IPCC WGII Fourth Assessment Report – Draft for Expert Review

Chapter 18 – Inter-Relationships between Adaptation and Mitigation

Coordinating Lead Authors
R.J.T. Klein (Netherlands), S. Huq (Bangladesh)

Lead Authors
F. Denton (Senegal), T.E. Downing (UK), R.G. Richels (USA), J.B. Robinson (Canada), F.L. Toth (IAEA / Hungary)

Contributing Authors
B. Biagini (GEF / Italy), S. Burch (Canada)

Review Editors
M. Grubb (UK), U. Safriel (Israel), A. Allali (Morocco)

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Executive summary

This chapter identifies inter-relationships between adaptation and mitigation in climate policy, and assesses their significance and potential for climate policy. The six key messages of this chapter are as follows:

- **On a global scale, climate policy is not about choosing between mitigation or adaptation to climate change.** Adaptation is a necessity, because no mitigation effort will prevent climate change from happening in the next few decades. On the other hand, reliance on adaptation alone could eventually lead to a magnitude of climate change to which effective adaptation will be possible only at very high social and economic costs.

- **Whilst there are many differences between adaptation and mitigation, the two options are inter-related in at least three ways.** First, both options contribute to preventing dangerous anthropogenic interference with the climate system, thus creating the possibility of exploring trade-offs and synergies. Second, both adaptation and mitigation are subject of international climate policy negotiations and the same global institutions are involved in facilitating their implementation in developing countries. Third, the capacities of society to mitigate and to adapt are both strongly linked to development pathways, in particular on a local scale.

- **Analysis of the inter-relationships between adaptation and mitigation may promote the effective implementation of climate policy.** Meeting multiple objectives (*e.g.*, by developing synergies between adaptation and mitigation) can increase the cost-effectiveness of options and make them more attractive to potential funders and other stakeholders. However, an exclusive focus on synergies may lead to essential options without synergetic effects being overlooked.

- **A preliminary analysis of options that have both adaptive and mitigative effects suggests that their potential to benefit climate policy would be limited.** Whilst many options exist that have such synergetic effects, it is unclear whether these effects are serendipitous and whether their benefits justify policy intervention.

- **One way of promoting both adaptation and mitigation would be to enhance society's response capacity.** This would facilitate the effective implementation of both options, as well as their mainstreaming into ongoing and future sectoral planning and development. However, little empirical information is available on what determines response capacity and on how it can best be enhanced.

- **Insufficient information is available to evaluate the overall costs and benefits of pursuing inter-relationships between adaptation and mitigation.** To provide decision-makers with unambiguous guidance on the desirability of inter-relationships requires empirical research on, among other things, trade-offs and synergies, the link between response capacity and development pathways, and the role of institutions in promoting both adaptation and mitigation.

18.1 Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) identifies two options to address climate change: mitigation of climate change by reducing greenhouse gas emissions and enhancing sinks, and adaptation to the impacts of climate change. Most industrialised countries have committed themselves, as signatories to the UNFCCC and the Kyoto Protocol, to stabilising greenhouse gas emissions at 1990 levels by the year 2000 and to reducing their overall greenhouse gas emissions by at least 5% compared to 1990 by the period 2008–2012 (an assessment of current efforts aimed at mitigating climate change is presented by Working Group III). However, because of the lag times in the global climate system, no mitigation effort, no matter how rigorous and relentless, is going to prevent climate change from happening in the next few decades (see relevant chapters in Working Group I). In fact, the first impacts of climate change are already being observed (see Chapter 1).

Adaptation is therefore a necessity (Parry *et al.*, 1998). Chapter 17 presents examples of adaptations to climate change that are currently being observed but concludes that there are limits to effective adaptation. Even if these limits were to be removed, however, reliance on adaptation alone could well lead to a magnitude of climate change in the long run to which effective adaptation is only possible at very high social and economic costs (as, for example, shown for sea-level rise in Europe by Lonsdale *et al.*, 2005; Poumadère *et al.*, 2005; Olsthoorn *et al.*, 2005). It is therefore no longer a question of whether to mitigate climate change or to adapt to it. Both mitigation and adaptation have become essential in reducing the risks of climate change.

18.1.1 Background and rationale

The level of climate change impacts, and whether or not this level is dangerous (*cf.* Article 2 of the UNFCCC), is determined by both mitigation and adaptation efforts. Nonetheless, discussions on mitigation and adaptation have been rather unconnected in both climate research and climate policy, involving largely different communities of scholars and negotiators. Only recently policymakers have expressed an interest in exploring inter-relationships between adaptation and mitigation beyond integrated assessment modelling, which has in turn triggered an increased research effort. In particular, the link between the two climate response options vis-à-vis development is becoming a focus for policy and research.

Traditionally, the focus of climate policy has been on energy policy, with little attention being given to enhancing sinks or to adaptation. As energy supply relies predominantly on fossil fuels (the main source of anthropogenic greenhouse gas emissions), energy policy has been the logical entry point for mitigation. This policy focus was reflected in the IPCC Second Assessment Report (SAR). Since the publication of the SAR, the international climate policy community has become aware that energy policy alone will not suffice in the quest to control climate change and limit its impacts. Climate policy is being expanded from energy policy to consider a wide range of options aimed at sequestering carbon in vegetation, oceans and geological formations, and at reducing the vulnerability of sectors and communities to the impacts of climate change by means of adaptation. Consequently, the IPCC Third Assessment Report (TAR) provided a more balanced treatment of mitigation and adaptation, illustrating the increased interest in adaptation.

Recognising the finitude of funds and the consequent need to explore trade-offs between the long-term global benefits of mitigation and the immediate local benefits of adaptation, the question has now arisen as to exactly how much adaptation and mitigation would be optimal, when and in which combination (GAIM Task Force, 2002). In addition to exploring trade-offs, opportunities are being sought to develop synergies between adaptation and mitigation. Synergies in climate policy are created when measures that control atmospheric greenhouse gas concentrations also reduce adverse effects of climate change, or vice versa.

The amount of literature that deals explicitly with inter-relationships between adaptation and mitigation is still small. Yet it is also very diverse: there is no consensus in the literature as to whether exploring and exploiting inter-relationships between adaptation and mitigation is desirable (*cf.* Venema and Cisse, 2004; Klein *et al.*, 2005). The small size of the literature and the lack of consensus pose a challenge to policymakers and academics alike. As a possible first step in addressing this challenge, this chapter does not only assess the available literature on inter-relationships between adaptation and mitigation; it also presents an analytical framework with which such assessment can be done consistently and in line with earlier climate policy analysis.

18.1.2 Structure of the chapter

Box 18.1 summarises the differences, similarities and complementarities between adaptation and mitigation. This chapter then uses this information as the starting point for assessing to what extent adaptation and mitigation are related, and if and how any such inter-relationships could be exploited in climate policy. The chapter is structured as follows. Section 18.2 summarises the knowledge relevant to this chapter that was presented in the IPCC Third Assessment Report (TAR). Section 18.3 then frames the challenge to climate policy of deciding when, how much and how to adapt and mitigate as a decision-theoretical problem, based on which Section 18.4 describes and assesses three categories of inter-relationships between adaptation and mitigation: (*i*) trade-offs and synergies, (*ii*) climate policy and institutions, and (*iii*) response capacity. Section 18.5 then assesses the literature for elements for effective implementation of climate policy that relies on inter-relationships between adaptation and mitigation. Section 18.6 outlines information needs of climate policy and priorities for research.

Box 18.1: Differences, similarities and complementarities between adaptation and mitigation

IPCC TAR used the following definitions: mitigation is any “anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases” (IPCC, 2001a: 379), whereas “[A]daptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC, 2001a: 365).

There are a number of important differences between mitigation and adaptation. Given the global nature of climate change, meaningful mitigation actions need to involve several countries (a sufficient number of major greenhouse gas emitters to foreclose leakage), whereas adaptation activities largely take place at local, regional or national levels. Adaptation rarely expands beyond national boundaries, although some adaptation strategies might result in spillovers over national boundaries (*e.g.*, by changing international commodity prices in agricultural or forest product markets). The costs of mitigation arise locally (economic spillovers are possible) while its benefits are dispersed globally (ancillary benefits might be realised at the local/regional level). Both the costs and benefits of adaptation accrue predominantly locally (with the possibility of spillovers to other regions and to other actors, for example in flood protection or coastal zones). The benefits of mitigation spread over decades to centuries (disregarding possible near-term ancillary benefits) while the benefits of most adaptation efforts can be realised within years and over decades. Correspondingly, there is a long delay between paying for the mitigation costs and realising their benefits from smaller climate change while the time span between outlays and returns of adaptation is much shorter. These asymmetries imply that mitigation is driven by international agreements and ensuing national public policies (sometimes supplemented by community-based initiatives), whereas the bulk of adaptation actions are driven by the affected private actors and communities, possibly assisted by public policies. This also entails that mitigation policies require rigorous implementation measures while adaptation is largely fostered by the self-interest of the affected agents. Finally, mitigation is by necessity based on information available today whereas adaptation strategies can benefit from improving information about climate change and its impacts over the coming years and decades.

There are a number of linkages between mitigation and adaptation at different levels of decision-making. Mitigation efforts can foster adaptive capacity if they eliminate market failures and distortions as well as perverse subsidies that prevent actors to make decisions on the basis of the true social costs of the available options. However, mitigation expenditures imply diverting social or private resources and reduce the funds available for adaptation, especially if they accrue to social groups adversely affected by climate change (*e.g.*, agriculture in many regions). Similarly, the implications of adaptation activities can be both positive and negative for mitigation endeavours. For example, if afforestation is part of a regional adaptation strategy, it also makes a positive contribution to mitigation. In contrast, if adaptation actions imply increased energy use from carbon emitting sources (*e.g.*, indoor heating and cooling, irrigation and alike), this would affect mitigation efforts negatively.

Mitigation and adaptation are connected in the local and national policy portfolios and their relative importance depends on local priorities and preferred approaches in combination with international responsibilities.

18.2 Summary of relevant knowledge in IPCC TAR

Compared to the SAR, two of the Working Groups preparing the IPCC TAR were restructured. The scope assigned to Working Group II was limited to impacts of climate change on sectors and regions and to issues of vulnerability and adaptation, while Working Group III was commissioned to assess the technological, economic, social and political aspects of mitigation. Whereas there were concerted efforts to assess linkages of both mitigation and adaptation to sustainable development (see Chapter 20), there was little room to consider the direct relationships between these two domains. The integration of results and the development of policy-oriented synthesis were therefore difficult (Toth, 2003).

The attempt to establish the foundations of the Synthesis Report (IPCC, 2001a) in the final chapters of Working Groups II and III produced limited results. Chapter 19 in Working Group II presented "Reasons for concern about projected climate change impacts" in a summary figure that outlines the risks associated with different magnitudes of warming, expressed in terms of the increase in global mean temperature. Largely based on integrated assessment models (IAMs), Chapter 10 in WG III summarised the costs of stabilising CO_2 concentrations at different levels. These two summaries are difficult to compare because the questions as to what radiative forcing and climate sensitivity parameters should be used to bridge the concentration-temperature gap remains unanswered. Moreover, many statements in the two working group reports were themselves distilled from a large number of reviewed studies. Yet the generic assumptions underlying the methods, the specific assumptions of the applications, the selected baseline values for the scenarios, and many other postulations implicit in the parameterisation of mitigation and adaptation assessments were largely ignored or remained hidden in the Synthesis Report.

Nonetheless, the TAR presented new concepts for addressing inter-relationships between adaptation and mitigation. Local adaptive and mitigative capacities vary significantly across regions and over time. Superficially they appear to be strongly correlated because they share the same list of determinants. However, aggregate representation across nations or social groups of both mitigation and adaptation is misleading because the capacity to reduce emissions of greenhouse gases and the ability to adapt to it can deviate significantly. As the TAR pointed out: "one country can easily display high adaptive capacity and low mitigative capacity simultaneously (or vice versa)" (IPCC, 2001b: 107; see also Yohe, 2001). In a wealthy nation the damages may fall on a small but influential social group and the costs of adaptation can be distributed across the entire population through the tax system. Yet in the same country, another small group might be hurt by mitigation policies without the possibility to spread this burden. In addition to the conceptual deliberations, the TAR discussed inter-relationships between adaptation and mitigation at two levels: at the aggregated, global and national levels and in the context of economic sectors and specific projects.

