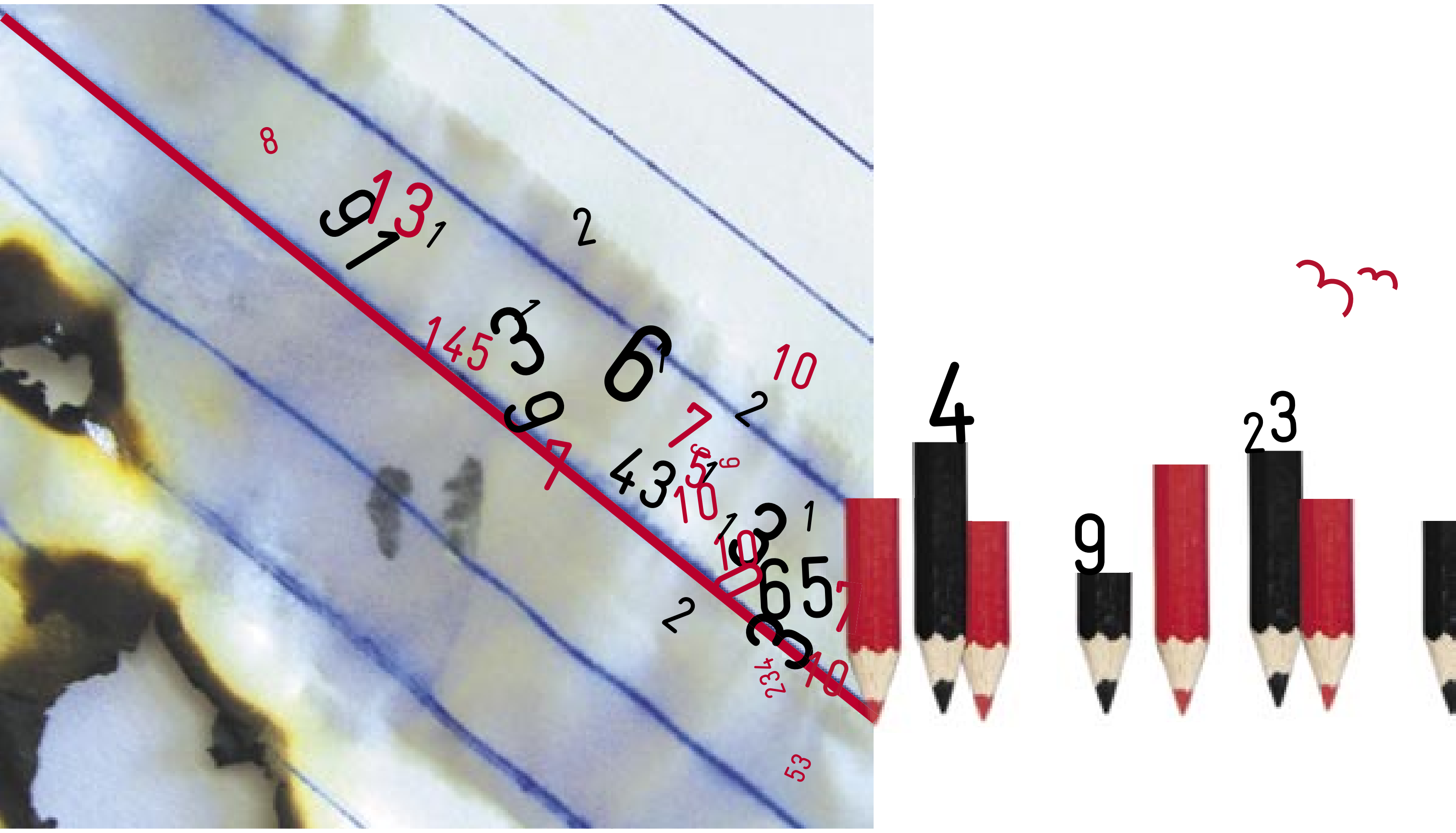

Economic Approaches to Climate Change Adaptation

and their role in project prioritisation and appraisal

gtz | Climate Protection Programme

commissioned by

Federal Ministry
for Economic Cooperation
and Development

List of Acronyms

CoP	Conference of the Parties to the UNFCCC
ENSO	El Niño-Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHGs	Greenhouse Gases
GISS	Goddard Institute for Space Sciences
GTZ	Gesellschaft für Technische Zusammenarbeit
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least Developed Countries
NAPA	National Adaptation Program of Action
NOAA	National Oceanic and Atmospheric Administration
OECD	Organisation for Economic Co-operation and Development
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
US$	United States dollar

Preface

In the public discourse on climate change we have come to accept that some of its impacts are and will be unavoidable. Adaptation can mute these impacts, but cannot by itself solve the problem of climate change. It will nevertheless be a key response to reduce vulnerability, particularly in developing countries that will be hit hardest by climate change.

But adaptation is not an easy or cost-free option. For sensible approaches to adaptation, uncertainty and imperfect information have to be dealt with, as well as public goods issues and financial constraints. An important question in this context is: Who will pay for adaptation? The Stern Review of 2006 calls climate change "the biggest externality the world has ever seen". The costs of climate change impacts are mainly borne by those who had very little or no part in causing them.

Support in dealing with the adaptation challenges in developing countries must address uncertainty and how to deal with information gaps, but it must also deal with the critical question of setting priorities for public and / or governmental action. Because adaptation means something different in every country or region of the world, defining what needs to be done with scarce resources is not at all trivial. Compared to making the case for the benefits of early action in mitigating the causes of climate change, economists have been relatively silent on the costs and benefits of adaptation action.

In this paper the authors Peter Kuch and Simone Gigli have been applying their economist's thinking to the challenge of how to prioritise and appraise adaptation options in developing countries. As we foresee plenty of work ahead of us in order to make adaptation happen, we hope this work on economic approaches to climate change adaptation will both help the conceptual discussion along and will assist us in getting the priorities right in practical adaptation action.

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Executive Summary

The goal of this paper is to assist the project prioritisation process with regard to climate change adaptation activities. We will be discussing some of the constraints on effective climate risk management and suggesting how economic approaches could be applied to evaluating adaptation projects.

Poor countries and people are particularly vulnerable to the adverse effects of climate change.

Even if greenhouse gas emissions can be stabilised in the near future, there will be climate change impacts that cannot be avoided, such as higher temperatures, changing patterns of precipitation, prolonged droughts, rising sea levels, more frequent intense storms and a spread of vector-borne diseases. Poor countries and people are often the most vulnerable to these effects because of their geographic location, heavy reliance on subsistence farming and fishing, fragile natural resource base, malnutrition and poor public health. They are also most likely to have limited adaptive capacity due to a lack of financial and human capital resources, dysfunctional governments, lack of infrastructure, and poorly functioning markets. These problems are sometimes compounded by natural catastrophes and civil strife.

Climate change adaptation must be made an integrative part of development activities.

There is therefore an urgent need to assist developing countries in adapting to climate change, *i.e.*, in dealing with the inevitable adverse effects of climate change. Adaptation measures initiated by governments, donor agencies or development organisations are important as autonomous adaptation, *i.e.*, measures taken by individuals, households and businesses, often proves inadequate or insufficient. Also, adaptation costs may be lowered if activities are carefully planned and coordinated by public entities (so-called planned or policy-driven adaptation).

A country's adaptive capacity is inextricably linked to its economic development. In some cases trade-offs may exist between development and adaptation priorities and the independent pursuit of one set of objectives may confound the success in achieving the other. In order to create a win-win situation, both adaptation and development goals ought to be simultaneously pursued.

