and applied research to support adaptation implementation through the NCCARF – National Climate Change Adaptation Research Facility.

This is illustrates a deliberate attempt to facilitate the "mainstream" climate change issues into policies and programs while ensuring the inclusion of best available knowledge as it arises.

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 and implementation of regional adaptation planning and implementation in the Caribbean. The 5Cs is now fully functional, 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, at the University of the West Indies. The 5Cs has also been recognised by the United Nations Institute for Training and Research (UNITAR) as a Centre of Excellence. Similarly, the Pacific Island states have traditionally taken a regional approach to addressing development issues through various intergovernmental organizations, including: The Secretariat of the Pacific Community (SPC) including its Applied Geoscience and Technology Division (SOPAC); The Secretariat to the Pacific Regional Environmental Program (SPREP); and the Pacific Islands Forum; among others.

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 & Scott, 2008; Rodima-Taylor et al, 2011).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, Foster, and Winkelman 2009). ICLEI, a non-profit network of more than 1200 local government members across the globe provides web-based information (www.iclei.org) in support of local sustainability efforts using customized tools and case studies on assessing climate resilience and climate change adaptation. By working with several pilot communities, the ICLEI organization developed its Climate Resilient Communities™ Program, which now appears to have expanded its efforts. Most notable is ICLEI's collaboration with King County, WA and the University of Washington's Climate Impacts Group to develop a procedural guidebook for local, regional, and state governments on how to begin preparing for the impacts of climate change (Snover et al. 2007).

Typically conducted in collaboration with locally-based university researchers and consulting teams, most of these adaptation plans initially focus on few high-risk areas. 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; Rodima-Taylor et al, 2011; Mimura, 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 interjurisdictional partnerships, and the existence of a supported collaborative framework between research and management:

- Developing a mixed portfolio of research products, stakeholder and vulnerability assessments, and communication approaches and applications
- Performing basic and applied research on local climate dynamics impacts, and information prototypes relevant to stakeholder interests
- Supporting 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). 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.

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.

15.3.2.2. Monitoring, Modeling, and Spatially Integrated Tools

The use of a (computerized) 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 human-natural world coupled systems can achieve efficient, effective and equitable adaptation to global climate change. Monitoring and modeling systems are the essential forms of computer-aided decision support tools for assessing climate change impact and adaptive options. Using data extraction and retrieval functions, monitoring systems provided an effective means for issuing early warnings about potential environmental hazards resulting from climate change (e.g. Alter, 2004). In addition, the complex, multi-scale, interdisciplinary nature of climate change impact on human-natural word coupled systems has made the computer-based modeling approach a robust tool for understanding the evolving processes and the future conditions of the systems (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 to a much higher level (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. As a result, much more powerful, process-visual and spatially implicit decision support systems have been developed. A typical 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). This system provides not only an instant monitoring of the spatial-temporal variation of river channel flow across the whole drainage basin, but also choices for regulating the use of water resources when river channel flow reaches a critical state of drying up. 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).

15.3.2.3. 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). The Invasive Species Forecasting System (ISFS) (Stohlgren et al., 2005) and the Yellow River flow control system (Li and Li, 2009) outlined earlier are typically top-down based tools.

In the *bottom-up* tools, a large number of stakeholders or actors make their own 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. These tools show the degree of acceptance of all stakeholders on adaptive options and the spatio-temporally aggregated patterns of climate change impacts so as to yield the most acceptable adaptive options. 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 parts of the system. As

a result, top-down based tools may yield adaptive options that cannot be accepted by most individuals, while bottom-up based tools may select adaptive options acceptable to most individuals but non-beneficial for significantly minimizing the impacts to the whole system. There has so far been no one tool that suits all circumstances of adaptation decision making, and the specification of the problem and the available 'inputs' to the decision process may provide a choice of a suitable tool (Gimblett, 2002).

15.3.2.4. Synthesis Reports

Extensive interdisciplinary syntheses of technical information on climate change impacts and adaptive options are able to yield convincing assessment reports (Pyke et al., 2007). This is reflected by the most well-known assessment reports of the Intergovernmental Panel on Climate Change (IPCC, 2007), 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 Assessment products. These reports are explicitly designed as decision support resources for policy makers (Mahoney et al., 2001).

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).