The WGII report pointed out that "Adaptation is a necessary strategy at all scales to complement climate change mitigation efforts" (IPCC 2001c: 6) but also elaborates the complex relationships between the two domains at various levels. Some relationships are synergistic while others are of trade-off nature. The report noted the arguments in the literature about the trade-off between adaptation and mitigation because resources committed to one are not available for the other but notes that this is "debatable in practice because the people who bear emission reduction costs or benefits often are different from those who pay for and benefit from adaptation measures" (IPCC 2001c: 94). From the dynamic perspective, "climatic changes today still are relatively small, thus there is little need for adaptation, although there is considerable need for mitigation to avoid more severe future damages. By this logic, it is more prudent to invest the bulk of the resources for climate policy in mitigation, rather than adaptation (IPCC 2001c: 94). Yet, as WGIII noted, one should bear in mind the intergenerational trade-offs. The impacts of today's climate change investments on future generations' opportunities should also be considered. Investments might enhance the capacity of future generations to adapt to climate change, but at the same time they may displace investments that could create other opportunities for future generations (IPCC 2001b: 484).

WGIII Chapter 10 outlined the iterative process in which nations balance their own mitigation burden against their own adaptation and damage costs. "The need for, extent and costs of adaptation measures in any region will be determined by the magnitude and nature of the regional climate change driven by shifts in global climate. How global climate change unfolds will be determined by the total amount of greenhouse gas emissions that, in turn, reflects nations' willingness to undertake mitigation measures. Moreover, balancing mitigation and adaptation efforts largely depends on how mitigation costs are related to net damages (primary or gross damage minus damage averted through adaptation plus costs of adaptation). Both mitigation costs and net damages, in turn, depend on some crucial baseline assumptions: economic development and baseline emissions largely determine emission reduction costs, while development and institutions influence vulnerability and adaptive capacity" (IPCC 2001b: 604).

Discussions of inter-relationships between adaptation and mitigation are sparser at the sector/project level. Some chapters in WGII noted the mitigation linkages when discussing climate change impacts and adaptation in selected sectors, primarily those related to land-use, agriculture and forestry. WGII Chapter 5 noted that "[A]fforestation in agroforestry projects designed to mitigate climate change may provide important initial steps towards adaptation" (IPCC 2001c: 296). Chapter 8 emphasised sustainable forestry, agriculture and wetlands practices that yield benefits in watershed management and flood/mudflow control but involve trade-offs such as wetlands restoration helping to protect against flooding and coastal erosion, but producing methane release.

WGII Chapter 12 observed the complexities in land management in Australia and New Zeeland "where control of land degradation through farm and plantation forestry is being considered as a major option, partly for its benefits in controlling salinisation and waterlogging and possibly as a new economic option with the advent of incentives for carbon storage as a greenhouse mitigation measure (IPCC 2001c: 608). Chapter 15 mentioned soil conservation practices (*e.g.*, no tillage, increased forage production, higher cropping frequency) implemented as mitigation strategies in North America (IPCC 2001c: 756). It observed that the Kyoto Protocol mentions human-induced land-use changes and forestry activities (afforestation, reforestation, deforestation) as sinks of greenhouse gases for which sequestration credits can be claimed and that agricultural sinks may be considered in the future. The market emerging in North America to enhance carbon sequestration leads to land management decisions with diverse effects. The negative consequences of reduced tillage implemented to enhance soil carbon sequestration include the increased use of pesticides for disease, insect and weed management; capturing carbon in labile forms that are vulnerable to rapid oxidation if the system is changed; and reduced yields and cropping management options and increased risk for farmers. The beneficial consequences of reduced tillage (especially no-till) are reduced input costs (*e.g.*, fuel) for farmers; increased soil moisture and hence reductions in crop water stress in dry areas; reduction in soil erosion; and improved soil quality (IPCC 2001c: 758).

In chapters dealing with other sectors affected by climate change impacts and mitigation, less attention was paid to their linkages. WGII Chapter 8 mentioned energy end-use efficiency in buildings having both mitigation and adaptation benefits as improved insulation and equipment efficiency can reduce the vulnerability of structures to extreme temperature episodes and emissions. An example of the remote causalities between mitigation and adaptation across space and time was provided by Chapter 17. Small island states are recognised to be vulnerable to climate change and tourism is a major source of income for many of them. While over the long term, milder winters in their current markets could reduce the appeal of these islands as tourist destinations, they could be even more severely harmed by increased airline fares "if greenhouse gas mitigation measures (*e.g.*, levies and emission charges) were to result in higher costs to airlines servicing routes between the main markets and small island states" (IPCC 2001c: 862).

Finally, WGII Chapter 8 drew attention to a linkage between adaptation and mitigation in the Kyoto Protocol that establishes a surcharge on mitigation projects implemented as Clean Development Mechanisms. "One key issue is the size of the "set-aside" from CDM projects that is dedicated to funding adaptation. If this set-aside is too large, it will make otherwise viable mitigation projects uneconomic and serve as a disincentive to undertake projects. This would be counterproductive to the creation of a viable source of funding for adaptation" (IPCC 2001c: 444).

18.3 Decision-making on inter-relationships between adaptation and mitigation

18.3.1 Objectives, decision processes

Climate change is one of the most complex issues facing humankind. Experts still debate both the magnitude and timing of the problem. Uncertainties exist in our understanding of the greenhouse effect, its likely consequences, and the efficacy of various countermeasures. Yet, uncertainty need not lead to paralysis. A portfolio of actions is available for reducing the risks of climate change. Each needs to be evaluated on its individual and collective merits. Policymakers need to decide what constitutes the right mix of near-term actions in the face of the many long-term uncertainties. Among the actions under consideration are investments in (*i*) mitigation: actions that eliminate or reduce greenhouse gas emissions, or remove greenhouse gases from the atmosphere; (*ii*) adaptation: actions that help human and natural systems to adjust to climate change should it occur; (*iii*) technology: R&D to enhance mitigative and adaptive capacity; and (*iv*) research: continued research to reduce uncertainties about how much change will occur, at what rate and what effects it will have.

The list of options suggests a multitude of possible decision-makers both spatially and temporally. Mitigation is being debated by the UNFCCC and its subsidiary bodies. It is also being discussed independently by member states. And more recently, there has been a great deal of activity taking place at the grassroots level. Adaptation decisions embrace both the public and private sector. With proactive adaptation, decisions often involve large construction projects in the hands of public sector decision-makers. With reactive adaptation, decisions are often localised, involving many private sector agents. Decisions related to technology development, demonstration, and diffusion are similarly diffuse, involving both the developers and users of technology. The same applies to scientific research.

It is difficult and perhaps counterproductive to explore the payoffs from various types of investments without a conceptual framework for thinking about their interactions. Decision analysis provides one such framework. It allows for the systematic evaluation of near-term options in light of the careful consideration of the potential consequences. The next several decades will require a series of decisions on how best to reduce the risks from climate change. There will no doubt be opportunities for learning and midcourse corrections. The immediate challenge facing policy makers is what actions make sense today in the face of the many long-term uncertainties.

Figure 18.1 provides a caricature of the climate policy “decision tree”. In the language of decision analysis, the squares represent points at which decisions are made, the circles represent the reduction of uncertainty in the outcomes, and the arrows indicate the wide range of possible decisions and outcomes. The diagram is by no means exhaustive. Nor do we intend to search for the optimal set of near-term decisions. Such a quest is beyond the scope of this chapter. Indeed, it is questionable whether such an analysis is even possible given the diversity of decisions required at the international, domestic, and local levels.

The first decision node summarises some of today’s investment options. How much should we invest in mitigation? In adaptation? In expanding mitigative and adaptive capacity? And in research to reduce scientific uncertainty? Once we act, we have an opportunity to learn and make mid-course corrections. The outcome nodes represent some of the types of learning that will occur between now and the next set of decisions. The outcomes are uncertain; the uncertainty may not be resolved but there will be new information which may influence future actions. Hence, the expression “act, then learn, and then act again” (Beltratti, 1996).

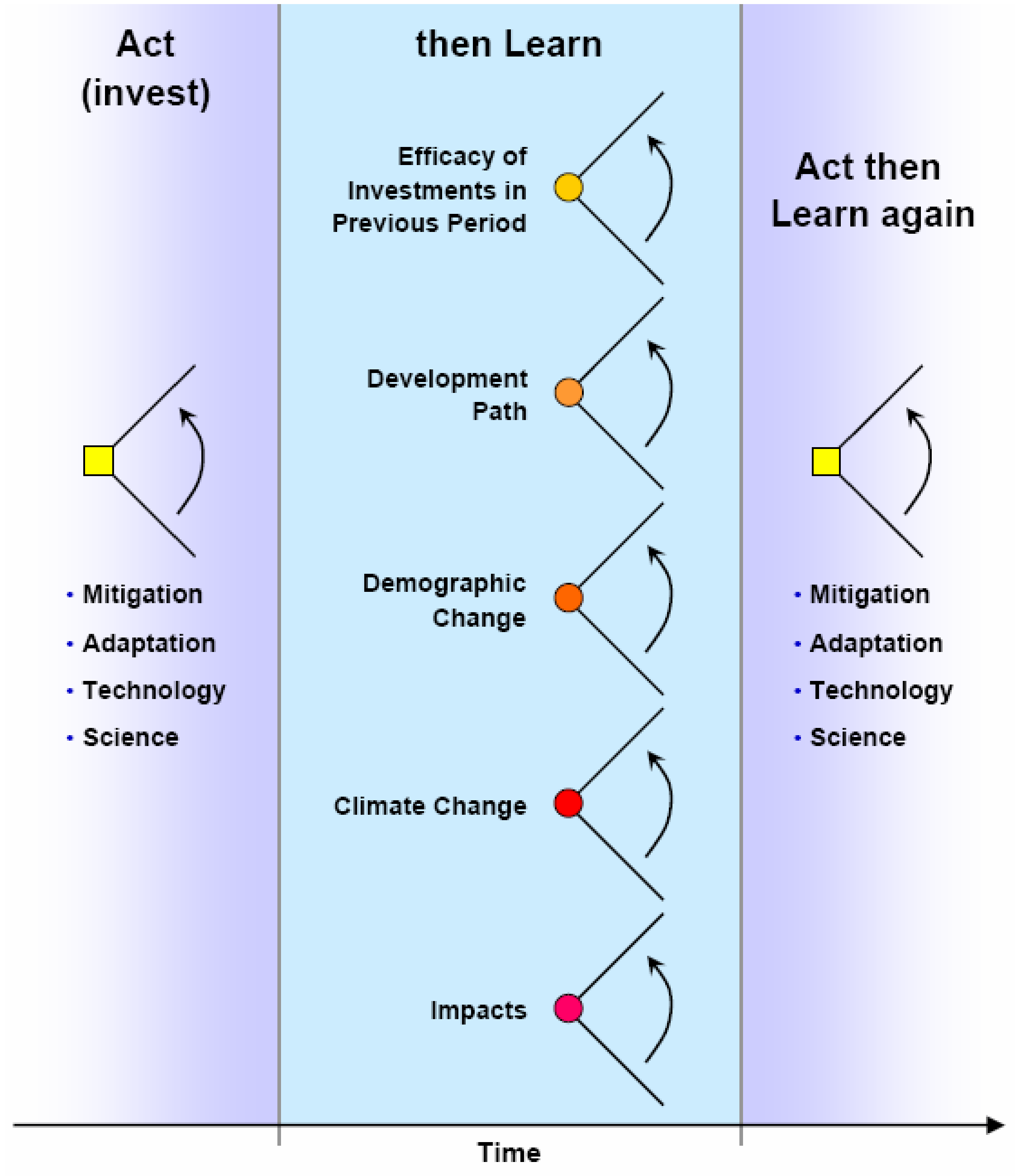

Figure 18.1: *The dynamic nature of the climate policy process. The squares are decision nodes, with arrows indicating the wide range of actions. The circles are outcome nodes, with wide range of potential consequences.*

The outcome nodes reflect uncertainty in the consequences of the decision nodes. How effective is each action in meeting its respective goal and what have we learned to facilitate the achievement of future goals? For example, are countries achieving their mitigation targets? What have we learned about the ability of existing institutions to implement reductions mandated at the international, domestic, and local level? What are the marginal and total costs of implementation and the impact on market and non-market systems? What will be the population and their economic status in 2050, 2100? What is the significance of increasing life spans? Will there be shortfalls in the size and capacity of the workforce? Presumably we will also learn more about the likelihood, nature, and magnitude of climate change and its consequences in the future.

