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Chapter 17 – Assessment of Adaptation Practices, Options, Constraints and Capacity

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Executive Summary

Societies have a long record of adapting to the impacts of weather and climate. But climate change poses novel risks, often outside the range of experience.

There is now a growing set of examples of adaptation practices that take climate change into account. These measures are being put in place in both developed and developing countries, and involve policies, institutions, technologies and individual actions.

Adaptation measures are seldom undertaken in response to climate considerations alone, but rather as part of a broader set of responses to address a range of socio-economic and environmental considerations. In many cases adaptation measures have been put into place in response to current extreme events.

Adaptations are planned and undertaken by public and private actors at multiple levels including individuals, communities, national and international institutions. Decisions across these levels are interdependent – actions taken at one level can enhance or constrain options at another.

The capacity to adapt at many scales is linked to indicators of development which include education, health, and governance, in addition to income. However, the existence of high aggregate adaptive capacity need not translate into real action. Even developed countries might face constraints to adaptation.

Societies and groups within them are differentially vulnerable to multiple stresses associated with climate and socio-economic changes. These vulnerabilities are dynamic and have been demonstrated to be reduced by adaptive actions. However, violent conflict, infectious diseases, and other stressors are reducing adaptive capacity in particular regions.

There are emerging opportunities for promoting adaptation and enhancing adaptive capacity through planning processes, addressing climate variability, and through mechanisms for social learning and adaptive management.

Mainstreaming adaptation in development provides a number of benefits for implementing adaptation measures efficiently and effectively. Adaptation considerations are becoming part of such processes as water resource management, infrastructure planning, and community development in many regions. It is too early to assess the sustainability of these initiatives.

There are limits to adaptation both within socio-economic and natural systems. In particular systems might be constrained in their ability to adapt to significantly large deviations in climate from average conditions, as well as to high rates of change.

17.1 Concepts and methods

17.1.1 Key terms: adaptation, vulnerability, resilience

Adaptation to climate change takes place through adjustment to enhance resilience or reduce vulnerability in response to observed or expected changes in climate and its effects. Adaptation occurs in ecological, physical and human systems. Adaptation therefore involves changes in social and environmental processes, practices and functions to reduce vulnerability through moderating potential damages or to benefit from new opportunities. Adaptations to variability in weather and climate can reduce vulnerability and hence build resilience for dealing with a changing climate.

Individuals and societies will adapt to both observed and expected climate change. Although many sectors and sections of contemporary society are dependent on resources that vary with climate, there are well-established observations of human adaptation to climate change over the course of human history (McIntosh *et al.*, 2000; Mortimore and Adams, 2001). Nevertheless, many individuals and societies remain vulnerable to present-day climatic risks, which may be exacerbated by future climate change. Research on the processes of adaptation has increasingly demonstrated that some adaptation is undertaken by individuals in response to observed or expected change, while other types of adaptation is undertaken by governments on behalf of society, sometimes in anticipation of change but also in response to individual events (Adger, 2003; Kahn, 2003; Klein and Smith, 2003). Adaptation decisions made by individuals are shaped by the institutional context within which they take place. Government policies and individual adaptations are not independent of each other – they are embedded in governance processes that reflect the relationship between individuals, their capabilities and social capital, government and available technologies.

All adaptation involves conscious and observable actions that change system characteristics (Reilly and Schimmelpfennig, 2000). While some adaptation actions directly change the parameters of risk and vulnerability associated with an identifiable climate change impact (Jones, 2001), others may simply increase the resilience of a system and the capacity to adapt in the future. There are limits to adaptation in terms of fundamental non-linear abrupt changes in the earth system (Scheffer *et al.*, 2001; Schneider, 2004), but also in terms of the availability of technologies, the irreversible nature of impacts of large-scale changes on ecosystems, and in the legitimacy and sustainability of human responses (Callaway, 2004; Adger *et al.*, 2005).

Vulnerability to climate change refers to the propensity of human and ecological systems to suffer harm and ability to respond to stresses imposed as a result of climate change impacts. Vulnerability is function of exposure and sensitivity to hazard and the capacity to adapt (Smit *et al.*, 2001). Although vulnerability depends on adaptive capacity, sensitivity, and exposure to the impacts of climatic change (Kelly and Adger, 2000; Smit *et al.*, 2000; Turner *et al.*, 2003; O'Brien *et al.*, 2004; O'Brien *et al.*, 2004), it also depends on the distribution of resources and prior stressors.

Exposure in this context is the impacts of climate change experienced by a social, physical or ecological system. Exposure can be modified by adaptation. Sensitivity is the degree to which a system will respond to the exposed change in climatic conditions. This has been measured, for example, by changes in ecosystem productivity or changes in species distributions, as a result of perturbations in temperature or precipitation (Kumar and Parikh, 2001; Parmesan and Yohe, 2003).

Adaptive capacity is the ability of a system to evolve in order to accommodate climate changes or to expand the range of variability with which it can cope (Jones, 2001; Yohe and Tol, 2002). Adaptive capacity is a vector of resources and assets that represent a resource to draw on to undertake adaptations. All societies have inherent capacities to cope with and adapt to climate variability in the present day. These capacities are, however, unevenly distributed and are influenced by the resources available to cope with exposure, the distribution of resources within populations, and the institutions which mediate both resources and coping with climate change and variability. Many comparative studies have noted that the poor and marginalized have historically been most at risk from climatic shocks (Turner *et al.*, 2003) even where societies have been, in aggregate, well adapted.

Planning effective adaptation to climate change and its associated risks requires robust and transferable methods of identifying who and what is vulnerable and the capacity of systems and social groups to cope with both climate variability and climate change. New adaptation research has focused on decision-making frameworks that elaborate the economic costs or potential welfare outcomes of adaptation decisions (Fankhauser *et al.*, 1999; Callaway, 2004; Adger *et al.*, 2005). Much of this new research is focused on adaptation decisions taken by governments or other decisions that impinge on future adaptation action. A prior question is the identification of where adaptation interventions should take place – i.e. those systems and communities vulnerable to climate change or other environmental stresses. Recent research in this area focuses on the dynamic nature of vulnerability and demonstrates that changes in vulnerability of particular groups are outcomes of changes in specific elements of adaptive capacity (Leichenko and O'Brien, 2002). In summary, human response to climate change risks is uneven: vulnerabilities remain following adaptation, and new vulnerabilities will emerge despite adaptation.

17.1.2 Methods used to analyze adaptation.

The methods adopted to analyse adaptation depend on the research question being asked. Table 17.1 outlines important questions in adaptation research, and highlights the principal methods used to answer these. The first question involves research that assesses the future potential impacts of climate change when adaptation measures have been adopted. The other questions in Table 17.1 (questions 2-5) involve research on the design and prioritization of adaptation policies and measures for realizing implementation of them (Burton *et al.*, 2002; Fussel and Klein, 2002; Mirza, 2003). Research on potential impacts of climate change after adaptation is often based on global analysis that incorporates global targets and schedules of GHG mitigation policy in order to provide the scientific basis for decision makers to found actions to avoid 'dangerous interference with the climate system' (Corfee-Morlot and Hohne, 2003). On the other hand, research on adaptive capacity, societal learning and future adaptation options are useful to promote the implementation of adaptation measures those are appropriate for reducing causes of vulnerabilities in a focused region including the enhancement of adaptive capacity (Lim *et al.*, 2005).

Research on the effects of adaptation on climate change impacts (Question 1 in Table 17.1) primarily uses simulation modelling of future states, outlined for example in IPCC guidance for impacts and adaptation assessment (Carter *et al.*, 1994) and other guidelines (Benioff *et al.*, 1996; Parry and Carter, 1998; Jones, 2001). These studies often take future climate scenarios as inputs into simulations that estimate future impacts of climate change considering the effect of adaptation measures. Models range from those on biophysical process to empirical-statistical models on exposure and sensitivity. Several economic studies have used computable general equilibrium models to estimate welfare change under climate change considering ripple effects through markets (Darwin, 2004). Adaptation is inherently a dynamic responsive process, yet the type and degree of adaptation in global modelling studies are usually taken as input assumptions in a static manner. Thus local circumstances which promote or hamper the introduction of the adaptation measures are rarely considered except for the local-scale modelling studies which look at adaptation from a development or individual perspective (Ziervogel *et al.*, 2005). Some recent global-scale studies attempted to link the expected level of adaptation with representative socio-economic factors such as GDP per capita (Hijioka *et al.*, 2002; Nicholls, 2004). But GDP per capita, are limited proxies for economic development because they ignore non-market effects, distribution of well-being and price distortions.

Table 17.1: Key research questions on adaptation and primary methods used for analysis

Question	Methods used	Examples	Type of uncertainty
Q 1 What are the effects of adaptation on climate change impacts?	Modelling and scenarios	Numerous examples from impact studies with assumed adaptation	End-to-end uncertainty from emissions scenarios to dose-response uncertainties
Q 2 What adaptations are socially and environmentally beneficial?	Normative policy frameworks based on vulnerability analysis, scenarios, cost benefit analysis, multi-criteria analysis, technology risk assessments	Adaptation Policy Framework (Lim *et al.*, 2005); Adger *et al.* (2005); (others)	Uncertainty related to assumptions in the aggregation of aggregate welfare and comparison on incommensurable impacts
Q 3 What constitutes the capacity to adapt?	Indicators, modelling studies of specific hypothesised components of adaptive capacity	Brooks *et al.* (2005); Yohe and Tol (2002); Moss *et al.* (2001); Haddad(2005)	Uncertainty related to contested knowledge on determinants of adaptive capacity
Q 4 How does society learn to adapt?	Economic modelling, anthropological and sociological methods for identifying learning in individuals and organisations	Berkhout *et al.* (2004); Hertin *et al.* (2003); Tompkins *et al.* (2005); Shepherd (2004); Patt and Gwata (2002)	Uncertainty surrounding causality in constructivist and inductive research methods and in perceptions of risk.
Q 5 What adaptations are likely to be used in the future?	Scenarios and technology assessments.	Dessai *et al.* (2005); Dessai and Hulme (2004); Klein *et al.* (2005)	Uncertainty surrounding causal mechanisms and system boundaries and feedbacks

Uncertainty in methods of adaptation research derives from performance of impact assessment model, assumption on the level of expected adaptation, future climate scenarios usually projected by climate models. For managing uncertainty explicitly, several studies have started to use probability or cumulative density functions (Jones and Page, 2001 see Chapter 2 for detail; Webster *et al.*, 2003). Level of establishment and confidence of assessment model differs significantly among sectors affected by climate change, time and spatial scales, measuring unit and others. Bio-physical models based on observed physical or biological processes are often argued to be more easily verified than socio-economic models because of data availability, apparent deviation of aggregate behaviour from the predictions of rational choice and other reasons in social systems. Such modelling approaches are useful in identifying the technical possibilities for adaptation and the potential damages avoided. They do not by themselves, however, provide information on the likelihood of adaptation options being used or adopted or on the relative benefits of various adaptation options.

The second question in Table 17.1 (What adaptations are socially and environmentally beneficial?) addresses normative issues of priorities for adaptation policies and measures. Criteria for evaluating benefit of adaptation measures include effectiveness, efficiency, equity and legitimacy (Adger *et al.*, 2005). Effectiveness relates to the capacity of an adaptation action to achieve its expressed objectives. The effectiveness of adaptation can often be directly measured – for example the numbers of houses removed from high hazard locations can be counted – but more often the effectiveness of an adaptation measure is more elusive: effectiveness depends on the evolution of actions over time. The effectiveness of strategies for adapting to climate change depend on the social acceptability of options for adaptation, the institutional constraints on adaptation, and the place of adaptation in the wider landscape of economic development and social evolution. Efficiency needs to be measured by comparing costs and benefits of adaptation measures. However, estimation of costs and benefits contains various challenges such as the valuation of non-market goods and externality. Equity usually focuses on the distributional consequences of environmental decisions, from the uneven spatial impacts of environmental change to the distribution and consequences of political and social change. For adaptation, the first step to assess the fairness of adaptation is to highlight who gains and who loses from any impact or adaptation policy decision. Legitimacy is the extent to which decisions are acceptable to participants and non-participants that are affected by those decisions. The social acceptability of the procedures for implementation of adaptation actions is an important characteristic (Adger *et al.*, 2005; Schroter *et al.*, 2005).

Adaptation processes involve the interdependence of agents through their relationships with each other, with the institutions in which they reside, and with the resource base on which they depend (Adger, 2003). In this area, cost benefit analysis, multi-criteria analysis, cost effectiveness analysis, and expert judgment have all been advocated and used as appropriate methods and frameworks (Fankhauser *et al.*, 1999; Niang-diop and Bosch, 2005). Uncertainty of these methods derives from limited knowledge on cost and benefit of adaptation options, failure in selection and weighting of criteria, insufficient understanding of how externalities relate to human welfare, given the well-established disparity between aversion to loss compared to gains in environmental quality. Although the methods of assessment have been well established and obtained the consensus, confidence level depends on quality and quantity of those information, which are different among focused regions.

The third question in Table 17.1 relates to the determinants of adaptive capacity. Research in this area builds on case study research as well as meta-analytical techniques and on the development of indicators to test specific hypotheses (Yohe and Tol, 2002). It is useful to learn from past and present adaptation strategies to understand both the processes and opportunities by which adaptation have been taken place and the limitations which hampered practicing adaptation. It tells the baseline state of adaptive capacity and indicates the prerequisites to be promoted and obstructions to be removed for enhancing adaptive capacity which enables the prioritized adaptations. Campbell(1999) surveyed strategies those were taken to cope with two periods of drought from 1972 to 1976 and from 1994 to 1995 in S.E. Kajiado District in Kenya and compared them with considering socio-economic states as well as institutional and political issues in the two periods. It provided empirical evidence of the dynamic responses that one rural society prone to recurrent drought-related food insecurity has made to the complex interactions between exogenous and local political, economic, social and demographic, and environmental process. Statistical relationships between impacts of natural disaster and proxies of determinants of adaptive capacity are analyzed in order to understand the relative importance of the determinants quantitatively (Yohe and Tol, 2002; Brooks *et al.*, 2005; Haddad, 2005). Confidence level of assessment depends on availability of reliable record of historical and present hazards and socio-economic conditions in the same period.

