Adaptation to climate change and variability in the context of sustainable development

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Abstract

In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) demonstrated international agreement that global co-operation is required to formulate and implement adaptation strategies. However, the development of further understanding of adaptation, and movement towards international agreement on what steps should be taken in order to facilitate it, has lagged well behind mitigation.

This paper describes a variety of current perspectives on adaptation. It then moves on to report on the state of knowledge and thinking as reflected in recent research in Uganda, Antigua and Barbuda, and Pakistan. On this basis, the paper concludes with the identification of several possible approaches to the development of international co-operation on adaptation in the context of the United Nations Framework Convention on Climate Change and the Kyoto Protocol.

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Introduction

The United Nations Framework Convention on Climate Change recognises both adaptation and mitigation as essential responses to the risks of climate change. Mitigation is the reduction of greenhouse gas emissions and the sequestration of carbon dioxide in vegetation and soils to help stabilise the concentration of greenhouse gasses in the atmosphere. Adaptation is all adjustments in socio-economic systems designed to reduce vulnerability to climate change. Since the Convention was signed in Rio de Janeiro in 1992, there has been much focus has been on mitigation, and little attention paid to adaptation. However, the recognition that adaptation to climate change is imperative, and even urgent, is growing. This paper is a discussion of the range of possible adaptation responses and how they can be integrated into national economic development planning and investment.

Adaptation in developed and developing countries

Adaptation can reduce the impacts of climate change in both developed (Annex I) and developing countries. It has been authoritatively concluded that in developed countries the capacity to adapt is high (National Academy of Sciences 1992). This confidence must be qualified in three ways:

- First, adaptation is most applicable to heavily managed socio-economic sectors. In the National Academy Report these sectors are listed as farming, managed forests and grasslands, water resources, tourism and recreation, settlements and coastal structures, human migration, and domestic tranquillity. Natural landscape and marine ecosystems are delineated in the Report as areas that are sensitive to climate change and where adaptation is questionable.
- Second, the costs of adaptation remain largely uncharted (Rothman et al. 1998; Bein et al. 1999). It is commonly assumed that the costs will be relatively low in relation to national wealth, but this may not be the case. It will depend on the magnitude and rate of climate change, which remain uncertain.
- Third, confidence in the ability to adapt assumes that climate change will be slow and incremental, and will not involve dramatic events such as sudden shifts in ocean circulation. The probability of these events is presumably low, but they could be catastrophic.

These caveats notwithstanding, the view that developed countries can cope with the necessary adaptation without broad international agreement or concerted actions is widely accepted. Recognition is growing, however, that adaptation measures adopted in one country might have consequences for other countries. This applies most clearly in transboundary situations. For example, when adaptations to changing hydrological regimes are made in a country that shares a river basin with neighbouring countries, the repercussions are likely to be regional. Adaptation policies and measures may also affect the terms of trade, both regionally, in cases such as the European Union and under the North American Free Trade Agreement, and globally, through the World Trade Organization. As such, it seems likely that some international agreements or understandings will eventually be required.

In developing countries, especially the poorer, least developed, and most vulnerable to the effects of varying climate, the capacity to adapt is generally much lower than developed countries. This is due to a relative lack of financial resources; less access to technology; weaker scientific research and development capacity; fewer effective institutions, social and governmental organisation; and less development of skilled human resources. In addition, not only is the actual amount of national wealth a factor, but its distribution is also important. Countries with larger proportions of the population living in poverty have less adaptive capacity. The uncertainty about the response of natural ecosystems and potential loss of biodiversity is another impediment to the development of sound adaptation policies, especially in tropical countries.

The large divergence of adaptive capacity between fully developed and least developed countries is the major reason why the impacts of climate change are likely to be much greater in those regions where climate change, measured in terms of mean temperature change, is projected to be least (IPCC 1996a). These regions can be described as low latitude or tropical. Significantly larger changes in mean annual temperature are projected for middle and high latitudes. However, the fact that the more highly developed countries, with greater adaptive capacity, are largely located in these regions is expected to reduce impacts.

Since the UNFCCC was agreed to in 1992, major emphasis has been placed on attempting to reduce greenhouse gas emissions. At the time of this writing (June 2000), negotiators were seeking ratification and implementation of the Kyoto Protocol. The goal is to complete these negotiations by the time of the sixth meeting of the Conference of the Parties (COP-6) to be held in The Hague in the Netherlands in November of 2000. So far, there has been little discussion of international co-operation for adaptation, with the exception of National Communications under the Convention.

This paper is intended to place adaptation more firmly in the context of sustainable development. By drawing attention to the importance of both mitigation and adaptation as components in a balanced portfolio of responses, it is the author's intention to help stimulate more debate and more rapid progress. Substantial mitigation will take considerable time to achieve. Adaptation measures to address existing and future vulnerability can be taken now.

The Climate Convention context

From the outset of the negotiations for the UNFCCC in the late 1980s, adaptation to climate change was treated as secondary to mitigation. The ultimate objective of the Convention is stated as the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." What followed this initial formulation was overwhelming concentration on mitigation: how much mitigation is needed, when, at what rate, and what is the appropriate distribution of responsibility for achieving agreed upon targets on schedule? The requirement that the agreement be international stems from the global nature of climate change. Since all countries contribute greenhouse gases to the atmosphere, albeit in unequal amounts, it is imperative that all countries agree on their respective responsibilities in order to avoid the "free rider" problem—where non-Parties enjoy the benefits of the steps taken without actually participating.

Nevertheless, the Convention does recognise the eventual need for adaptation. This is specified in Article 4.1 of the Convention as well as in Article 4.4, which provides that "Annex II Parties shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting the costs of adaptation to those adverse effects." According to one commentator, "This provision is the clearest expression of the acceptance that the Convention is as much about adaptation as it is about mitigation" (Yamin 1998).