To this end, climate change adaptation will need to be fully integrated in development strategies, plans and projects. This also means making development investments "climate proof", *i.e.*, reducing the portion of official aid flows that is vulnerable to climate change. Investments by richer countries in strengthening the adaptive capacity of developing countries and other adaptation activities are very critical as poor countries often face severe financial and other constraints to initiating such measures on their own.

Donors and national governments play an important role in helping developing countries overcome their constraints to adaptive actions.

The main constraints to taking adaptive actions in developing countries are the lack of financial resources but also poor social, institutional, political and technological conditions. Capacity building activities by donor agencies are therefore of great importance. Furthermore, the public good nature of adaptation activities leads to an insufficient level of provision of such measures. In this case, the public sector will need to step in to supplement or facilitate climate risk reduction activity where it is bound to prove inadequate. This is true, for example, when it comes to providing relevant climate information as a prerequisite for efficient adaptation. Often, readily understood geographically relevant climate information is not available thus making it difficult for decision-makers to efficiently assess climate change risks, prioritise adaptation efforts, design projects, or mobilise action. Yet other constraints to proper adaptive action may be found in the compartmentalisation of governments where often the relatively weak environment ministry is responsible for climate change related activities and collaboration with other relevant ministries is limited, and in a sectoral segmentation within development cooperation agencies providing comparatively little power and funds to climate change departments.

Development planners need sufficient information about the economics of climate change adaptation.

For climate risks to be efficiently managed in the context of development activities, it is important that decision-makers have sufficient knowledge about the costs and benefits of adaptation options. Thus far, however, this knowledge is very limited: only very few global estimates exist along with some estimates for selected countries and sectors. Despite the obvious importance of relevant and usable climate information for climate risk management, for example, economic analysis of the value (benefits) of weather data and forecasting is largely lacking. This has undoubtedly handicapped the prioritisation of funding for activities to generate such information.

How to best set priorities for adaptive action in the context of development projects.

Efficient climate change adaptation means that the total benefits from any adaptation activity exceed its total costs and, where possible, that the benefits from the last euro/dollar spent on each adaptation activity be equalised. This, however, has to be assessed separately for each adaptation measure in the project portfolio, which is as such a very data- and labour-intensive effort. Development planners have to find a way to efficiently prioritise existing adaptation options. At the most basic level, it makes a lot of sense to focus the provision of assistance on those countries which suffer the most from observed/historical climate variability due to their geophysical vulnerabilities and their limited response capabilities. Also, priority for involvement might be given to adaptation assistance in countries where the donor is already heavily involved in development assistance.

Another way to prioritise adaptation options would be to extract information regarding primary vulnerabilities and/or preferred adaptation strategies from the National Communications prepared by Non-Annex I countries or the National Adaptation Programmes of Action by Least

Developed Countries. These data, augmented by other sources, can then be used to create some sort of ordinal index of vulnerability or adaptive capacity.

Project appraisals will help developers maximise the surplus of total social benefits over costs from the available budget and rank their adaptation options accordingly.

Once the most vulnerable countries and/or most severely lacking adaptive capacity have been identified, project appraisals should be done to identify the most inexpensive method for accomplishing a specified objective, or to guide the economically efficient allocation of limited funds among competing projects. Project appraisals are also useful to demonstrate the cost-effectiveness or the excess of benefits over costs (economic efficiency) of selected projects and can thus facilitate the task of convincing decision-makers that selected projects are worthwhile and should be funded.

Project appraisal will generally employ some variant of benefit-cost or cost-effectiveness analysis, and is done in the context of selecting projects for funding from a fixed budget allocation. Since benefit-cost analysis is the more difficult task and likely to be more relevant to GTZ decision-making, this paper concentrates primarily on the ways in which to accomplish benefit-cost analyses of adaptation projects. Cost-effectiveness analysis allows the analyst to ignore the problems inherent in placing monetary values on such disparate benefits as reduced loss of life and habitat preservation, but on its own provides no assistance in choosing between projects that save lives and those that serve other objectives, such as habitat preservation. The biggest problem areas in project assessment are likely to be those associated with the basic projections of future climate risk and the amount of the risks any particular project would mitigate as these are often the most difficult and imprecise estimates.

1

Introduction

There is general consensus among climate scientists that even if the emissions of greenhouse gases (GHGs) into the atmosphere are successfully stabilised in the near future, those emissions that have already occurred will produce significant changes in the earth's climate. These changes will manifest themselves both as rising mean temperatures and as changes in mean precipitation, but also as greater weather variation and more frequent extreme weather events. Among the expected consequences are prolonged droughts, more frequent floods, rising sea-levels, more frequent intense storms, and the spread of vector-borne diseases.

Developing countries are particularly vulnerable to the impacts of climate change because of their location, high dependency on climate-sensitive natural resources and a general lack of resources that would allow them to counter the adverse effects of climate change, i.e., adapt to climate change. As a result, development activities by international donors are critical with regards to enhancing developing countries' capacities to adapt to climate change. At the same time, integrating climate risks into development strategies, plans and projects is essential in making investments more efficient. However, several studies reveal that climate change and the risks it poses to development have thus far not received much attention by development cooperation agencies (van Aalst and Agrawala, 2005; World Bank, 2006; Burton and van Aalst, 1999). Consequently, there is an urgent need to manage the risks of climate change more efficiently by putting them in the mainstream of development activities. In this context, it is important to have sufficient knowledge about the economics of climate change adaptation, inter alia, the costs and benefits of different adaptation options in order to both achieve an effective prioritisation of development projects and have a basis for justifying their implementation.

Even though climate change adaptation has recently been receiving increased attention at national and international levels[1], it has hardly been on the agenda of economists. According to the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), most of the literature on costs and benefits of adaptation "remains quite limited and fragmented in terms of sectoral and regional coverage" (Adger et al., 2007). This paper attempts to move from the economists' conceptualisation of the problem to outlining steps for managing climate risks by effectively prioritising climate change adaptation measures, and then suggesting how economics could be applied to evaluating adaptation projects.

The paper first outlines the vulnerability of developing countries to the impacts of climate change, thus revealing the importance of adaptation measures being undertaken in the context of development assistance, and the distributional aspects of climate change and adaptation (Section 2).

[1] Adaptation was a major focus of the 12th Conference of the Parties (CoP) to the UNFCCC (November 2006, Nairobi), after receiving only limited attention at previous CoPs since CoP-1 in 1995.

Section 3 provides examples of different adaptations over different time-frames, while Section 4 discusses the various constraints to adaptive action. The paper then turns to aspects of costs and benefits of adaptation, for example, in connection with the information requirements for effective adaptation (Section 5). The next section (Section 6) then discusses potential ways to prioritise development activities with a view to helping developing countries adapt to the adverse effects of climate change. Section 7 deals with the appraisal and ranking of proposed projects and outlines some limits of existing methods. The last section (Section 8) is an attempt to distill the implications of the preceding sections. A glossary of some "technical" concepts used in this paper is provided in Annex 1 in order to facilitate communication.