The issue of development paths is particularly complex. Climate change mitigation and adaptation will both be affected by, and have impacts on, broader socio-economic policies and trends, such as those related to development, sustainability and equity. In the present context, it is unclear whether development should be characterised as a decision node, an uncertainty node, or both. Given the focus of this chapter, we treat development paths as a critical uncertainty, recognising the inherent interactions between decisions related to mitigation and adaptation and those related to development.

Figure 18.2 shows schematically how decisions on climate policy relate to development paths. Particular climate policy decisions, and the climate policy decision problem itself, are rooted in the larger context of response capacity and development paths. Thus the act-learn-act-again framework is connected to a larger set of policy decisions that are not driven by climate policy. Ideally, those connections would be explicit and the act-learn-act-again framework would be expanded to include, insofar as possible, explicit consideration of those larger contextual factors. In some cases this might involve only an explicit consideration of the implications of climate policy measures for sustainable development. In others it might extend to the development of a sustainable development policy framework in which climate goals are embedded. In either case, the decision framework connects climate policy to the larger world of sustainable development analysis and policy.

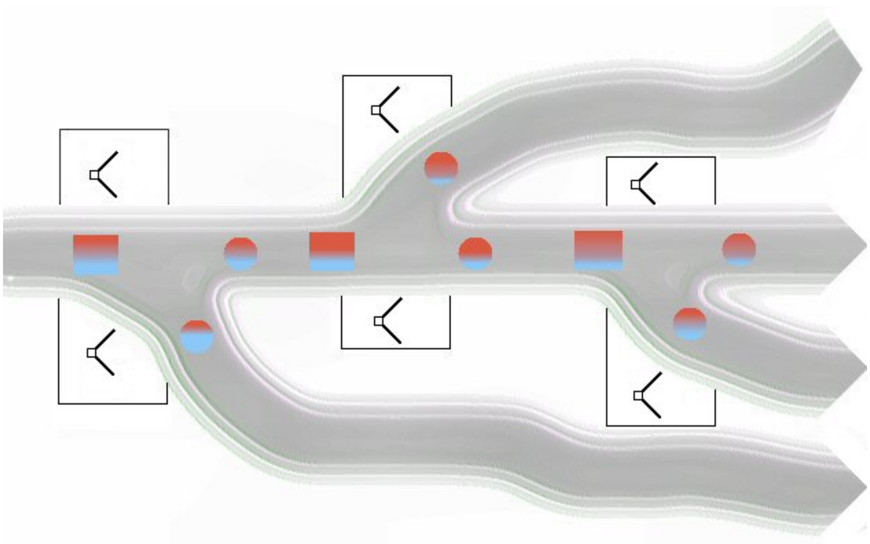

Figure 18.2: *Climate policy decision-making and development paths framing climate policy decision making. Climate policy decisions (the rectangular panels of decision nodes) connect to underlying socio-economic and technological development paths (the branching streams). The development path frames and constrains response capacity—indicated by the squares with a blend of mitigation (red) and adaptive (blue) capacity. Climate policy choices (the square nodes) may not be related to development policy, either at the international scale (above the path) or local actors who are unlikely to influence development pathways (below the path). Climate responses may occur at key junctures. The outcomes of these branch-decisions, sometimes called tipping points, is represented by the circular nodes, also shaded according to the balance of mitigative or adaptive capacity. As the path unfolds, different mitigation and adaptation options may be available and the success of their outcomes may change.*

Box 18.2: Mitigation Policy

Programs and specific interventions that might reduce either the rate at which the radiative balance is changing or the ultimate level at equilibrium, assuming one is reached. Mitigation policies include not only interventions designed to reduce the emission of greenhouse gases but also actions such as reforestation (or reducing deforestation), removal of radiatively active gases from the atmosphere, and altering the earth's albedo in ways that affect the earth's radiative balance.

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Box 18.3: Cost-Effectiveness Analysis, Cost-Benefit Analysis and the Tolerable Windows Approach

The ultimate goal of the UNFCCC is "the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." Mitigation costs are of secondary importance. The Convention states that "policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible costs." In other words, once a maximum safe level of concentrations has been determined, the goal is to identify a "least-cost" way for meeting the objective subject to the constraint.

Most (but certainly not all) economists would argue that cost-effectiveness analysis, while useful, does not go far enough. Policy makers need to consider both the costs of policies and what they might achieve in terms of reducing environmental damages. Unfortunately, our ability to conduct such analysis at the present time is limited due to problems with quantifying and valuing impacts.

In cost-benefit analysis, the goal is to minimise the sum of mitigation costs and damages. By introducing damages into the calculation, one can explore assumptions about the effects of adaptation on impacts and hence the extent to which adaptation can reduce damages. However, to date, there have been relatively few attempts to simultaneously treat mitigation and adaptation as decision variables. Indeed, most analysis of the benefits of adaptation have assumed a given level of mitigation (either implicitly or explicitly) and then examined the consequences of alternative adaptation decisions. Unlike the mitigation analysis, adaptation analysis has been bottom-up by necessity. That is, it is conducted at a much smaller level of aggregation.

Consistent with the decision tree framework (Figure 18.1), cost-effectiveness and cost-benefit analyses are not only deterministic, but also probabilistic. This adds a powerful dimension to the analysis in that it allows for the consideration of uncertainty, particularly the occurrence of low probability, high consequence events. Outcomes are identified for key uncertainties and probabilities are assigned to each. For example in one multi-model study of optimal hedging strategies, probabilities were assigned to temperature change and impacts. As with the deterministic analysis, the focus was on a single investment category – the optimal near-term mitigation.

The tolerable windows approach (TWA) combines aspects of cost-effectiveness and cost-benefit analysis. It is based on the premise that decisions about the limits to unacceptable climate change impacts and costs are normative judgements based on the values and perceptions of social actors and derives fields or corridors of long-term CO_2 emissions. For any specific cost-impact combination, if the corridor exists, it contains all emission paths that prevent surpassing the impact limit without exceeding the cost limit any time during the time horizon (typically 100 to 200 years). If such a corridor does not exist, willingness to pay for mitigation, willingness to tolerate higher impacts or a combination of the two is required to find at least one feasible pathway. Probabilistic versions of the TWA model are not available as yet but it is possible to conduct standard uncertainty analyses. This includes exploring sequential decision-making when an emission path is prescribed for a given period and the model computes its implications for the long-term emission corridor. The TWA therefore takes explicit social decisions about acceptable impacts and costs and produces a domain of feasible mitigation strategies but leaves the actual choice within this domain to decision-makers who can consider factors and goals not included in the model.

Although we have presented examples of how actual analyses fit into the decision tree framework, the main purpose of the framework is to provide a structure for thinking about an extremely complex problem. Although convenient for purposes of economic analysis, outcomes do not have to be expressed in a common unit. Nor is cost-effectiveness or cost-benefit analysis the only way to evaluate specific investments. Indeed, it is not even necessary to agree with the present structuring of the decision problem. What is necessary is to recognise the interrelationship of what might initially appear to be a group of unrelated and disconnected decisions and begin to think about how to take advantage of their synergies and trade-offs.

18.3.2 Spatial and temporal scale issues in decision-making

Climate change decision-making – acting, learning, then acting – is not a once-and-for-all event. Rather it is a process that is likely to take place over decades if not centuries. Furthermore, it does not occur at discrete intervals but is driven by the pace of social, economic, scientific and political processes. Decisions are taken at different spatial and social scales, and by a variety of actors (see Section 18.3.3).

The nature of the decisions changes over time. For example, mitigation choices may initially begin with easy measures such as adoption of low-cost supply and demand-side options in the energy sector. Through successful investment in research and development, a host of low-cost alternatives should become available in the energy sector allowing for a transition to low-carbon-venting pathways. Given the current composition of the energy sector, this is unlikely to happen overnight but through a series of decisions over time. Initially, adaptation decisions are likely to address current climatic risks (*e.g.*, drought early-warning systems) and be anticipatory or proactive (*e.g.*, land-use regulations). With increasing climate change, autonomous or reactive actions (*e.g.*, purchasing air conditioning) are likely to increase.

Decision-making on inter-relationships between adaptation and mitigation takes place at more than one spatial and institutional scale, implying different actors and objectives (see Section 18.3.3). A common decision-making hierarchy is from policy to implementation. Policy refers to the agenda setting and regulatory role of policymaking bodies (*e.g.*, a new law on renewable energy). Strategic planning refers to the translation of policy into action through programmes (*e.g.*, guidance for urban planning on energy efficiency). Operational implementation is within the remit of specific actors with direct effects on sectoral and regional activities (*e.g.*, decisions to purchase air conditioning). The latter two categories are consistent with the common division between strategies and measures in the UNFCCC documents.

These decision-making scales are often congruent with spatial scales, although many decisions span more than one spatial scale. Within a policy framework, at a highly aggregated, international scale, mitigation and adaptation are often seen as substitutes: the more mitigation is undertaken, the less adaptation is necessary and vice versa. Resources devoted to mitigation might impede socio-economic development and reduce investments in adaptive capacity and adaptation projects.

National and sub-national decision-making is often a mixture of policy and strategic planning. The mitigation-adaptation trade-off is problematic at this scale because the effectiveness of mitigation outlays in terms of averted climate change depends on the mitigation efforts of other major greenhouse gas emitters. Thus, the magnitude of necessary adaptation is disconnected from an individual country's mitigation. A national policy example of synergies might be a new water law that requires metered use, enabling water companies to adjust their charges in anticipation of scarcity and conserve energy through demand-side measures. This policy would then be implemented in strategic plans by water companies and environment agencies at a sub-national level.

At the operational scale of specific projects, there may be trade-offs or synergies between adaptation and mitigation. However, the majority of projects are unlikely to have strong inter-linkages. Section 18.4.1 summarises the insights from recent work on these issues, including examples such as community afforestation to support sustainable livelihoods.

The linkages between adaptation and mitigation also link across scales (Cash and Moser, 2000; Rosenberg and Scott, 1996). A policy framework is often seen as essential in driving strategic investment and operational projects (*e.g.*, Grubb, 2003, Grubb *et al.*, 2002 for technological innovation). Or, operational experience is seen as a precursor to developing sound strategies and policies (BP?). In many cases the results of action at one scale have implications at another scale (*e.g.*, local adaptation decisions that increase greenhouse gas emissions, or national carbon taxes that change local resource use).

18.3.3 Stakeholder roles, risk and decision-making

In the act-then-learn characterisation of decision-making, the roles of various stakeholders embrace different aspects of mitigation-adaptation linkages. Stakeholders may be characterised according to their constitution (public or private), level of decision-making (policy, strategic planning or operational implementation), geographic scale (local, national or international) and networks (single actor, stakeholder regime or institution). In addition, decision-making may be motivated by climatic risks or climate change (*e.g.*, climate-driven, climate-sensitive, climate-related) and the domain of action might cover mitigation only, mitigation-adaptation linked, or adaptation only.