Research answering the fourth question in Table 17.1 on learning in adaptation focuses on dynamic features of adaptive capacity. The choice of adaptation strategy changes over time and is dependent on societal institutions for dialogue, competencies in organisations that are adapting, and the availability of appropriate technological solutions (de Loe *et al.*, 2001; Berkhout *et al.*, 2004; Shepherd, 2004). Decision making on the choice of adaptation strategies reflects the past experiences of practicing adaptation and perceptions of the results of the experiences. Careful monitoring and evaluation of implemented adaptation measures can enable the assessment of what is working, what is not working, and why (Perez and Yohe, 2005). The purpose of monitoring is to keep track of progress in the implementation of an adaptation strategy and its various components in relation to the targets. This enables management to improve operational plans and to take timely corrective action in the case of shortfalls and constraints. Evaluation is a process for systematically and objectively determining the relevance, efficiency, effectiveness and impact of an adaptation strategy in light of its objectiveness. This approach enables us to a) undertake midcourse corrections in implemented adaptations, so that they meet their objectives more efficiently; and b) improve their understanding of the determinants of adaptive capacity so that capacity development activities can be more successful from the start. In the process of monitoring and evaluation, participatory process can add value and enhance feasibility. Evaluation without quality data from effective monitoring processes will have no inputs with which to work and no basis for conclusion. Unsupported evaluations produce little more than hypotheses (Perez and Yohe, 2005).

17.2 Assessment of Current Adaptation Practices

17.2.1 Adaptation Practices

Adaptation practices refer to actual adjustments, or changes in decision environments which might ultimately facilitate adjustments, that enhance resilience or reduce vulnerability to observed or expected changes in climate. Thus, measures to develop a coastal defence system that reduces vulnerability to storm surges and anticipated sea level rise are an example of the former, while the establishment of climate risk screening guidelines by governments or donor agencies which might make downstream development projects more resilient to climate risks, is an example of the latter.

With an explicit focus on real world behaviour by particular decision-makers, assessments of adaptation practices differ from the more theoretical assessments of potential responses or how such measures might reduce climate damages under hypothetical scenarios of climate change. There are, however, relatively few observed actions that can be designated solely as adaptation to climate change. All adaptation takes place under multiple stresses and uncertainties. In addition, for planned adaptation to be effective, it is most often integrated or “mainstreamed” into other policy interventions or strategies.

Adaptation practices can be differentiated along several dimensions, such as by: spatial scale (local, regional, national); sector (water resources, agriculture, tourism, public health, and so on); actor (national or local government, international donors, private sector, and individuals); climatic zone (dryland, mountains, arctic, and so on); baseline economic development levels of the systems in which they are implemented (least developed countries, middle income countries, developed countries); or some combination of these and other categories.

There is a long record of practices to adapt to the impacts of weather as well as natural climate variability on seasonal to interannual time-scales – particularly to the El Nino Southern Oscillation (ENSO). In addition to climate variability, recent decades have also witnessed growing evidence of impacts of long term trends in the climate system, and there is now growing evidence of measures being designed and implemented to adapt to such impacts. There are also some examples of adaptation measures that also explicitly take into account scenarios of long-term climate change or how such long-term changes might impact variability. In many of the above cases the adaptation measures are designed to respond not just to stand-alone climate risks but to simultaneously address or be integrated with responses to other development, social, public health and other considerations

(Smit *et al.*, 2001). Consistent with this, vulnerability to climate change is increasingly considered within the broader context of other contextual socio-economic conditions, as well as other stresses. The treatment of adaptation and vulnerability in the literature and practice underscores the importance of integrating or 'mainstreaming' adaptation into other social and development policies and initiatives.

Adaptation practices to climate risks can therefore be viewed at three levels: to current variability; observed medium and long-term trends in climate; and anticipatory planning in response to model-based scenarios of long-term climate change (Figure 1). The responses across the three levels are closely intertwined, and indeed might form a continuum. Adapting to current climate variability is already sensible in an economic development context, given the direct and certain evidence of the adverse impacts of such phenomena (Smit *et al.*, 2001; Agrawala and Cane, 2002). It is also a good 'no-regrets' measure to cope with the impacts of long term climate change, as many human induced changes in climate will manifest themselves through enhanced or altered climate variability. In a number of cases however anthropogenic climate change might in addition require forward looking investment and planning responses that go beyond short-term responses to current climate variability. This, for example, includes planning for water resource management and hydropower generation in river systems affected by glacier retreat (Shrestha and Shrestha, 2004), and resettlement and infrastructure planning in regions affected by creeping hazards related to permafrost melt (Schaedler, 2004) and sea level rise (Titus, 1998; Shukla *et al.*, 2004).

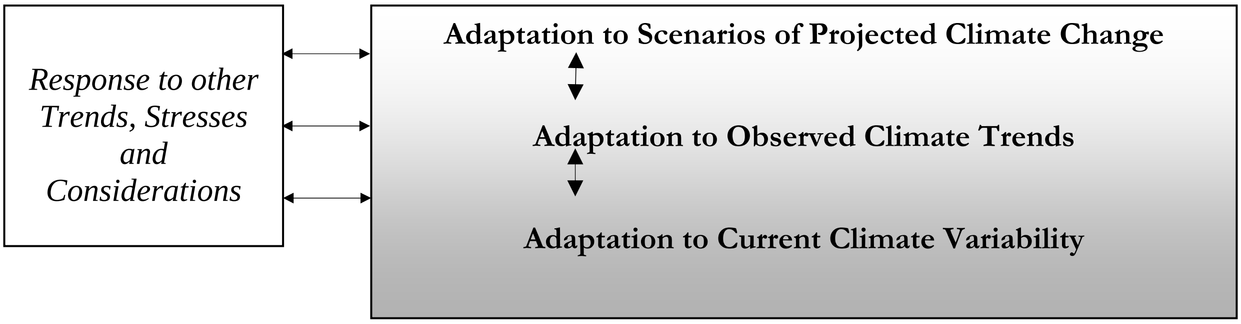


Figure 17.1: *Adaptation practices across time-scales and links to other priorities*

17.2.3 Examples of Adaptation Practices

There is a growing body of evidence and documented practice on adaptation actions in response to climate variability in a number of sectors (particularly agriculture and water resource management), by a range of individual and institutional actors, and in a wide variety of settings. This includes description and assessment of primarily *reactive* or *ex-poste* adaptations – that include migration, emergency relief, to responses that are more *proactive* to anticipated risks (such as crop and livelihood diversification, crop switching, seasonal climate forecasting, early warning systems, insurance mechanisms, water storage, and so on). In many cases or contexts where sufficient information on anticipated climate risks is not available or too uncertain, or if resources to implement anticipatory measures are lacking, then reactive adaptation might be the only option. However, recent reviews indicate that a 'wait and see' or reactive approach is often inefficient and could be particularly unsuccessful in coping with irreversible impacts, non-linear damages, and long-lived investments and infrastructure (Smith, 1997; Easterling *et al.*, 2004).

Proactive practices to adapt to climate variability have advanced significantly since that late 1980s with the development of operational capability to forecast several months in advance the onset of El Nino and La Nina events (Cane *et al.*, 1986), as well as improvements in climate monitoring and remote sensing to provide better early warnings on complex climate related hazards (Dilley, 2000). Since the mid-1990s a number of institutional mechanisms have also been established to facilitate proactive adaptation to seasonal to inter-annual climate variability. These include institutions that produce and disseminate regular seasonal climate forecasts (NOAA, 1999; Agrawala *et al.*, 2001), and the regular regional and national forums and implementation projects worldwide to engage with local and national decision-makers to design and implement anticipatory adaptation measures in agriculture, water resource management, food security, and a number of other sectors (Basher *et al.*, 2000; Broad and Agrawala, 2000; O'Brien and Leichenko, 2000; Patt and Gwata, 2002). There have also been cross-national evaluations of adaptation practices in response to the 1997-98 El Nino events (Glantz, 2001).

In addition to adaptation practices to address seasonal to interannual climate variability, a growing number of measures are now being put in place to cope with the impacts of observed trends in climate, as well as scenarios of climate change. The Tsho Rolpa risk reduction project in Nepal is an example of adaptation measures being implemented to address the creeping threat of glacial lake outburst flooding (GLOF) as a result of rising temperatures (Box 17.1).

There are also a number of examples of infrastructure projects both in developed and developing countries which explicitly consider scenarios of future climate change. Long-lived assets like infrastructure typically have a “bath-tub” curve for maintenance costs, which decline after the initial stabilization period and begin to increase again only after a long time due to wear and tear as the asset reaches the end of its useful life. Meanwhile, climate change – through changes in mean temperature, precipitation and sea levels, as well as their variability – is projected to increase progressively. Climate change impacts on infrastructure will therefore also be more significant just when it is reaching the end of its useful life. The coupling of these two effects would increase the economic impact of climate change on infrastructure (Shukla *et al.*, 2004 Figure 17.2).

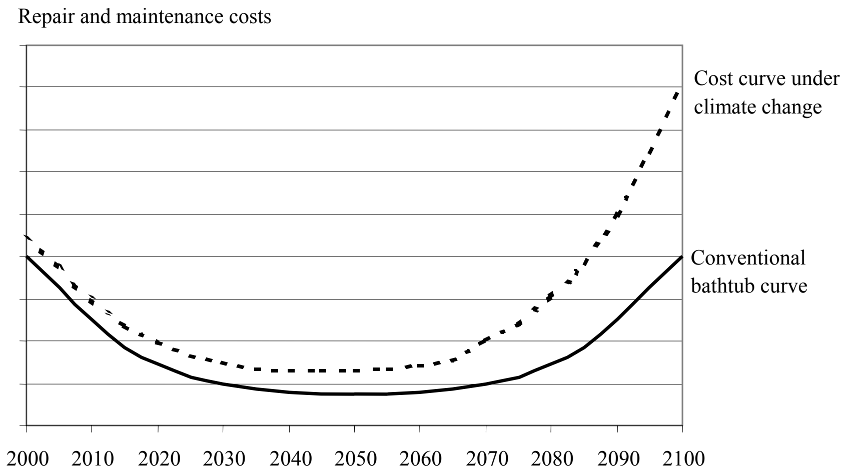


Figure 17.2: *Climate change impacts on infrastructure maintenance costs.*

Box 17.1: Tsho Rolpa Risk Reduction Project in Nepal as observed anticipatory adaptation

Several Himalayan glacial lakes have witnessed significant expansion in size and volume as a result of rising temperatures. This increases the likelihood of catastrophic discharges of large volumes of water in events which are known as Glacial Lake Outburst Floods (GLOFs). One of the most dangerous glacial lakes in Nepal is the Tsho Rolpa lake at an altitude of about 5000m, and whose size increased from 0.23 square kilometres in 1957-58 to 1.65 square kilometres by 1997.

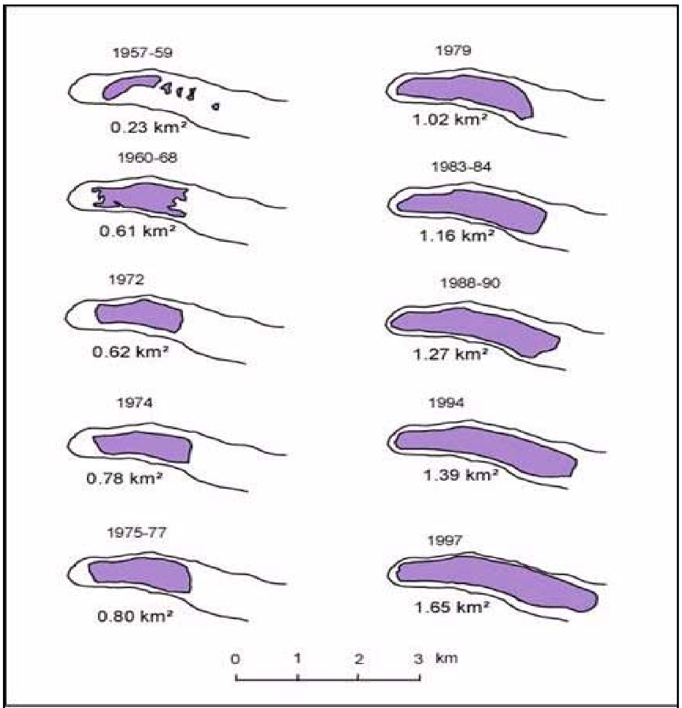


Figure 2

The Tsho Rolpa glacial lake project in one of the most significant examples of collaborative anticipatory planning by the government, donors, and experts in GLOF mitigation. Tsho Rolpa was estimated to store approximately 90-100 million m^3, a hazard that called for urgent attention. A 150-meter tall moraine dam held the lake, which if breached, could cause a GLOF event in which a third or more of the lake could flood downstream. The likelihood of a GLOF occurring at Tsho Rolpa, and the risks it posed to the 60MW Khimti hydro power plant that was under construction downstream, was sufficient to spur HMG to initiate a project in 1998, with the support of the Netherlands Development Agency (NEDA), to drain down the Tsho Rolpa glacial lake. To reduce this risk, an expert group recommended lowering the lake three meters by cutting an open channel in the moraine. In addition, a gate was constructed to allow water to be released as necessary. While the lake draining was in progress, an early warning system was simultaneously established in 19 villages downstream of the Rolwaling Khola on the Bhote/Tama Koshi River to give warning in the event of a GLOF. Local villagers have been actively involved in the design of this system, and drills are carried out periodically. The World Bank provided a loan to construct the system. The four-year Tsho Rolpa project finished in December 2002, with a total cost of USD 2.98 million from The Netherlands and an additional USD 231,000 provided by Government of Nepal. The goal of lowering the lake level was achieved by June 2002, which reduced the risk of a GLOF by 20%. The complete prevention of a GLOF at Tsho Rolpa necessitates further reducing the lake water, perhaps by as much as 17 meters. Expert groups are now undertaking further studies, but it is obvious that the cost of mitigating GLOF risks is substantial and time consuming. The cost, however, is much less than the potential damage that would be caused by an actual event in terms of lost lives, communities, development setbacks, and energy generation.

Source: Agrawala *et al.* (2003)

Early examples where climate change scenarios have already been incorporated in infrastructure design include the Confederation Bridge in Canada and the Deer Island sewage treatment plant in Boston harbour in the United States. The Confederation Bridge is a 13 kilometre bridge between Prince Edward Island and the mainland. The bridge provides a navigation channel for ocean-going vessels with vertical clearance of about 50m (McKenzie and Parlee, 2003; Transportation Canada, 2005). Sea level rise was recognised as a principal concern during the design process and the bridge was built one metre higher than currently required to accommodate sea level rise over its hundred year lifespan (Lee, 2000; NRC, 2005). In the case of the Deer Island sewage facility the design called for raw sewage collected from communities onshore to be pumped under Boston harbour and then up to the treatment plant on Deer Island. After waste treatment the effluent would be discharged into the harbour through a downhill pipe. Design engineers were concerned that sea level rise would necessitate the construction of a protective wall around the plant, which would then require installation of expensive pumping equipment to transport the effluent over the wall (Klein *et al.*, 2005). To avoid such a future cost the designers decided to keep the Deer Island treatment plant at a higher elevation, and the facility was completed in 1998.