Over the first five years of the life of the Convention, up through the agreement on the Kyoto Protocol, a disproportionate amount of attention has continued to be devoted to mitigation. Six considerations help to explain the reluctance to address adaptation:

- Adaptation has been thought of as a long-term strategy that can be delayed until the effects of climate change are more evident and less uncertain.
- Adaptation has been so broadly defined that the potential range of adaptation measures is extremely large. At the same time, there is still neither adequate information on the costs of adaptation nor an agreed upon basis for the determination of priorities.
- The developed country Parties have been concerned about exposing themselves to substantial and ill-defined demands for assistance under Article 4.4. Guidance provided by the developed countries to the Convention's financial mechanism, the Global Environmental Facility (GEF), has so far worked to restrain the provision of assistance for adaptation.
- The GEF was initially established in response to developing country demands for international funding to meet the additional costs of responding to the need

for global environmental protection. A criterion for GEF funding, therefore, has been that global environmental benefits be demonstrated in order for an initiative to be eligible. In the case of adaptation, it is generally believed that the benefits are overwhelmingly domestic, and therefore additional funds beyond normal development assistance are not justified except where genuinely global benefits can be demonstrated.

- Many development activities already account for present day climate as well as its associated probable future variability and extremes (in theory, at least). Since it is not yet, and may never be, possible for atmospheric science to distinguish with certainty between normal climate variability and climate change on either a local or regional scale, it follows that there is no scientific basis for distinguishing between adaptation measures to natural climate factors (and their costs) and to climate change.
- Throughout the international negotiations, developing country representatives have regarded adaptation as a potential source of outflows or costs. Mitigation measures, however, have been seen as potential sources of inflows or financial assistance (through Joint Implementation and the Clean Development Mechanism).

Of these six biases against addressing adaptation more aggressively, two have lost much of their credibility: lack of urgency and lack of global benefits.

Lack of urgency

The recent dramatic increase in the financial costs of weather-related natural disasters has helped to create a sense of urgency. While it cannot be scientifically proven that the magnitude of the climate variability and extremes currently being experienced is linked directly to climate change, there is certainly a possibility that this is the case. Atmospheric scientists generally agree that such a pattern is consistent with the changes that could be expected as a result of atmospheric destabilisation and intensification of the hydrological cycle caused by climate change. The cost of weather-related disasters in 1998 exceeded the cumulative cost of all such disasters in the 1980s (Annan 1999). The extreme losses of 1998 can be attributed to the unprecedented strength of the 1997-98 El Niño event. Here, again, a link to climate change is possible but not proven. Despite these necessary qualifications, the link between climate change and current extreme events is sufficient cause for alarm, and has fuelled the sense of urgency.

Lack of global benefits

The argument that adaptation measures do not yield substantial global benefits is offset by the recognition that the costs of adapting to climate change have, in effect, been imposed on all countries by the historical emissions of greenhouse gases primarily from the developed country Parties. Indeed, the acceptance of responsibility in meeting the costs of adaptation, as stated in Article 4.4, is tacit recognition of this culpability (Fankhauser 1996). Furthermore, the prevention of large-scale losses from climate-related natural disasters can have substantial global benefits. In the case of Hurricane Mitch, for example, the economic losses in Guatemala and Nicaragua equalled approximately ten years of economic growth. Such setbacks are occurring more and more frequently, and are a real cost to global economic development. This is in addition to the growing costs of emergency relief and rehabilitation for disasters, the growing threat that is posed to political and

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The remaining four reservations about adaptation are addressed in this paper. While completely satisfactory answers are not yet available, it is becoming increasingly clear that the costs of adaptation to climate change need not be a huge black hole with an unlimited capacity to absorb financial resources. Ways are being sought to distinguish the costs of adaptation to climate from adaptation to climate change. While this distinction cannot be based on a rigorous scientific distinction between climate, climate variability, and climate change, there is an emerging sense of what might be considered reasonable incremental costs. At the same time, developing countries are recognising that there is a strong case to be made for additional assistance in their efforts to meet the costs of adaptation. The outcome is likely to depend more on negotiation than on science, but the gap in positions no longer looks unbridgeable.

What is meant by 'adaptation to climate change?'

The UNFCCC does not define adaptation, and there is generally a lack of a formally agreed-upon definition. The closest thing to an authoritative definition may be found in text from an IPCC Technical Analysis where it is stated that "adaptation refers to the adjustments in ecological, social or economic systems in response to actual or expected climate stimuli, their effects or impacts. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change" (IPCC 1996b).

It is sometimes claimed in the new research and policy literature on adaptation to climate change that adaptation is a new field about which there is little knowledge or experience. This is true if it is applied strictly to anthropogenic climate change. It would be a mistake, however, to assume that an entirely new field of science is being created. While the scope of adaptation is clearly very wide, the range is dramatically reduced if a distinction is made between adaptation to climate and adaptation to climate change (Burton 1997).

Adaptation to climate has always been an essential part of the evolution and survival of both natural and human systems. In all regions, the pattern and design of human settlements and infrastructure, agricultural practices and crop selection, and a range of various other activities have been successfully adapted to the prevailing climate over the centuries. In each of the socio-economic sectors at risk from climate change there exists both theoretical and practical knowledge concerning responses to climate as well as climate variability and extremes (Washington Advisory Group 1999). The character of this knowledge differs from sector to sector. In agriculture, for example, there is a great deal of practical knowledge and local experience in every farming community. This is the basis of day-to-day decisions individual farmers make about factors such as cultivators, timing, and methods of cultivation. This fundamental knowledge is augmented by a considerable body of knowledge encompassed in crop models, which correlate to the responses of various types of crops with a wide range of climatic and weather variables.