Stakeholders are exposed to a variety of risks, including financial, regulatory, strategic, operational, or to their reputations, physical assets, life and livelihoods (*e.g.*, Institute for Risk Management, 2002). Risk is commonly defined as the probability of a consequence, while uncertainty is often taken to represent structural and behavioural factors that are not readily captured in probability distributions (*e.g.*, Stainforth *et al.*, 2005, Tol, 2003). Stakeholder decision making includes awareness and perception of climate change issues, negotiation, bargaining and social norms (Clark *et al.*, 2001), analytical frameworks (see Section 18.3.1), and information and monitoring systems. Faced with the deep uncertainty of climate change, stakeholders may adopt a precautionary approach with the intention of stimulating technological (if not social) change. For instance, estimates of the social cost of carbon, one measure of the benefits of mitigation, are sensitive to the choice of decision framework (including equity weighting, risk aversion, sustainability considerations, and discount rates for future damages) (Downing *et al.*, 2005, Tol, 2004).

Relatively few public or corporate decision-makers have direct responsibility for both adaptation and mitigation. For example, adaptation might reside in a ministry of environment while mitigation policy is led by a trade or economic ministry. However, criteria relating to either mitigation or adaptation, or both, are increasingly common in decision-making. For example, local development plans might screen housing developments according to energy use, water requirements and preservation of green belt. Development agencies have begun to screen their projects for relevance to mitigation and adaptation (*e.g.*, Burton and Van Aalst, 1999; Klein, 2001; Eriksen and Næss, 2003).

Many stakeholders embrace concerns related to mitigation (*e.g.*, energy efficiency) and adaptation (*e.g.*, sustainable communities, poverty reduction) through environmental policies and not necessarily climate change per se. Preliminary work by Nagai and Hepburn (2005) suggests that there may be a trade off between cost-effective emission reductions and the achievement of other sustainable development objectives --- in other words, more expensive projects per emission reduction unit tend to contribute more to sustainable development then cheaper projects.

18.3.4 Response capacity and development pathways

As outlined in the IPCC TAR (Working Group II, Ch.18 and Working Group III, Ch. 1)[1] and discussed at more length in Chapter 17 of this volume and Chapter 12 of the Working Group III report, the ability to implement specific adaptation and mitigation measures is dependent upon the existence and nature of adaptive and mitigative capacity, which make such measures possible and affects their extent and effectiveness. In that sense, specific adaptation and mitigation measures are rooted in their respective capacities.

Adaptive capacity has been defined in the Third Assessment Report (Working Group II, Ch.18.1) as "the potential, capability, or ability of a system to adapt to climate change stimuli or their effects or impacts." In a parallel way mitigative capacity has been defined in the Third Assessment Report (Working Group III, Ch. 1.5) as the "ability to diminish the intensity of the natural (and other) stresses to which it might be exposed." Clearly these two categories are closely related, though in accordance with the differences between adaptation and mitigation measures discussed in section 18.1 above, the capacities also differ somewhat. In particular, since adaptation measures tend to be both more geographically dispersed and smaller in scale than mitigation measures (Dang *et al.*, 2003), adaptive capacities refer to a slightly broader and more general set of capabilities than mitigative capacities. Despite these minor differences, however, adaptive and mitigative capacities are driven by similar sets of factors. As such, the term response

[1] For discussions on adaptive capacity, see Working Group II, Chapter 18.1, 18.5 and 18.6. For the introduction of the concept of mitigative capacity, see Working Group III, Chapter 1.5.

capacity may be used to describe the ability of humans to manage both the generation of greenhouse gases and the associated consequences (Tompkins and Adger, 2003).

Little work has yet been done in identifying the determinants of response capacity. With regard to mitigative capacity, Yohe (2001) has suggested the following list of determinants:

- range of viable technological options for reducing emissions
- range of viable policy instruments with which the country might effect the adoption of these options
- structure of critical institutions and the derivative allocation of decision-making authority
- availability and distribution of resources required to underwrite their adoption and the associated, broadly defined opportunity cost of devoting those resources to mitigation
- stock of human capital, including education and personal security
- stock of social capital, including the definition of property rights
- country's access to risk-spreading processes (*e.g.*, insurance, options and futures markets, *etc.*)
- ability of decision makers to manage information, the processes by which these decision makers determine which information is credible and the credibility of the decision makers themselves

Yohe suggests a similar set of determinants for adaptive capacity, but adds the availability of resources and their distribution across the population. Recent research has sought to offer empirical evidence that demonstrates the relative influence of each of these determinants on actual adaptation (Yohe and Tol, 2002).[2] These determinants of both adaptive and mitigative capacity expand on those identified in the Third Assessment Report and agree closely with those offered by (Moss *et al.*, 2001) and (Adger *et al.*, 2004). The linkages between adaptive and mitigative capacity are demonstrated by the striking similarities between these sets of determinants, which show that both the ability to adapt and the ability to mitigate depend on a mix of social, biophysical and technological constraints (Tompkins and Adger, 2003). Recent research has pointed to the necessity of broadening these lists of determinants to include important factors such as socio-political aspirations (Haddad, 2005), risk perception and perceived adaptive capacity (Grothmann and Patt, 2005).

These discussions of determinants indicate the close connection that exists between response capacities and the underlying socio-economic and technological development paths that give rise to those capacities. In important respects, the determinants listed above are important characteristics of such development paths. Those development paths, in turn, underpin the baseline and stabilisation emission scenarios that will be discussed in Chapter 3 of Working Group III and used to estimate emissions, climate change and associated climate change impacts[3]. That is, the determinants of response capacity can be expected to vary across the underlying emission scenarios reviewed in this Fourth Assessment Report. Different underlying scenarios imply different levels and types of response capacities, and thus different likely or even possible levels of adaptation and mitigation.

[2] See WGII Chapter 17.3 for a more detailed discussion of adaptive capacity.

[3] The climate change and climate change impact scenarios assessed in the Fourth Assessment Report will be primarily based on the SRES family of emission scenarios, which define a spectrum of different development paths, each with associated socio-economic and technological conditions and driving forces. Each family of emission scenarios will therefore give rise to a different set of response capacities.

This situation is summed up in Figure 18.3, which shows adaptation and mitigation measures as being rooted in adaptive and mitigative capacity. The adaptive and mitigative capacities are in turn contained within, and strongly affected by, the nature of the development path in which they exist. The figure also illustrates that adaptation, mitigation and their respective capacities overlap substantially but are not identical[4].

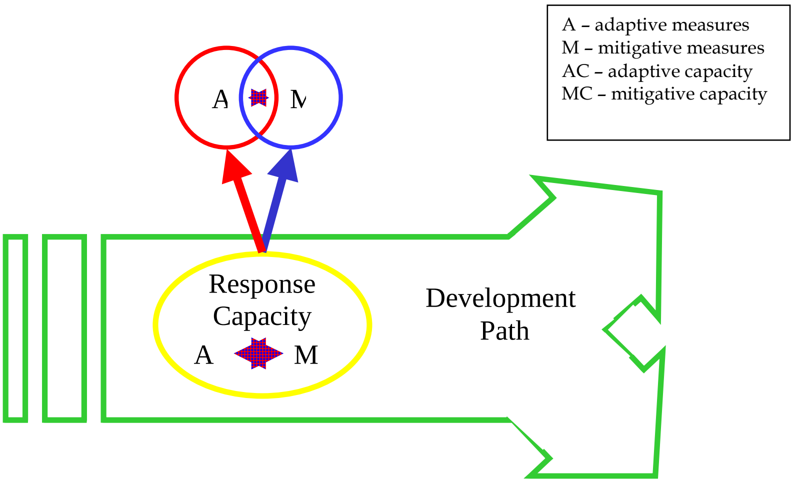

Figure 18.3: *Adaptation and mitigation are made possible through response capacity, which in turn is deeply rooted in the underlying socio-economic and technological development path which gives rise to these capacities. Different development paths imply different response capacities.*

The concept of development paths is discussed at more length in chapter 12 of the Working Group III report. Here it is sufficient to think of a development path as the complex array of technological, economic, social, institutional and cultural characteristics that define an integrated trajectory of the interaction between human and natural systems over time at a particular scale. Such technological and socio-economic development pathways find their most common expression in the form of integrated scenarios (Swart *et al.*, 2004).

In the climate change context, the TAR noted that "[c]limate change is thus a potentially critical factor in the larger process of society's adaptive response to changing historical conditions through its choice of developmental paths" (Banuri *et al.*, 2001). Later in the same volume, the following typology of critical components of development paths is presented (Toth *et al.*, 2001):

- Technological patterns of natural resource use, production of goods and services and final consumption
- Structural changes in the production system
- Spatial distribution patterns of population and economic activities
- Behavioural patterns that determine the evolution of lifestyles

The importance of the connection shown in Figure 18.3 among measures, capacities and development paths is threefold. First, as pointed out in the Third Assessment Report, a full analysis of the potential for adaptation or mitigation policies must also include some consideration of the capacities in which these policies are rooted. This is increasingly being reflected in the

[4] That is, as discussed in Section 18.4, there can be trade-offs or synergies among specific adaptation and mitigation measures.

literature being assessed in other chapters of this assessment[5]. Second, such an analysis of response capacities should in turn encompass the nature and potential variability of the underlying development paths that strongly affect the nature and extent of those capacities. This suggests the desirability of an integrated analysis of climate policy options that assesses the linkages among policy options, response capacities and their determinants, and underlying development paths[6]. As yet this type of assessment is in its infancy.

Third, the linkages between climate policy measures and development paths described here suggest a potential disconnection between the degree of adaptation and/or mitigation that is possible and that may be desired in a given situation. On the one hand, the development path will determine the response capacity of the scenario. On the other, the development path will strongly influence the levels of greenhouse gas emissions, the associated climate change, the likely degree of climate change impacts and thus the desired mitigation and/or adaptation in that scenario (Metz *et al.,* 2002; Nakicenovic, 2000; Swart *et al.,* 2003).

However, there is no particular reason that the response capacity and the desired levels of mitigation and/or adaptation will change in compatible ways. As a result, particular development paths might give rise to levels of desired mitigation and adaptation that are at odds with the degree of adaptive and mitigative capacity available. For example, particular development path scenarios that give rise to very high emissions might also be associated with a slower growth, or even a decline, in the determinants of response capacity. Such might be the case in scenarios with high degrees of military activity or a collapse of international cooperation. In such cases, climate change impacts could increase, even as response capacity declines.

The various possible connections among desired adaptation and/or mitigation and adaptive and mitigative capacity are shown schematically in Figure 18.3. That figure shows the directions of emissions, impacts and response capacity associated with four notional scenarios that represent different development pathways. It can be seen that in all four scenarios, increases or decreases in emissions lead to corresponding increases or decreases in climate change impacts (and therefore in required adaptation and/or mitigation). In the case of scenarios 1 and 4, these changes in impacts are associated with corresponding changes in response capacity. All move in the same direction. But in the cases of the scenarios 2 and 3, increases or decreases in impacts are associated with the opposite effect on response capacity. In scenario 2, the need for climate policy responses increases, while desired response capacity goes down: a very undesirable outcome. In scenario 3 the fortunate result is that the capacity for response increases while the need declines.

[5] On adaptive capacity, see especially chapters 17 of this volume. On mitigative capacity, see the discussions in chapter 12 of the WGIII report. Each of the regional and sectoral chapters in Working Group II, and sectoral chapters in Working Group III will also discuss adaptive or mitigative capacity as relevant to their region/sector.