15.3.2.5. Insurance and Social Safety

Climate change can bring about severe risks to societies, making a certain number of workers lose jobs and many households fall into poverty. Provision of insurance may allow these people and households to recover quickly and encourage them to adopt new techniques so as to increase assets in a short period. 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).

Damage to households caused due to climate change, however, normally occurs over a wide range. and small localized insurance companies may easily become bankrupt when a large area encounters severe climate changes. For this reason, governments at all levels need to develop special markets so as to allow these insurance companies to operate (Huber, 2004).

15.4. Capabilities for Adaptation Planning and Implementation

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

There is growing recognition that adaptation planning is an essential element to reduce the negative consequences of climate change and to take advantage of its positive impacts (Ayers and Huq 2009, Wilbanks and Kates 2010, Ford et al. 2011). However, there are a number of challenges and obstacles to normalize adaptation planning on the regional, national and local scale in a large number of countries. One of the most significant challenges is to 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. It will also require the participation of informal institutions through interactions among stakeholders according to cultural, social, and political conditions in societies (Carmin et al. 2012).

Chapter 14 describes the importance of these institutional arrangements for adaptation to climate change. It recognizes tangible resources are important for adaptation, including those associated with strong governance measures (institutions, networks, and civil and political rights) that contribute to the adaptive capacity of nations, regions, cities, and communities. Institutional arrangements can also promote long-term sustainability of adaptation activities, and reduce future remedial costs from maladaptation, poor decision making tools, and mismatches in development trajectories. Assessment in Chapter 14 of the international literature highlights that adaptation planning can be integrated into national subnational policies and plans using existing institutional structures and processes. But it also identifies that this integration requires adequate political support, resources, capacity, and reliable climatic information. This chapter assesses how far 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.

15.4.1.1. Institutional Capacity of National and Local Governments

The review of the 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 (Tompkins et al. 2010, Huntjens et al. 2012). In the context of adaptation planning, there is no evidence to show that adaptation planners are working towards transitions. Instead, those embarking upon adaptation policy planning often start with an assessment of what is currently taking place (Tompkins et al. 2010).

Other literature provides a more comprehensive perspective of institutional arrangements for adaptation planning. 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. They propose a robust and flexible process through institutions and policy processes that continue to work satisfactorily when confronted with social and physical challenges, and they are capable of changing at the same time. It relates also to the need to foster transitions in the adaptation process from actions focusing on specific targets to creating deeper systematic change in public and private organizations mentioned in the introduction of this section. Systematic changes are important to create adaptive institutions capable of managing complexity and uncertainty which are needed for successful governance of adaptation to climate change (Pahl-Wostl 2009; Tompkins et al. 2010, Huntjens et al. 2011, Huntjens et al. 2012).

The literature highlights the importance of institutional arrangements at the local level. Climate adaptation is uniquely linked to location, and it is often a responsibility of local governments, stakeholders, and communities (Mattew et al. 2012). Along those lines, Carmin et al. (2012) recognize the importance of developing regulations, policies, and codes to support the institutionalization of local climate actions. Their research in Durban and Quito shows the benefits of linking adaptation to local development initiatives. They found adaptation was seen as a means to set out the development path of cities promoting sustainability and resilience, and at the same time addressing the projected impacts of climate change. However, even in the positive examples mentioned above, the institutionalization of adaptation planning is a complicated process. 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.

The experience of other local governments illustrates the difficulties of institutionalizing adaptation planning. 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. This is in response to the Green Paper of the European Commission that requires the integration of climate-proofing into the Strategic Environmental Assessment Directive. The study showed the current structure of the municipal organization represents an obstacle to the institutionalization of climate change. That structure 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 no national requirements or guidelines to help local governments integrate climate change into spatial planning. The lack of national guidelines is also reported in a recent study in Norway (Amundsen et al. 2010). The support of multilevel institutional arrangements to help local governments incorporate adaptation into their planning processes is relevant given the interdisciplinary nature of adaptation planning and the coordinating role local governments need to assume in that process. 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. The authors highlight that institutions governing in a void will lack resources and legitimacy, and will therefore lack the capacity to govern. For them, the institutionalization of climate change integration has begun. but it is unknown whether the municipalities will be successful in developing the governing capacity needed.