Other examples where ongoing planning is incorporating scenarios of climate change in project design are the Quinhai-Tibet Railway in China (Brown, 2005); the Konkan Railway in western India (Shukla *et al.*, 2004); a coastal highway in Micronesia (Hay *et al.*, 2004); the Copenhagen metro in Denmark (Fenger, 2000); and the Thames Barrier in the UK (Hall *et al.*, 2005). The Thames Barrier and associated defence improvements were planned and built over a 30 year period following the 1953 floods to protect London to a high standard (generally one in a 1000 year event). The original design of the Thames barrier allowed for sea level rise, although climate change was not an explicit consideration at that time, in other words it was "non deliberate" adaptation. . The barrier also did not make any specific allowance for changes due to climate change in fluvial flows coming down the Thames or the size of the storm surges arising in the North Sea. Rising sea level and rapidly increasing development within the tidal flood plain mean that flood risk is increasing and by the year 2030 improved arrangements will be required if flood protection standards are to be maintained at present levels. Given these challenges the UK Environment Agency has set up the Thames Estuary 2100 project to develop a Flood Risk Management Plan for London and the Thames Estuary for the next 100 years. A multi-pronged study of adaptation options is currently underway which includes assessment of 337 kilometres of coastal defences including nine major flood control barriers, how society and its needs interact with flood risk throughout the Thames estuary, and how political and other drivers will shape the choice and implementation of particular options. Tompkins *et al.* (2005) document some other adaptation practices that have been put in place in the UK (Table 17.2).

A majority of examples of consideration of climate change scenarios relate primarily to the implications of sea level rise. In this context, the Quinhai-Tibet Railway is a notable exception. The railway, scheduled for completion in 2007 crosses the Tibetan Plateau with about a thousand kilometres of the railway at least 13, 000 feet (4, 000m) above sea level. Five hundred kilometres of the railway rests on permafrost, with roughly half of it "high temperature" permafrost which is only 1 °C – 2 °C below freezing (Brown, 2005). Thawing of such permafrost, as is expected as a result of rising temperatures, can threaten the stability of the railway line. To prevent this from happening design engineers have put in place a combination of insulation and cooling systems to minimize the amount of heat absorbed by the permafrost.

In addition to specific infrastructure projects there are now also examples where climate change scenarios are being considered in more comprehensive risk management policies and plans.

Adaptation to current and future climate is now being integrated within the Environmental Impact Assessment (EIA) procedures of several countries in the Caribbean. It has also been extended toward incorporating natural hazard impact assessment in the project preparation and appraisal process, as well as the EIA guidelines, of the Caribbean Development Bank. Like the Caribbean countries, Samoa's EIA guidelines also include consideration of climate change.

Table 17.2: *Examples of observed adaptations to climate change in the UK distinguished by their purposefulness and primary focus.*

	Implementing adaptation	Building adaptive capacity
Planned (deliberate)	Millennium Green urban development, Nottingham, UK: climate change-sensitive design for energy and water usage. Norwich Union Flood Maps: Accurate assessment of flood risk for properties to estimate insurance premiums.	National planning regulation (PPG25) on development and flood risk promoting precautionary decision-making taking account of climate change in development decisions. London Climate Change Partnership is made up of public, private and voluntary sector organizations and produces scenarios and plans for adaptation for London under climate change.
Unplanned (non deliberate)	Thames Barrier	UK Rail Safety and Standards Board has planned for impacts of weather extremes on railway infrastructure for the UK that incorporates scenarios consistent with climate change.

Source: Adapted from Tompkins *et al.* (2005)

The implications of climate change are also being increasingly considered in the design of hot weather alert plans. While the formulation or revision of such plans is often triggered by recent heat wave episodes (e.g. 1995 heat wave in Chicago; the 1999 heat wave in Toronto; and the 2003 heat wave in France), there is also recognition of the fact that such events might become more frequent or worsen under climate change. Public health adaptation measures have now been put in place that combine weather monitoring, early warning, and response measures in a number of places including metropolitan Toronto (Smoyer-Tomic and Rainham, 2001; Ligeti, 2004) and France (ONERC, 2005).

Another example of consideration of climate change scenarios in the design of a comprehensive adaptation strategy is the case of the New York City water system. Changes in temperature, precipitation, sea level rise, and extreme events have been identified as important parameters for water supply impacts and adaptation in the New York region (Rosenzweig and Solecki, 2001). Following this assessment the New York City Department of Environmental Protection (NYCDEP) initiated work in 2003 to develop a wide-ranging approach to the adaptation of the water supply infrastructure to climate change. A nine-step adaptation framework and an 8-step adaptation assessment procedure have been developed to guide initial analyses of adaptation possibilities across the broad scope of NYCDEP functions. A key feature of these procedures is explicit consideration of several climate variables, uncertainties associated with climate change projections, and time horizons for different adaptation responses, including capital turnover cycles. Adaptations are divided into managerial, infrastructure, and policy categories and are assessed in terms of time-frame (immediate, interim, long-term) and in terms of the capital cycle for different types of infrastructure. Generalised risk assessments are provided for a range of impacts and adaptations, followed by detailed multi-dimensional cost-benefit analysis as the range of adaptations is refined. As examples of adaptation measures currently under examination, a managerial adaptation that can be implemented quickly is a tightening of drought regulations in the event of an unusually severe drought. A longer-term infrastructure adaptation is the construction of flood-walls around low-lying wastewater treatment plants to protect against sea level rise and higher storm surges. In the case of watersheds, the temperature and rainfall changes under climate change will require an assessment of vegetation and land purchase protocols. A potential policy measure that is being examined is increased integration of the New York City water system with other regional systems such as Long Island and Delaware.

17.2.4 Assessment of Adaptation Practices

Assessment of adaptation practices can be undertaken to accomplish three interlinked, but nevertheless distinct goals. First, it can be used to be used to establish priorities for adaptation. It can also be used to screen specific adaptation measures in order to select the appropriate responses for implementation in a given context. Both these objectives are *ex ante*. The third objective is relevant once specific adaptation policies and measures are in place, and seeks to assess their on accomplishing desired goals of reducing the net impact of climate change, as well as any ancillary effects. These assessments are often conducted independently by analysts, or working in conjunction with stakeholders. There is a subjective element to all such assessments, and the degree to which they employ explicit criteria for evaluation varies considerably.

Unlike greenhouse gas mitigation, which has to be coordinated internationally, adaptation to climate change is essentially a local, or in some cases, a regional issue. This implies that adaptation decisions will be made to a large extent based on well established local decision-making procedures. Some adaptations will have a public good character and as such may be provided by the state (local authorities or national governments). In making these adaptation decisions the authorities will apply traditional decision support tools such as cost-benefit analysis, cost-effectiveness analysis, multi-criteria analysis and expert judgment. Other, perhaps most, adaptation decisions will be taken by private agents (individuals or firms). The more sophisticated actors among them will base their decision on the investment appraisal techniques of corporate finance. They may, for example, calculate the net present value of an adaptation investment, analyse its risks and returns or determine the return on capital employed.

What most of these decisions will have in common is that they will in some way be based on a comparison of the advantages and disadvantages of a certain course of action, that is, its economic, financial and/or non-monetary costs and benefits. In addition to the level and type of adaptation, decision makers will also have to determine the timing of their action. And at least for the time being, adaptation decisions will be taken under considerable uncertainty.

The following paragraphs outline the three key methods and examples for evaluating adaptation practices: benefit cost analysis, cost-effectiveness analysis, and multi-criteria evaluation. Information on the costs and benefits of adaptation (Box 17.2) are a key input to most of these evaluation approaches.

Box 17.2 : Adaptation Costs and Benefits

Costing is a key element for most assessments of adaptation practices. It is explicitly part of cost-benefit analysis and cost-effectiveness analysis, but also forms a critical component of multi-criteria analysis as well as expert judgment. Some of the main issues underlying the assessment of adaptation costs and benefits can be illustrated via a hypothetical example shown in the table below.

	Current climate	Changed climate
Current adaptation	Adaptation cost: 90 Ordinary climate damage: 50 Climate change damage: 0	Adaptation cost: 90 Ordinary climate damage: 50 Climate change damage: 200
Extended adaptation	Adaptation cost: 150 Ordinary climate damage: 20 Climate change damage: 0	Adaptation cost: 150 Ordinary climate damage: 20 Climate change damage: 120
Net benefit of extended adaptation	Incremental adapt. cost: 60 Incremental adapt. benefit: 30+0 *Net benefit: - 30*	Incremental adapt. cost: 60 Incremental adapt. benefit: 30+80 *Net benefit: +50*

In this example, society is spending an amount of 90 on current adaptive measures – say, a flood protection system. Included in these costs are both monetary components (e.g., capital costs) and non-monetary components (e.g., the impact on the environment). This level of adaptation is sufficient to prevent most adverse climate effects, but not all. There is a residual damage of 50, for example due to occasional extreme flooding. The current level of adaptation is preferred over more comprehensive measures, because in this example the additional cost of more comprehensive protection (150 – 90 = 60) are higher than the additional benefits of reduced flood damages at the margin (50 – 20 = 30). In this hypothetical example, climate change results in enhancement of flood risk and the extra costs of adaptation (150 – 90 = 60) are more than offset by the reduced costs of climate change (200 – 120 = 80). Here, the climate change benefits alone are sufficient to justify adaptive action, but the extra reduction in ordinary climate impacts (50 – 20 = 30) is an important ancillary benefit. The ancillary benefits occur because the extended protection system will reduce the impact of current floods, in addition to reducing the damage from enhancement of flood risk under climate change.

This simplistic example helps to flesh out two important issues: The costs of adaptation have to be measured against current adaptive measures, and many adaptive measures may have climate change as well as non-climate change-related benefits.

The timing of adaptation decisions

In deciding the optimal timing for adaptation, decision makers will compare the present value costs of adaptation now (PVN) with the present value costs of adaptation at a later stage (PVL). If adaptive measures taken now cost ACN and will reduce annual climate damages to DCN over the lifetime of the project. If damage is discounted at the rate δ, NPVN can be written as

$$PVN = ACN + DCN0 + \Sigma\ DCNt\ \delta t$$

If adaptation is undertaken a period later, the costs of adaptation can be discounted, but climate impacts in the initial period will not be mitigated. That is, they will reach a level of DCU0 > DCN0. It is also possible that adaptation costs (ACL) and subsequent damage costs (DCL) will change, for example because of innovations in adaptation techniques. NPVL then becomes

$$PVL = ACL\delta + DCU0 + \Sigma\ DCLt\ \delta t$$

Box 17.2 (continued): Adaptation Costs and Benefits

The benefit of early adaptation can be expressed as the change in the two present value streams:

$$(PVN - PVL) = (ACN - ACL\delta) + (DCN0 - DCU0) + \Sigma\ (DCNt - DCLt)\delta t$$

The expression shows that the timing of adaptation will be driven by the relative magnitude of three cost components. The first is the difference in adaptation costs over time, (ACN - ACLδ). The effect of discounting would normally favour a delay in adaptation measures, and so would the prospect of potentially cheaper and more effective adaptation techniques to be developed in the future (ACN > ACL). However, there is also a class of adaptations where early action is cheaper. They include adjustments to long-term development plans and long-lived infrastructure investments such as water and sanitation systems, bridges and ports. In each of these cases, it will be cheaper to make adjustments early, in the design phase of the project, rather than incur the cost and inconvenience of expensive retrofits.

The second component concerns the short-term benefits of adaptation (DCN0 - DCU0). Early adaptation will be justified if it has immediate benefits (that is, DCN0 < DCU0), for example by adapting to the effects of climate variability. Also in the second category fall adaptations that have strong ancillary benefits, such as measures to preserve and strengthen the resilience of natural ecosystems. Another important example is health investments, which have poverty-alleviation benefits that are at least as large as the climate change benefits.

The third component has to do with the longer-term effects of early adaptation (Σ(DCNt - DCLt)δt). Early adaptation is justified if it can lock in lasting benefits (that is, DCNt < DCLt), for example by preventing long-term damage to ecosystems.

Dealing with uncertainty

Uncertainty about the exact nature of climate change impacts at the local and regional level (for example in terms of precipitation) makes it difficult to fine-tune adaptation measures. Adaptation decisions will be taken under uncertainty. Conceptually, this means that most of the adaptation benefits (avoided climate impacts) in the illustrative example shown earlier should be interpreted as expected benefits, that is, the probability-weighted mean over the range of possible outcomes. Risk averse decision makers may pay more attention to negative outcomes, and if the potential cost of inaction is substantial, adaptation decisions may be based on the precautionary principle.

One set of adaptation measures that are easy to agree on, even in the face of uncertainty, are win-win measures. That is, adaptations that would be justifiable even in the absence of climate change. Many measures to deal with climate variability (for example, long-term weather forecasting and early warning systems) may for example fall into this category. Schelling (1992) has argued that one of the best adaptation measures available would be (sustainable) economic development, and it is easy to agree that better health care, access to safe drinking water and improved sanitary conditions for the world's poorest households are clear win-win measures. Fankhauser *et al.* (1998) have argued that given the prevailing uncertainties, the best way to account for potential climate change in current investment decisions may be to increase the flexibility and robustness of systems – allowing them to function under a wide range of climatic conditions and withstanding more severe climatic shocks.

The call for increased flexibility and robustness applies equally to physical, natural and social systems. In the case of physical capital, the capacity of water storage systems may be increased in anticipation of future droughts, for example, or coastal protection measures may be strengthened to withstand more severe storms and floods. In the case of natural capital, measures to protect the environment may increase the ability of species to adapt to a changing climate. Meanwhile regulatory frameworks that encourage individual adaptability would help to increase the flexibility and robustness of economic systems.

17.2.4.1 Benefit-Cost Analysis

Benefit-cost analysis focuses on monetised benefits and costs of alternative measures. In the case of adaptation it involves identifying all benefits and costs over the lifetime of a proposed adaptation measure; converting the costs and benefits to a single metric (usually in monetary terms); discounting the future value of benefits and costs (Dolan *et al.*, 2001). Adaptation measures where discounted benefits exceed discounted costs are considered preferable, and alternatives can be ranked according to the ratio of the benefits to the costs (Toth, 2000) or their net benefits (Fankhauser, 1996; Fankhauser *et al.*, 1997).

There is a small methodological literature that has devoted itself to the definition of costs and benefits in the context of climate change adaptation (Fankhauser, 1996; Callaway, 1997; Smith, 1997; Fankhauser *et al.*, 1998; Callaway, 2004). Studies looking at the costs and benefits of adaptation in conjunction are still relatively rare. Most systematic studies were undertaken in the context of impact assessments, where adaptation costs form a significant part of total impacts. In addition there are a number of case studies that look at adaptation options for particular sectors (e.g., Fankhauser, 1994; Shaw *et al.*, 2000 all for sea level rise); or particular countries (e.g., Smith, 1998 for Bangladesh; World Bank, 2000 for Fiji and Kiribati; Dore and Burton, 2001 for Canada). Smith and Lazo (2001) reviewed the use of benefit-cost analysis participating in the US Country Studies Program to examine coastal protection measures to adapt to sea level rise (Table 17.2).