[6] Such an integrated assessment approach was proposed in the *Synthesis Report* of the IPCC's Third Assessment Report (Watson 2002)

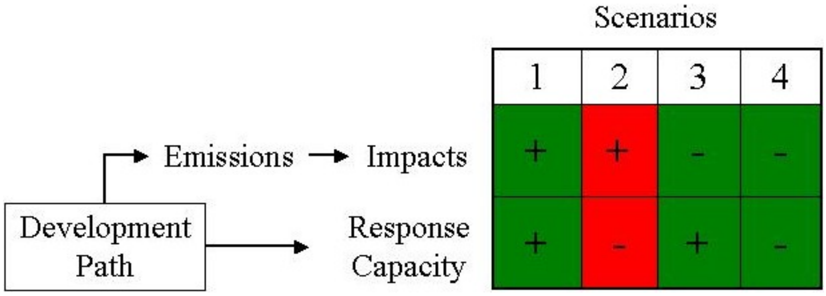

Figure 18.3: *Linkages between response capacity and the need for adaptation and mitigation. While the need for mitigation and adaptation will rise and fall with the level of climate change impacts and associated level of emissions, in a given development path scenario, response capacity may or may not change accordingly. In scenarios 1 and 4, response capacity changes in the same direction as changes in desired adaptation or mitigation, while in scenarios 2 and 3, response capacity changes in the opposite direction. In scenario 2, shown in red, the need for adaptation and/or mitigation increases, while response capacity declines, a highly undesirable outcome.*

Of course the notional scenarios that are shown in Figure 18.3 represent only a simplified schematic outline of the various logical possibilities among these factors. Much more work is needed to determine whether any of these outcomes are empirically feasible and to assess the complexities (such as the differences between adaptive and mitigative responses and capacities in particular situations) that are not shown in the figure.

18.3.5 Adaptation, mitigation and sustainable development

The linkages among climate policy, response capacities and development paths suggested in the previous section help to understand the nature of the relationship between climate policy and sustainable development. There is a small but growing literature on the nature of this relationship (Banuri, 2001; Beg *et al.*, 2002; Cohen *et al.*, 1998; Markandya *et al.*, 2002; Metz *et al.*, 2002; Munasinghe *et al.*, 2000; Najam *et al.*, 2003; Robinson *et al.*, 2001; Schneider *et al.*, 2000; Smit *et al.*, 2001; Swart *et al.*, 2003; Wilbanks, 2003). Much of this literature emphasises the degree to which climate change policies can have effects, sometimes called ancillary benefits or co-benefits, which will contribute to the sustainable development goals of the jurisdiction in question. This amounts to viewing sustainable development through a climate change lens. It leads to a strong focus on integrating sustainable development goals and consequences into the climate policy framework and on assessing the scope for such ancillary benefits. For instance, reductions in greenhouse gas emissions might reduce the incidence of death and illness due to air pollution and benefit ecosystem integrity – both of which are elements of sustainable development. The challenge then becomes ensuring that actions taken to address environmental problems don't obstruct regional and local development (Beg *et al.*, 2002). A variety of case studies demonstrate that regional and local development can in fact be enhanced by projects that contribute to adaptation and mitigation. Urban food growing in two UK cities, for instance, has resulted in reduced crime rates, improved biodiversity and reduced transport-based emissions (Howe and Wheeler, 1999). Similarly, agro-ecological initiatives in Latin America have helped to preserve the natural resource base while empowering rural communities (Altieri, 1999).

An alternative approach is based on the finding in the Third Assessment Report that it will be extremely difficult and expensive to achieve stabilisation targets below 650 ppm from baseline scenarios that embody high emission development paths. Conversely, low emission baseline scenarios may go a long way toward achieving low stabilisation levels even before climate policy is include in the scenario (Morita *et al.*, 2001). This recognition leads to an approach to the linkages between climate policy and sustainable development—equivalent to viewing climate change through a sustainable development lens—that emphasises the need to study how best to achieve low emission development paths (Metz *et al.*, 2002; Robinson *et al.*, 2003; Swart *et al.*, 2003).

It has further been argued that sustainable development might decrease the vulnerability of developing countries to climate change impacts (McCarthy *et al.*, 2001), thereby having implications for the necessary amount of both adaptation and mitigation efforts. For instance, economic development and institution building in low-lying, highly populated coastal regions may help to increase preparedness to sea level rise and decrease vulnerability to weather variability (McLean *et al.*, 2001). Similarly, investments in public health training programmes, sanitation systems and disease vector control would both enhance general health and decrease vulnerability to the future effects of climate change (McMichael *et al.*, 2001). Framing the debate as a development problem rather than an environmental one helps to address the special vulnerability of developing nations to climate change while acknowledging that the driving forces for emissions are linked to the underlying development path (Metz *et al.*, 2002).[7]

Both approaches to linking climate change to sustainable development suggest the desirability of integrating climate policy measures with the goals and attributes of sustainable development. This suggests an additional reason to focus on the inter-relationships between adaptation, mitigation, response capacity and development paths that are indicated in Figures 18.2 and 18.3. If climate policy and sustainable development are to be pursued in an integrated way, then it will become important not simply to evaluate specific policy options that might accomplish both goals, but also to explore the determinants of response capacity that underlie those options and their connections to underlying socio-economic and technological development paths.

There is general agreement that sustainable development involves a comprehensive and integrated approach to economic, social and environmental processes (Munasinghe, 1992; Banuri *et al.*, 1994; Pezzoli, 1998; Najam *et al.*, 2003). However, early work tended to emphasise the environmental and economic aspects of sustainable development, overlooking the need for social, political or cultural change (Barnett, 2001; Lehtonen, 2004; Robinson, 2004) . More recently, the importance of social, political and cultural factors – for example, poverty, social equity, governance – has increasingly been recognised (Lehtonen, 2004) to the point that social development[8] is now given equal status as one of the ‘three pillars’ of sustainable development. This is evidenced by the convening of the World Summit on Social Development in 1995 and in the fact that the Millennium Summit in 2000 highlighted poverty as fundamental in bringing balance to the overemphasis on the environmental aspects of sustainability. The environment-poverty nexus is now well recognised and the linkage between sustainable development and achievement of the Millennium Development Goals (United Nations, 2000) has been clearly articulated (Jahan and Umana, 2003). In order to achieve real progress in relation to the Millennium Development Goals, different countries will settle for different solutions (Dalal-

[7] Of course it is important also to acknowledge that climate change policy cannot be considered a substitute for sustainable development policy even though it is determined by similar underlying socio-economic choices (Najam *et al.*, 2003).

[8] taken here to include also political and cultural concerns

Clayton, 2003), and these development trajectories will have important implications for the mitigation of climate change.

In attempting to follow more sustainable development paths, many developing nations experience unique challenges, such as famine, war, social, health and governance issues (Koonjul 2004). As a result, past economic gains in some regions have come at the expense of environmental stability (Kulindwa 2002), highlighting the lack of exploitation of potential synergies between sustainable development and environmental policies. Technology, institutions, economics and socio-psychological factors, which are all elements of both response capacity and development paths, affect the ability of nations to build capacity and implement sustainable development, adaptation and mitigation measures (Nederveen *et al.*, 2003).

18.4 Inter-relationships between adaptation and mitigation

18.4.1 Trade-offs and synergies

Analysts working on global-scale climate analyses remain divided in their formulation of the adaptation-mitigation linkages. Some consider them as substitutes and seek the optimal policy in cost-benefit frameworks while others emphasise the diversity of impacts (with little scope for adaptation in some sectors) and the asymmetry of social actors who need to mitigate versus those who need to adapt.

As an example of new results from global cost-benefit analyses, Nordhaus (2001) estimates the economic impact of the Kyoto-Bonn Accord with the RICE-2001 model. He finds that without the US participation the resulting emission path remains below the efficient reduction policy (that balances estimated costs and benefits of emission reductions) whereas the original Kyoto Protocol implied higher than efficient abatement. Among the many recent applications of another cost-benefit model, FUND is adopted to demonstrate an interesting trade-off between mitigation and adaptation (Tol and Dowlatabadi, 2001). Taking malaria as a climate-related disease, the authors observe that people with an annual income of USD 3,000 or more do not die of malaria and all world regions surpass this threshold by 2085 in most IPCC IS92 scenarios. Progressively more ambitious emissions reductions in OECD countries gradually decrease the cumulative malaria mortality if one considers only the impact side, i.e., the biophysical effects of climate change mitigation on malaria prevalence. However, if the economic effects of mitigation efforts (the slower rate of economic growth) are also taken into account then, according to the FUND model, the malaria-mortality improvements due to slower global warming will be gradually eliminated and eventually surpassed by the losses due to the reduced rate of income growth. Cost-benefit models are recognised by many as sources of guidance on the magnitude and rate of optimal climate policy while others criticise them for ignoring the sectoral (economic and social), spatial and temporal distances between those who need to mitigate versus those who need to adapt to climate change.

The Tolerable Windows Approach (TWA) adapts a different approach to integrating mitigation and impact/adaptation concerns. The ICLIPS (Integrated Assessment of Climate Protection Strategies) model identifies fields of long-term greenhouse gas emission paths that prevent rates and magnitudes of climate change generating what is considered to be unacceptable regional or sectoral impacts without imposing intolerable mitigation costs on societies. This “relaxed” cost-benefit framework can be used to explore trade-offs between climate change or impact constraints and mitigation cost limits in terms of the existence and size of long-term emission fields. For any given impact constraint, increasing the acceptable consumption loss due to climate protection expenditures increases the emission field and allows higher near-term emissions but involves higher mitigation rates and costs in later decades. Conversely, for any given mitigation cost limit, increasing the tolerated level of climate impact also enlarges the emission field and allows higher near-term emissions (Toth *et al.*, 2002; 2003a,b). This formulation allows the exploration of side-payments for enhancing adaptation in order to tolerate impacts from larger climate change. The TWA is helpful in exploring the feasibility and implications of crucial social decisions (acceptable impacts and mitigation costs) but, unlike CBA, it cannot provide an optimal policy.

Cost-effectiveness analyses (CEAs) depict a rather remote relationship between mitigation and adaptation. They implicitly assume that some sort of a global climate change target can be agreed upon that would keep all climate change impacts at the level that can be managed via adaptation or taken as “acceptable losses”. Global CEAs have proliferated since TAR. In addition to exploring least-cost strategies to stabilise CO_2 concentrations, CEAs are also adopted to stabilising radiative forcing and global mean temperature. The stabilisation literature is assessed in WGIII Chapter 3.

Looking into the details of specific adaptation and mitigation activities at less aggregated scales reveals diverse linkages. The four types include mitigation projects fostering or hindering adaptation (land-use related activities) and adaptation projects fostering or hindering mitigation (*i.e.*, reducing or increasing greenhouse gas emissions).

Afforestation, reforestation and forest conservation have been advocated for decades as essential mitigation options. Recent studies, however, reveal a more differentiated picture. Based on an extensive survey of dissolved carbon in the Amazonian river system, Mayorga *et al.* (2005) suggest that a small and rapidly cycling pool of organic carbon accounts for the large carbon fluxes from land to water to atmosphere in the humid tropics. This means that the absorbed CO_2 is released in about five years. Another study finds that in arid and semi-arid regions afforestation massively reduces water yields (UK FRP 2005). This has direct and wide-ranging negative implications for adaptation options in several sectors like agriculture (irrigation), power generation (cooling towers), and ecosystem protection (minimum flow to sustain ecosystems in rivers, wetlands and on the banks). Afforestation and reforestation may also have negative impacts on biodiversity, as shown by Caparros and Jacquemont (2003), due to the over-plantation of fast-growing alien species. These studies demonstrate the intricate relationships between climate change mitigation, adaptation, and also linkages to other environmental concerns like water resources and biodiversity with profound policy implications. The land-use and forestry mitigation options in the Marrakech Accord may alter land allocation to the detriment of the poor in regions where land is scarce, may reduce water yields and distort water allocation in water-stress regions, and may negatively affect biodiversity. All three implications reduce the scope for adaptation to climate change (excluding effective but more expensive options due to increased land rents, precluding forms and magnitudes of irrigation due to higher water prices, *etc.*).

While the implications of some mitigation strategies for adaptation and other development and environment concerns have been recognised recently, the effects of adaptation on greenhouse emissions (energy use, land conversion, agronomic techniques like increased use of fertilisers and pesticides, water storage and diversion, coastal protection) have been known much longer but have remained largely unexplored. For example, many adaptation options are known to involve increased energy use and hence interfere with mitigation efforts if the energy is supplied from carbon-emitting sources. Yet it is not straightforward to separate the adaptation effects from those of other drivers in regional or national energy demand projections. For the USA state of Maryland, Ruth and Lin (forthcoming) find that at least in the medium term up to 2025, climate change contributes relatively little to changes in the energy demand. Nonetheless, the climate share varies with geographical conditions (changes in heating and cooling degree days), economic (income) and resource (relative costs of fossil and other energy sources) endowments, technologies, institutions and other factors. Such "mitigation rebound" effects of adaptation are likely to be minor in most countries and regions but more in-depth studies are needed to estimate their magnitude over the long term.