By the same token, Tompkins et al. (2010) study climate change adaptation in the United Kingdom. They consider a broad range of adaptation actions, from small adjustments to creating deeper systematic change in public and private organizations. They find that adaptation in the UK has been dominated by government initiatives but with little real evidence of climate change adaptation initiatives trickling down to local government level. A key question for Tompkins and coauthors is 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. Although they believe it is too soon to evaluate the results of adaptation actions, the authors consider the transition to a deeper systematic change 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. They recognize current work emphasizes iterative learning and stakeholder participation, rather than the broader political context, or the agendas driving the change. In the context of adaptation planning, they find there is no evidence to show that adaptation planners are working towards transitions.

15.4.1.2. Role of Spatial Planning

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). Institutional arrangements are particularly relevant for planning. Biesbroek et al. (2009) stress spatial planning coordinates the different relevant socio-economic objectives and desires, and it is often seen as a holistic approach 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. They suggest the link between climate change and sustainable development has fostered new transdisciplinary approaches for mitigation and adaptation to climate change. Transdisciplinary approaches could create opportunities to foster changes in formal rules and informal codes of behavior in societies. By the same token, 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. Social learning is particularly relevant to this discussion. It is an important but under-investigated feature of planning and policy processes, and a particularly critical goal in the adaptation of innovations (Holden 2008). Attention to build a better understanding of how and why social learning occurs in different contexts will contribute to build more efficient adaptation planning initiatives. Holden (2008) suggests this knowledge is needed to improve the impact factor of plan and policy changes, to improve the transferability of 'best practices,' and to bolster public support and engagement in public affairs. However, she highlights that although learning is central to planning theory and practice, there is no coherent theory of learning within the planning process. She suggests the challenge that social learning attempts to address is how democratically engaged communities may engage productively and effectively with large scale social problems that require the involvement of multiple institutions, expert knowledge and political will to articulate, debate and ultimately solve. This is the type of systematic changes needed to strengthen adaptation planning.

Providing spatial planning a bigger role in institutionalizing adaptation planning at the local level will require the participation and cooperation of a multitude of sectors to avoid potential conflicts (Juhola and Wesrerhoff 2011). The Anguelovski and Carmin (2011) study on institutions on urban climate governance provides contributions along those lines. Their study 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 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.

This issue emerges as a serious problem in the literature. 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. These results are consistent with those in Europe mentioned above. Koch et al. (2007) suggest constraints relating to capacity, lack of awareness and poor information flow need to be addressed. They also demonstrate how adaptation challenges the hierarchical manner in which government works, and a more collaborative approach to climate change adaptation is needed. For them, adaptation needs to be mainstreamed, and institutional networks need to be strengthened in order for adaptation mechanisms to be effectively implemented.

15.4.1.3. Institutional Arrangements and Disaster Risk Reduction

One of the areas where institutional arrangements for adaptation planning can be particularly relevant is the coordination with disaster risk reduction (DRR). The rapid growth of climate-related hazards and disasters in developed and developing countries fostered the creation of emergency response organizations at the national and subnational level. The urgency to address disasters makes this a relevant topic for societies and facilitates the connection with climatic events. It is an area where decision-makers seek a better understanding of present and future risks and their consequences for development. This is also an area where spatial planning could play a major role building bridges between DRR approaches and adaptation planning. It can play an important role in reducing vulnerability, establishing incentives and opportunities to foster the development of adaptive capacity, and establish protocols for decisions (Agrawal and Perrin 2008, Agrawal 2010). However, the international literature reports little progress has been made integrating DRR and adaptation into climate change at the national 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 DRR. New institutional arrangements would need to bridge the divide between adaptation and DRR, particularly in terms of legislation, operational and management structures, working agendas, and time horizons (Schipper and Pelling 2006; Birkmann and Teichman 2010, Falaleeva et al. 2011).

The interaction between adaptation planning and DRR is particularly important at the local level. Storch and Downes' (2011) study of current and future city-wide flood risks to Ho Chi Minh City in Vietnam 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. It defines a better understanding of the relationship between future urbanization and climate change impacts、 and elements for sustainable adaptation. However, it is not clear how far these results are or will be used to improve institutional arrangements for adaptation planning at the local level.