Table 17.3: *Benefit-Cost Ratios[a] from Coastal Resources from Selected Countries*

Location	Level of Protection	Sea Level Rise Scenario 0.3 m	0.5 m	1.0 m
China (Zhujiang Delta)	Full Protection	7.7	14.3[b]	12.8
Estonia (Tallinn & Pärnu)	Full Protection	—	—	0.9 & 2.3[c]
Poland (entire coastline)	Full Protection	2.6	—	4.6
	Partial Protection	3.3	—	—
Venezuela (all study sites)	Full Protection	—	0.02	—
Uruguay (entire coastline)	Full Protection (sea walls)	7.6 - 21.6	7.0 - 30.8	10.3 - 42.9
	Full Protection (beach nourishment)	3.2 - 9.0	3.2 - 13.9	4.9 - 20.4

a. Benefit-cost ratios calculated from the benefit-cost analyses in the national reports.
b. Ratio based on a benefit-cost analysis for a 0.65 m scenario.
c. These ratios are for a 1.0 m sea level rise and a 1.5 m storm surge respectively.

The majority of studies concentrate on agriculture and sea level rise. In most cases they do not try to optimise the adaptive response, but study the costs or benefits of certain policy (Tol *et al.*, 1998). A global vulnerability assessment (GVA) based on a series of country studies, for example, found that coastal adaptation could reduce the number of people at risk from flooding by almost 90 per cent, at an annual cost of around 0.06 per cent of GDP (Table 17.4). Subsequent studies for Senegal (Dennis, 1995) and Uruguay (Volonte, 1995) tested whether adaptation costs of this magnitude are justifiable from an economic efficiency point of view. They conclude that the preferred strategy for Senegal would be “important area protection”, with perhaps even a lower level of protection in Uruguay. Studies for US coastal areas, in contrast, generally find even quite comprehensive adaptation measures to be justified economically. Farming studies tend to find similarly positive results. Relatively simple adaptive measures like a change in planting date and increased irrigation could reduce yield losses by at least 30 per cent. More comprehensive adjustments could eliminate the majority of losses and in some cases turn losses into gains. However, adaptation gains are very unevenly distributed. A global study by Reilly *et al.* (1994) found that adaptation would be less effective in developing countries, where adaptive and institutional capacity is more limited. Most of the adaptive measures typically considered in farming studies are assumed to be low and sometimes zero cost options. Nevertheless, it remains an important shortcoming of many studies of agricultural adaptation that the costs of adaptation are not clearly spelt out. As such, it is difficult to ascertain the economic efficiency at least of those measures that are known to be more costly.

In another application of this approach, You *et al.* (2001) evaluated adaptation strategy to mitigate flood damage in China using a welfare-optimization model. They estimated optimal amounts of investment in flood control infrastructure for scenarios which assumed both the occurrence and non-occurrence of climate change. Significant loss of human welfare occurs when flood control infrastructure is planned without considering climate change, and the phenomenon occurs in future. On the contrary, this loss can be minimized by planning for flood control with considering climate change. Also, the sub-optimal case, where the region is prepared for climate change but the phenomenon does not occur, has been considered. This case may be considered to be as desirable as the case where no planning for climate change takes place and climate change does not occur. This is because the investment made in view of climate change would be also utilized for controlling floods in future caused by factors unrelated to climate change. By adopting the minimax regret principle, investment in flood control considering climate change was shown to be a good strategy even if there is uncertainty in the occurrence of climate change.

While BCA, if done in a comprehensive manner, can facilitate direct comparison of adaptation costs and benefits along a common metric, it also has several limitations. It is data intensive, only provides aggregate numbers and not how the benefits and costs are distributed, and conversion to a single monetary metric might not adequately account for non-market costs and benefits.

17.2.4.2 Cost-Effectiveness Analysis

Cost-effectiveness analysis (CEA) offers an alternate to BCA when adaptation benefits cannot be measured reliably or cannot be reliably monetised. Typically it is used to find the least expensive option to meet a certain goal, which could for example be costs per life saved. CEA can also be used when there might be multiple benefits to consider, but which can be reduced to a common (though non-monetary) metric. This can be accomplished using an Adaptation Decision Matrix (Benioff *et al.*, 1996) which weights benefits in terms of their priority and scores specific measures in terms of their ability to achieve the various benefits. Cost-effectiveness can then be computed in terms of cost of measure per unit of incremental benefit. This approach at evaluating adaptation measures has been employed by the Uruguay Country study for evaluating measures to adapt to sea level rise.

Table 17.4: *The impact of adaptation by farmers on agricultural impact*

Study/study area	*Climate scenario*	*Type of adaptation*	*Climate impacts* without adaptation	*Climate impacts* with adaptation	*Impact change no adaptation to adaptation*
Easterling et al. (1993)			*yield change (bn$)*		*% impact red.*
Missouri, Iowa, Nebraska, Kansas (MINK)	1930s climate analogue; base year 1980s	change in planting date and tillage practices, change in crops, improved irrigation and crop drought resistance	-1.33 - -2.71	-0.53 - -1.92	29 - 60
Rosenzweig and Parry (1994)			*change in cereal prod. (%)*		*% impact red.*
Developed countries	$2xCO_2$ base year 2060	small shifts in planting date (< 1 month), change in crops, additional irrigation ("level 1 adaptation")	-3.5 - 11.3	4.0 - 14.0	24 - >100
Developing countries			-10.8 - -11.0	-9.0 - -12.0	-9[1]- 17
World			-1.2 - -7.6	0.0 - -5.0	34 - 100
Adams et al. (1993)			*welfare change (bn$)*		*% impact red.*
United States	$2xCO_2$ base year 1990	as Rosenzweig and Parry (1994)	2.15 - -13.00	10.82 - 9.03	>100
Reilly et al. (1994)[2]			*welfare change (bn$)*		*% impact red.*
Developing countries	$2xCO_2$ base year 1989	as Rosenzweig and Parry (1994)			
- GDP/cap < $500			-2.07 - -19.83	-0.21 - -14.59	26 - 90
- GDP/cap $500-2,000			-1.80 - -15.01	-0.43 - -10.67	41 - 76
- GDP/cap > $2,000			-0.33 - -0.82	-0.60 - -1.02	20 - 46
E. Europe & former USSR			1.89 - -10.96	2.42 - -4.88	29 - 56
OECD			2.67 - -15.10	5.82 - -6.47	57 - >100
World			-0.13 - -61.23	7.00 - -37.62	39 - >100

Notes:
[1] Worldwide adaptation alters terms of trade to the disadvantage of developing countries.
[2] Based on Rosenzweig and Parry (1994) yield data.
Source: Fankhauser *et al.* (1998)

1 ***Table 17.5:*** *Multi-criteria Analysis of adaptation practices for Fiji (Source: World Bank (2000))*

Goal	Adaptation measure	No regrets?	Level of implementation	Bottom up or top down	Negative Environmental impacts?	Culturally acceptable?	Timing	Cost-benefit
Moderate impacts on coastal areas								
Protection of critical ecosystems	Increase public awareness		Generic	Both	No	Yes	Immediate	Positive
	Prohibit extraction of reef and sand	Yes	Sector specific	Both	No	May increase building costs	Immediate	Positive
	Prevent mangrove removal	Yes	Sector specific	Both	No	Unknown	Immediate	Positive
	Control pollution	Yes	Generic	Top down	No	Unknown	Immediate	Unknown
	Control overfishing	Yes	Sector specific	Both	No	Loss of food	Immediate	Positive
Protection of towns and property	Engineered structures (such as seawalls)	No	Site specific	Top down	Probably	Unknown	Unknown	Unknown
	Set back development from shoreline	No	Site specific	Both	Unknown	Land tenure?	Can wait	Unknown
Land use policies	Raised structures	No	Site specific	Both	Unknown	Unknown	Can wait	Unknown
Control of erosion	Coastal hazard mapping	Yes	Site specific	Top down	No	Yes	Immediate	Unknown’
	Mangrove replantation	Yes	Sector specific?	Both	No	Yes	Immediate	Positive
	Engineering works in passages	No	Site specific	Top down	Probably	Unknown	Can wait	Unknown
	Groynes	No	Site specific	Top down	Probably	Unknown	Immediate	Positive(?)
Moderate impacts on water resources								
Water resource management	Leakage control	Yes	Sector specific	Both	No	Yes	Immediate	Positive
	Pricing policies (fees, levies, surcharges)	Yes (?)	Sector specific	Top down	No	Problematic	Immediate	Positive
	Conservation plumbing	Yes	Sector specific	Both	No	Unknown	Immediate	Positive
Catchment management	Stricter penalties to prevent waste	Yes (?)	Generic	Top down	No	Resistance?	Immediate	Positive
	Reforestation, soil conservation	Yes	Generic and site specific	Both	No	Yes	Immediate	Positive
	Establishment of a Water Authority	Yes	Sector specific	Top down	No	Unknown	Immediate	Positive
Alternative water supply	Expansion of rainwater collection	Yes	Sector and site specific	Both	Unknown	Maybe	Immediate	Unknown
	Alternative groundwater use	Yes	Sector and site specific	Top down	Unknown	Land tenure?	Can wait	Unknown
	Desalination	No (?)	Sector and site specific	Top down	Unknown	High costs	Can wait	Unknown
Flood control	Importation	No (?)		Top down	No	High costs	Can wait	Negative
	Diversion channels, weirs, etc.	No	Sector specific	Top down	Probably	Unknown	Immediate	Unknown
	Land use controls, flood proof housing	No (?)	Site specific Site specific	Both	No	Land tenure?	Immediate	Unknown
Moderate impacts on agriculture								
Community sustainability programs	Traditional weather-resistant practices	Yes	Sector specific	Bottom up	No	Yes	Immediate	Positive
	Agroforestry, water conservation	Yes	Sector specific	Both	No	Unknown	Immediate	Positive
Sustainability production systems	Flexible farming systems	Yes	Sector specific	Top down	No	Unknown	Immediate	Positive (?)
Research	Mapping of suitable cropping areas	Yes	Generic	Top down	No	Unknown	Immediate	Positive
Land use policies	Avoid cultivation on marginal lands	Yes	Site specific	Top down	No	Disruptive	?	Positive

Moderate impacts on public								
health	Poverty reduction programs	Yes	Generic & site specific	Top down	Unknown	Yes	Immediate	Positive?
Integrated adaptation strategies	Improved sanitation and water supply	Yes	Sector and site specific	Both	No	Yes	Immediate	Positive
and control of diarrhoeal disease	Waste management		Sector and site specific					
	Protection of ground water	Yes	Sector and site specific	Both	No	Unknown	Immediate	Positive
	Squatter settlement management	Yes	Site specific	Both	No	Unknown	Immediate	Positive
	Community-based vector control	Yes	Site specific	Both	Unknown	Yes?	Immediate	Positive
	Improved preparedness (monitoring)	Yes	Sector and site specific	Bottom up	No	Unknown	Immediate	Positive
Control of dengue fever	Prevention of exposure							
	Reduce destructive practices to coral	Yes	Sector specific	Top down	No	Yes	Immediate	Positive
	reefs	Yes	Sector specific	Bottom up	Unknown	Difficult?	Unknown	Unknown
Control of ciguatera poisoning	Monitoring and public awareness							
		Yes	Sector specific	Both	No	Food, income?	Immediate	Positive
		Yes	Sector specific	Both	No	Yes	Immediate	Positive
Moderate impacts on tuna								
fisheries	Multilateral agreements	Yes	Sector specific	Top down	Unknown	Distrust?	Immediate	Positive
Stronger regional collaboration	Better ENSO forecasting	Yes	Generic	Top down	No	Yes	Immediate	Positive
Research	Improved tuna management	Yes	Sector specific	Top down	No	Yes	Immediate	Positive
	Diversification of domestic fleets	No	Sector and site specific	Top down	Unknown	Problematic	Can wait	Positive
Fleet management								

17.2.4.3 Multi-Criteria Analysis

Multi-criteria analysis (MCA) refers to a broad array of evaluation methods which explicitly take into account multiple criteria. They may include, but not be limited to economic criteria such as costs. These criteria can be specified by an analyst or be solicited from relevant stakeholders. MCA involves the specification of objectives, alternative measures/interventions, criteria for evaluation, scoring of specific measures against the criteria, and weights ascribed to the various criteria. The selection of criteria and their weights involve considerable amount of expert judgment. The results of an MCA can be aggregated into a single index value to reflect the overall merit of specific adaptation measures (Dolan *et al.*, 2001).

There are a number of examples of the use of MCA techniques both to screen for adaptation priorities and to evaluate specific adaptation measures. The Adaptation Decision Matrix developed by the US Country Studies Program is an example of an MCA technique used to select adaptation options in a number of national assessments in developing countries (Benioff *et al.*, 1996). Mizina *et al.* (1999) selected twelve, later screened to four, adaptation options for Kazakhstan agriculture under climate change. The analysts also selected eight policy objectives, ranging from maintain food security to maximize employment, which they weighted (1 to 5). Each adaptation option was scored by the analysts on each objective, and the weighted scores aggregated by one of two algorithms. There was presented as an illustrative exercise – there is no evidence that any of the adaptation options was implemented, nor were the connections with policy decisions addressed.

Yin (2001) uses a multi-criteria method, applying a so-called analytic hierarchy process (AHP) to assess the relative performance of adaptation options to deal with climate change impacts on agriculture, fisheries, forestry, health, water resources, energy and coastal regions in the Georgia basin of Canada. The adaptation options were selected by the analysts and the process was undertaken according criteria selected by the analysts, but involving stakeholders in the region. Stakeholders were required to complete pair-wise comparisons of the selected options, thereby contributing to the scoring and prioritized ranking of the selected adaptation measures. The report notes the limits of the approach taken, and there is no indication that the results directly influenced the resource use decision making in the area.

Dolan *et al.* (2001) use MCA to assess adaptation measures to climate change in Canadian Prairies. Six criteria were used for this purpose: effectiveness; (ii) economic efficiency; (iii) flexibility; (iv) institutional compatibility; (v) farmer implementability; and (vi) independent benefits. The criteria were then used to assess adaptation measures for different stakeholders (farmers and government). They then select three potential adaptations, six criteria, optional weights on criteria, and assign scores (0 to 5) for each adaptation option on reach criterion. Several aggregation models are employed, including the common sum of weighted scores, to calculate an overall relative score for each adaptation option. The paper shows that, quite apart from the subjectivity of the methods, the approach has very limited utility for actual decision making in agriculture. A more participatory assessment using MCA was used by the World Bank which examined the planning implications of climate change and sea level rise in Viti Levu, Fiji (World Bank, 2000). A range of specific adaptation practices was identified along with criteria for their evaluation, as shown in Table 17.3.