Examples of inter-relationships between adaptation and mitigation are shown in Figure 18.4 and Table 18.1. On the local and operational scale, there are many projects concerned with energy efficiency, solar energy or forest management. Individual responses to heat waves or water shortages are related to adaptation more than mitigation. Community action is often key, scaling up to sustainable livelihoods. The examples are typically aimed at development and resource management and may have only weak links to national strategies or policies. Climate change is often given as a context of the action, but is not the main purpose.

A diverse cluster of actions are more strategic in nature. Typical examples include tourism and conflicts over water use as well as energy use (including long distance flights), spatial planning and building design in urban areas, natural resource conservation and links to sustainable livelihoods, and rural enterprises. These programmes tend to be driven by development and adaptation aims, but have significant roles in mitigation. Some actions, such as linking CDM to poverty reduction and land use planning, are more driven by mitigation policies and strategies, with a concern for adaptation synergies.

Synergies and trade-offs at the broader policy level are diverse. There are many examples of analyses of inter-relationships between adaptation and mitigation (*e.g.*, in global comparisons of costs and benefits, linking climate policy to global change and development pathways, and synergies with other multi-lateral agreements). However, there are fewer examples of explicit policy linkages (*e.g.*, through integrated programmes, regulations, or economic instruments). The UNFCCC negotiations cover mitigation and adaptation, but in different forums. The CDM surcharge and some of the climate funds are specific examples of linkages. Spanning policy and strategic planning, capacity building is a critical link (*e.g.*, the National Capacity Self Assessment exercises). Insurance has a role in both adaptation and as investment for mitigation. Trade regimes affect global and local development.

The outcomes of mitigation policies (such as carbon taxes and increased fuel prices) could have significant operational effects on adaptation, altering present and possibly desirable resource use. Geoengineering is a special case of large scale mitigation efforts that could influence resource use, impacts and adaptation. An example of an adaptation policy (in the sense of regulation and legal frameworks) that might affect negotiations over mitigation is the prospect of liability for climate impacts. In a less legal framework, concerns over large-scale and abrupt climate change impacts plays a role in awareness of the potential risks and motivations for urgent mitigation strategies. Ecological feedbacks have been reported that could exacerbate climate change; to the extent that these are influenced by human actions and adaptation they are included in this table.

Recent studies have begun to address many of these linkages in detail:

Afforestation, reforestation and forest conservation: Based on an extensive survey of dissolved carbon in the Amazonian river system, Mayorga *et al.* (2005) suggest that a small and rapidly cycling pool of organic carbon accounts for the large carbon fluxes from land to water to atmosphere in the humid tropics. This means that the absorbed CO_2 is released in about five years. Another study finds that in arid and semi-arid regions afforestation reduces water yields (UK FRP 2005). This has direct and wide-ranging negative implications for adaptation options in several sectors like agriculture (irrigation), power generation (cooling towers) and ecosystem protection (minimum flow to sustain ecosystems in rivers, wetlands and on the banks).

Land use and biodiversity: Afforestation and reforestation may have negative impacts on biodiversity (Caparros and Jacquemont 2003), due to the over-planting of fast-growing alien species. The land-use and forestry mitigation options in the Marrakech Accords may alter land allocation to the detriment of the poor in regions where land is scarce, reduce water yields and distort water allocation in water-stress regions and negatively affect biodiversity.

Effects of adaptation on greenhouse gas emissions: The requirements of adaptation projects (*e.g.*, energy use, land, fertilisers and pesticides, water, coastal protection) have remained largely unexplored. For example, many adaptation options are known to involve increased energy use and hence interfere with mitigation efforts if the energy is supplied from carbon-emitting sources. Yet it is not straightforward to separate the adaptation effects from those of other drivers in regional or national energy demand projections. For the USA state of Maryland, Ruth and Lin (forthcoming) find that at least in the medium term up to 2025, climate change contributes relatively little to changes in the energy demand. Nonetheless, the climate share varies with geographical conditions (changes in heating and cooling degree days), economic (income) and resource (relative costs of fossil and other energy sources) endowments, technologies, institutions and other factors. Such "mitigation rebound" effects of adaptation are likely to be minor in most countries and regions but more in-depth studies are needed to estimate their magnitude over the long term.

Health effects: Tol and Dowlatabadi (2001) observe that people with an annual income of USD 3,000 or more do not die of malaria. All world regions are expected to surpass this threshold by 2085 in most IPCC IS92 scenarios. Progressively more ambitious emissions reductions in OECD countries gradually decrease the cumulative malaria mortality if one considers only the impact side, that is, the biophysical effects of climate change mitigation on malaria prevalence. However, if the economic effects of mitigation efforts (the slower rate of economic growth) are also taken into account then, the FUND model shows improvements in mortality from malaria due to slower global warming will be gradually eliminated and eventually surpassed by the losses due to the reduced rate of income growth.

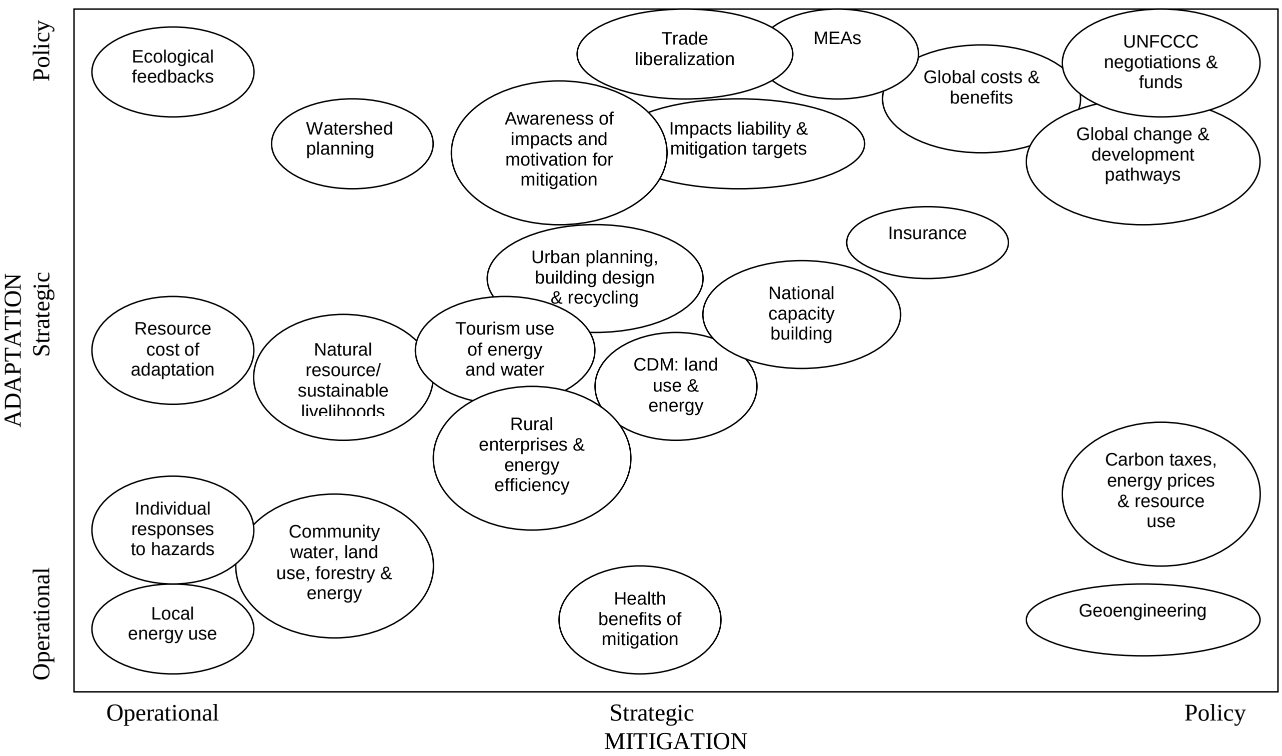

Figure 18.4: *Clusters of inter-relationships between adaptation and mitigation. Note: the ellipses are located in a rough fashion in order to be readable. Many actions would span across at least two levels. For example, the CDM is a negotiated policy that is implemented as a national or corporate strategy resulting in operational projects.*

Table 18.1: *Examples of clusters of inter-relationships between climate change adaptation and mitigation.*

Type of linkage	Description	Examples	References
Local energy use for development	Greenhouse gas emissions are reduced as people switch to renewable energy / more efficient energy usages for development and poverty reduction objectives	Rural electrification and renewables, micro hydropower, solar, efficient stoves	Chakrabarti and Chakrabarti (2002), Al Malki, *et al.* (1998), Venema and Cisse (2004), GEF (2005), GEF (2005), Cida (2005)
Individual responses to climatic hazards	Responses to climatic hazards increases or reduces energy consumption and greenhouse gas emissions	Heat waves stimulate purchase and use of air-conditioners, water crises lead to conserving water and energy	Smith *et al.* (2002), WHO (2004)
Community water, land use, forestry and energy	Communities use their resources more effectively to adapt to climate change, with ancillary benefits for mitigation and v.v.	Paddy rice, water demand and methane, climate risks in Tanzania, GEF small grants, Finnish technology programme, fuelwood in the Himalayas, community forestry in Mexico	Bergkamp *et al.* (2003), Paavola (2004), Ebrahimian (2003), Lehtilaa *et al.* (2005), Singh *et al.* (2003), Prasad *et al.* (2001), Klooster and Masera (2000)
Natural resources and sustainable livelihoods	Natural resources are managed, providing protection to communities from climatic events	Bioenergy in Australian forests, sustainable livelihoods (*e.g.*, Sudan), mangrove protection (*e.g.*, Vietnam)	Fung *et al.* (2002), IUCN *et al.* (2004)
Tourism use of energy and water	Tourism is related to climate and travel costs, local demand for energy and water may strain local resources	Hotel heat pumps, water supply in Mallorca, travel costs and emissions in New Zealand	Chan and Lam (2003), Essex *et al.* (2004), Becken (2002), Becken and Simmons (2002), Ceron and Dubois (2005)
Watershed planning	Water resource and hazard planning, implications for hydroelectric power	Restoration in Maharashtra, glacial lakes in Nepal, micro-hydropower in the Philippines	IUCN *et al.* (2003), Alam and Murry (2005), GEF (2005), mata and Budhooram (2005)
CMD: land use, energy use	Encourage communities to use renewable energy instead of fossil fuels.	Renewable technology, forest use, community energy planning	Barua (2001), Fearnside (1999), Kuzma and Dobrovlny (2004)
Carbon taxes, energy prices and resource use	Effect of mitigation on resource use at an operational level	Food security, household welfare	Rosenberg and Scott (1996), Tiezzi (2005)
Resource cost of adaptation	Investment in infrastructure with significant resource costs and use of greenhouse gases	Road planning in the Pacific	Edy (2004)
Health benefits of mitigation	Mitigation can reduce environmental health stresses	Improved air quality	Cifuentes *et al.* (2001), Alcamo *et al.* (2002)
Urban planning. Building design and recycling	Urban planning and energy balance link mitigation and adaptation, Intelligent building	Urban food production, recycling, heat island mitigation	Howe and Wheeler (1999), Holland (1999), Estes *et al.* (1999), Sailor (2002),

	designs can reduce the energy needed to provide heat and lighting		Herton *et al.* (2003), Mills (2003)
Awareness of impacts and motivation for mitigation	Perception of dangerous climate change motivates mitigation action	Regional and stakeholder assessments	Kerr and Allen (2001)
Multi-lateral Environmental Agreements	Land cover and biodiversity management links to both mitigation and adaptation	Land cover in German official development assistance	Klein (2001)
Ecological feedbacks	Ecological impacts, often with some human element, driving further releases of greenhouse gases	Drought and fires in Europe, permafrost and methane in Russia	
Impacts liability and mitigation targets	Legal implications of future climate impacts linked to mitigation targets and motivation	Global assessments	Tol and Verheyen (2001)
National capacity building	Increase the ability of a nation to respond to climate change	National Capacity Self Assessments, various projects such as C3D, Climate and Development	Murray and Huq (2005)climate policy paper
Global change and development pathways	Scenarios and planning to mainstream climate change in development	Global scenarios group, mainstreaming, development agencies screening tools, synergies in Vietnam	Munasinghe and Swart (2005), Raskin *et al.*, Robinson and Herbert (2001), Berg *et al.* (2002), Dang *et al.* (2003), Swart *et al.* (2003), Wilbanks (2003), Davidson *et al.* (2003)
Trade liberalisation	Increased economic efficiency by reducing trade barriers to enhance adaptation capacity, while increasing transport	Opening European markets to agricultural exports from Africa, globalisation and economic restructuring	Obrien, New Economic Foundation
Insurance	Insurance is a mechanism to spread risks as well as a major investor with a role in mitigation	Risk management, finance	Dlugolecki and Keykhah (2003)
Geoengineering	Large scale mitigation efforts	Solar radiation reflectors, deep ocean or geological carbon storage, fertilisation of the oceans	Dowlatabadi, Busseler *et al.* (2004)
Global costs and benefits	Analyses of optimal balances of adaptation and mitigation, using a variety of global methods	Efficiency and equity, cost-benefit, tolerable windows	Tol (2001, 2003, 2005), Downing *et al.* (2005)
UNFCCC negotiations and funds	Allocation of resources and development of frameworks	Special Climate Fund	