2

Climate change vulnerability of developing countries and distributional aspects of climate change and adaptation

Kelly and Adger (2000) define vulnerability as "the ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being", whereas the impacts of climate change can be seen as an external stressor. Vulnerability is thereby a function of a society's exposure to stresses, its sensitivity to the exposure and its adaptive capacity (IPCC, 2001). It is, among other issues, dependent on a country's social and economic development, and efficient governance, e.g., functioning government institutions. Developing countries are often the most vulnerable to the adverse impacts of climate change and the least able to afford adaptive activities (see Table 1). They are most frequently low-lying small island states or located in the tropical or sub-tropical latitudes, where disruption of monsoon cycles would produce severe droughts or extensive inundation; where exhausted soils, inappropriate cultivars and lack of fertiliser routinely cause low crop yields; where prevalent malnutrition and poor sanitation and water supplies make them vulnerable to the spread of infectious and vector-borne diseases; and where much of the population live in substandard structures that offer little protection from extreme weather events.

Furthermore, developing countries' economies rely heavily on activities such as agriculture, forestry, fishing and tourism, all of which are particularly sensitive to the adverse weather conditions brought about by climate change. Their governments are often unstable and their bureaucracies frequently inefficient and ineffective. Health care, transportation and communication infrastructure are most often rudimentary; emergency response capability, where it exists, is likely to be in the hands of the military which may actually have only limited capability for dealing with major natural disasters. The poor, almost by definition, are engaged in day-to-day survival and do not have the leisure to contemplate future impacts from climate change, nor do they have the human or financial capital to prepare for them.

Table 1

Vulnerability and adaptive capacity of developing countries (by region)

Region	Vulnerability and adaptive capacity
Afrika	Adaptive capacity is low due to low GDP per capita, widespread poverty (the number of poor grew over the 1990s), inequitable land distribution, and low education levels. There is also an absence of social safety nets, in particular after harvest failures.
———	Individual coping strategies for desertification are already strained, leading to deepening poverty. Dependence on rain-fed agriculture is high.
———	More than one quarter of the population lives within 100 kilometres of the coast and most of Africa's largest cities are along coasts vulnerable to sea level rise, coastal erosion, and extreme events.
———	Climate change has to be recognised as a major concern with respect to food security, water resources, natural resources productivity and biodiversity, human health, desertification, and coastal zones.
———	Adaptive capacity will depend on the degree of civil order, political openness, and sound economic management.
Asia	Investing to create or modify major infrastructure, e.g., larger reservoir storage, increased drainage capacity, higher seawalls.
———	Adaptive capacity varies between countries depending on social structure, culture, economic capacity, and level of environmental degradation.
———	Areas of concern include water and agriculture sectors, water resources, food security, biodiversity conservation and natural resource management, coastal zone management, and infrastructure.
———	Capacity is increasing in some parts of Asia, for example the success of early warning systems for extreme weather events in Bangladesh, but is still constrained due to poor resource bases, inequalities in income, weak institutions, and limited technology.
Latin America	Some social indicators have improved over the 1990s including adult literacy, life expectancy, and access to safe water.
———	However, other factors such as high infant mortality, low secondary school enrolment, and high income inequality contribute to limiting adaptive capacity.
———	Areas of particular concern are agriculture, fisheries, water resource management, infrastructure, and health.

Small Island States	Adaptive capacity of human systems is generally low in small island states, and vulnerability high; small island states are likely to be among the countries most seriously impacted by climate change.
———	Areas of concern are food security, water resources, agriculture, biodiversity and coastal management, and tourism.
———	Islands with very limited water supplies are highly vulnerable to the impacts of climate change on the water balance.
———	Declines in coastal ecosystems would negatively impact reef fish and threaten reef fisheries, those who earn their livelihoods from reef fisheries, and those who rely on the fisheries as a significant food source.
———	Limited arable land and soil salinisation make agriculture of small islands, both for domestic food production and cash crop exports, highly vulnerable to climate change.
———	Tourism, an important source of income and foreign exchange for many islands, would face severe disruption from climate change and sea level rise.

Source: Adapted from Multi-Agency Report (2003), based on IPCC (2001).

It is widely recognised that climate change originates from the carbon dioxide emissions of industrialised countries, while poor countries – which have benefited least from the combustion of hydrocarbon fuels – will be most affected. In general, however, the impacts of climate change will not be evenly distributed across countries and regions, and over time (see Box 1). While some countries or regions will lose, others will benefit from climate change impacts such as higher temperatures or changed precipitation patterns. Still, even within these two groups there will be countries or regions that will experience greater losses/benefits than others (Tol et al., 2003).

Concern about the distribution of climate change impacts, the burden of mitigation efforts, and the distribution of the costs and benefits of adaptation activities originates in a sense of fairness. Very importantly, however, how they are distributed may also affect the willingness of individuals and countries to finance adaptation activities from which they will not directly benefit. In this context, investments by richer countries in strengthening the adaptive capacity of developing countries and other adaptation activities are very critical as poor countries often face severe financial constraints to initiating such measures on their own. The goal of development activities should thereby be to avoid the exacerbation of existing inequalities.

Box 1

Examples of the uneven distribution of future climate change impacts across systems and sector

Fresh water resources:

By mid-century, annual average river runoff and water availability are projected to increase by 10-40% at high latitudes and in some wet tropical areas, and decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics, some of which are presently water stressed areas. **

Food products:

Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions. *

At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2°C), which would increase risk of hunger. *

Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease. *

Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes. **

Coastal systems and low-lying areas:

Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. Those densely-populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk. The numbers affected will be largest in the mega-deltas of Asia and Africa while small islands are especially vulnerable. ***

Health:

Studies in temperate areas (mainly in industrialised countries) have shown that climate change is projected to bring some benefits, such as fewer deaths from cold exposure. Overall it is expected that these benefits will be outweighed by the negative health effects of rising temperatures worldwide, especially in developing countries. **

The balance of positive and negative health impacts will vary from one location to another, and will alter over time as temperatures continue to rise. Critically important will be factors that directly shape the health of populations such as education, health care, public health prevention and infrastructure and economic development. ***

Note: Level of confidence in the whole statement: *** very high confidence; ** high confidence; * medium confidence.

Source: IPCC (2007).

3

Short-term versus long-term adaptation

According to the IPCC, adaptation is broadly defined as any "adjustment in natural or human systems in response to experienced or future climatic conditions or their effects or impacts – which may be beneficial or adverse" (Smit et al., 2001).

In general, adaptation activities can be autonomous or planned. Autonomous adaptation refers to the action undertaken by individuals, households and businesses without public intervention. It often takes the form of a response to already apparent climate impacts. Planned (or policy-driven) adaptation, on the other hand, is associated with public actors and refers to adaptation measures that result from deliberate policy-decisions. It can be reactive, i.e., in response to actual climate impacts, or anticipatory, i.e., undertaken before climate impacts are felt. The need for policy intervention (planned adaptation) is defined by the extent to which private actors (autonomous adaptation) are able to reduce negative impacts from climate change and the related costs. By nature, autonomous adaptation is likely to not be efficient in reducing (the costs of) climate change impacts and preventing societies from suffering harm from future climate risks. While adaptation costs may prove to be relatively high if measures are taken autonomously, they can be reduced if adaptation activities are well planned and coordinated. Box 2 provides some examples of adaptation and disaster response measures.