MCA approaches offer the ability to incorporate a wide range of criteria which might be relevant to assess adaptation measures. They are also quite amenable to be used in a participatory setting where stakeholders are actively involved. The principal pitfalls stem from the subjectivity involved in ascribing weights to different criteria and measures, which can influence the final result considerably (Niang-diop and Bosch, 2005).

17.3 Assessment of Adaptation Capacity, Options and Constraints

17.3.1 Adaptive capacity and its relationship to vulnerability

Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change. Responses can include adjustments or changes in characteristics or behaviour. The presence of adaptive capacity enables the design and implementation of effective adaptation strategies, in reaction to evolving risks and stresses, so as to reduce the likelihood and the magnitude of harmful outcomes resulting from climate change (Brooks and Adger, 2005). It is also necessary to take advantage of opportunities or benefits from climate change, such as a longer growing season or increased potential for tourism (O'Brien *et al.*, 2005). Adaptive capacity is influenced by the resources available for adaptation, and by the ability or capacity of that system to use these resources effectively in the pursuit of adaptation, consciously or unconsciously (Reilly and Schimmelpfennig, 2000). These resources may be natural, human, financial, or institutional, and might include access to ecosystems, information, expertise, and social networks.

While determinants of adaptive capacity are often linked to general indicators of development, it is important to point out that adaptive capacity is not a concern unique to regions with low levels of economic activity. High income per capita is considered neither a necessary nor a sufficient indicator of the capacity to adapt to climate change (Moss *et al.*, 2001). Furthermore, even within the wealthiest developed countries, some regions, localities, or social groups have a lower adaptive capacity (O'Brien *et al.*, 2005). In short, adaptive capacity is needed to minimize risk as well as take advantage of opportunities in both developed and developing countries.

Much of the current understanding of adaptive capacity comes from vulnerability studies and assessments. Vulnerability is often considered an outcome of climate change, influenced by adaptive capacity and consequent adaptations (Smit *et al.*, 2001). However, vulnerability can also be seen as a state or condition that exists prior to exposure to climate change. Many of the same contextual factors that contribute to a state of vulnerability also undermine adaptive capacity (O'Brien and Vogel, 2004). Climate change meanwhile may alter social, economic, or institutional factors in ways that enhance contextual vulnerability. Both types of vulnerability have been demonstrated to be reduced by adaptive options. Research on climate change vulnerability has thus provided valuable insights on adaptive capacity and adaptation. Methods and frameworks for assessing vulnerability either depend upon or embed an understanding of the determinants of adaptive capacity (Turner *et al.*, 2003; Schroter *et al.*, 2005). Through a growing body of vulnerability research, it is becoming clear that the underlying causes of vulnerability must be addressed in order to develop the capacity to adapt to climate variability and long-term climate change (Kelly and Adger, 2000).

Among the methods available to assess vulnerability, the indicator approach has been widely used to make comparisons of both vulnerability and adaptive capacity across the globe, as well as regionally and nationally. For example, in quantitative approaches to vulnerability, national-level adaptive capacity was represented by proxy indicators for economic capacity, human and civic resources, and environmental capacity (Moss *et al.*, 2001). Even if vulnerability indices do not explicitly include determinants of adaptive capacity, the indicators selected often provide important insights on the factors, processes and structures that promote or constrain adaptive capacity (Eriksen and Kelly, 2005). One clear result from research on vulnerability and adaptive capacity is that some dimensions of adaptive capacity are generic, while others are specific to particular climate change impacts. Generic indicators include factors such as education, income, and health. Indicators specific to a particular impact, such as drought or floods, may relate to institutions, knowledge and technology (Yohe and Tol, 2002; Downing, 2003; Brooks and Adger, 2005).

Adaptive Capacity and Coping Capacity

Adaptation is often described as responses taken in order to cope better with a variable and changing climate, and to expand coping ranges (Jones, 2001). Although adaptive capacity and coping capacity are related, adapting and coping are not synonymous. While the process of adaptation consists of adjustments in practices, processes or structures made in response to the actuality or threat of long-term climate change and leading to an evolving change in physical or social conditions, coping refers to actions performed in response to the actuality of present climatic stress, often aimed at restoring a previous state and generally of a short duration (Eriksen and Kelly, 2005).

A system may cope with a recurrent hazard for the duration of the event, and provided that the system copes successfully, it may revert to its pre-hazard state. Nevertheless, in this case the system's adaptive capacity has not been realized and adaptation is minimal. The coping range of a system may expand, and often this is an indication of new adaptations. The coping range may also contract, often in relation to an increased state of vulnerability. Future climate change may exceed current coping capacity. For example, a sudden discontinuity in climate, such as an extreme cold front in a normally temperate or tropical climate zone, may represent a shock that exceeds a system's ability to cope. Likewise, sequential extreme weather events, such as a series of hurricanes, may also limit a system's ability to cope (WBGU, 1998). The literature in this area establishes, therefore, that unless adaptive capacity is enhanced and adaptations are undertaken, current coping capacity can be considered insufficient for responding to climate change.

17.3.2 Determinants of adaptive capacity, role of technology

Technology plays an important role in adaptation to climate change. Innovation, which refers to the development of new strategies or technologies, or the revival of old ones in response to new conditions (Bass, 2005), is an important aspect of adaptation, particularly under uncertain future climate conditions. Cooling systems, improved seeds, desalinisation technologies, and other engineering solutions represent some of the options that can lead to improved outcomes and increased coping under conditions of climate change. IN public health, for example, there have been successful applications of seasonal forecasting and other technologies to adapt health provision to anticipated extreme events (Ebi *et al.*, 2005). Often, technological adaptations and innovations are developed through research programs undertaken by governments and by the private sector (Smit and Skinner, 2002). The capacity to undertake such programs may be linked to economic resources, institutions, incentives, etc. Technological capacity can thus be considered a key aspect of adaptive capacity. Many technological responses to climate change are, however, related to a specific type of impact, such as higher temperatures, decreased rainfall, etc. For this reason, determinants of adaptive capacity that take into account the nature of climate change and the characteristics of the system or population are important to understanding whether and how adaptations will take place (Brooks and Adger, 2005).

The capacity of societies to adapt to climate risks has frequently been linked with levels of economic development, with the assumption that more economically 'developed' societies have greater access to technology and resources to invest in adaptation (refs). However, new studies carried out since the TAR show that adaptive capacity is influenced not only by factors that promote or constrain the adoption of technologies and management practices, but also by the economic, social, political, environmental, institutional, and cultural factors that create both external and internal incentives as well as barriers to adaptation (Klein and Smith, 2003; Berkhout *et al.*, 2004; Eriksen and Kelly, 2005; Næss *et al.*, 2005; Tompkins, 2005).

A distinction has been made between adaptation to climate change as a challenge for technology and management, and adaptation to climate change as a challenge for development in general (Burton *et al.*, 2002). There is a recognized need for theoretical frameworks to understand how decision-makers process information about climate risks, identify and assess adaptation options, and choose whether, when, and how to employ them (Parson *et al.*, 2003), in order to reduce vulnerability as an outcome of climate change. However, there is also a need to consider adaptive capacity within a development framework (Burton *et al.*, 2002), to reduce vulnerability as an existing state or condition.

National indicators of adaptive capacity
The determinants of national adaptive capacity represent an area of contested knowledge. Some studies relate adaptive capacity to levels of development, including political stability, economic well-being, human and social capital, and institutions (AfDB *et al.*, 2003). However, recent research has questioned the usefulness of equating adaptive capacity with development. Haddad (2005) has shown empirically that the ranking of adaptive capacity of nations is significantly altered when national aspirations are made explicit. He demonstrates that different aspirations (e.g., seeking to maximize the welfare of its citizens, to maintain control of their citizens, or to reduce the vulnerability of the most vulnerable groups) lead to different weightings of the elements of adaptive capacity, and hence to a set of competing rankings of the actual capacity of countries to adapt.

There are competing notions of governance and the role of social capital in meeting societal needs for collective action for adaptation (Dasgupta, 2003; Pelling and High, 2005). The engagement of individuals in social and economic networks is hypothesized to be significant for economic performance as well as generic adaptive capacity. Based on empirical experience in adapting to present day weather extremes, Adger (2003) shows that associations, networks and capital form a vital element in adaptive capacity. Elements of governance such as trust are important in adaptive capacity, but its determinants and its evolution in the future remain uncertain (Adger and Vincent, 2005).

This set of research on adaptive capacity, in summary shows some convergence on the importance of development and resources as indicators of generic adaptive capacity. Many studies are careful to point out, however, that indicators of adaptive capacity at one scale are not necessarily representative of adaptive capacity at other scales of analysis (Downing *et al.*, 2001; Moss *et al.*, 2001).

The literature is contested on the usefulness of these lessons on generic adaptive capacity and the sensitivity of the results. There is some evidence that national-level indicators of vulnerability and adaptive capacity are used by climate change negotiators, practitioners, and decision-makers in determining policies and allocating priorities for funding and interventions (Eriksen and Kelly, 2005). However, few studies have been globally comprehensive, and a comparison of results across five vulnerability assessments shows that the 20 countries ranked 'most vulnerable' show little consistency across studies (Eriksen and Kelly, 2005). Furthermore, they fail to capture many of the processes and contextual factors that influence adaptive capacity, thus provide little insight on adaptive capacity at the level where most adaptations will take place (Eriksen and Kelly, 2005).

Local context for adaptive capacity
Although national indicators can provide a relative and comparative understanding of adaptive capacity, the capacity to adapt to climate change depends heavily on the local context. Indices based on aggregated data can hide heterogeneity at smaller spatial scales. Furthermore, indicator studies

generally provide only snapshots of vulnerability and fail to represent the dynamics of vulnerability and adaptive capacity over time (Leichenko and O'Brien, 2002; Eriksen and Kelly, 2005). An alternative and complementary approach is based on specific contextual studies that include both qualitative and quantitative methods for identifying vulnerability and adaptive capacity, including how it may evolve over time. Such place-based studies provide insights on the conditions that constrain or enhance adaptive capacity (Schroter *et al.*, 2005).

Although the lessons from studies of local-level adaptive capacity are context-specific, they establish some broad criteria by which to assess the adaptive capacity of communities. The nature of the relationships between community members is critical, as are access to and participation in the wider decision-making processes. In areas such as coastal zone management, the expansion of social networks has been noted as an important element in developing more robust management institutions (Tompkins *et al.*, 2002). Local groups and individuals often feel their powerlessness in many ways, although none so much as in the lack of access to decision makers. Building successful community-based resource management for example, in the form of co-management arrangements, can potentially enhance the resilience of communities as well as maintain ecosystem services and ecosystem resilience.

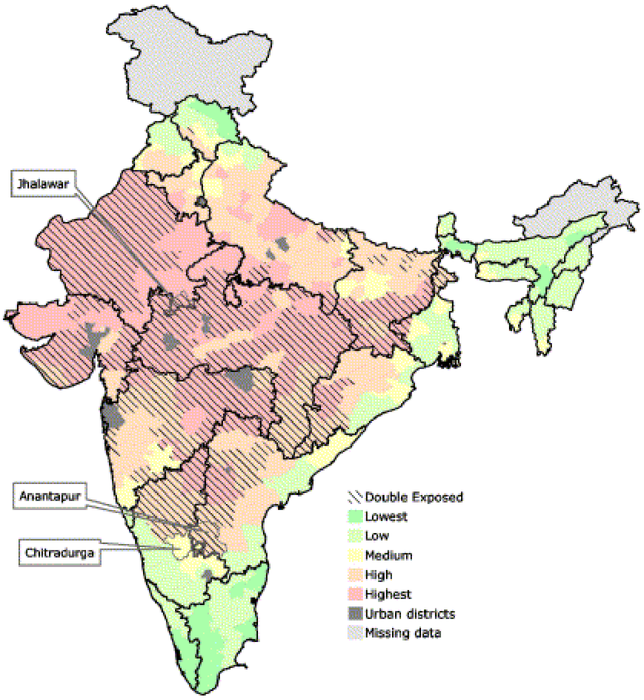
However, adaptation at any one scale may be constrained by factors outside the system in question. At the local scale, such constraints may take the form of regulations or economic policies determined at the regional or national level that limit the freedom of individuals and communities to act, or make certain potential adaptation strategies unviable. There is a growing recognition that vulnerability and the capacity to adapt to climate change are influenced by multiple processes of change (refs). Conflicts, urbanization, trade liberalization, and infectious disease can influence adaptive capacity, either positively or negatively. Mapping the capacity to adapt to climate change and trade liberalization in India, O'Brien *et al.* (2004) show that districts with low adaptive capacity are more likely to be vulnerable to both climate change and globalization (**Box 17.3**).

Adaptive capacity is highly heterogeneous within a society or locality and for human populations it is differentiated by age, class, gender, and social status. Box 17.4 describes how adaptive capacity and vulnerability to climate change impacts are different for men and women, with gender-related vulnerability particularly apparent in resource-dependent societies and in the impacts of extreme weather-related events.

Box 17.3: Mapping Adaptive Capacity to Multiple Stressors

The capacity to adapt to climate change is not evenly distributed across or within nations. Yohe and Tol(2002) identify a number of factors that account for differences in national adaptive capacity: institutional, technological, equity, etc. However, adaptive capacity is also highly differentiated within countries, where multiple processes of change interact to influence vulnerability and shape outcomes from climate change. In India, for example, both climate change and trade liberalization are changing the context for agricultural production. Some farmers are able to adapt to these changing conditions, including the discrete events such as drought and rapid changes in commodity prices. Other farmers may experience predominately negative outcomes from these simultaneous processes. Identifying the areas where both processes are likely to have negative outcomes provides a first step in identifying options and constraints in adapting to changing conditions.

Mapping vulnerability of the agricultural sector to both climate change and trade liberalization at the district level in India, O'Brien *et al.* (2004) considered adaptive capacity as a key factor that influences outcomes. A combination of biophysical, socioeconomic, and technological conditions were considered to influence the capacity to adapt to changing environmental and economic conditions. The biophysical factors included soil quality and depth and groundwater availability, whereas socioeconomic factors consisted of measures of literacy, gender equity, and the percentage of farmers and agricultural wage labourers in a district. Technological factors were captured by the availability of irrigation and the quality of infrastructure. Together, these factors provide an indication of which districts most likely to be able to adapt to drier conditions and variability in the Indian monsoons, as well as respond to import competition and export opportunities resulting from liberalized agricultural trade. The results of this mapping showed higher degrees of adaptive capacity in districts located along the Indo-Gangetic Plains (except in the state of Bihar), and lower capacity in the interior parts of the country, particularly in the states of Bihar, Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh, and Karnataka.