18.4.2 Climate policy and institutions

The ultimate objective of the UNFCCC, as stated in Article 2, is

> "to achieve ... stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system … within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

At first sight, this objective refers only to mitigation: reducing greenhouse gas emissions such that atmospheric concentrations are stabilised. The Kyoto Protocol to the UNFCCC, agreed in 1997 and effective since 16 February 2005, requires Annex I parties (*i.e.*, the developed-country signatories) to reduce their greenhouse gas emissions by an average of 5.2% compared to 1990 levels by the first Commitment Period of 2008 to 2012. Major greenhouse gas emitting countries have already established national (and in the case of the European Union, Europe-wide) regulations and policies for reducing greenhouse gas emissions from industrial and domestic sources. Australia and the United States of America have initiated alternative policies for reducing their greenhouse gas emissions, including the Asia-Pacific Partnership on Clean Development and Climate, agreed in Vientiane, Laos, in July 2005. This partnership allows Australia, China, India, Japan, South Korea and the United States of America to set their goals for reducing greenhouse gas emissions individually, but without enforcement mechanism.

Developing countries do not have to meet emission-reduction targets under the Kyoto Protocol, yet a number of countries have put in place mitigation policies. These include the development of wind energy in India and the establishment of targets for renewable energy development in China (refs.). In addition, the Clean Development Mechanism (CDM) under the Kyoto Protocol, which enables non-Annex I Parties to implement mitigation projects with funding from Annex I Parties, has spawned a large number of projects that enable developing countries to make contributions to reducing greenhouse gas emissions. Through their obligations under the Montreal Protocol on Substances that Deplete the Ozone Layer, developing countries have already reduced their emissions of greenhouse gases that are also ozone-depleting substances, such as CFCs.

In spite of these mitigation efforts, the stabilisation level at which dangerous anthropogenic interference with the climate system can still be prevented does not only depend on greenhouse gas emission reduction (or sink enhancement). It also depends on the degree to which adaptation can be expected to be effective in addressing the consequences of climate change. In other words, the higher the ability of ecosystems and society to adapt to potential impacts, the higher the level at which atmospheric greenhouse gas concentrations can be stabilised before anthropogenic interference with the climate system becomes dangerous (see also Chapter 19). Adaptation can thus complement mitigation in meeting the ultimate objective of the UNFCCC.

In parallel with the progress made on mitigation, adaptation is beginning to receive the attention that many adaptation scholars have been advocating, both in the academic arena and in climate policy (*e.g.*, Burton, 1994, 2000; Pielke, 1998). Until recently, adaptation was contained in a single COP decision (decision 11/CP.1), which set out three stages of adaptation that some believe were drafted in a manner to enable further decisions on adaptation to be delayed (Burton *et al.*, 2002). Additional decisions have since been taken, most importantly decisions 5/CP.7, 6/CP.7 and 28/CP.7, the latter introducing the opportunity for least-developed countries (LDCs) to prepare National Adaptation Programmes of Action (NAPAs). As stated in Decision 28/CP.7:

> "The rationale for developing NAPAs rests on the low adaptive capacity of LDCs, which renders them in need of immediate and urgent support to start adapting to current and projected adverse effects of climate change. Activities proposed through NAPAs would be those whose further delay could increase vulnerability or lead to increased costs at a later stage."

The increasing importance of adaptation to international climate policy was also reflected in the establishment of four funds that can be used to support adaptation activities: the Strategic Priority Piloting an Operational Approach to Adaptation, the Adaptation Fund, the Least-Developed Countries Fund and the Special Climate Change Fund (see Section 18.5.2).

The introduction of the NAPAs and the four funds reflects the increased recognition that climate change poses a threat to development issues such as water supply, food security, human health, natural resource management and protection against natural hazards. This recognition has moved adaptation from being the "handmaiden to impacts research in the mitigation context" (Burton *et al.*, 2002) to an activity that is considered crucial within the broader context of sustainable development. The link between adaptation and sustainable development is particularly relevant when seeking to enhance the capacity of countries and communities to adapt to climate change, which is often limited by lack of resources, poor institutions and inadequate infrastructure, amongst other things (Smith *et al.*, 2003; see Section 18.3.4).

The term "mainstreaming" has emerged to describe the integration of policies and measures to address climate change into ongoing development activities. Mainstreaming aims at ensuring the long-term sustainability of investments, as well as at reducing the sensitivity of development activities to both today's and tomorrow's climate. Mainstreaming is seen as making more efficient and effective use of financial and human resources than designing, implementing and managing climate policy separately from ongoing activities. By its very nature, energy-based mitigation (*e.g.*, fuel switch and energy conservation) can be effective only when mainstreamed into energy policy. For adaptation, however, this link has not appeared as self-evident until recently. Mainstreaming is based on the premise that human vulnerability to climate change is reduced not only when climate change is mitigated or when successful adaptation to the impacts takes place, but also when the living conditions for those experiencing the impacts are improved (Huq and Reid, 2004).

The incorporation of development concerns into climate policy and the subsequent emergence of mainstreaming as the preferred process of implementing adaptation (Sperling, 2003) demonstrate that climate policy involves more than decision-making on adaptation and mitigation. Klein *et al.* (2005) described three current roles of climate policy: (*i*) to control the atmospheric concentrations of greenhouse gases (*ii*) to prepare for and reduce the adverse impacts of climate change and take advantage of opportunities, and (*iii*) to address development and equity issues. Although climate change is not the primary reason for poverty and inequality in the world, addressing these issues is seen as a prerequisite for successful adaptation and mitigation in many developing countries (Sperling, 2003).

In addition to the three current roles of climate policy, a fourth role could be identified: to facilitate the successful integration and implementation of adaptation and mitigation in sectoral and development policies (Klein *et al.*, 2005). This requires the building of response capacity, both on the macro and the micro-scale, as well as creating mechanisms and incentives for mainstreaming. It would not require developing synergies between mitigation and adaptation per se, but rather between building adaptive and mitigative capacity, and thus with development (see Section 18.3.4). With this new role of climate policy comes the awareness of the importance to involve a greater range of actors in the implementation of adaptation and mitigation, including sectoral, sub-national and local actors (see Section 18.3.3). This is reflected in the respective roles of institutions at these levels.

Institutions tend to be the locus of power enactment, influence and negotiation (North, 1990). Some analysts have focused on institutional architecture and adaptive capacity (Adger 2000). (The complexity of decisions relating to climate means that non-climate institutions would be a logical resource for drawing support, exploiting synergies, building capacity and raising awareness on climate impacts. The trouble is that climate policy has largely evolved in a separate cluster with little interaction between the scientific and development world. Equally, organisations such as the World Trade Organisation (WTO) should also be concerned with climate change and its impacts (Newell, 2004). It is becoming increasingly clear that the wide array of decision-making required can not be reached under the UNFCCC umbrella alone and both regional and international grouping with similar interests in climate prevention should also be vehicles to channel effective decision making. Multilateral development institutions do offer an opportunity to coherently formulate policies and build synergies. In areas where environmental causes and consequences have the same origins and where countries share the same ideals of human and sustainable development, regional co-operation could create “win-win” opportunities in both economic integration and addressing the adverse effects of climate change (Denton *et al.*, 2002).

Getting development institutions to incorporate climate change and environmental concerns, especially in the African context, calls for a paradigm shift as environmental issues tend to be divorced from development and usually relegated to ministries with little financial and political clout such as the environment ministry.

The implementation of adaptation strategies would, to a large extent, depend on local stewardship, but both governments and regional organisations such as the Permanent Interstate Authority on Drought and Desertification (CILSS) and the West Africa Economic and Monetary Union (UEMOA) could help or hinder such efforts. Whilst such formal structures may help build consensus on adaptation and/or mitigation, it is important, especially in the context of the West African Sahel, to focus on societal pressure groups and the indigenous and innovative practices that communities have crafted to build resilience to climate extremes and change. Water management institutions in Africa have extensive knowledge on water issues but often they suffer from limited capacity and tend not to use climate change adaptation or mitigation as a template for their development projects. Yet it is certain that the development of irrigation systems in the Senegal River, for instance, could help reinvigorate agricultural productivity, but this should be done with vulnerability of climate variability in mind to increase the resilience of farmers and pastoralists who depend on the river as their main livelihood.

Organisations such as UEMOA who are actively engaged in energy development to address the perennial problem of energy poverty in the continent should also focus on how to exploit mechanisms such as the Clean Development Mechanisms in order to mitigate against present and future emissions, especially with the use of renewables. UEMOA countries (*i.e.*, Benin, Burkina Faso, Cote d’Ivoire, Niger, Senegal and Togo) are vulnerable to drought and desertification and while mitigation may not be their main concern it does offer opportunities to reduce negative impacts that are pervasive in deforestation and land use change. Institutional arrangements are a viable option for mainstreaming climate change into development and regional objectives and thus build synergy through the formulation of coherent policies.

Perhaps due to their contextual experiences, the countries in UEMOA have developed a National Action Plan as part of their commitment to the United Nations Convention to Combat Desertification but similar reflexes need to be created and strengthened vis-à-vis the UNFCCC. Both adaptation and mitigation efforts could be enhanced through institutional frameworks. However, because climate change tends to be perceived as remote and secondary, institutions that deal with this issue tend to be under-resourced and under-staffed with few individuals specialised in issues ranging from biodiversity to climate change. Without the relevant capacity and resources, regional and non-climate institutions, particularly those in developing countries, may not be able to grasp the wide ranging complex issues that are inherent to climate policy.

Organisation such as the World Trade Organisation and the European Union could, through specific mechanisms, integrate environmental policy into their economic rationales. The agricultural sector, particularly industrial agriculture and the use of strong fertiliser accounts for the production of emissions such as methane and nitrous oxide. Ironically whilst many governments under the UNFCCC are advocating a less-fossil fuel dependent pathway, they are also taking on agricultural trade policies that would amount to vast increases in energy demands of both agricultural production and distributions systems (Shrybman, 2000). However, this may not be a key issue in some of the least Developed Countries where consumption of energy in still low, since agriculture in rural areas tends to be predicated on animal and human energy with few mechanised agricultural practices. The tendency in agriculture is toward human power and animal traction and this is likely to continue in the foreseeable future (Karekezi *et al.*, 2002). However, it is an entirely different story for industrialised nations who could use certain mechanisms such as the WTO Agreement on Agriculture and the Common Agricultural Policy (CAP) as advocacy and implementing tools on mitigation policies. Climate abatement in the face of the many contentious issues surrounding globalisation, subsidies and equity within the WTO seems to be a non-issue – at least for the moment – especially since analysts are not adopting critical lenses to the combined impacts of globalisation and pervasive subsidies.