Box 2

Examples of adaptation measures and disaster response capacities

Adaptation measures encompass those activities that are designed to stimulate protective actions or to provide permanent protection from the adverse effects of climate change, such as sea-level rise, floods, droughts, and vector-borne diseases. On the part of individuals, these can consist of relocating or elevating structures, changing cultivars or crops, and installing irrigation equipment. Early-warning meteorological and hydrological systems are particularly important public sector damage-prevention services. In addition, adaptation measures provided for by the public sector can include: engineered facilities (e.g., sea walls, irrigation and drinking water supplies, weather and sea monitoring stations), legislative measures for urban planning, building codes and land-use control (especially in flood plains), as well as research activities to develop drought-resistant and salt-water tolerant plant varieties, more efficient water management, more resilient building techniques, and more precise weather and tide predictions. It is important to note that damage prevention can sometimes be most efficiently provided by activities that enhance the stock of natural capital for reasons other than protecting national cultural heritage or eco-tourism. In Vietnam, for example, a mangrove planting project to protect coastal populations from typhoons and storms over the period 1994 to 2001 was estimated to have a benefit-to-cost ratio of 52 (Stern, 2006). Restoring mangroves or coastal wetlands can, in some cases, be more cost-effective than civil engineering solutions to flood-damage prevention.

Basic disaster response capacities include the essential transportation and communications infrastructure for speedily mobilising and moving emergency workers (police, fire, health, rescue personnel), food, water and medicines to the scene of the disaster. Similarly, this same infrastructure would be needed to evacuate the injured and threatened away from the scene, to hospitals and shelters. At the most rudimentary level, the physical infrastructure needed for this would include such things as roads, vehicles, telephone lines, radio-communication and aircraft. It would also involve the construction of hospitals, shelters, storage depots, as well as amassing stockpiles of food, water, medicines, blankets, tents, etc. Non-physical infrastructure is also needed in the form of trained personnel, who are appropriately organised and directed, and operational plans for response and evacuation. Beyond these basic needs, public and/or private programs will need to be set up providing compensation for damage and injury, as well as funds for rehabilitation and reconstruction of dwellings, public facilities and enterprises. Some of these could involve the creation of risk-transfer mechanisms, especially insurance against weather-related losses.

In the short term, adaptation can only draw upon the resources that are readily available to a country (referred to as fixed capital stock), either owned by the country itself or made available by donors. If we exclude "disaster responses", i.e., ex-post relief, rehabilitation and reconstruction activities, as not fitting into the commonly accepted definitions of adaptation, there are likely to be no "very short-term" adaptation options. However, societies are considered as having an inherent ability to deal with spatial and temporal climate variations, as "many social and economic systems – including agriculture, forestry, settlements, industry, transportation, human health, and water resource management – have evolved to accommodate some deviations from 'normal' conditions, but rarely the extremes" (Smit et al., 2001).

In the longer term, as additional resources become available – either because they are diverted from other budgetary priorities or come from increased revenues or foreign assistance – it becomes possible to enhance adaptive capacities, to take concrete measures such as initiating or enhancing early warning systems, and to launch other damage prevention activities. As the time-frame expands and more information and resources become available, activities can become more complex and build upon earlier actions and existing knowledge ("dynamic adaptation") (IPCC, 2001). Table 2 gives examples of autonomous and planned adaptation actions in the short and long run. Annex 2 provides an overview of adaptation options with fixed and flexible capital stocks, distinguishing between short- and long-run adaptation.

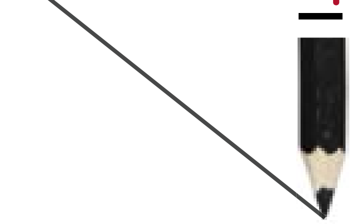
Table 2

Examples of autonomous and planned adaptation in the short and long run

Type of response to climate change	Autonomous adaptation	Planned adaptation
Short run	Making short-run adjustments, e.g., changing crop-planting dates Spreading the loss, e.g., pooling risk through insurance	Developing greater understanding of climate risks, e.g., researching risks and carrying out a vulnerability assessment Improving emergency response, e.g., implementing early warning systems
Long run	Investing in climate resilience if future effects are relatively well understood and benefits easy to capture fully, e.g. localised irrigation on farms	Investing to create or modify major infrastructure, e.g., larger reservoir storage, increased drainage capacity, higher seawalls Avoiding the impacts, e.g., land use planning to restrict development in floodplains or in areas of increasing aridity.

Source: Stern (2006).

4



Constraints to adaptive action

Low adaptive capacity of developing countries

Chapter 4.1

Countries differ widely in their adaptive capacity. This becomes evident if the potential capacities of the Netherlands and Bangladesh to deal with sea-level rise and storm surges are compared. Both are low-lying coastal countries but they obviously differ greatly in wealth, per capita income, physical infrastructure and the technical expertise necessary for dealing with these climate change risks. A stark contrast as this, however, is of little help in explaining differences that exist in the adaptive capacities of developing countries but may help to prioritise development assistance efforts.

In general, developing countries' capacities to confront future risks from climate change are highly correlated to most measures of economic development but are also constrained by social, institutional, political and technological conditions. Currently available financial and other resources are, in many cases, already stretched to their limits from dealing with the consequences of catastrophes, such as droughts, floods or earthquakes, and such persistent problems as disease, malnutrition and illiteracy. A general lack of transportation, communications, health and education infrastructure are also major impediments to economic development as well as to preparing for climate change impacts. Dysfunctional or weak governmental institutions (both legislative and executive) may be a particular constraint to implementing adaptive measures at the sub-national level.

Social and educational underdevelopment may impede efficient adaptation as societies might lack the appropriate human capital for such actions. This may be true, for example, in countries with high illiteracy rates or disfunctional health systems – factors which reduce the effectiveness of capacity building efforts such as imparting knowledge about the effects of climate change, and training individuals and communities in taking appropriate adaptive measures.

So-called adaptation technologies can help countries adapt to climate change but they are to date more widely used in developed countries. For example, countries around the North Sea apply advanced technologies to protect their shore lines from rising sea levels, while small island states in the Pacific and Caribbean often lack such resources. In general, adaptation technologies exist for coastal zone protection, water resources management, the agriculture and health sectors, and infrastructure (see Table 3). They can be grouped in "hard" technologies, examples being efficient irrigation systems or drought-resistant seeds, and "soft" technologies, such as crop-rotation patterns or insurance schemes. A mixed form would be early warning systems as they combine the use of hard measuring devices with soft skills such as knowledge about their application, risk awareness raising and action stimulation (UNFCCC, 2006). Non-availability of such technologies is an important constraint to a country's adaptive capacity.

Table 3

Examples of infrastructure technologies for adaptation

Hard technologies	Soft technologies
Building sector	
Lay out cities to improve the efficiency of combined heat and power systems and optimise the use of solar energy Minimise paved surfaces and plant trees to moderate the urban heat island effects and reduce the energy required for air conditioning	Limit developments on flood plains or potential mud-slide zones Establish appropriate building codes and standards Provide low-income groups with access to property

Transporting sector	
Cluster homes, jobs and stores Control vehicle ownership through fiscal measures such as import duties and road taxes as well as through quotas for vehicles and electronic road pricing Develop urban rail systems	Promote mass public transportation Use a comprehensive and integrated system of planning Link urban transport to land-use patterns
Industrial sector	
Use physical barriers to protect industrial installations from flooding	Reduce industrial dependence on scarce resources Site industrial systems away from vulnerable areas

Source: UNFCCC (2006).