Districts in India that rank in the highest in terms of climate change vulnerability and globalization vulnerability are considered to be double exposed (depicted with hatching).
Source: O'Brien *et al.* (2004).

Box 17.4: Gender aspects of vulnerability and adaptation

Empirical research on vulnerability and adaptation has established that the capacity to adapt to climate change depends on factors such as health, governance and political rights, and economic well-being (Pelling, 2003; Brooks *et al.*, 2005). At different levels of analysis, entitlements to these assets are socially differentiated along the lines of age, ethnicity, class, religion and gender (Cutter, 1995; Wisner, 1998; Enarson, 2000; Denton, 2002). Climate change therefore has gender-specific implications in terms of both vulnerability and adaptive capacity as well as in emissions and technologies (Dankelman, 2002). The role of gender in influencing adaptive capacity and adaptation is thus an important consideration for the development of interventions to enhance adaptive capacity and to facilitate adaptation.

There are structural differences between men and women through, for example, gender-specific roles in society, work and domestic life. These differences affect the vulnerability and capacity of women and men to adapt to climate change. In the developing world in particular, women are disproportionately involved in natural resource-dependent activities, such as agriculture (Davison, 1988; Shahra, 2003), compared to salaried occupations. As resource-dependent activities are directly dependent on climatic conditions, changes in climate variability projected for future climates are likely to affect women through a variety of mechanisms: directly through water availability, vegetation and fuelwood availability and through health issues relating to vulnerable populations (especially dependent children and elderly). Most fundamentally, the vulnerability of women in agricultural economies is affected by their relative insecurity of access and rights over resources and sources of wealth such as agricultural land. It is well established that women are disadvantaged in terms of property rights and security of tenure, though the mechanisms and exact form of the insecurity are contested (Agarwal, 2003; Jackson, 2003). This insecurity can have implications both for their vulnerability in a changing climate, and also their capacity to adapt productive livelihoods to a changing climate.

There is a body of research that argues that women are more vulnerable than men in particular ways to weather-related disasters. The impacts of past weather-related hazards have been disaggregated to determine the differential effects on women and men: for examine hurricane Mitch in 1998 (Bradshaw, 2004) and for natural disasters more generally (Fordham, 2003). Whilst there are not always discernable gender differences in the immediate impacts of events such as hurricanes, in terms of deaths, they are often manifest in the post-event recovery period. The disproportionate amount of the burden endured by women during rehabilitation has been related to their roles in the reproductive sphere (Nelson *et al.*, 2002). Children and the elderly tend to be based in and around the home and so are often more likely to be affected by flooding event with speedy onset. Women are usually responsible for the additional care burden during the period of rehabilitation, whilst men generally return to their pre-disaster productive roles outside the home. Fordham (2003) has argued that the key factors that contribute to the differential vulnerability of women in the context of natural hazards in South Asia include: high levels of illiteracy, minimum mobility and work opportunities outside the home; and issues around ownership of resources such as land.

Access to and responsibility for resources such as water and fuelwood are also different among men and women. Research has shown a projected change in the availability of water resources under climate change (Arnell, 2004). Although formal rights to water are rarer for women than for men, they are often able to gain access through informal mechanisms. Increasing water scarcity, however, is likely to necessitate further policy restrictions, which without explicit reference to gender equity might have a greater adverse effect on women (Zwarteveen, 1997).

Research has argued that due to the differential effects of climate change impacts on men and women, adaptation actions and policies should take these differences into account for both equity and effectiveness reasons. Greater availability of seasonal forecasts and other climate predication tools is thought to increase adaptive capacity (Ziervogel and Calder, 2003). But to ensure maximum benefit, seasonal forecasts need to be targeted to suit the needs of the end user (Ziervogel, 2004). An empirical study in Limpopo province, South Africa, shows gender differences in the application and uptake of seasonal forecasts (Archer, 2003). Women prefer to receive the information through extension officers, whilst men would rather hear forecasts on the radio. If this gender difference is not actively considered, there is a chance that women who, by virtue of their role in agriculture in

Limpopo province, might perversely be least likely to benefit. More recent work has traced the process of information transmission through stakeholder networks (Ziervogel and Downing, 2004).

Gender differences in vulnerability and adaptation reflect wider patterns of structural gender inequality. Recognition of gender issues within development discourses has a longer history, and is now routinely considered when assessing projects and initiatives (Chant, 2000; Buckingham, 2004). Lessons from the analysis of gender and development dilemmas for mainstreaming gender into climate change concerns (Denton, 2004) include: interventions that ignore gender concerns reinforce the differential gender dimensions of vulnerability; and a shift in policy focus away from reactive disaster management to more proactive capacity building (Mirza, 2003), tends to reduce gender inequality.

17.3.3 Dynamics of adaptive capacity, options and constraints

Adaptive capacity varies widely among different temporal and spatial scales. The differences between scales are determined by environmental factors as well as the various demographic, social, economic, political and cultural features of different human systems (Chan and Parker, 1996; Burton *et al.*, 1998; Scheraga and Grambsch, 1998; Uitto, 1998; Adger *et al.*, 2004). Furthermore, regional differences in adaptive capacity are not only a function of location and resource availability, but also of the ability of institutions to implement adaptation measures (Ivey *et al.*, 2004). In addition, Schneider (2004) points out that the dynamics of adaptive capacity is based on societal values, perceptions and levels of cognition. For example, the implementation of certain national adaptation measures will depend on whether or not they concur with public opinion and social norms (Haddad, 2005). The social dynamics of adaptive capacity are also dependent on the ability of human systems to act collectively (WBGU, 1998). It is therefore important to examine and understand what contributes to adaptive capacity at a variety of scales, as well as how vulnerability changes over time as biophysical, social, economic, institutional, and technological conditions change.

Spatial variations

Adaptive capacity varies spatially, from households and local scales to national and global scales. One cause of spatial variability is that the magnitude and probability of occurrence of certain extreme weather conditions varies significantly from location to location. For example, El Nino is an extreme weather event with global effects. However, these effects vary in type and magnitude from continent to continent depending on climate, hydrology, geography, agricultural practices and extent of adaptation (Glantz, 2001). Certain social, economic, cultural and environmental factors will make a system particularly vulnerable or adaptable to some types of hazards but not others. These factors influence the adaptive responses that different systems will employ (WBGU, 1998; Adger *et al.*, 2004; Reid *et al.*, 2004). For instance, different societies have different perceptions and thus different reactions to certain risks. These differences are largely shaped by the different cultural settings and the media that characterize various geographical areas.

Another explanation for spatial variability is that adaptation processes that are built from the bottom up and are based on social capital transform the perceptions of climate change from a global to a local problem. This local capacity to adapt suggests that some groups within society may be less at risk than modelling studies have portrayed because of their latent ability to cope in times of stress (Adger, 2003). Pastoralists in the Sahel region, for example, have adapted to significant rainfall decreases and a decline in resource availability in the course of the 20^{th} century, with limited reserves or resources to invest in new livelihood sources (Hulme *et al.*, 2001; Brooks, 2004).

Temporal variations

Research has demonstrated that adaptive capacity varies over time. Current coping mechanisms reflect past adaptations, and influence whether a system is able to implement the necessary long-term adaptation measures to reduce future vulnerability. Studies of similar hazardous events recurring at different times in a given region show vastly different consequences because of societal transformations that occurred between the events (Abel, 1976; De Vries, 1977; Rayner and Malone, 1998 cited in IPCC, 2001; WBGU, 1998). The level of adaptive capacity of each system fluctuate over time, as the political, social, economic, institutional, and technological factors that determine adaptive capacity change (Brooks, 2003; Adger *et al.*, 2004).

Bangladesh serves as an example of how adaptive capacity can change over time (Mirza *et al.*, 2001). Over the past two decades, flood forecasting and warning systems in Bangladesh have improved significantly, with the result that residents are increasingly evacuated to safer places. Public education on the benefit of drinking purified water has expanded, as has the supply of safe drinking water. Treatment and facilities of diarrhoeal diseases have also improved. These have contributed to reduce the number of deaths during flood hazards in Bangladesh over the past fifty years (Figure 17.2) (Mirza *et al.*, 2001; Mirza, 2003). Nevertheless, adaptive capacity is not equally distributed within Bangladesh, and there is evidence that among the urban poor, women and children remain disproportionately vulnerable to floods (Rashid, 2000).

Relationship between Adaptive Capacity and Adaptation

Adaptation is portrayed in much of the literature as the realization of adaptive capacity in response to changing conditions. In contrast, adaptive capacity infers only an ability to identify and implement adaptations that enhance resilience or reduce vulnerability to observed or expected changes in climate. However, there is wide evidence that even when adaptive capacity is considered to be high, adaptation is not always timely or effective, particularly when coping with events outside of recent experience. Despite a high capacity to adapt to heat stress through relatively inexpensive adaptations, both residents and health services in urban areas in some parts of the world, including in North American and European cities, continue to experience high levels of mortality (Klinenberg, 2002; Weisskopf *et al.*, 2002; Keatinge, 2003).

Although adaptation may occur autonomously and instantaneously, a system typically requires time to translate its adaptive capacity into successful adaptations. In other words, adaptive capacity represents potential rather than actually adaptation. A system with a high capacity to adapt at present is likely to have low social vulnerability to hazards occurring in the future (Adger *et al.*, 2004). Adaptation not only depends upon the capacity of system to adapt, but also on the motivation of the system to realize its adaptive capacity and to reduce its vulnerability to the effects of climate change (Burton *et al.*, 2002). The failure of current adaptation to keep pace with development is described by Burton(2005) as an adaptation deficit. This failure is exemplified by continued high losses from climate-related disasters, such as floods or hurricanes.

The characteristics of future climate change are likely to be very different than the past, particularly in terms of the rate and magnitude of change. Thus, to reduce the adaptation deficit, the future adaptive capacity of a system should not represent a simple extension of past of adaptive capacity, since the current situation may not be representative of the extent or magnitude of future climate change. Most literature in this area concludes that improved knowledge of the nature of climate change is essential for understanding the relationship between adaptive capacity and adaptation and identifying appropriate level of responses (Parson *et al.*, 2003; Adger *et al.*, 2004; Ivey *et al.*, 2004).

17.4 Enhancing adaptation: Opportunities and constraints

17.4.1 Climate driven initiatives for enhancing adaptation

One recurrent focus at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP) is the need to emphasize the importance of adaptation to climate change. Another pressing issue is the need for the Least Developed Countries (LDCs) to have more support from the international community regarding climate change since they are relatively more vulnerable to the adverse impacts of human induced climate change (Huq *et al.*, 2003). In response, many international and national climate driven initiatives have been initiated to enhance adaptation.

Global Environment Facility (GEF)

Since financial capacity is influential in determining the adaptive capacity of a system, three funds have been created to support climate change adaptation, the Special Climate Change (SCC) Fund, the Least Developed Countries (LDCs) Fund and the Kyoto Protocol Adaptation Fund. The GEF is the operating entity for all three financial mechanisms. GEF projects are managed by the three GEF implementing agencies:

- the United Nations Environment Programme
- the United Nations Development Programme
- the World Bank

These executing agencies are expected to work separately yet complement each other. The GEF now also works with a variety of executing agencies that contribute to the management and execution of GEF projects. The seven international organizations employed as GEF executing agencies are:

- the African Development Bank (AfDB)
- the Asian Development Bank (ADB)
- the European Bank for Reconstruction and Development (EBRD)
- the Inter-American Development Bank (IDB)
- the International Fund for Agricultural Development (IFAD)
- the UN Food and Agricultural Organization (FAO)
- the UN Industrial Development Organization (UNIDO)

The UNFCCC (2004) noted that many of the priority issues identified in the capacity-building framework are currently being addressed by the GEF, its implementing agencies, and other multilateral and bilateral agencies but significant gaps, especially in the access to financial resources, still need to be filled. The pledge of $410 million per year from developed countries for climate change activities will be initiated in 2005 (Huq, 2002). Furthermore, the UNFCCC (2004) noted that, to date, there has been an increase in the number of funding sources available for activities relating to climate change and urges the Council of the GEF to ensure that adequate funding is available to enable developing countries to meet their commitments under the Convention, taking into account the fact that developed countries may also provide financial resources through bilateral, regional and other multilateral channels.

In 2003, the GEF proposed that a new strategic priority in the climate change focal area, entitled "Piloting an Operational Approach to Adaptation", would be implemented. The aim of the new strategic priority is to provide support for establishing pilot or demonstration projects that show how adaptation planning and assessment can be practically translated into projects that will provide real benefits, and may be integrated into national policy and sustainable development planning. By piloting approaches to adaptation, it is expected that the GEF will be able to effectively provide future guidance from the convention on adaptation without prejudice to which fund is designated as the source of funding for such activities (GEF, 2003). The decisions from UNFCCC COP 9 requested the GEF to initiate the Piloting an Operational Approach to Adaptation strategy as soon as possible (UNFCCC, 2004). Although global adaptation funds are not yet active at the international level, the Kiribati Adaptation pilot provides an example of a country-focused project aimed to reduce vulnerability to climate change and variability. The Republic of Kiribati is one of the first Pacific Island countries attempting to incorporate risk management and adaptation into its national economic planning by establishing the Kiribati Sanitation Public Health and Environment Improvement Project (SAPHE) to address problems of waste disposal and water resources. This is one of the first projects focusing exclusively on adaptation to climate change and will provide an early test case for the global adaptation funds (Van Aalst and Bettencourt, 2004).

In the past, the GEF only allowed funding to be allocated to adaptation projects that produce global environmental benefits. This approach is not applicable for adaptation projects since most of the benefits of adaptation activities are observed on a local scale. Furthermore, GEF policies were in favour of larger projects, which may not necessarily respond to the needs and scale of the most vulnerable countries. However, more widespread participation in climate change adaptation is being promoted under the new GEF strategic priority, Piloting an Operational Approach to Adaptation. For example, both incremental environmental benefits and development costs will be eligible for financing (GEF, 2003). Plus, the decisions from UNFCCC COP 9 gave recognition to the current level of funding for full and medium sized projects as well as the small grants programme, which facilitates adaptive capacity building activities in developing countries (UNFCCC, 2004). The main practical lessons learned by the GEF Small Grants Programme to date are as follows:

- Local benefits stimulate global environmental benefits since the greater the options for increased living standards, the greater the importance attached to an environment project by a community.
- Sustainable solutions to climate change or energy problems are those that are owned by the community since communities routinely invent or improve and adapt existing, practices or technologies to fit their own situations and meet their most pressing needs.
- Capacity development promotes integration and sustainability. For example, where a community operates a micro-hydropower plant, the capacity of individual technicians and management teams may need to be strengthened to ensure maintenance of the scheme and develop tariff setting.
- Complementary partnerships between different development sectors, including water, agriculture and micro-finance, among others, are crucial for effectiveness. Generally, partnerships lead to the co-financing of complementary activities related to climate change projects. Partnerships also play an important role in sustaining project activities or the impacts of a project after funding from SGP ends.
- Adapting technologies to suit local conditions is a process that generally requires training and capacity development to enable the manufacture, marketing and sale of the revised products in an established market. Before new technologies are introduced to communities, it is essential that an assessment be carried out to gauge existing capacity and understand what is needed to adapt to the proposed changes. Experience shows that projects can fail to recover if a technical problem occurs where the adaptation is drastically different from the prior technology and there is no in-built capacity to fix the problem.
- Financing options should fit the scale and scope of community objectives.