Consequently, alongside the need to use existing mechanisms within the WTO to integrate climate and economic considerations, there is also a considerable need to address contradictions between policies relevant to the reduction of greenhouse gas emissions and agricultural trade policies. Energy remains a quintessential input in agro-processing, transportation and packaging, and the combined effect of increases in energy consumption in the agricultural sector and impacts of agricultural trade policies are not thought through within the broad parameters of climate change. Other sectors such as forestry need to be looked at within specific mechanisms of the EU from an environmental/climate perspective. The main legislative mechanism that deals with forests tends to be linked to the CAP. Policies within the CAP offer some support for agricultural and silvicultural activities that could help increase carbon sequestration. A recent addition to the EU's effort is the establishment of a Working Group on Forest Sinks within the European Climate Change Programme (ECPP). Such actions need to be encouraged as they have the ability to help implement some of the key objectives of the protocol.

18.5 Elements for effective implementation

This section will address the question of the apparent gap between response capacity and actual adaptive and mitigative behaviour. Although the adaptive and mitigative capacity literature does not claim that building capacity will necessarily lead to improved responses to the climate change risk, little work has been done to explicate the widely noted variation in response to climate change among communities with similar capacities. It is apparent, therefore, that capacity is a necessary, but not sufficient, condition for action. Risk perception, socio-political aspirations, institutional structure and historical culture, for instance, may help to explain part of the variation in action among groups with similar levels of response capacity.

18.5.1 Identifying and evaluating inter-relationships

18.5.2 Financing and institutions

Box 18.4: *The role of the GEF on climate change adaptation and mitigation*

The Global Environment Facility (GEF) is a multilateral fund with the mandate to finance the incremental costs of activities that produce global environmental benefits in the areas of biodiversity, climate change, international waters, land degradation and persistent organic pollutants. GEF operations started in the early 1990s. The GEF was made the financial mechanism of the UNFCCC in 1992 and operates through three implementing agencies (UNEP, UNDP and the World Bank) and seven executing agencies, including regional development banks.

Since its inception, the GEF has allocated $4.5 billion in total, supplemented by more than $14 billion in co-financing, for more than 1,400 projects in 140 developing countries and countries with economies in transition. The share for climate change is about $1.6 billion (1991-2003) (GEF, 2003).

The GEF operational strategy states that "The overall strategic thrust of GEF-financed climate change activities is to support sustainable measures that minimise climate change damage by reducing the risk, or the adverse effects, of climate change. The GEF will finance agreed and eligible enabling, adaptation and mitigation activities in eligible recipient countries." (GEF, 1994). The operational strategy proposes a mix of short- and long-term measures to reduce greenhouse gas emissions and enhance sinks, and also includes a plan for adaptation interventions. During its first decade of operations, however, the GEF climate change portfolio focused primarily on mitigation.

Several operational programmes define the GEF climate change programme and focus on removing barriers to cost-effective energy efficiency and renewable energy; commercialising promising new technologies (*e.g.*, fuel cells); and, more recently, sustainable transportation (Eberhard and Tokle, 2004). Adaptation was initially supported only in the context of national communications. New trends in the climate change mitigation portfolio include:

- For energy efficiency: a renewed commitment to market transformation for the diffusion of energy-efficient technologies in the industry and building sectors
- For renewable energy: focus on on-grid, off-grid, rural energy programmes and renewable energy for productive uses
- For sustainable transport: a departure from a technology-focused (fuel-cell buses, *etc.*) approach in favour of a more integrated approach to sustainable mobility, including modal shift, non-motorised transport, bus-rapt transit and other policy-related interventions

UNFCCC guidance to the GEF on adaptation evolved from an initial staged approach starting with support for studies and vulnerability assessments (Stage I) and capacity building (Stage II), rapidly evolving towards concrete project implementation. Further guidance to the GEF with respect to adaptation was provided by UNFCCC COP-7, COP-9 and COP-10. Adaptation activities will be supported through four different funds:

- The Strategic Priority Piloting an Operational Approach to Adaptation (SPA), supported under the GEF trust fund (which includes support for projects that combine mitigation and adaptation interventions)
- The Least-Developed Country Fund (LDCF), designed to support the development and implementation of National Adaptation Plans of Action (NAPAs) for the 48 least-developed countries
- The Special Climate Change Fund (SCCF), established to addresses special needs of developing countries in the ambit of climate change, and whose top priority is adaptation
- The Adaptation Fund (AF), established after the entry into force of the Kyoto Protocol, which directs that 2% of the share of the proceeds from CDM projects be placed in a fund for adaptation

The LDCF, SCCF and AF create opportunities for the GEF to finance activities closely integrated with mainstream development in several traditional sectors, including water, agriculture and coastal planning. The SPA, on the other hand, provides a concrete opportunity to test integration among GEF focal areas and multilateral environmental agreements on the ground, including projects that combine adaptation and mitigation. Adaptation projects will address both current variability and extremes and climate change.

The implementation of adaptation projects imposes an additional cost to vulnerable countries in achieving their development goals. The additional cost of meeting adaptation needs will be supported by the GEF through the four funds listed above. Baseline activities that would be implemented in the absence of climate change are expected to be covered by existing budget lines, through government, bilateral aid, private sector, NGO resources, World Bank loans or other multilateral sources. The expected outcome of this approach is that adaptation funding will be closely connected to mainstream development planning and investment, and that the traditional development sectors (*e.g.*, water and agriculture) will become the focus for GEF adaptation projects.

The evolution of GEF funding for climate change over time is shown in Figures 18.5 and Table 18.2.

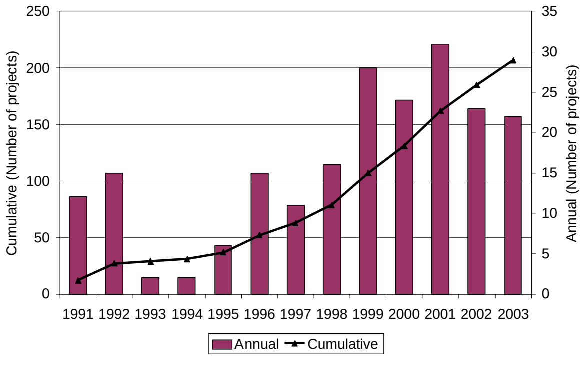

Figure 18.5: *Number of GEF climate change projects in work programme (Eberhard and Tokle, 2004).*

Table 18.2: *GEF resources allocated for climate change by country.*

Rank	Country	Total Approved Allocations (US$ Million)	GEF Funds (US$ Million) Total including pipeline	Total CO_2 Megaton Emissions (2000)
1	China	312.16	438.21	2,790.5
2	India	129.61	134.84	1,070.9
3	Mexico	117.08	173.48	424.0
4	Brazil	82.31	93.81	307.5
5	Philippines	63.75	66.88	77.5
6	Poland	54.39	68.19	301.3
7	Morocco	47.76	47.76	36.5
8	Uganda	32.53	32.53	1.5
9	Tunisia	28.66	29.66	18.4
10	Indonesia	27.74	29.74	269.6
11	Thailand	19.71	19.71	198.6
12	Cuba	19.08	19.08	30.9
13	Croatia	18.47	18.47	19.6
14	Vietnam	17.41	39.66	57.5
15	Sri Lanka	15.64	16.39	10.2
16	Chile	15.55	15.55	59.5
17	Peru	15.24	15.24	29.5
18	Lithuania	13.95	13.95	11.9
19	Romania	12.31	12.64	86.3
20	Russia	12.18	37.18	1,435.1

Looking ahead, three issues are expected to reshape the GEF portfolio in the years to come:

- The expanding role for adaptation, including making the adaptation fund operational
- The impact of the Resource Allocation Framework directing funding based on greenhouse gas emission reduction and other measures of impact; a shift toward larger emitters
- Exploration of synergies between the GEF and the CDM and other sources of carbon finance

18.5.3 Relevance to policy and development

18.6 Information needs

The information needs for understanding inter-relationships between adaptation and mitigation, with the implications for research priorities, related to decision frameworks, trade-offs and synergies, institutions and implementation.

Decision frameworks relating adaptation and mitigation (separately or conjointly) should be tested against the roles and responsibilities of stakeholders at all levels of action. Global optimising models may influence some decisions, while experience at the project level is important to others. Hybrid approaches to integrated assessments across scales (top down and bottom up) should be further developed (Wilbanks and Kates, 2003).

Representations of risk and uncertainties need to be related to decision frameworks and processes (Kasperson and Kasperson, 2005). Climate risk, current and future, is only one aspect of adaptation-mitigation decision-making; the relative importance and effect of other drivers needs to be understood.

Research on actual trade-offs and synergies, grounded in case studies and sectoral assessments, is at an early stage. The extent to which adaptation-mitigation links are substantial and urgent is still a gap. Many analysts suggest the links are either serendipitous (*e.g.*, outside the domain of project planning) or modest in terms of either conflicts or co-benefits. If the urgent priority for adaptation is risk management among vulnerable livelihoods, the implications for greenhouse gas emissions are likely to be quite small.

At a global or international level, a socially, economically and environmentally justifiable (or optimal) mix of mitigation, adaptation and development remains a research need. The extent to which a global optimum is consistent with national or local mixes of strategies, or indeed achievable, requires a concerted effort. The distributional effects would be an important factor is evaluating tolerable or optimal climate policies. Understanding of the social cost of carbon, linking to risk assessment, is fragmentary.

Unintended effects of mitigation for adaptation and vice versa are poorly documented although many links have been suggested, including market failures such as perverse subsidies. The ability of institutions to mediate such unintended effects may be key (*e.g.*, Cash and Moser, 2000). The necessity of links between public policy and private action, from global negotiations to local levels and across sectors remain problematic.

At the pragmatic level of project design, many technical uncertainties will need resolution in order to demonstrate effective linkages. Examples from agro-forestry include:

- Resilience of tree-based production systems to increased inter-annual climate variability. There are reasons to think that deep-rooted tree-based production systems are more resilient to inter-annual variability because their root systems explore a larger volume of soil and often attain the water table. Maintenance of permanent vegetation cover improves and sustains hydrologic function of the soil, which should improve the situation in both drought and wet years. This is particularly pertinent to fragile (erodable) soils.
- Ability of agro-forestry systems to maintain production in the face of long-term climate change. With a longer lifespan than annual cropping systems, up front investments are often higher. As such the returns on investment are often maximised several years after the establishment. Thus for agroforestry systems, where future options for farmers are limited by choices made at the time of establishment, the long-term sustainability issue in the face of climate change needs careful consideration.
- Carbon sequestration potential of agro-forestry systems. Of particular concern are the N_2O emissions (*e.g.*, shade coffee systems, improved fallow systems). Below-ground carbon sequestration in no-till agroforestry systems should be high.

Progress in implementing adaptation-mitigation programmes and projects is gathering pace.

Collecting the current experience and building a solid information base for future action is a priority. The development of a broad-spectrum of response capacity needs to be effective in order to seize opportunities and overcome constraints on implementation in sectoral policies. Effective institutional development, use of financial instruments, participatory planning and risk management strategies are areas for learning from the emerging experience (Klein *et al.*, 2005). Protocols for action should be compared.

The literature on the extent to which adaptation would affect different groups of societies is relatively scant. Climate mitigation in the forest and energy sectors are likely to affect women and men differently, drawing upon inferences from studies of environmental degradation and energy poverty. Mitigation action through the Clean Development Mechanism could also help or hinder women's access to energy and energy technologies but, to date, little has been done on cross gender analyses and the degrees of vulnerability, resilience and response capacity. Adaptation strategies would be relevant in climate sensitive sectors such as water and agriculture and women tend to assume the bulk of the responsibility of water management in both productive and non-productive uses and they provide the active labour force in agriculture. Adaptation strategies such as irrigation, use of crop resistant species in agriculture, water storage, *etc.* could generate new opportunities for women but this assertion need to be backed with empirical work.

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