15.4.1.4. Enhancing Institutional Capacity

A number of other urban areas have created climate change adaptation initiatives. Many of those urban areas have started those initiatives motivated by the potential risk of climate change impacts (Bierkman et al. 2010, Rosenzweig and Solecki 2010, Carmin et al. 2012). Section 15.2.2.3 of this chapter listed a number of examples of these adaptation plans. Anguelovski and Carmin (2011) show local governments tend to formalize and institutionalize their adaptation strategies through the establishment of dedicated climate units or as crosscutting units often at the Mayor's office. Although it is difficult to evaluate adaptation plans developed by urban areas due to their recent

creation and implementation, there are two considerations that can be extracted from them. These cases illustrate the importance of political support from key local decision-makers for the institutionalization and mainstreaming of adaptation planning. This support is also essential to: facilitate the coordination of adaptation policies across sectors and departments, to convene the participation of stakeholders, and to foster collaboration among public, private, scientific and social organizations.

It is difficult to predict the sustainability and efficiency of the formalization of these institutional arrangements. The experience of cities in the U.S. is peculiar given the fragmentation of government structures in that country, but the long-term institutionalization and mainstreaming of adaptation planning in cities of other countries will likely need support from national governments, particularly to foster institutional arrangements. This is particularly relevant in the case of developing countries where local governments lack economic, human, and technological resources to design and implement adaptation planning. For example, Berrang-Ford et al. (2011) found that upper levels of government, particularly national governments, often used institutional mechanisms such as laws and policies to foster adaptation at the local level. Other literature shows national governments are also important to establish horizontal networks that promote information-sharing (Westerhoff et al. 2011), or to facilitate the coordination of budgets and financing mechanisms (Alam et al. 2011; Kalame et al. 2011).

But new polices or plans require municipal commitment to change traditional modes of operation in public organizations. Focusing on achieving a better understanding of the motivations for changing behaviors, or a better explanation of what drives organizations and stakeholders to initiate institutional adjustments, will contribute to strengthen adaptation planning (Carmin et al. 2012).

The diffusion of knowledge, information, and ideas can foster some of these changes. Networks can operate as a means through which institutional rules and norms are diffused, and they can facilitate new forms of action. Carmin et al. (2012) recognize exogenous forces (international, regional and national) can lead to institutional change in certain local responses to climate change (mitigation) in urban areas. But they consider these forces have a limited impact on climate adaptation. For them, the recent emergence of adaptation to climate change as a new policy domain has not been translated yet into best practices or models to emulate or guide concrete actions in other urban areas. For them, an endogenous driving force for change is a local champion. For example, a local champion, often the mayor or other public official, has been a key driving force behind the recent creation of local adaptation plans in several urban areas such as New York, Chicago, Mexico City, Quito, London, and Durban.

The international literature has also considered the role of communities in adaptation to climate change. Chapter 14 showed communities have a long history of participating in vulnerability assessment and risk-mapping that has been carried into adaptation initiatives as a means to identify climate-related hazards and risks (Van Aalst et al. 2008). Frazier et al. (2010) explore stakeholder participation in the context of coastal hazards. They identified differing views and interests among stakeholders regarding adaptation strategies. They found also that adaptation planning tends to be more difficult in areas that lack recent disaster experience. Mathew et al. (2012)'s study on climatic hazards in Kochi, India, describes the benefits of defining adaptation options in consultation with local authorities. However, the international literature has not yet given much attention to institutional adjustments in community-based adaptation planning.

Other authors have studied the role of the business community in adaptation planning. Howe (2011) considers the adaptive capacity of businesses vary with the types of business, location, and socio-cognitive characteristics of business owners. He believes business preparedness is an important element building community resilience to climate change. Tompkins et al. (2010) point out that although they support some economists who suggest adaptation will occur spontaneously through marginal adjustments in markets and individual behavior, there are good reasons for public policy intervention. But the perspective put forward by the Stern Review suggests market forces are unlikely to lead to efficient adaptation. 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 (Tompkins et al. 2010).

The literature reviewed in this section highlights the importance of institutional arrangements for adaptation planning. The literature suggests initial steps have been taken in this direction in some local and national governments in developed and developing countries. Although it is too soon to evaluate these initiatives, it is clear this is an area that requires more attention by the international community, and national and local governments. The literature review identifies a number of obstacles to foster changes in institutional structures, and modes of operation to foster systematic changes needed for long-term and flexible adaptation approaches.

15.4.2. 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.