Weather and climate variables are also taken into account in design standards for components of infrastructure. For example, in water management, transportation, forestry, tourism and recreation, health protection, and coastal zone management, factors of climate variability and extremes are always an element in design and decisions, either formally or informally. In addition, residential, commercial and industrial properties, bridges, highways, drainage channels, and docks and harbours are frequently subject to weather and climate-related standards that are officially approved, the implementation of which is commonly the responsibility of construction companies and other members of the private sector. Thus, adaptation to climate change is not something that must start from scratch. It is an incremental process that can build upon a long history of previous adaptation. What is new is the need to adapt much more rapidly because of the impact of human activities on climate. This is likely to be more difficult and more expensive, and is a legitimate charge against the global economic resources that are available through such financial mechanisms as the Global Environment Facility.

In order to develop the science of climate change adaptation, it will be necessary to build on this existing knowledge in increments that allow for new and, probably wider, ranges of variability and extremes than have previously been considered. However, there is one important new element that implies that the science of adaptation to climate change will require more than incremental changes to the sum of previously employed methods for adapting to climate change. Risk management for climate and weather variability and extremes has previously been quite compartmentalised. Different weather variables with different underlying causes affect different sectors. Accordingly, those concerned with weather and climate variability have developed their sciences quite separately from one another. In this way, agricultural priorities, and therefore techniques, are likely to be distinct from those applied in forestry, water resources management, and building and infrastructure design. For example, farmers are more concerned about the likelihood of frost or drought, and less concerned with the heating and ventilating of large buildings for human occupation. The sciences of agronomy, hydrology, forestry, architecture, construction design and engineering, and human health have all developed unique approaches and terminologies for risk assessment. Now they are confronted with a risk to which they are all vulnerable, albeit in different ways and to different degrees. This common threat is forcing a convergence of methodologies and terminologies towards what might be called integrated risk assessment for climate change. This process is only beginning, and its momentum is apparent in the growing field of integrated assessment modelling.

The identification of adaptation needs and their assessment

Within this broad conception of adaptation to climate change it becomes necessary to specify, within each country and each locality, what the adaptation needs are and to prioritise them. In developed countries it has thus far been assumed that the various socio-economic groups will have the capacity to adapt, and that little or no overall planning or policy is required. To the extent that preparatory action

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is thought necessary, it has tended to focus on research for future adaptation that has concentrated on climate impact studies.

In developing countries the search for adaptation needs and the development of priorities has received a little more attention. The reasons for this are that the need for adaptation is likely to be greater and the capacity is known to be less. Developing country governments have also been hoping, and in some cases requesting, that Annex II Parties will assist them in meeting the costs of adaptation. It is therefore in their best interests to be able to demonstrate that adaptation needs exist and can be assessed. The decisions of the Conference of Parties (COP) reflect recognition of this.

The Global Environment Facility has been designated the financial mechanism for the Convention, and it functions under the guidance of and with accountability to the COP. At the first meeting of the Conference of the Parties (COP-1), held in Berlin in 1995, it was agreed in Decision 11/CP.1 that adaptation would take place in developing countries in three sequential stages, using short, medium and long-term strategies. The stages are specified as follows:

- Stage I was defined as the planning level, to involve studies for identifying the impacts of climate change, those countries or regions that are particularly vulnerable, and policy options for adaptation and capacity building.
- During Stage II, as envisaged in Article 4.1(e) of the Convention, measures are to be implemented in those countries/regions that have been identified in Stage I as particularly vulnerable. These activities are to include capacity-building to prepare for adaptation.
- Stage III will concentrate on measures to facilitate adaptation, including insurance, as envisaged in Article 4.1 (b) and Article 4.4 of the Convention.

At the fourth meeting of the COP in Buenos Aires in 1998, based on communications between the Parties to the Convention Secretariat, it was agreed that it was time to move from Stage I to Stage II.

During the first few years of the Climate Change Convention, support to developing countries under Stage I was limited (with few exceptions) to assistance in preparing National Communications. This is expected to continue under Stages II and III. One commentator cites "reluctance on the part of the GEF to finance adaptation measures" (Yamin 1998), which is said to be "fuelled by donor concern about responsibility for adaptation costs" (Yamin 1998). The reluctance stems in part from the GEF's constitutional mandate to fund actions that result in "global environmental benefits." Adaptation benefits are assumed to be domestically concentrated and to generate no easily quantifiable global environmental benefits (Werksman 1993).

There has been some additional support for adaptation studies. Prominent among these are the U.S. Country Studies Program (Smith et al. 1996), and the Country Studies supported by the GEF through the United Nations Environment Programme, which sponsored analyses in Cameroon, Pakistan, Estonia, and

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Antigua and Barbuda in 1998. In addition, the Netherlands has supported a number of Country Studies, and one project has been carried out in Uganda in association with the World Resources Institute with the support of the U.S. Agency for International Development (Apuuli et al. 2000). The GEF also supported an important regional initiative in the Caribbean (GEF 1995), and the World Bank and others have supported development of an adaptation strategy for Bangladesh (World Bank, forthcoming). However, these are exceptions that prove the rule about the relative lack of major or widespread support for adaptation to date.

A review of these studies reveals no case in which a specific adaptation measure is identified that clearly applies to climate change alone, and does not also yield additional or co-benefits from the reduction of damages from known climate variability. Most of the studies have focused primarily on the potential impacts of climate change and have devoted little attention to adaptation beyond the creation of long lists of needed adaptation measures. However, discussions of the contents of three of the studies, which may be considered exceptional, are included here.

Uganda

In the course of the Uganda study, a useful distinction emerged between crosscutting measures with regard to a variety of government policies and programmes that are multisectoral, and single sector measures. These sectoral measures may be further subdivided into groups that can be considered general and specific. When this three-fold grouping of adaptation measures is applied to other adaptation studies, almost invariably examples of all three types are identified. In the case of Uganda, the following crosscutting measures were proposed at a workshop that was attended by government experts, policymakers, university-based scientists, and environmental non-governmental organisations (Republic of Uganda 1997).