- Flexible methods for providing credit are important but the development and maintenance of high quality goods and services to sustain new markets and facilitate repayment should also be ensured. Lack of a critical mass to sustain demand reduces the momentum for the manufacture of new products.
- "Learning by doing" enhances management and ownership since it depends on the capacity of project partners to collect, analyze and store information at every stage of implementation, and to manage and share the knowledge generated in the process. With accumulated knowledge, country programme teams have used the lessons and experiences from previous projects to feed and inform the design of new projects.
- Since SGP climate change projects involve a long-term process of change, a project needs to be participatory, integrative and interactive to be effective. Relationships between ranges of partners must establish and communication networks should be established to discuss challenges, identify problems and correct courses of action.
- Since community climate change projects are usually low budget, they can potentially be scaled up and are easier to learn from than larger projects that are more conservative and bureaucratic (GEF, 2003)

In order to evaluate the success of any improvement strategies and document the progress of the GEF, the UNFCCC (2004) requested the GEF to report to the COP11 (November 2005) and at subsequent sessions on how activities identified in the Buenos Aires programme of work on adaptation and response measures have been supported, and the barriers, obstacles and opportunities presented, through:

- The strategic priority “Piloting an Operational Approach to Adaptation”,
- The small grants programme,
- Efforts to address adaptation in the climate change focal area and to mainstream it into other focal areas of the Global Environment Facility,
- The Least Developed Countries Fund and efforts to finance the preparation of national adaptation programmes of action, and
- The Special Climate Change Fund

National Adaptation Programmes of Action (NAPA)

It is envisioned that NAPA will serve as a direct way to communicate information relating to the vulnerabilities and adaptation needs of the least developing countries (Burton *et al.*, 2002). The presentation and evaluation of completed national strategies to international stakeholders will facilitate the sharing of experience, the transfer of technology and the collaboration between private and public sectors over national, regional and global scales. Furthermore, the presentation of completed NAPA at international conventions will help LDCs overcome their current difficulties with international climate change regime negotiations (UNFCCC, 2002; UNFCCC-SBI, 2004).

The Least Developed Countries (LDCs) Fund was established to support the preparation of NAPA. An LDC Expert Group (LEG) was created to support the preparation and implementation of NAPA. One additional mandate of the LEG is to promote regional cooperation and synergies with other multilateral environmental treaties. Many countries are presently undertaking anticipatory national planning for climate change. It was expected that there would be completed NAPA by the UNFCCC COP 9. So far no LDCs have moved beyond the initial stages of NAPA preparation. Consequently the LEG decided that the current NAPA guidelines (decision 28/CP.7) would be retained without revision but that the LEG annotated guidelines could be revised to accommodate the needs and difficulties expressed by LDC Parties in the use of the guidelines so far. However, the UNFCCC

(2004) noted that the preparation of national communications and of NAPA in least developed countries has contributed to the development of adaptive capacity on an individual level within and across institutions. The training of individuals from different sectors, including non-governmental actors, to make institutional capacity-building a priority for the creation and strengthening of basic institutional infrastructure has also been implemented. In addition, the UNFCCC (2004) requested the LEG, in consultation with least developed countries, to include in its report to the twenty-third session of the Subsidiary Body for Implementation (SBI) information on the potential technical and financial difficulties that least developed country may have in the implementation of national adaptation programmes of action.

The creation of the LDC Fund and the ongoing process to prepare NAPA is a prominent example of the belief that it is possible and desirable to develop national adaptation policies. However, the extent to which NAPA will focus on balancing the development of adaptation policy with the implementation of adaptation measures is not yet certain. The indications to date suggest that the primary focus will be on measures (Burton and van Aalst, 2004).

In addition to NAPA, many independent internal reviews are being carried out as part of national strategies. To date, completed country studies in Bangladesh, Brazil, China, India, South Africa and West Africa have illustrated that positive examples of development and climate change synergies exist. Despite the positive progress of these regions, implementation remains a challenge without further support, research and stakeholder involvement. Furthermore, there are numerous divides that require bridging such as those between the following:

- Development and climate change precedence,
- Mitigation and adaptation measures,
- Global and national interests,
- Sustainable and economic development,
- Climate change and climate variability, and
- Developed and developing country priorities.

A number of key lessons from these completed country studies were identified by Huq *et al.* (2003) as part of the Development and Climate Project, which is an initiative of the UNEP Risoe Centre on Energy, Climate and Sustainable Development (URC), the National Institute of Public Health and Environment (RIVM) in the Netherlands, and the International Institute for Environment and Development (IIED). These lessons can be referred to by other LDCs as they prepare their respective country studies as well as their NAPA. They include:

- Information on climate change impacts needs to be translated into practical language for policy makers to understand.
- National and international climate change research needs to be supported and shared with policy makers.
- Information must be suited to the stakeholder in order to increase their involvement.
- Public awareness must be promoted.
- Special focus should be given to the most vulnerable regions and populations within each country.
- Adaptation to climate change should be effectively mainstreamed into national and sectoral development.
- Sharing results with other LDCs should be implemented.
- Strategies for improving the negotiating capacities of LDCs should be developed, especially concerning funding issues

17.4.2 Mainstreaming

17.4.2.1 Current Mainstreaming Initiatives

Within the adaptation field, particularly the areas focusing on current vulnerabilities, there is a growing consensus that the key to adaptation is as much about enhancing broad adaptive capacity as it is about identifying and implementing particular adaptation measures (Munasinghe and Swart, 2000; Adger *et al.*, 2002; Burton *et al.*, 2002; Smit and Pilifosova, 2003). The capacity to adapt to climate change is generally considered to be related to the availability of financial resources, the availability of technology, the access to information, and the existence of legal, social and institutional arrangements. Thus, fundamental development schemes that promote successful economic progress, effective poverty alleviation and improved access to technology, education and resources, as well as the strengthening of legal, social and institutional arrangements, will help to reduce vulnerability to climate change. The incorporation of climate change adaptation measures into development activities is the foundation for mainstreaming climate change adaptation into development.

In the climate change and development context, the term “mainstreaming” has been used to refer to many types of integration of climate change vulnerabilities or adaptations into some aspect of policy development, planning or decision making. These include integration of climate information into environmental data sets, vulnerability or hazard assessments, broad development strategies, macro policies, sector policies, institutional or organizational structures, or in development project design and implementation (Burton and van Aalst, 1999; Huq *et al.*, 2003). The term “mainstreaming” in this report refers to the incorporation of initiatives, measures and strategies to reduce vulnerability to climate change into existing policies, programs, resource management structures, disaster preparedness programs, livelihood enhancement activities, and other sustainable development initiatives. By implementing mainstreaming initiatives, it is anticipated that adaptation to climate change will become part of or will be consistent with other well established programs, particularly sustainable development planning. On the other hand, vulnerability or risk assessments can identify adaptation needs and options or ways of enhancing adaptive capacity, and, in this way, may contribute to mainstreaming.

The vulnerability of a country or a community is generally considered to be related to its exposure and/or sensitivity to changing conditions and its capacity to adapt to those exposures or sensitivities. Reducing vulnerability can be achieved through reducing exposure to hazardous conditions and/or through enhancing adaptive capacity to better deal with or manage hazardous conditions (Leichenko and O'Brien, 2002; Yohe and Tol, 2002; Adger, 2003; Brooks, 2003; Handmer, 2003; Polsky *et al.*, 2003; Smit and Pilifosova, 2003; O'Brien *et al.*, 2004). Initiatives to reduce vulnerability can be mainstreamed with programs to reduce exposure (settlement, location and design, infrastructure, livelihoods, diversification and enhancement, hazard prediction and early warning programs). Vulnerability can also be reduced by programs to improve adaptive capacity (wealth, access to resources, education, information, technology, institutions).

Mainstreaming of adaptation to climate change can occur at several levels, including international programs, regional cooperation schemes, national policies, provincial activities, and local community actions.

An example at the **international** level would be the International Federation of Red Cross and Red Crescent (IFRC) activities, which acknowledge that since specific climate change impacts will not be uniform across the globe, risks should be evaluated and dealt with on local, national and regional levels. As such, the IRFC is working to facilitate a link between local and global response through its Climate Change Center (Van Aalst and Helmer, 2003). Also, several of the projects in the GEF-AIACC Program are directed at incorporating actions to deal with climate change risks into resource management and development programs. The Adaptation Policy Framework (APF) of UNDP/GEF (Lim *et al.*, 2005) notes "… the overall objectives of an adaptation strategy must fit within the development priorities of a country (for example, poverty alleviation, food security enhancement, action plans under multilateral environmental agreements, etc.)" Furthermore, the World Bank, together with AFDB, ADB, DFID, DGIS, EC, BMZ, OECD, UNDP, UNEP, prepared a document "Poverty and Climate Change: Reducing the Vulnerability of the Poor" intended to contribute to the integration of adaptation to climate change into poverty reduction and development initiatives (AfDB *et al.*, 2003). It provides examples of adaptation considered as "part and parcel of overall sustainable development efforts".

An example at the **regional** level is the Mainstreaming Adaptation to Climate Change in the Caribbean (MACC) project. In connection with the Caribbean Planning for Adaptation to Climate Change (CPACC) project and the Adapting to Climate Change in the Caribbean (ACCC) initiative, the MACC project assess the likely impacts of climate change on key sectors, (i.e. water, agriculture and human health) while also defining responses at community, national and regional levels. The MACC focuses on regional efforts that are aimed at vulnerability assessments, utilizing resources to reduce vulnerability, and building awareness and capacity to support adaptation mechanisms. It also acknowledges the strong commonalities between dealing with extreme weather events and adapting to climate change (Trotz, 2003). Hence, regional efforts to build capacity in disaster mitigation (e.g. under the Caribbean Disaster Emergency Response Agency (CDERA)) represent a form of mainstreamed climate change adaptation.

An example at the **national** level could involve the cooperation between local actors and global organizations to sustain long term climate change adaptation (cited in Reid *et al.*, 2004). In recognition of this cooperation, the UK Department for Environment, Food and Rural Affairs (DEFRA) is developing an adaptation policy framework in order to merge efforts on climate change adaptation across different levels of government and the private sector (UK-DEFRA, 2004). In fact, DEFRA funded The UK Climate Impacts Programme (UKCIP) in 1997 to help organisations implement vulnerability assessments and prepare precautionary adaptation schemes. UKCIP also carries out climate change research in collaboration with regional and national stakeholders thus providing a bridge between researchers and decision-makers in government organisations and business (UKCIP, 2005).

Also, the mainstreaming of adaptation to climate change into environmental impact assessment (EIA) processes is a noteworthy feature of the Caribbean countries. It has recently been extended toward incorporating Natural Hazard Impact Assessment (NHIA) in the project preparation and appraisal process of the Caribbean Development Bank (CDB) as part of the Bank's EIA process. In many Caribbean countries activities that require EIA will consider climate change. For comprehensive mainstreaming of climate change adaptation the many initiatives related to addressing vulnerabilities not captured under EIAs would need to be addressed via sector programs, social and economical policies and community-based initiatives.

A **sub-national** example would be where a development program in a province to improve livelihoods of people was designed to recognize risks and opportunities associated with climate change.

At a **community** scale an example would be an emergency preparedness program or a coastal infrastructure program that is modified to deal with risks associated with sea level rise and changes in storm frequency, extent or severity.

17.4.2.2 Constraints and opportunities

A key feature of effective mainstreaming is to ensure that adaptation initiatives can fit within the relevant policy or decision structures at each level. One constraint of current mainstreaming activities is that conventional climate change adaptation measures have often related to conditions that people do not identify with. The implementation of potential adaptation options has been rare to date because decision structures are not comprehensively considered in climate change impact and adaptation studies. It is difficult to subsequently fit suggested climate change adaptations into policies and decision systems if they are not identified and developed in light of the actual decision-making processes and structures in mind at the outset.(Christoplos *et al.*, 2001). Institutional constraints to climate change adaptation mainstreaming measures are discussed further in section 17.4.2.

Notwithstanding the progress in studies and programs about impacts and adaptation to climate change, very few practical climate change adaptation initiatives that make changes in communities or countries to decrease vulnerability to climate hazards have been seriously entertained (Huq *et al.*, 2003 …). One reason for this limited progress in practical adaptation is that most of the work has focused on long-term climate norms and physical impacts. For example, the UNFCCC and its principal funding agency, the Global Environmental Facility (GEF), have responsibility under the climate change convention to sponsor activities that address adaptation to anthropogenic climate change interpreted as long-term changes in average conditions and not adaptation to normal climate, normal climatic variations or extreme events. There has been a tendency for adaptations to long-term changes in temperatures and other norms to be disregarded as priorities by vulnerable communities and development agencies (Brown and Damery, 2002; Hutton and Haque, 2003; Mirza, 2003; Ford and Smit, 2004 …). Furthermore, climate change is often addressed from a scientific perspective in isolation from the other conditions affecting resources and people's wellbeing, and separate from the decision processes related to resources and development (Beg *et al.*, 2002; Burton *et al.*, 2002; Downing, 2003; Ford and Smit, 2004 ….). This view limits opportunities for implementing adaptations or incorporating such adaptations into development programs.

While such a distinction is important for funding under the UNFCCC/GEF, it is of less importance to most development organizations and to the individuals (farmers, coastal dwellers, water users, etc) who are susceptible to climate-related conditions. This approach is problematic on a local scale because many vulnerable people are more interested in coping with the stress of today and tomorrow than adapting to climatic conditions that could possibly occur several decades from now. Individuals are more concerned with immediate threats to their food, water, health and livelihoods related to extremes such as droughts and floods rather than on longer term development goals and regardless of what portion of the events or hazards might be attributed to natural variation or to human-induced climate change.