15.4.2.1. 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). Unfortunately, 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). The integration into a common platform of an economic optimization model and a hydrology model, WEAP (Water Evaluation And Planning system), is used to analyze the spatial and temporal effects of different water and agricultural policies under different climate scenarios. It permits the prediction of different climate and policy outcomes across farm types (water stress impacts and adaptation) at basin level (aquifer recovery), and along the policies' implementation horizon (short and long run) (Varela-Ortega et al., 2010).

15.4.2.2. Early Warning Information Systems

Monitoring and early warning systems (EWS) play an important role in helping to adjust adaptation implementation, especially on the local scale. However the current science and technology do not resolve the uncertainties in modeling, and in the response of ecosystems to climate change and management interventions. Precise information to address key questions of adaptation may be impossible (or prohibitively expensive or time-consuming) to acquire. If this is the case and if the information is needed for a specific adaptation action, then it may be that the action is not practical or is at a high risk for failure with implementation (West et al. 2009). However, the need for precise climate information is often overstated (Smith et al, 2009).

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). EWSs are also set up by FAO, USAID and others providing realtime updates on global weather hazards, food security and remote sensing data for a number of developing countries which are available at their websites.

15.4.2.3. 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).

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). 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. In remote areas of the Philippines, participatory 3-dimensional modelling, a community-based tool which merges GIS-generated data and local peoples' knowledge to produce relief models, is being used to establish visual relations between resources, tenure, their use and jurisdiction, thus contributing to the ability of the community to deal with climate change hazards and trends (IAPAD, 2010). GIS was utilized to form modelling processes of climate change adaptation which are repeatable, justifiable, and have involved critical input from regional stakeholders which supports the development of convincing arguments for better protection of key spaces in the landscape (Bardsley and Sweeney, 2010). 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 and wireless sensor networks, geographic information systems and Web-based tools) being applied to climate change issues, and investigates their use in developing countries. It also gives people who work on climate change an understanding of the technologies that will increasingly be used in their field, not just the nature of the technologies, but their potential benefits and application areas as well.

15.4.2.4. 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, 2010). The linkage between disaster risk reduction (DRR) and adaptation can help communities to build resilience and live with change.

15.4.2.5. Technology Development, Transfer, and Diffusion

Technology is an essential part for adaptation to climate change, and the capability to access technologies is an important component of the adaptive capacity of the society. In some settings, new technologies need to be developed to make adaptation more effective and efficient, such as local climate models, new varieties tolerant of high temperature and low water availability, and efficient water treatment. As the impacts of climate change vary with local settings, there are many cases where traditional and existing technologies are more relevant to adaptation. Furthermore, technologies will be more effective when used within multiple and integrated adaptation measures that cut across sectors and social, institutional, and infrastructural dimensions (Rawlani and Soveacool, 2011).

Several important technologies for adaptation are those related to information collection and diffusion, including technologies to observe and project climate changes, to communicate with people during extreme events and emergencies, and to disseminate information including emergency alerts. Climate projections and downscaling of their results are a basis for adaptation planning and implementation, providing profiles of possible impacts and vulnerability of target places. Though advanced climate models have been developed in recent decades, their spatial resolution is not yet sufficient for local adaptation, and their results inevitably include uncertainties of the extent and timing of climate change. Many developing countries still lack the capacity to access the climate models, and to apply their results to their countries or localities.

In disaster risk management, it is pointed out that technology choices can contribute to both risk reduction and risk exacerbation (Jonkman *et al.*, 2010). Technologies are often used to strengthen physical infrastructure, such as bridges, buildings, or river channels, so that they can withstand higher levels of external forces or hazards. At the same time, it has been suggested that relatively centralized high-technology systems are tenacious, which offer efficiency under normal conditions but are subject to cascading effects in the event of emergencies. In some circumstances, technologies to reduce short-term risk and vulnerability can increase future vulnerability to larger extreme events.

Physical facilities are constructed for climate change adaptation, which have long lifetimes of several decades or more. The gradual changes in social conditions, such as land use, transport, water and sanitation infrastructure, and housing stock, also take many decades. If the planning is maladaptive rather than adaptive, the consequences can be serious. This leads to another aspect of technology development and transfer that might promote more flexible solutions, for example multiple, smaller dams that can resolve local as well as more distant needs. This has been expressed in part of Thailand's Sufficiency Economy approach, where local development is judged against its contribution to local, national and international wealth generation (UNDP, 2007).