Proposed multisectoral and crosscutting measures

- strengthening Uganda's meteorological services so that they could provide reliable medium to long-term drought and flood advisories;
- strengthening the Early Warning Information capacity, especially for food security and short-term climate prediction;
- incorporating climate change and variability information and projections into Uganda's long-term development plans, such as the National Environment Action Plan (NEAP), the Water Action Plan (WAP), the Forest Action Plan (FAP), the Poverty Eradication Action Plan (PEAP), and the Decentralisation Process;
- conducting an inventory of existing practices and policies used to adapt to different climates in all agencies and sectors in order to begin more detailed identification of adaptation measures for evaluation and adoption;
- ensuring that the Uganda Disaster Preparedness Committee (UDPC) includes

long-term climate change and climate variability hazard reduction in its work-plan;
- promoting awareness of climate variability and change and potential response alternatives throughout Ugandan society.

Proposed general sectoral measures
- reviewing agricultural policies to find ways of reducing existing vulnerability and avoiding creation of new vulnerabilities;
- renegotiating the Nile Waters Agreement to include climate change response plans;
- reviewing the Uganda Forest Action plan to ensure that climate variability and change have been adequately considered.

Proposed specific sectoral measures
- reducing reliance on monoculture planting of matoke bananas;
- expanding irrigation and increasing irrigation efficiency;
- adopting contingency plans aimed at managing current climate variability, for both droughts and floods, at both the national and local levels, but especially in the most vulnerable districts;
- ensuring that development on potential dam sites along the Nile River and other basins is controlled to ensure future development without encumbrances;
- encouraging water conservation at all community levels, using appropriate methods, including market based systems;
- enhancing and strengthening the Uganda Tree Seed Project to ensure that original biodiversity is protected against climate change and climate variability;
- reducing geographic fragmentation of forests to ensure that forest types can freely migrate in the face of climate change;
- encouraging off-site biodiversity protection in order to avoid species extinction.

Antigua and Barbuda

Probably the most comprehensive study to date of climate change impacts and adaptation needs at the national level was completed in Antigua and Barbuda in 1998. This is largely because the country is relatively small, with about 170 square miles (440 km^2) and a population of about 64,000, which meant that no part of the national territory was excluded from the study. Thus, the six sectors examined account for virtually all the economic activity and environmental resources of the country. The study encompassed coastal zones, fisheries, agriculture (including forestry and livestock), water resources, human health, and human settlements and tourism.

For each of these sectors, detailed studies of potential impacts were made, and a list of more than 60 adaptation needs was assembled. No attempt was made to establish priorities for adaptation between sectors, although some preliminary screening of adaptation measures was carried out within sectors.

The report concludes that the major sources of impacts are likely to be hurricanes, sea level rise, and drought. It is not possible to say with confidence to what extent hurricanes may increase in frequency and severity, or how rapidly sea level rise may occur, nor how much more frequent and intense the area's recurrent droughts may become under climate change. It is clear, however, that all three of these phenomena now cause substantial damage to the economy, and that present adaptation measures are insufficient. Antigua and Barbuda presents a clear "win-win" or "no regrets" adaptation case. Augmentation of present measures is needed, and will yield higher benefits the more rapidly climate change related impacts intensify. The water resources and human settlements and tourism sectors illustrate the situation.

Water resources

Potable water supplies in Antigua and Barbuda are already limited, especially in the dry season and during the recurrent drought years. There is competition among users for available water. When supplies are not sufficient to cater to all, municipal uses and the commercial hotel sector receive water services at the expense of agriculture. High variability between seasons and between years compounds the difficulty of water management. According to the report, "There is no national water resources management policy or strategy to cope with the stressed water situation and the possible impacts of climate change." The report proposes a general, sector-wide adaptation approach, which would require the launching of a Water Resources Management Action Programme that would include, but not be limited to, the following components:

- more efficient management of existing supplies and infrastructure;
- the initiation of institutional arrangements to limit future demands and to establish integrated water resources management;
- the strengthening of water resources monitoring and information systems;
- promoting conservation.

In Antigua and Barbuda, as elsewhere, improved water management is an urgent requirement. Such actions would yield benefits in the near term, regardless of climate change. With climate change these actions are likely to be even more beneficial. Conversely, unless water management is improved, the impacts of climate change will be that much greater.

A number of specific measures have been proposed in addition to the general measures outlined for the Water Resources Management Action Programme, including:

- displacement devices that reduce the amount of water toilet tanks hold;
- low-flow faucets;
- watershed rehabilitation;
- setting up new reservoir capacity to capture and store excess flows produced by altered precipitation, run-off patterns, and storms;
- digging deep wells.

These are in addition to the existing plans of the Antigua Public Utilities Authority (APUA), which call for increased desalination capacity, exploration of deep aquifers, automatic water transmission control, and decreased "leakage" through waste control measures and diminished illegal connections.

Human settlements and tourism

Hurricanes and tropical storms are the major risk to human settlements and infrastructure in Antigua and Barbuda. Even a small increase in the frequency or intensity of such storms could have severe effects on the national economy. In September 1989, Hurricane Hugo caused an estimated EC$154.1 million (East Caribbean Dollars) in direct damage, including EC$130 million to buildings. This amounted to 17.6% of the Gross Domestic Product (GDP), which was comparable to five or more years of economic growth at current average rates. In September 1995, Hurricane Luis had worse consequences, and the cost of direct damages was estimated at EC$364.5 million, which was 30.5% of GDP, equal to about ten years of economic development.

The following adaptation measures have been proposed to reduce the vulnerability of human settlements and infrastructure to climate change:

- hazard mapping, which involves identifying the areas that are most vulnerable to the effects of climate change on maps;
- flood control, which includes cleaning watercourses and drains, and prevention of filling-in of the natural drainage system;
- land use controls and enforcement, which includes:
    - implementing zoning regulations to demarcate specific areas for different types of land use, such as building densities and height limits within each zone;
    - creating building codes and planning and infrastructure standards; and
    - establishing setback requirement for coastal zones;
- retrofitting existing structures, which involves refurbishing old structures to bring them up to building code standards and, more importantly, strengthening their resilience against hurricanes and droughts;
- capacity building, which involves strengthening institutions such as the Development Control Authority and other agencies responsible for environmental management. It also encompasses improvements in inter-agency co-ordination;
- improving forecasting and early warning systems in order to increase preparedness;
- a public education and information systems programme, to heighten the public awareness of global warming and its effects.