In response to these constraints, climate change adaptation schemes are beginning to focus on enhancements to the capacity of societies to deal with present and near future conditions as well as adapting to longer term climate change (Goklany, 1995; Burton, 1996; Huq *et al.*, 1999 …; Downing, 2001). Since adaptation to climate is not a new concept and many economic and social activities have been consciously designed to take into account the present climate and its variability, existing management of climate effects represents a logical starting point for climate change adaptation. In addition, analysts in the climate change adaptation field must recognize that adaptation initiatives should relate to the concerns and vulnerabilities of the subject country or community and that the initiatives should be compatible with or part of existing policy and decision processes in the subject country or community (Adger, 2003; Klein and Smith, 2003 …) Furthermore, attention should been given to participatory and decision-oriented approaches (Comfort *et al.*, 1999; Jones, 2001; Burton *et al.*, 2002; Brooks, 2003; Polsky *et al.*, 2003 …). Finally, development programs should be implemented in conjunction with climate change programs (AfDB *et al.*, 2003)

Recognition is increasingly being given to the fact that climate change includes both changes in average conditions and changes in the frequency, extent and/or severity of climate extremes and conditions normally considered to be climate variability (Houghton *et al.*, 2001; Smit and Pilifosova, 2003). Adaptation to climate-related hazards will become closely related to development programs and initiatives aiming to improve disaster preparedness and management, and to enhance people's capacities to deal with problems with water supply and quality, droughts and food supplies, floods and other threats to lives and livelihoods (Apuuli *et al.*, 2000; Jones, 2001; Burton *et al.*, 2002; AfDB *et al.*, 2003 …; Handmer, 2003; Smit and Pilifosova, 2003)

17.4.3 Limits to adaptation (physical, social, migration)

The main limits to effective adaptation, which are identified in the literature (Brooks, 2003) are:

- Financial
- Institutional,
- Social and Cultural,
- Technological, and
- Informational.

In addition, the effectiveness of adaptation measures may be compromised by other natural or anthropogenic stressors acting concurrently with climate change. Since the successful implementation of adaptation measures depends on the eradication of these barriers, the UNFCCC COP 8, under the New Delhi Five-Year Work Programme, requested all parties to evaluate and report the extent to which gaps and barriers to adaptation have been identified and diminished in their national communications, where possible, and in other reports. Although the formal review of the work programme will not take place until 2007, an intermediate review was carried out at COP 10 in 2004 to evaluate the effectiveness and progress of the program (UNFCCC, 2004).

Financial Barriers

First, the rising economic cost of disasters due to the coupling of climate change, increased standards of living and population growth has raised awareness that the risks facing development efforts must be addressed (Christoplos *et al.*, 2001). There is an increasing international commitment to promote and implement adaptation to climate change, but the lack of associated funding and the lack of linkages with relevant work on poverty are barriers to this pledge. Outreach to the poorest communities remains limited because working with the poor is expensive and significantly reliant on external sources of funding. In addition, adaptation is often regarded as a lower priority or a conflicting precedence to shorter term economic development within both developed and developing nations (ref???).

Secondly, there is an emerging awareness that the current mechanisms and sources of funding will not be able to cover the financial requirements of rehabilitation, mitigation and adaptation. Post-emergency reconstruction lending has numerous serious drawbacks. First, reliance on anticipated reconstruction funding provides little incentives for countries to engage in active risk management to reduce their vulnerabilities to natural disasters before they occur. As a result, many countries find themselves unprepared to cope with the impacts of natural disasters and little attention is paid to the development of adaptive capacity, including risk management solutions. Second, since funding is often delayed, government efforts to quickly revive the economy are jeopardized and countries are usually left with higher debt burdens, which further dampen the incentives for active adaptive capacity building (Gurenko, 2004). However, Christoplos *et al.* (2001) have suggested that "the insurance industry may provide a viable channel of resources for both dealing with the impact of disasters and for promoting risk mitigation through the power of the market."

The IFRC World Development Report 2000, presented insurance as a potential key feature of poverty alleviation. Insurance facilitates the transfer of risk from individuals and governments to insurance companies and capital markets, thereby alleviating extended hardship after a disaster and disruption to development programmes due to unforeseen expenditure on rehabilitation. Along with active mitigation and land planning, insurance can become an effective risk financing technique available to the government to manage the funding gap between traditional sources of funding and the losses resulting from sever natural disasters (Gurenko, 2004). But the lack of information by which insurers and household can accurately judge risk present major challenges to the expansions of such mechanisms for poor people in the South (Christoplos *et al.*, 2001). For example, only 0.3-8% of total economic losses from natural disasters is insured in developing countries compared to 40-100% in industrialized countries. This gap is more pronounced for private dwellings as most of insured losses reflected in the figures are due to a relatively high insurance coverage for commercial and industrial facilities. Also, studies show that the impact of natural disasters and the ability of countries to absorb them is a direct function of the size of national economies, concentration of major economic activities and assets in disaster prone areas, the size of government tax base and, of course, the level of insurance penetration (Gurenko, 2004).

Institutional Barriers

The inherent site-specific character of adaptation projects and the fact that many are likely to be small-scale is a major challenge for international institutions, particularly donors. Consequently, international institutions must become more responsive and flexible to these realities (Reid *et al.*, 2004). Burton and Van Alast (2004) state that the sector, country and location specific nature of climate risks warrants the identification and management of climate risks as an integral part of country strategic planning and project development. In view of this, the UNFCCC COP10 welcomed the progress made in the implementation of decision 5/CP.7, which concerns the special situation of least developed countries and their specific needs and concerns and arising from the adverse effects of climate change (Article 4, paragraphs 8 and 9, of the Convention) but acknowledged that there is a need to further implement this decision in order to address the gaps in implementation that remain. The COP10 decided to make institutional capacity-building a priority for the creation and strengthening of basic institutional infrastructure. In addition, emphasis will be given to the strengthening of institutions and centres through targeted research programmes and to the raising of awareness and involvement at various levels of national governmental organizations on climate change issues and capacity-building activities.

Another institutional barrier to adaptation may be the location of climate change policymaking within government ministries and civil society, both in developed and developing countries. Natural disaster risk management is often overlooked by humanitarian policymakers and practitioners as a result of organisational divisions between relief and development. Plus, the roles of state and civil society when dealing with risks are often contested. For example, the structural adjustments and the decline of state control over public services as a result of decentralisation effects the traditional role of NGOs to fill temporary gaps in state capacity. Instead, NGOs may be responsible for providing the services that have been handed over by governments to civil society, services that they may not be able to sustain (Christoplos *et al.*, 2001). Wisner (*ref?*) also points out that although declarations concerning the reforming of institutions and regulatory frameworks usually accompany disasters, systems often lack the political will and capacity to carry through with these reforms. However, efforts are being made to increase cooperation and bridges between different actors and different perspectives. For example, ProVention is a global coalition of governments, international organisations, academic institutions, the private sector and civil society organisations, led by the World Bank, the International Federation of Red Cross and Red Crescent Societies and UNDP, aimed at addressing the conceptual and operational gaps between these actors and promoting adaptation and risk management within development and humanitarian agendas (Christoplos *et al.*, 2001).

Additionally, existing interventions for adaptation within international climate change regimes are focused on mitigation within polluter industries and countries instead of giving priority to the vulnerabilities of the systems facing the greatest risk and disadvantage. Emissions from developing countries are growing with their development and are expected to match the total emissions from industrialized countries within the next few decades. However, the developed world will continue to remain disproportionately responsible for global emissions those who have been least responsible for creating the crisis are likely to remain the most vulnerable. This is because the impact of climatic events is not only a function of the intensity of the event but of the adaptive capacity of the system. The most vulnerable systems are those which are the poorest and least able to adapt to these changes (Downing *et al.*, 1996; Rayner and Malone, 1998; Sagar and Banuri, 1999; Adger *et al.*, 2003). Therefore, existing interventions should be renewed and enhanced to establish clear priorities for their use and to gain an understanding of where capacity needs to be improved and what capacities need to be supported and strengthened (Najam *et al.*, 2003).

Social and Cultural Barriers

The lack of a mutual and unified understanding of climate change issues across different social and cultural groups is another barrier to adaptation. The uncertainty surrounding both the future predictions of climate change and the effectiveness of planned responses is often used as a justification for inaction. In addition, the need for the development of sustainable lifestyles and the need to prevent dangerous climate change are often viewed as self evident (WBGU, 1998).

The first major problem with these beliefs is that different definitions of sustainability and different scales of hazards lead to different interpretations and difficulties in communication. In other words, what is sustainable or dangerous for one group may not be for others. Furthermore, it was stated at the UNFCCC (2004) that in some developing countries, awareness by the public of climate change and its impacts is very low, and that much work needs to be done to overcome this situation. In response, some intergovernmental, non-governmental and community-based organizations, as well as the private and public sectors, are working actively to raise awareness about, and increase understanding of, the causes and impacts of climate change as well as on adaptation and mitigation actions (Mesghena, 2002).

Secondly, by assuming that everyone else shares these beliefs, groups that believe they will not be adversely affected by a particular process may not care about groups that will be. For the case of climate change, most of the resistance comes from the industrialised world, where people are generally not used to dealing with climate-related disasters. Such beliefs are also often viewed at many non-governmental organisations, research institutes and government establishments (Brooks, 2003).

Technological Barriers

Transferring appropriate technologies to developing countries and ensuring their effective implementation forms an important component under the United Nations Framework Convention on Climate Change For example, one intention of the Buenos Aires Action Plan, which was established at the UNFCCC COP 4 in 1998, was to boost work on transferring climate-friendly technologies to developing countries. In addition, technology transfer is likely to play a major role while implementing the international instruments such as the CDM (ref???). However, the inappropriate transfer of technologies also acts as a barrier to adaptation.

One major dilemma is that many transfers involve technologies that are developed in industrialised countries without regard to their applicability in developing countries. It is important that only the latest technologies are transferred and that they meet the capacity of the receiving country. There are several instances of failure of technology transfer when specialised training and capacity building are not included in the transfer project. Successful technology transfer must consider, for instance, the type of needs of the developing country, the requirements of the technology to meet those needs, the available expertise and the factors affecting adoption, assimilation and adaptation of the imported technology. In addition, the technologies being transferred should help the receiving country fulfil other important development objectives outside of climate change. Efforts should also be made to adapt the technology to local conditions. For example, in a country with large labour population, a labour oriented technology is likely to be preferred to a highly automated mechanical option (Adams, 1997; Parikh and Kathuria, 1997; Ramanathan, 2002).

The UNFCCC COP10, welcomed the progress made in the implementation Buenos Aires Action Plan but acknowledged that there is a need for further implementation in order to address the gaps that remain, and insists that action relating to adaptation follow an assessment and evaluation process, based on national communications and/or other relevant information, so as to prevent maladaptation and to ensure that adaptation actions are environmentally sound and will produce real benefits in support of sustainable development. The Subsidiary Body for Scientific and Technological Advice at the UNFCCC COP10 has also decided to focus on maintaining and improving the UNFCCC technology information clearing house, with more emphasis on extending outreach programs to developing countries and enhancing networking between national and regional centres working on the dissemination of technology information. The expected outcome of this task is a pilot network of technology transfer centres, developed among individual nodes that can make context-specific and language-relevant information available to their local audience groups.

Furthermore, the Expert Group on Technology Transfer (EGTT), noted at COP10 that fewer than ten technology assessment reports have been received by the UNDP to date. Consequently, the limited number of reports has obstructed the UNDP from conducting an extensive preliminary analysis with the purpose of identifying technology priorities that may be common across countries and regions and other issues relevant to the preparation of their second national communications. However, the completed reports provide a resource of lessons learned that can assist countries in the analysis of technology needs and gaps in the future.

Informational Barriers

Another specific barrier to adaptation concerns the quality and the rigor of climate change studies. The sense of urgency and demand for prompt action is especially imperative for the most vulnerable countries. In some cases the adaptation policies and measures needed may be very evident, and further delay in design and implementation while studies are carried out may not be defensible. On the other hand, the situation in many countries is that there is insufficient knowledge or information upon which to base good policy choices. For example, it would be comparatively easy to allocate adaptation funds to engineered structural adaptations but it cannot be safely assumed that such adaptation measures would be the most cost-effective in reducing vulnerability to climate change in the long run.

In many regions of the world, climate change impacts are not yet truly severe and the consequences are likely to be incremental and cumulative. Therefore, taking the time to develop sufficient policies could prevent the implementation of ineffective adaptation measures. However, in regions where present day climate variability and extremes are already impacting development, there is need for more urgent anticipatory action (Burton *et al.*, 2002). As such, climate change studies must ensure that countries are able to cope with both existing and anticipated hazards so that damage from such hazards does not hold back development efforts, heighten existing vulnerability and undermine the foundation on which adaptive capacity is based. Reducing vulnerability to existing hazards is therefore the most vital starting point for reducing the risks associated with climate change and addressing current developmental issues (Adger *et al.*, 2004).

In response to the apparent informational barriers, the UNFCCC COP10 put emphasis on improving data collection and information gathering, and the analysis, interpretation and dissemination of such data and information to end-users within and by developing countries. This will be facilitated through the enhancement of systematic observation and monitoring networks in countries with observation stations that feed into the Global Climate Observing Systems and through increased data sharing on a global level. In addition, the Subsidiary Body for Scientific and Technological Advice agreed to establish a structured five-year work programme focused on the scientific, technical and socio-economic aspects of impacts of, and vulnerability and adaptation to, climate change. The programme will address data and methodologies, vulnerability assessments, adaptation planning and actions, and integration into sustainable development (UNFCCC-SBSTA, 2004).

Multiple Stressors

Adaptation to climate change can also be hindered by the occurrence of multiple stressors, such as violent conflict, disease and hunger, which often overshadow the impacts of climate change. Many deaths that are caused by naturally occurring hazards, might not have resulted under different economic and political circumstances. However, the risks involved in disasters are often connected with the vulnerability inherent in normal life. For example, wars are often inextricable linked with famine and disease and have sometimes coincided with drought. The multiplication of stressors makes it harder for a system to cope with each stressor individually. Plus, the large debts faced by developing countries make the cost of building adaptive capacity unattainable. Therefore, equal emphasis should be put on the natural hazard itself as well as the surrounding social environment (Wisner *et al.*, 2004).

In response to the recommendations by the UNFCCC to improve adaptive capacity in order to decrease vulnerability to climate change, many countries are now giving attention to the identification of possible adaptation measures. Although National Communications to the Climate Convention and many independent climate studies list possible adaptation measures, the limits of many adaptation options are already apparent. Migration, for example, plays an important role in livelihood resilience and coping with climate variability in many parts of the developing world. *Expand.* Burton and Van Aalst (2004) also suggest that little effort is made to show how these measures relate to existing policy. This could be attributed to the inevitable difficulties that are involved in addressing policy issues or the expectation that separate adaptation measures could more easily be funded from upcoming adaptation funds rather than measures that are mainstreamed within other developmental schemes. In addition, many policies may discourage sound adaptation or may serve to increase vulnerability.

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