Technology transfer plays a pivotal role in adaptation. On the international scale, efforts have been concentrated in the UNFCCC framework focusing on five main themes: technology needs and needs assessments, technology information, enabling environments, capacity building, and mechanisms for technology transfer. One of the key projects is developing a technology transfer clearinghouse called TT:CLEAR (UNFCCC, 2012). For technology transfer, it is equally important to enhance the policy and regulatory environment in order to facilitate and sustain technology transfer, and increase uptake and absorption. There is not only a need for technological solutions, but also for strengthening the absorptive capacity of the public and private sectors so that they can properly absorb, employ and improve the most appropriate technologies. In this respect, multilateral institutions can help with actions from the public and private sectors in both developed and developing countries. The public sector provides the appropriate regulatory framework and creates the necessary business environment, and the private sector provides concomitant funding (Tessa and Kurukulasuriya, 2010).

15.4.2.6. 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 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 recreational opportunities or management goals (West et al. 2009). Tschakert and Dietrich (2010) emphasize that facilitation of anticipatory (forward-looking) learning as an iterative socio-institutional process is a key element for adaptation and resilience in the context of climate change in Africa.

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-up environment sector of Australia, there were some important issues raised that relate to the form and content of education about and for climate change adaptation in accredited courses and other professional development initiatives (Lyth et al., 2007). They 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.

15.4.2.7. Local and Traditional Knowledge

Local and traditional knowledge is gained by longtime recognition and adjustment to adverse events. As one case, it is effectively utilized for disaster risk reduction in the coastal zone of Vietnam (Duc, 2010). However it can sometimes be effective for climate change adaptation – a long-term process. 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).

The adaptation of farmers in eastern Oklahoma in 1930s has shown that rural populations may have an impressive 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. It constitutes and enhances adaptive capacity to climate change impacts (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. Elderly persons mentioned that their coping strategy would be to simply stay at home and wait for the flood to retreat. The strategy is effective for relatively slow processes such as tide, or slow rising flood. However it shows severe constraints in major floods, especially in terms of children fatality (Birkmann, 2011). The integration of indigenous peoples' knowledge and observations of environmental processes in developing collective responses to climate change is outlined in Africa, Australia, small islands in the Asia-Pacific region, and the Arctic Ocean in a special volume of 'Climatic Change' (Green and Raygorodetsky, 2010). They concluded that a knowledge co-creation that brings together local indigenous and conventional scientific paradigms helps to realize the purpose of developing climate change mitigation, adaptation strategies and actions.

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).

15.4.3. Learning and Capacity-Building

15.4.3.1. 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). Adaptive management is thought to be an effective strategy because it emphasizes managing based on observation and continuous learning, and it provides a means for addressing varying degrees of uncertainty in current and future climate change impacts (West et al., 2009). Because there is a growing awareness that mitigation efforts will not be widespread enough to stave off changing climatic conditions, there is a strong consensus that adaptation efforts are needed (Nath and Behera, 2010). 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 there are difficulties in providing information about the variability of the specific changes that are likely to occur on the local scale and the timing of extreme events, local communities require the tools to cope with a variety of challenges. However, 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, such as potable water, and for programs to increase education and to address human health. Yet 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). Moreover, many of the least developed countries are located in geographically vulnerable regions, such as cyclone and sea-level rise impacted small island states, and drought prone regions including those in northern Africa. There are poor and low income communities within countries and other marginalized populations that are also more vulnerable because they tend to settle in more hazardous physical environments and regions deemed less desirable by more powerful sectors of society (McBean and Ajibade, 2009). Greater exposure to vulnerability 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).

15.4.3.2. Balancing Mitigation and Adaptation Responses to Climate Change

Three major themes where adaptation and mitigation issues are expected to coincide are agriculture, built-up 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 services. However, to avoid the potential negative impacts on the resilience of indigenous populations, and local development and biodiversity,

policymakers should try to foster synergies between mitigation and adaptation, by developing guidelines or standards for mitigation projects (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).

15.4.3.3. 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).

15.4.3.4. 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)

15.4.4. 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 (Ojima et al 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 (2008) international strategy 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. The impacts of climate change now give them a renewed role as adaptation tools for a changing climate. Their importance in this respect is threefold:

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.