Pakistan

The Pakistan Country Study, also conducted in 1998, concentrated on the water, agriculture, and forest sectors. Within these three sectors, the Pakistan study is one of the most sophisticated yet undertaken, especially in its use of socio-economic scenarios of future growth and development and its treatment of adaptation to climate change in the context of economic development. Pakistan has a hot, arid climate that would support a much lower population were it not for exogenous river flow, which permits extensive irrigation. Pakistan's Indus Plains have the world's largest contiguous irrigation system, and there is year round cropping in much of the area. Water potential, waterlogging and salinity, and water use efficiency are the current key issues, and will continue to be in the future. Population growth has been rapid, from 32.5 million in 1947 at the time of independence to an estimated 138 million in 1999, and is projected to reach approximately 229 million by 2020.

A number of climate change scenarios were employed in the Pakistani study. In general,

> … the results show that while the total water storage in the system remains insufficient, the water resources operation under various climate scenarios shows that the problem will become more acute in the future. The problem

will become more serious if the increase in temperature is coupled with the decrease in precipitation. The net overall capacity of the system to supply water in time will decrease in Pakistan unless some urgent actions are taken (Government of Pakistan 1998).

The adaptation strategy for the water sector may be summed up as "the conservation and efficient use of water in an informed and efficient manner" (Government of Pakistan 1998). The report concludes that water managers will be forced to re-evaluate the operations of the whole system and revise the allocation of water for agriculture in various irrigated areas. Adaptation options reviewed in the report include:

- mitigating the hazards of floods;
- altering streamflow regime by the construction of reservoirs;
- alleviating economic damages of waterlogging and salinity;
- augmenting supplies;
- re-allocating the available resources (Government of Pakistan 1998).

With regard to agriculture, the Pakistani study reports that the production of major crops like wheat, rice, cotton, and sugarcane will have to double by the year 2020 in order to meet the needs of the country's growing population. "...climate change would further demand to increase the annual growth rate in agriculture of around 0.1% and 0.2% for the periods 1997-2020 and 2021-2050 respectively" (sic.) (Government of Pakistan 1998). The study concludes that this expansion of production, and the water inputs it will require, are feasible. However, it will necessitate the adaptation of very high efficiency irrigation systems as well as improved agronomic practices. The study uses a coupling of sprinkler and drip irrigation systems with chemigation facilities as an example of this.

Conclusions to be drawn from the county studies

Despite the many political and geographical factors that set Pakistan, Uganda, and Antigua and Barbuda apart from each other, there is one general conclusion that may be drawn from all three: many of the activities recommended for adaptation to climate change would be needed in any case. There is a risk level that each country maintains with regard to elemental factors such as the availability of potable water and crop security. If this risk level is to be maintained, the threat of climate change is a reason for the recommended actions to be accelerated. At this point, risk levels in many countries are no longer consistent with sustainable development, which means that climate change ought to add even more force to the argument for accelerating adaptation. However, adaptation to climate change is not limited to the simple hastening of development activities that would have happened in any case. It will only be successful if complemented by parallel changes in policy, management practices, and innovations in monitoring, forecasting, and research. In addition to the concurrence of results among the three studies discussed here, these conclusions are consistent with those emerging from other studies, such as the U.S. Country Studies Program, as well as the more limited adaptation studies that have been completed in developed countries.

The assessment of adaptation measures

Attempts to measure the costs of adaptation to climate change are few and far between. In the impact and adaptation studies cited, the common pattern has been that major emphasis is placed upon impacts, and then lists of possible adaptation options are generated. In some cases a preliminary screening of measures has been carried out, but there has not been a thorough assessment of adaptation to date. This is not for lack of methodology or guidelines on how to proceed, nor for a lack of theory on cost. It is simply a matter of time before well-grounded estimates of adaptation costs become commonplace.

In 1999, Stratus Consulting prepared the Compendium of Decision Tools to Evaluate Strategies for Adaptation to Climate Change for the Secretariat of the UNFCCC. Despite the use of the word "strategies" in the title, most of the tools in this volume actually refer to the evaluation of specific projects. The Compendium describes nine tools that are applicable to multiple sectors, including benefit-cost analysis, risk analysis, expert judgement, and a range of screening techniques. Twenty-three additional tools are described for selected sectors: water (5), coastal zones (5), agriculture (11), and human health (2). These largely consist of physical and economic models, as well as some more general methodologies.

A more detailed description of the application of benefit-cost analysis has also been prepared for the GEF (Smith et al. 1997). In addition, guidelines for impact and adaptation assessment have been prepared and widely disseminated in country study programmes (Feenstra et al. 1998; Carter et al. 1994; Benioff et al. 1996).

More theoretical groundwork on the potential costs of adaptation has been developed in a number of papers (Fankhauser and Tol 1996; Yohe 1996). Methodological questions regarding the costing of adaptation are also addressed in the work of the IPCC and elsewhere.

In a practical demonstration of the application of benefit-cost methods, Smith and others (Smith et al. 1998) discuss three case studies: flood prevention measures on the Meuse river in the Netherlands; augmentation of storage capacity by 25% in a proposed water supply reservoir in the western United States; and adaptation to a one-metre sea level rise in the height of a bridge between New Brunswick and Prince Edward Island, Canada. In theory, in all three situations there is a case to be made for precautionary or anticipatory adaptation measures involving changes in project design. However, in each case the benefits of these measures would only justify the cost under the most severe assumptions about the occurrence of extreme events and the discount rates most favourable to the project. Discount rates greater than 5% result in virtually zero present value for avoided climate change impacts in the middle and latter part of the next century. In order for the bridge raising and the dam enlargement to be justified, it would be necessary to assume a 100% probability of a one-metre rise in sea level or a 10% decrease in precipitation respectively.