The public goods problem and the role of economic incentives

Regardless of the wealth of a country, adaptation activities undertaken by private actors are considered to be insufficient and sometimes inadequate. They will therefore need to be supplemented by measures provided for by public institutions, particularly as many necessary adaptation measures are, by their very nature, public goods[2]. Those measures will not be adequately[3] undertaken by private actors because those who do not pay for them cannot be excluded from benefiting from them, thus creating a tendency for people to be "free riders", i.e., they do not pay their fair share of the costs. Erecting storm-surge barriers, sea walls or reservoirs, generating meteorological/hydrological information and implementing emergency rescue services are examples of such public goods. It may be the case that some adaptive measures could be provided by the private sector, but organised markets that would be necessary to provide these measures have not yet been developed in particular countries. Examples of these measures might include property damage insurance, credit and water for irrigation.[4]

Therefore, the public sector will need to step in to supplement or facilitate private climate risk reduction activity, where it is bound to prove inadequate. This will, to some extent, occur every-

[2] Conceptually, however, public goods need not necessarily be supplied by governments.

[3] "Adequacy" here is defined in terms of "economic efficiency", such that all adaptation activities are undertaken for which their societal benefits exceed their societal costs.

[4] This is certainly likely to be the case for reinsurance and more exotic risk transfer mechanisms such as weather index insurance and weather-related financial derivatives.

where, but the need for public sector involvement in adaptation activity will be greater, the less developed a country is. Government involvement need not necessarily mean that the public sector has to provide every needed risk reduction measure. Where adaptation would not involve strictly public goods (i.e., where non-payers could be excluded), government could proscribe (ban) risky behaviour; or where this would not be politically feasible or appropriate, economic incentive approaches could be used to induce desired private adaptation activity.

In this context, economic incentives can range from subsidising climate risk reducing activities or taxing risk increasing activities, to schemes which place a quantitative limit on a risky activity. The remaining amount of that activity could then be bought and sold under an adequate framework provided for by the government, such as the cap-and-trade schemes that exist for sulfur dioxide or GHG emissions. Subsidies might be used to encourage the private sector, for instance, to develop drought-resistant crops, purchase more efficient irrigation systems or insurance policies, elevate structures or drill tube wells. Differential property taxes or marketable development permits might be used to discourage building activity in flood plains or along coast lines. Apart from these, several other economic incentives for private adaptation exist. One of these may be less obvious but is very important from the perspective of disaster mitigation where insurance markets exist; it relates to the extent that the premiums or the deductibles for disaster-loss insurance protection are reduced by risk-abating behaviour. Where lower premiums or deductibles are offered to those who engage in such behaviour, they provide an economic incentive for investments that will prevent or mitigate potential damage. In the extreme, the refusal of insurers to write flood insurance in flood-prone areas after experiencing heavy losses in them is a market-generated incentive that discourages settlements in the affected areas directly, or indirectly by lowering the values of existing property.

Chapter 4.3 Uncertainty and irrelevance of climate information

Even where adaptation does not involve public goods, the level of private adaptation activity is likely to be inadequate as it will often be constrained by the uncertainty surrounding the potential climate hazards. Consequently, the benefits to be derived from investments in adaptation activities are uncertain as well. Furthermore, the risks arising from complex climate change impacts are often difficult to communicate, particularly to a scientifically illiterate population, and estimates of their expected occurrence will tend to be heavily discounted by the general public.

Not unique to developing countries is the problem of available information being inadequate to assess climate change risks and to motivate adaptive behaviour.[5] Adaptation to climate change is essentially an exercise in risk management and to be done effectively it requires that there be an uninterrupted flow of relevant and usable climate information. Climate change impacts are for the most part future events that result from complex, hard to understand climatological phenomena, usually projected with very wide confidence-intervals. Even where broad regional information is accurately and clearly presented, estimates of local impacts may be scarce, or where those are available, they are likely to be presented as being highly uncertain. In order to prioritise adap-

[5] There is a good discussion of this issue in Benson and Clay (2004), specifically in Chapter 4.

tation options, however, decision-makers need more precise information about the implications of climate change for the locations, spatial scales and time-frames which are of direct concern to them (Agrawala and van Aalst, 2005).

Other constraints

Chapter 4.4

Some other factors that stand in the way of efficient adaptation can be found in the compartmentalisation within governments. Responsibility for climate change related activities often lies with environment agencies or ministries and effective collaboration with other relevant ministries, such as those dealing with economics and finance, transport or agriculture, is often lacking. Apart from this, the environment ministry is often one of the least powerful ministries in a government and has limited options for bringing adequate measures forward.

Another constraint can be found in the sectoral segmentation within development cooperation agencies themselves which may lead to a limited ability to integrate climate change considerations into their operations. Often, these agencies only have a very small number of climate specialists who may have little influence over projects and operational guidelines, or receive less funding for anticipatory adaptation actions than those who deal with more visible forms of assistance such as emergency response, disaster relief or reconstruction (Agrawala and van Aalst, 2005).

5

Costs and benefits of adaptation

Insufficient knowledge of costs and benefits of adaptation

Chapter 5.1

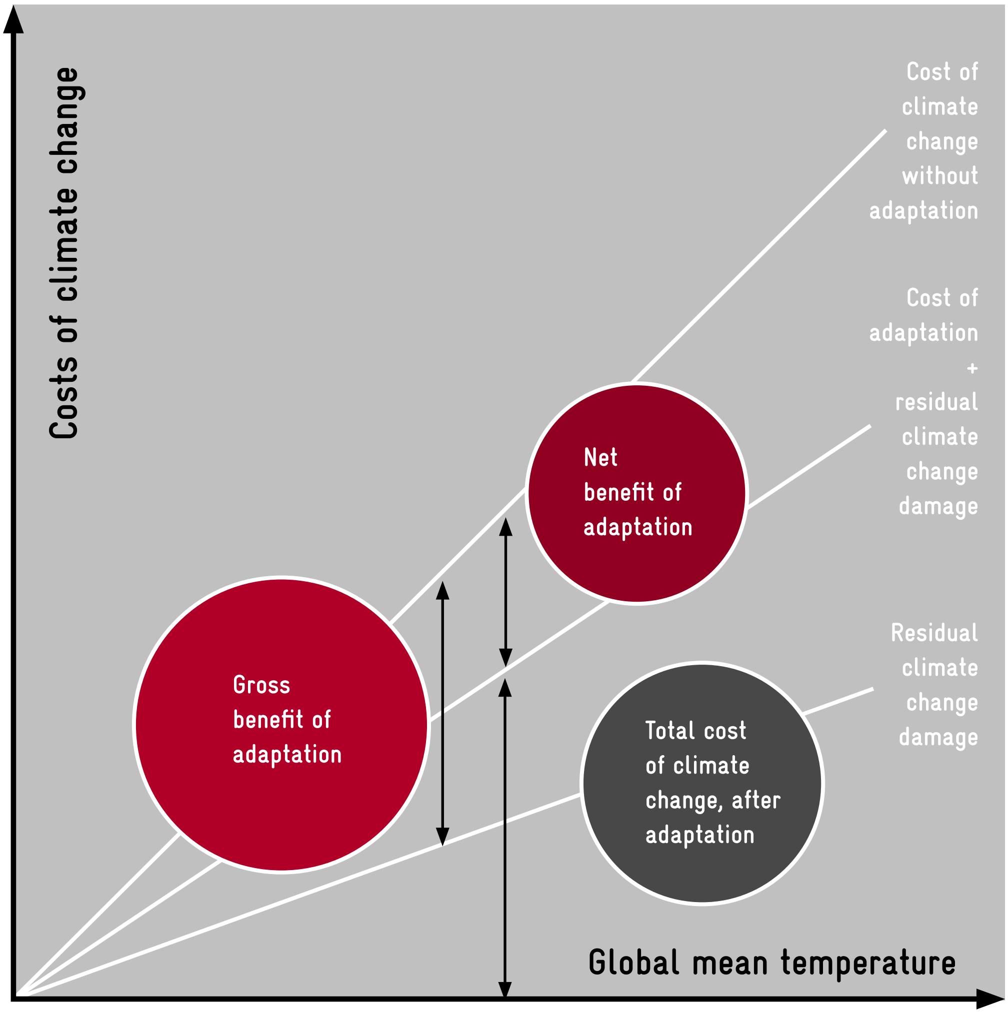
To date, knowledge about the costs and benefits of adaptation is still very limited. Very few global estimates of adaptation costs and benefits exist; those that do, however, not take account of recent developments, and only provide speculative numbers (Adger et al., 2007; Stern, 2006). Other studies examine the costs and benefits of adaptation for selected regions (mainly in OECD countries) or particular sectors (mostly covering sea level rise and agriculture, while a few studies look at the energy sector, water resource demand, or transportation infrastructure).