For example, Guatemala's Mayan Biosphere Reserve provides employment for over 7 000 people and generates an annual income of approximately US$47 million (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-Treves, Buck Holland and Brandon, 2005). Thus, protected areas provide a safety net which can be valuable in times of stress, such as extreme climate events.

For example, 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 (UNDP, 2008). 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. In Malaysia, the value of intact mangrove swamps for storm protection and flood control has been estimated at US$ 300,000 per km, which is the cost of replacing them with rock walls (Ramsar Convention on Wetlands, 2005).

15.5. Governing Adaptation

15.5.1. Cross-sector Coordination

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). 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 (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).

The process of adaptation describes how adaptation should be implemented by whom and why, and the discourse framework, either participatory or centralized, to guide the process of reaching the targeted goals and beneficiaries (Lindseth 2005). 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 organisations in providing an overarching system to comprehensively address a challenge (Biermann et al. 2009). The form of governance, especially how it is structured to manage fragmentations and enhance collaborations, blending knowledge types, and building trust and ownership, is likely to influence capabilities for adaptation implementation, the outcomes, and the scope of benefits (Dewulf et al. 2011). 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). 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). In coupled human-environment systems, the time lag characterizing human actions and environmental effects further confounds unilateral solutions. 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 (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). Sharing the burden of climate risks embodies an adaptation solution in adverting disproportionate impacts (Dellink et al. 2009). 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). This moral dichotomy is evident in the perception and preferences for mitigation and adaptation responses, and sharing causality and remedial responsibilities (Jagers and Duus-Otterström 2008). As system efficiency is comprised under climate change, synergies framed in integrative planning provide a chance to reduce trade-offs across scales, sectors and development goals (Agrawala and Van Aalst 2008).

15.5.2. Sustaining Adaptation Implementation

Building a public-private partnership is likely to favor sustainable outcomes of the implemented actions for adaptation. Balancing multiple initiatives competing for rule-settings under a private-public partnership has 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. The greater inclination for mitigation largely governed by a global process in a regulatory framework for greenhouse gas emission reduction (Ruhl 2010), as opposed to adaptation voluntarily implemented and predominantly occurring at the local level, creates the need for synergies in linking different scales of governance in sustainably achieving expected outcomes of interdependent climate change response strategies (Urwin and Jordan 2008). In avoiding risks and conflict of interests, integrative planning of mitigation and adaptation measures are inseparable responses to climate change especially at the local level (Granberg and Elander 2007).

15.5.3. Feedback and Adjustment Mechanism

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 (Tacoli 2009), especially among African herdsmen. 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 likely to have inescapable feedback trade-offs, such as efficiency over equity or equity over cost and legitimacy, etc. (Adger et al. 2009). Managing transitions in adaptation requires adaptive governance (Loorbach 2010, Tompkins et al. 2010). The problem of ambiguity which is less talked about also needs to be handled in adaptation planning, and especially in governance of natural resource systems (Brugnach et al. 2011), through dialogue, negotiation, opposition, persuasion and learning.

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).

15.6. Conclusions

This chapter reviewed the literature on climate change adaptation(CCA) to assess the progress and limitations of adaptation planning and implementation. 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.

Separating investments that have been applied solely “adaptation” as opposed to “development” has proven difficult in many cases, particularly 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 including Boston, Cape Town, Halifax, Ho Chi Minh City, London, New York, Rotterdam, Singapore, and Toronto demonstrates that the focus is mostly on risk reduction and the protection of citizens and infrastructure, with very few such as Rotterdam seeing adaptation as opportunity for transformation (Heinrichs et al, 2009; Birkmann et al. 2010). Other sectors such as energy, transport, and built infrastructure remain less engaged.

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.

Major investments in infrastructure projects designed to adapt to weather related hazards are being undertaken without awareness about of the impacts of climate change on 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).

Many climate-sensitive sectors in developing 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 lead 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, 2012). 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.

The major results of assessment are summarized in the Executive Summary of this chapter. Though it is not necessary to show them repeatedly, some of the unique results are as follows. Regarding the present status, it is said 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 have raised the importance of adaptation to climate change. 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. Different sectors (e.g., disaster risk reduction, water resource planning, agriculture, urban planning) treat adaptation within their traditional context of planning to various degrees. In these activities, the social dimensions of adaptation have attracted more attention, including the relationship between adaptation and development. In this context, it is emphasized to make the linkages between adaptation and development more explicit to link adaptation planning with co-benefits for development.