The Smith analysis does not negate the argument that precautionary or anticipatory adaptation merits consideration, especially when considering long-term infrastructure investments. The same group of experts have proposed three "simple rules" to guide adaptation decisions:

- Adaptation measures should be considered now, rather than delayed until more concrete evidence of climate impacts is available;
- Measures to increase flexibility and robustness in project design are justifiable; and
- Public (governmental) action to facilitate adaptation is needed, because without it autonomous adaptation will either not take place or will be less than optimal (Fankhauser et al. 1999).

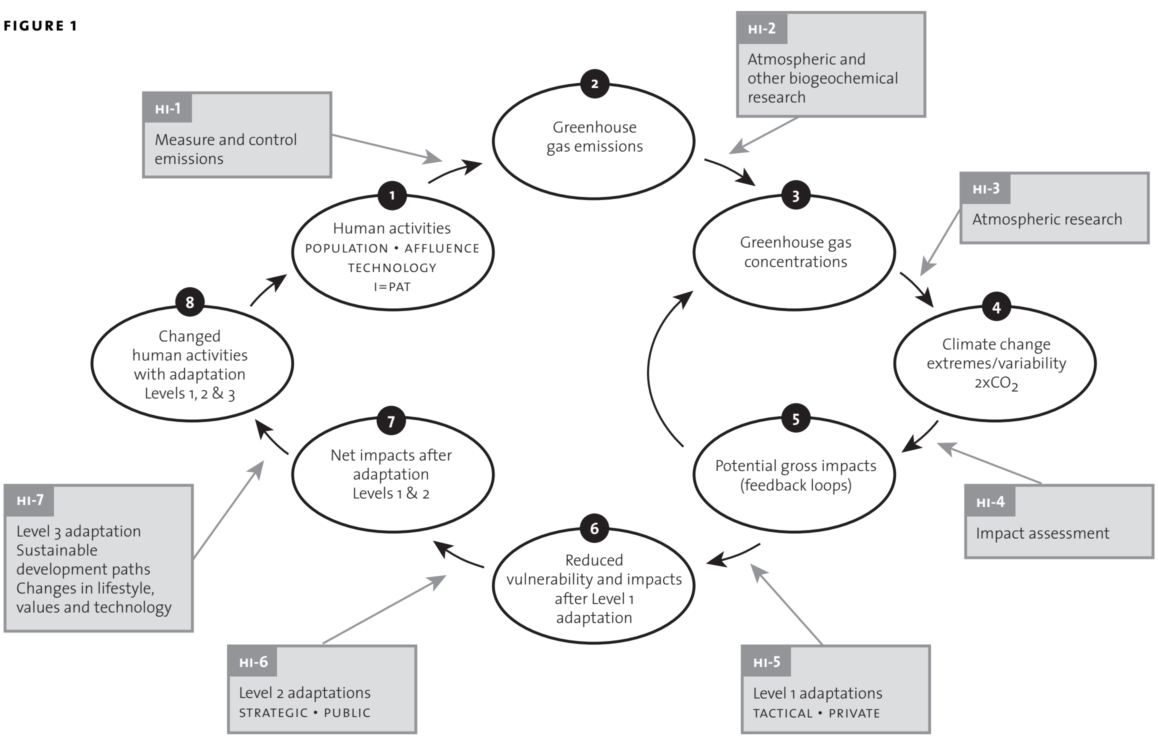
The literature also strongly suggests, however, that there is likely to be little justification for massive investment in adaptation measures in the short-term. It seems that adaptation measures can be justified, but at the project level the costs will be limited to marginal increases in the aggregate costs of projects justified in their own right, regardless of the impacts of climate change, or its speed.

This conclusion seems likely to be viable at the project level, i.e. when it relates to specific adaptation measures, and to some extent within sectors. However, as is demonstrated by the case studies of adaptation completed to date, there is an argument to be made for a more strategic approach to adaptation. So far none of the adaptation literature addresses the costs of the multisectoral and crosscutting measures that are being advocated to strengthen the capacity to adapt. When it comes to specific adaptation measures, it seems reasonable to make assessments based on the marginal increments that can be justified in project design to reduce potential losses from climate change related impacts. Where broadly based national programmes of water management (Pakistan), coastal zone management (Antigua and Barbuda), and management of floods and droughts (Uganda) are involved, it is not entirely clear how the benefits of incremental strengthening or acceleration are to be measured. Yet, at this stage in the evolution of the climate change regime, it is the strengthening of national capacity to adapt, and the modification of existing development plans to take climate change into account, that are most urgently required.

Adaptation and mitigation in the context of sustainable development

The conventional view has been that climate change is primarily a pollution problem. The problem begins with the emission of greenhouse gases from human activities, resulting in increased atmospheric concentrations, which give rise to cli-

FIGURE 1



mate change and adverse impacts on human socio-economic activities and on natural systems. It is this "pollution" view which has led to the emphasis on mitigation or the reduction of emissions. It is a rather linear cause and effect perspective. In fact, the relationship between people and climate is interactive and there is a long history of adaptation to climate (and slowly changing climate) that has been taking place over thousands of years, long before the emergence of anthropogenic climate change as a public policy issue.