According to the recent IPCC Fourth Assessment Report (Adger et al., 2007) “[a]daptation costs are usually expressed in monetary terms, while benefits are typically quantified in terms of avoided climate impacts, and expressed in monetary as well as non-monetary terms (e.g., changes in yield, welfare, population exposed to risk)”. Benefits from adaptation will accrue on a local level, where

– particularly in the longer term – they are likely to exceed costs. However, it is widely recognised that adaptation measures can only reduce the negative impacts of climate change and their associated costs to a limited extent, i.e., in most cases there will be residual damages (see Figure 1).

Figure 1

Costs and benefits of climate change and adaptation measures[6]



Note: Gross benefit of adaptation = damage avoided; net benefit of adaptation = damage avoided – cost of adaptation; cost of climate change = residual cost of climate damage + cost of adaptation.

Source: Stern (2006).

[6] For the sake of simplicity, the relationships between rising temperatures and the different costs of climate change/adaptation are shown as linear. In reality, (as Part II and Chapter 13 of the Stern Review demonstrate), the costs of climate change are likely to accelerate with increasing temperature, while the net benefit of adaptation is likely to fall relative to the cost of climate change.

With regard to the costs of adaptation in developing countries, some numbers can be found in the Stern Review (Stern, 2006). Based on the information provided in the National Adaptation Programs of Action (NAPA) of five Least Developed Countries (LDCs), immediately necessary adaptation activities will require total funding of US$133 million, which is about US$25 million on average for each of these LDCs. Extrapolation of that figure to all 50 LDCs implies total adaptation investments of US$1.3 billion, keeping in mind that the LDCs are often rather small countries (Stern, 2006). Elsewhere, the Stern Review states that the "additional costs to developing countries of adapting to climate change could run into tens of billions of dollars." This statement is supported by figures from World Bank and OECD, which estimate the additional costs of adaptation to range from US$9-41 billion, only including expenditures needed to protect all "development finance flows" against climate change impacts (World Bank, 2006).[7] Overall, multinational commitments to assisting developing countries in adapting to climate change are estimated to be between US$234 and 634 million (Stern, 2006).

Knowledge and information requirements and associated costs

Climate risks can be considered as arising from future changes in mean weather conditions, but more likely from changes in climate variability, especially from increases in the frequency and intensity of extreme events. In many cases, decisions about adaptation activities will therefore be made dependent on expected changes in climate variability rather than on longer-term changes in climate conditions. Effective targeting of adaptation activities will, at a minimum, require that the number of weather monitoring and gauging stations be greatly expanded. It also requires enhancing institutional capacities, development of human capital and transfer of adequate technology. Gathering and synthesising information on current climate variability generally requires low technical input and is, therefore, relatively inexpensive.

Extrapolating historical data to project near-term future climate change is probably useful and inexpensive if clear historical trends can be observed. However, trend analysis will most certainly miss tipping points and discontinuities[8] caused by climate feedback mechanisms (e.g., a suppression of the North Atlantic circular flow or a large-scale thawing of permafrost). Longer-term projections need to be done with sophisticated global climate models, which require the highest levels of technical qualifications to build, run and maintain the models, as well as immense computational capacity. Also, to provide some sense of the range of uncertainty in the resulting modelling predictions, identical scenarios need to be simultaneously run on a number of these models, thereby compounding the cost and effort required. Consequently, it may be most cost-effective for developing countries to initially focus efforts on collecting more data on current national weather and hydrographic phenomena and better synthesising them into forms (including short-term extrapolations) that can be used for risk management decisions. Longer-term climate change prediction may be left to international organisations (e.g., IPCC) and established centres in the major industrialised countries (e.g., the Max-Planck Institute, the Hadley Center, the National Center for Atmospheric Research and the Goddard Institute for Space Sciences (GISS)).

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[7] These figures have been slightly revised to US$4-37 billion, as presented in the Stern Review (Stern, 2006, p.442).

[8] Other than those arising from well-established long-term weather cycles, such as the El Niño-Southern Oscillation (ENSO) cycle in the Pacific Ocean.

Box 3

Initiatives by international and national organisations: the example of GCOS

A number of international and national organisations currently provide meteorological and hydrological information (and for some regions vegetation indices) relevant to predicting drought, flooding, water supplies, crop harvests, grazing conditions and fishing in developing countries.[9] The World Meteorological Organization, the International Oceanographic Commission, the UN Environment Program and the International Council for Science have joint forces to establish the Global Climate Observing System (GCOS). The aim of GCOS is to integrate data from various international and national global satellite systems to, inter alia, (i) characterise the state of the global climate system and its variability; (ii) enable the projection of global climate change information down to regional and local scales; and (iii) enable characterisation of extreme events important for impact assessments and adaptation, and the assessment of risk and vulnerability (www.wmo.int/pages/prog/gcos/).[10] The generated information should also be built into national disaster relief preparations, providing trained domestic personnel and computer capacity to access and utilise this information is essential, as well as is having adequate mechanisms to disseminate the resulting forecasts and alerts.

Despite the obvious importance of relevant and usable climate information for climate risk management, economic analysis of the value (benefits) of weather data and forecasting is largely lacking (IRI, 2007). This has undoubtedly handicapped the prioritisation of funding for activities to generate such information. Also, very few estimates on the costs of generating and disseminating climate risk information exist to date. The costs of developing operational regional climate centres in Africa, for example, are estimated to be in the order of US$200 million over ten years (Stern, 2006). By comparison, thus far expenditures on the entire weather forecasting effort for Southern Africa have been approximately US$5 million (Benson and Clay, 2004). To put these cost estimates into perspective, potential weather-related crop losses worldwide are estimated to be in the order of US$425 billion annually (CRMG/World Bank, 2006), while the costs of climate variability in Southern Africa will amount to at least US$1 billion annually (Benson and Clay, 2004).

[9] As pertains to developing countries, these include: The Food and Agriculture Organization's (FAO) Global Information and Early Warning System on Food and Agriculture (GIEWS), its ARTEMIS and AGROMET databases, the World Meteorological Organization's (WMO) Public Weather Services Program and the Japan Meteorological Agency's weather observations and forecasts. The US's National Oceanic and Atmospheric Administration (NOAA) is a major contributor to both FAO and WMO data.

[10] At present, this program is only in its formative stages, and will yet need to be implemented.

6

Priority setting for adaptation measures in the context of development activities

Preceding sections alluded to many of the vulnerabilities that developing countries have to the impacts of climate change and the constraints to adaptive capacity that need to be overcome. An important question for donor agencies, sectoral planners, development practitioners and policy-makers is therefore how to best set priorities for action.