Although national adaptation responses have diverse processes and outcomes in 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.

Another area that can be seen in progress of CCA planning and implementation is urban areas. 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 and know-how to institutionalize adaptation to climate change. The mismatch between the current structure and operational culture of municipal planning institutions and the need for multidimensional collaboration in adaptation is also reported in developed countries.

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. A no-regrets approach of improving resilience through an emphasis on disaster risk management has become increasingly common. However, climate change adaptation and disaster risk reduction are handled by separate agencies, although they share similar objectives and challenges. Therefore, there must be an effort towards better coordination. As CCA is a decision making under uncertainty, 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. 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.

For adaptation planning and implementation, a variety of tools are employed depending on the social and management context. This chapter assessed the present status of the tools including science supporting CCA, monitoring, modeling and spatially integrated tools, decision making tools, synthesis reports and insurance. 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. Monitoring and early warning systems play an important role in helping to adjust adaptation implementation, especially on the local scale.

For the governance of adaptation, there are a range of issues. Among them, an important subject is risk communication, which involves multiple pathway exchanges between decision-makers and local citizens. 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. Viewing risk communication as a social process allows for effective participatory approaches, relationship- building and the production of visual, compelling and engaging information for use by local stakeholders. Another point is that 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 and future coordination of implementation As a multidimensional issue involving many state and non-state actors functioning on varying scales of global, national and local levels, 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.

Frequently Asked Questions

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

More national-level plans and adaptation strategies for developed countries are mentioned in the literature than for developing countries; whereas, more implementation cases are documented at the local level in developing countries. Different sectors (e.g., disaster risk reduction, water resource planning, agriculture, urban planning) treat adaptation within their traditional context of planning to various degrees. Mainstreaming adaptation, i.e., continuous integration of adaptation planning into these different sectoral approaches to climate change impacts, is a challenge. There is a wide range of historical experience regarding climate change adaptation among different sectors. For instance, while individual farmers adapt their farming practice to the year-to-year change of climate (e.g., crop selection), farming systems adapt to changing climate over the long term (e.g., introduction of irrigation).

FAQ 15.2: How is climate change adaptation being coordinated across different levels of governance (e.g., international, national and local)?

The current literature has more emphasis on the need for and creation of coordination across levels of government than actual results and evaluations of such coordination. The lack of coordination across various levels of governance can be a barrier to successful adaptation. Adaptation is observed to occur where a top-down, technical approach is integrated into local, participatory approaches and decision making. Benefits of coordination are expected to include 1) priority setting among competing interests; 2) managing inclusion and exclusion; 3) mediating power relations; 4) aligning principles and norms; 5) identifying options for progressing from reactive to proactive adaptation processes; 6) expanding the adaptive capacity of local stakeholders; and 7) enhancing learning opportunities for policy formulation.

FAQ 15.3: What measures are being used and what capacities currently exist for climate change adaptation implementation?

Climate change adaptation (CCA) is a relatively new approach to addressing phenomena with long-term consequences, and it will take time to develop capacity and evaluation metrics. Evaluation is further complicated by the fact that "…adaptation operates on difference spatial and societal scales, and success or its sustainability needs to be evaluated against different criteria on these different levels" (Adger et al., 2005). Broad categories are developed for CCA evaluation that include *effectiveness* (was there a reduction in impacts and risk?), *efficiency* (was there a positive cost/benefit ratio?), and *equity* and *legitimacy* (did all stakeholders positively benefit from the CCA?).

FAQ 15.4: What are the barriers and opportunities for moving climate change planning to implementation?

There are barriers to transfer climate change adaptation (CCA) plans to their implementation. These barriers identified in the literature include inadequate technologies, a lack of strong leadership, a lack of supporting institutions and legislation, and inadequate financing. Activities that would help remove barriers to implementation include cost-benefit analyses to show the monetary benefits of CCA, addressing peoples' differing perceptions of climate risk, enhancing our understanding of the uncertainties inherent in projections of climate change and its impacts, and matching the scale of resource management to the scale of climate change impacts. Opportunities exist where there are co-benefits in implementing adaptation plans, and where engaging leadership leads to successful implementation and capacity building.

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