Figure 1 is a simplified view of climate and society as an interactive process. The climate cycle is represented by ovals (C1 to C8), and human intervention in the cycle is represented by rectangles (HI-1 to HI-7). One can enter the cycle at any point, and all the components operate continually. Following convention, the figure "begins" with the state of human activities at what can be assumed to be the present (C1). The environmental impact of human activities (I) can be described by the formula I=PAT, where environmental impact is a function of the level of population (P), the affluence or level of consumption prevailing in the population (A), and the technology in use to extract natural resources, produce goods and services, and dispose of (or recycle) wastes (T). In the case of climate change, the relevant consequence is the emission of greenhouse gases. The storage of carbon in biomass is also a result, although it is not depicted in Figure 1. Human Intervention 1 (HI-1) consists of the measurement of emissions (and carbon sequestration) and efforts to control or reduce them through activities such as increasing energy efficiency, fuel switching, and tree planting.

As a result of population, affluence, and technology, as well as efforts at reduction, a level of greenhouse emissions prevails at any one time, which gives rise to greenhouse gas concentrations in the atmosphere (C3). The second human intervention (HI-2) consists of atmospheric, oceanographic, biogeochemical, and other research aimed at better understanding the relationship between emission levels (cumulated over time) and actual recorded concentrations of greenhouse gases. The carbon cycle, for example, has yet to be measured in a full and consistent way. Some estimates show that, given the amount of carbon dioxide that has been emitted from anthropogenic sources, atmospheric concentrations should in fact be higher than they are. This is referred to as the problem of the missing carbon.

Greenhouse gas concentrations (C3), rather than the emissions, are used in global atmospheric models. The development of such Global Atmospheric Models (GCMS) (HI-3) is a necessary step in linking concentrations with projections of climate change (C4). While the models have become increasingly sophisticated over the past decade, they still fall well short of the level of detail and reliability required to predict the amount and rate of climate change. GCMS are especially criticised for lack of specificity at the regional and local scale, the level at which impacts are studied, and for providing much more information on means than on changes in variability and extremes. The models are also often designed to provide projections of climate conditions that are expected to prevail under an "equilibrium" condition of double the pre-industrial level of greenhouse gases. However, this assumption may be extremely inaccurate.[2]

2 For further information on climate change modelling, see Mahlman, this volume.

It is the task of the "impacts community" to assess the impacts on human and natural systems on the basis of the information made available through climate models and studies of climate variability and extremes (HI-4). Like the GCMS, the early generation of impact studies also relied heavily upon double-CO_2 scenarios. However, more recently, the impacts community has begun to pay more attention to the repercussions of climate variability and extremes, including present day climate as well as longer-term change.

The results of some impacts studies, especially on natural ecosystems, provide new understandings of feedback mechanisms (C5) which can affect GHG concentrations. For example, climate variability may lead to the melting of the permafrost in high latitudes, which, in turn, is expected to release substantial quantities of methane, which is a greenhouse gas, thus adding to the greenhouse effect.

Knowledge of impacts can be obtained from studies based on climate scenarios as well as current climate variability and extremes, and also from direct experience. Farmers, for instance, adjust their agricultural practices according to the weather, including their recent weather-related losses. There are also similar, often less obvious, adjustments being made in other economic sectors. This constitutes the first step in the adaptation process (HI-5).

Adaptation is not opposed to mitigation or an alternative to it. Progressively more aggressive adaptation is also a path towards effective and long-term mitigation.

Adaptation to climate change can be broken down into three levels of activity (Smit et al. 2000). A number of different terms have been used to describe these levels. For the purposes of this discussion, the terms Tactical, Strategic, and Metabolic are used. Tactical, or Level 1 adaptations (HI-5), are those that can be taken by individuals, small communities, or entrepreneurs in the private sector. They do not necessarily require government intervention, although the choice of adaptations adopted can be greatly affected by government policy. Tactical adaptations can reduce vulnerability to climate change, and thereby reduce impacts (C6).

Climate change is likely to result in impacts that exceed the capacity of actors at the individual and private level, however. In addition, public infrastructure and public goods are also vulnerable to climate change. This makes a case for government actions to reduce vulnerability by strategic interventions. Thus, a second level of adaptation is the Strategic Level. The government involvement can be at the sector level, including initiatives such as improved natural resources management, conservation of water resources, or protection of biodiversity. It can also happen more broadly, by means of an overall adaptation strategy. No country has yet adopted a broad adaptation strategy across sectors, but preliminary studies have been conducted in Uganda and Bangladesh. This work, perhaps with the support of the GEF, may eventually lead to the preparation of crosscutting multisectoral adaptation strategies (HI-6).

As with Level 1, some impacts will remain after the implementation of Level 2 adaptation, which represent vulnerabilities that cannot be easily removed in the short-term by policy interventions (C7). This brings into play the idea of Level 3, which is adaptation at the fundamental level, the Metabolic Level. The term Metabolic is meant to suggest the functioning of society as a whole, from the local to the global scale. It includes the adaptation measures adopted at Levels 1 and 2, but also extends to a broader category of changes including lifestyle, values, and technology. Precise prescriptions vary and are often hotly debated, but they include such measures as adopting "voluntary simplicity" in high income societies; environmentally friendly behaviour such as action to reduce one's individual ecological footprint; the widespread development and deployment of environmentally friendly technology; and the "dematerialization" of the economy. These and other measures have been seen as the core elements in a move toward sustainable development. To the extent that such adaptation succeeds, people are likely to be less vulnerable to climate change and variability. These same measures will also profoundly change the I=PAT formula, with the consequence that greenhouse gas emissions will be reduced.

From this perspective the distinction between adaptation to climate change and mitigation becomes moot. Adaptation is not opposed to mitigation or an alternative to it. Progressively more aggressive adaptation is also a path towards effective and long-term mitigation.

Muddling through

Gradually, the reasons for the past lack of attention to adaptation are being removed. It is increasingly being recognised that some marginal, incremental investments in adaptation measures at the project level are now justifiable. Studies show that the costs of such measures are not likely to be large, at least in the short-term. Even the difficult question of how to distinguish between the impacts of normal climate variability and anthropogenic climate change can be sufficiently clarified by research to encourage belief that negotiations can prove tractable and that reasonable decisions can be made on the basis of projections and models of climate change and its potential impacts, with reasonable and transparent assumptions. The remaining questions have more to do with the mechanisms for adaptation, and to what extent adaptation can be effectively addressed by itself, or can be addressed simultaneously with mitigation. The day may come when adaptation becomes so central to the climate regime, and the need for international co-operation so urgent and necessary, that a special Protocol for Adaptation may be negotiated.