Conceptually, this might be answered by an appraisal of the entire set of potential adaptation options in these countries. However, as will be seen in the next section, project appraisal is a very data- and labour-intensive effort which presupposes that one is dealing with a complete set of fully formulated projects, including complete information about the effects of all adaptation options. Efficiency in using staff and financial resources requires that the field of consideration be narrowed considerably beforehand to make the task more manageable. To this end, it should first be decided which adaptation options are "worthwhile" to be implemented and which are not, taking account of the climate change risks on the one hand and the costs of planning for adaptation on the other (see Box 4).

Box 4

Risk management framework for adaptation decisions

Uncertainty over the nature of future climate change is one of the principal challenges facing climate policy. The table below therefore illustrates the trade-offs facing those planning adaptation under uncertainty (Callaway and Hellmuth, 2006). The decision to implement an adaptation strategy should take account of the balance of risks and costs of planning for climate change that does not occur and vice versa.

Where the cost of planning for climate change is low, but the risks posed by climate change are high (top right box), there is a comparatively unambiguous case for adaptation. In contrast, where the costs of adaptation are high but the risks posed by climate change are low (bottom left box), the proposed adaptation responses may be disproportionate to the risks faced. Where the costs of planning for climate change and the risks of climate change are both low (top left box), there is little risk to the situation and the downsides are small, regardless of the choice made. In contrast, where the costs of both 'mistakes' are high, the stakes and risks are very high for the planner.

Box 4

Costs of planning for climate change \ Risks of climate change	Low risk	High risk
Low costs	Low risk	Plan for climate change
High costs	Don't plan for climate change	High risk

Source: Stern (2006).

Once a decision has been taken as to what adaptation measures should, in principle, be implemented, the question then arises how to prioritise actions and countries in development activities. If the relevant data existed, some sort of ordinal index of vulnerability/adaptive capacity would be created. Such an index could be the weighted sum of each country's ordinal scores with respect to elements such as elevation above sea level, number of severe hurricane/typhoon landfalls in the last decade, calories consumed per capita, GDP per capita, health professionals per thousand of population, telephone connections per thousand, the number of government-operated trucks and buses per thousand, miles of paved road, etc. The weighting problem could be simplified by normalising the scores for each component attribute. At its simplest, this would involve the subjective assignment[11] of a score between, for instance, 0 to 10 or 0 to 100, depending on how much "hair-splitting" one was inclined to do with each vulnerability attribute.[12] Assuming that higher scores are associated with greater vulnerability, then the higher a country's index score turned out to be, the higher the priority it would merit.

The raw material for such an exercise may come from the countries themselves. The UN Global Environment Facility (GEF) has been funding developing countries to carry out assessments of their vulnerability to climate change impacts and a number of these have been submitted to the UNFCCC (O'Brien, 2000; Huq and Klein, 2003; Burton et al., 2006). These countries have attempted to apply the UN Environmental Program's (UNEP) "Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies", using a mix of biophysical and economic models, empirical analogue studies, and expert judgments. It should be noted that local data availability seems to be a major constraint in applying the UNEP methodology, as it presupposes the existence of historical data which does not exist in most of the LDCs. The UN Development Program (UNDP) is also "assisting scores of countries in assessing adaptation needs" and bilateral aid also appears to be helping other countries do assessments (Burton et al., 2006). Furthermore, the Least Developed Countries Fund for Climate Change has "supported 44 least-developed country Parties to the UNFCCC in carrying out the preparation of National

[11] Ideally, this would be done by a panel of experts drawn from the most relevant discipline for each attribute.
[12] There is an extensive literature relevant to constructing theses sorts of indices.

Adaptation Programs of Action (NAPAs)" (GEF, 2006). As mentioned earlier, five of these have been completed as of November 2006 while another dozen or so are in the final stages of review (Stern, 2006). Presumably, these NAPAs are based on national assessments of climate change vulnerability and adaptive capacity. As of June 2006, 132 Non-Annex I countries had submitted initial National Communications to the UNFCCC which include "baseline assessments, vulnerability analysis and the identification of adaptation options and constraints" (Tearfund, 2006). Consequently, it appears that a good deal of information is already available to help set priorities for providing capacity building assistance and that more of it is on the way.

There are obviously other factors to be considered besides simply applying a numerical index in setting priorities. Since many needed enhancements to climate change adaptive capacity are also likely to be essential for accelerating the pace of economic development, extra weight for involvement might be given to adaptation assistance in countries where the donor is already heavily involved in development assistance. Furthermore, in figuring out which countries to help, especially until adequate information becomes available to predict the future impacts of climate change, it makes a lot of sense to focus on providing assistance to those countries which suffer the most from observed/historical climate variability due to their geophysical vulnerabilities and their limited response capabilities. Most often, climate change impacts will not be new or discrete, but they will rather manifest themselves as intensification of observed climate risks, i.e., in the form of longer droughts, increased flooding, and bigger storm surges. Consequently, even though the future is not likely to replicate the past, assisting in preventing damage based on observed extreme events will take one a long way towards helping to mitigate the future adverse effects of climate change (Burton et al., 2006).

Short of project appraisal per se, it may be necessary to establish priorities for providing adaptation assistance within countries. Here, many of the same considerations for prioritising individual countries will apply. Where nations have done NAPAs, it makes sense to adopt priorities implicit in their proposed Action Plans. Similarly, extra weight should be placed on enhancing adaptive capacity that would have the greatest complementarities with domestic economic development needs (e.g., literacy, health care, communication), or on other "no-regrets" adaptations, i.e., measures that are justified independent from the extent of climate change.[13] Finally, in selecting foci for adaptation assistance within a country, it would probably be most helpful to concentrate on mitigating those aspects of climate variability that result in the most damage to life and property (e.g., storm surges, drought). As a first step, this may very well imply assisting in the establishment of meteorological and hydrological monitoring, forecasting and dissemination systems which would provide reliable advance warnings of severe climate events.