In the Kyoto Protocol adaptation funding is specifically linked to mitigation for the first time. Article 12, which defines the Clean Development Mechanism (CDM), provides a levy for mitigation agreements to assist the most vulnerable developing countries in meeting the costs of adaptation. Negotiations are currently underway on the subject of the precise rules for implementation of the CDM, in anticipation of the day that the Kyoto Protocol will be ratified and go into force. While these negotiations are naturally focused on the mitigation aspects of the CDM, a number of important questions arise with respect to adaptation.[3] In the context of sustainable development and the ongoing negotiations, several other questions are now demanding attention.

3 Many of these questions are addressed in Farhana Yamin, "Adaptation and the Clean Development Mechanism," in The Clean Development Mechanism. Draft Working Papers, World Resources Institute, Washington D.C.: 1998: 43.

Will the adaptation levy that exists within the text of the CDM be extended to other Protocol tools?

The Kyoto Protocol contains guidelines for three mechanisms of international co-operation in the reduction of GHG emissions. These are:

- Joint Implementation (JI), as discussed under Article 6, which involves transfers of emission reduction units (ERUS) created by emission reduction or sequestration actions in one Annex B country to sources in another Annex B country in return for financial and other assistance.
- International emissions trading (IET), as detailed under Article 17, which enables transfer of assigned amount units (AAUS) between Annex B countries.
- The Clean Development Mechanism (CDM), covered in Article 12, which involves the generation of certified emission reductions (CERS) in developing

One of the stumbling blocks in the implementation of the UNFCCC has been the unwillingness of the developing country Parties to make any commitments to the reduction of their own emissions. At the same time, the developed country Parties have been slow to respond to the need for adaptation assistance. One way forward might be to develop a comprehensive approach to mitigation and adaptation in which developing countries would commit to some reduction in GHG emissions (and incidentally qualify to participate in JI and IET), while the developed countries would agree to a more flexible approach on adaptation assistance.

countries to be transferred from the developing country Party to an Annex B Party in exchange for financial and other assistance.

Of these tools, only the CDM carries the adaptation levy. Other things being equal, this would seem to bias the choice in the direction of JI and IET, and hence reduce the extent to which the CDM is used, and accordingly reduce (or fail to increase) the potential funds to be generated for adaptation. Accordingly, there is some question as to whether, in the interests of equity and in the generation of adaptation funds, the adaptation levy should not also be extended to all three of the mechanisms. This is, of course, a matter for governments to decide, but the answer will depend, in part, on the need for adaptation assistance.

How much money will be generated for adaptation?

Even if the adaptation levy were to be extended to all three mechanisms, it is not clear how much money is likely to be generated for adaptation, or whether this is likely to be adequate. Preliminary estimates suggest that even with the most favourable assumptions the CDM is not likely to generate substantial funds in the near term (Haites 1999). At the time of this writing, there were no estimates of the costs of aggregate adaptation needs in developing countries. However, research suggests that the open-ended need for funds that has been conjectured by some is unlikely to materialise, provided reasonable and transparent assumptions are made about impacts and the pace of climate change.

Will sufficient adaptation funds be made available for the most vulnerable countries?

It was agreed at COP-4 in Buenos Aires that it is time to advance to Step II for adaptation. The implication of this is that the developing countries that have been identified as particularly vulnerable to the impacts of climate change should begin receiving capacity-building assistance. Given the difficulties currently being experienced with the Kyoto Protocol and the CDM, the amount of resources made available to these countries through the GEF may actually be increased to enable progress in the implementation of Stage II, irrespective of the level of the mitigation efforts.

How should funds be allocated among the vulnerable countries?

If the Kyoto Protocol comes into force as proposed, and if the adaptation funds are generated by the CDM (or all three mechanisms), how should the international community proceed with the allocation of the funds among the more vulnerable countries?

Thus far the assumption has been that funds would be allocated on a project-by-project basis, in conjunction with feasibility studies. The financial distribution might also be influenced to some extent by a vulnerability index.[4] An additional approach would be to develop a formula or guidelines linked to mitigation efforts.

4 Some work in this direction is now underway (Moss 1999).

One of the stumbling blocks in the implementation of the UNFCCC has been the unwillingness of the developing country Parties to make any commitments to the reduction of their own emissions. At the same time, the developed country Parties have been slow to respond to the need for adaptation assistance. One way forward might be to develop a comprehensive approach to mitigation and adaptation in which developing countries would commit to some reduction in GHG emissions (and incidentally qualify to participate in JI and IET), while the developed countries would agree to a more flexible approach on adaptation assistance.

What is the proper relationship between mitigation and adaptation?

As it stands, the more effective the CDM is, and the more it is used, the more funds can be expected for adaptation assistance. Logic suggests that the reverse relationship should also hold true. Presumably, the more mitigation is implemented, the less need there will be for adaptation. A more appropriate relationship would therefore be one in which adaptation funds are increased in an inverse relationship to the achievement of mitigation targets and schedules. This logic stems from an economic optimisation perspective, in which mitigation and adaptation are seen as competing alternatives in a "zero sum" game. In other words, necessarily, the more of one, the less of the other. In terms of practice, rather than theory, it seems closer to the truth to suggest that the global community, as well as individual countries, will find it difficult to achieve enough of either. There is a strong prospect that climate change will not be slowed at a fast enough rate to prevent significant impacts. The precautionary principle might therefore be extended to the development of a mixed strategy of mitigation and adaptation, neither of which would be dependent upon the other for its financial support or its agreed pace of implementation.

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