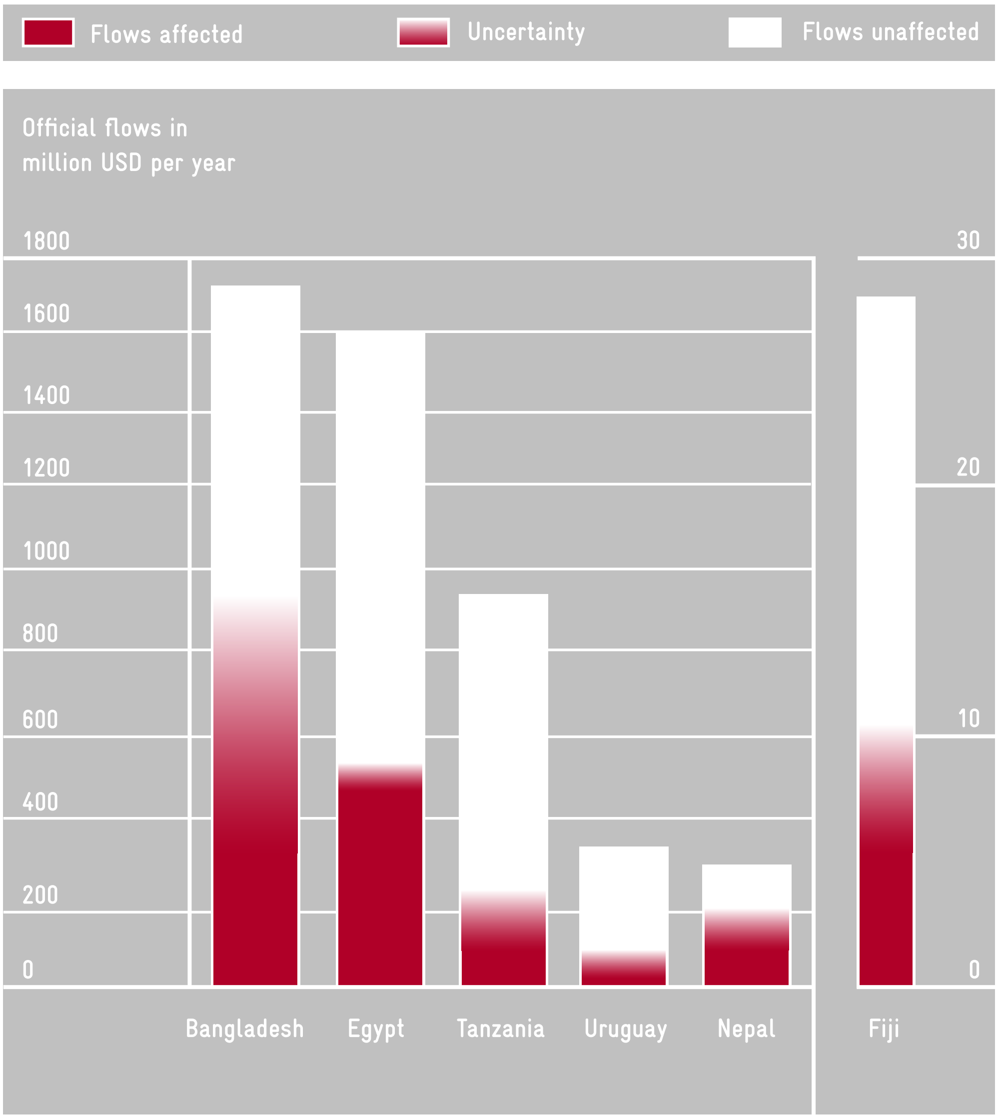
Overall, it seems important that international donors fully integrate (mainstream) adaptation into their development activities, and not treat adaptive interventions as ad hoc efforts, thus risking that development investments result in "mal-adaptation". In this context, it is recommended that donors analyse their development investments with regard to their exposure to climate risks, assess the degree of current attention paid to climate risks and climate change in their development strategies, plans and projects, and assess the specific implications of climate change on their core development activities (Gigli and Agrawala, 2007). With regard to avoiding mal-adaptation and

[13] "No-regrets" adaptation options include better management of natural resources, particularly of coastal habitats, land and water, and measures such as disease vector control and improved spatial planning.

a waste of funds, the first exercise becomes even more important as analyses of official aid flows found that a significant portion of investments is made in activities that are potentially affected by climate risks (Burton and van Aalst, 1999; van Aalst and Agrawala, 2005).
Figure 2 visualises the share of affected aid flows and activities in the case of six developing countries (see the OECD analyses by van Aalst and Agrawala (2005) of official aid flows across all donors into six case study countries).

Figure 2

Annual official flows and share of activities potentially affected by climate change



Note: Based on Creditor Reporting System; Official flows averaged over 1998-2000.
Source: OECD (2005).

7

Appraisal of adaptation projects

The roles of cost-effectiveness and benefit-cost analyses in project appraisal

Chapter 7.1

Project appraisals are theoretically done for either of two purposes. The first being to identify the most inexpensive method for accomplishing a specified objective (e.g., protecting against a five-meter storm surge). This is referred to as cost-effectiveness analysis.[14] The second purpose is to guide the economically efficient allocation of limited funds (i.e., an agency's budget or the funds available for investment) among competing projects. It is important to note that this discussion relates to determining how to accomplish a specified task or how to spend a predetermined budget, and not how to decide on the size of that budget or the appropriate strategy for accomplishing some social mission. As outlined here, these techniques relate to micro, not grand strategic decision-making. (For guidance on the latter, see Stern (2006), Technical Annex 2.)

While the objective is predetermined in the first case, the projects to be appraised in the second case can have very different objectives: for example, even though they all may relate to climate change adaptation, some may aim at preventing flooding and others at mitigating droughts. It may also involve choices among projects in different countries. In this sort of analysis, because we are comparing "apples and oranges", benefits must be converted to a common metric. Furthermore, because an efficient allocation of budgeted resources is required, benefits must also be made comparable to costs. Consequently, all benefits and costs have to be monetised. The process of estimating the monetary benefits and cost of all of the competing projects and then comparing them for purpose of deciding which to fund, is generally referred to as benefit-cost analysis.[15]

Project appraisals can also serve another purpose. By being able to demonstrate the cost-effectiveness or the excess of benefits over costs (economic efficiency) of selected projects, it is often easier to convince politicians and policy-makers that they are worthwhile and should be funded. Since benefit-cost analysis is the more difficult task and likely to be more relevant to GTZ decision-making, what follows will concentrate primarily on the ways in which to accomplish benefit-cost analyses of adaptation projects. Cost-effectiveness analysis allows the analyst to ignore the problems inherent in placing monetary values on such disparate benefits as reduced loss of life and

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[14] Comparing the cost effectiveness of alternative methods of dealing with a particular problem (comparing cost per unit of output) can prove useful for preliminary screening where there are a number of competing technologies.

[15] There is a rich literature on this topic. One of the classics in the field is Harberger's "Project Evaluation: Collected Papers", Markham Publishing Co., Chicago, 1973.

habitat preservation, but on its own provides no assistance in choosing between projects that save lives and those that serve other objectives, such as habitat preservation.

All appraisals regarding potential adaptation activities logically start with making estimates of anticipated adverse effects of climate change: What are the expected losses of life, increased injury and disease, damage to property, crop failure, etc., that are likely to result from climate change? These are the actual losses and damages anticipated in future years without any intervention, weighted by their probability of occurring in each year. Presumably much of this information would have already been gathered in doing the vulnerability assessments for setting priorities. Assuming that prioritisation has been focused merely on selecting one or a few of the adverse effects to be targeted in assistance projects, the estimates of these expected impacts may have to be refined.

The next step in the process is to identify feasible options for preventing/reducing the adverse effect(s) of concern. For each of these options, information must be acquired on their cost, their probability of success and the fraction of the expected damage/loss they are likely to prevent. In estimating the costs, care must be taken to include all of the cost associated with the option; not only the obvious budgetary outlays by an assisting agency, but also those required of the recipient country, as well as those born by the recipient population resulting from such things as necessary relocations of communities and the opportunity cost of idling of land and structures. Consequently, all societal costs have to be included, regardless of whether they are budgetary outlays by government or costs directly and indirectly imposed on people and enterprises, even if they are not easily monetised (such as those arising from associated ecological damages).[16] Care has to be taken as certain indirect costs are easy to overlook, such as where disaster relief or subsidised insurance induces higher-risk activity (sometimes termed "mal-adaptation"), nonetheless they should be included where they can be identified.

Turning to the benefit side of the benefit-cost analysis, for each of the adaptation options the raw benefits will be represented by the amount by which the relevant projected loss due to climate change will be reduced if the option is implemented. These estimates of expected loss-reduction are obtained by adjusting the expected non-intervention loss in each future year by the proportion of the loss that the adaptation option is likely to prevent, as well as by some estimate of the option's probability of success. Where enhancing adaptive capacity will also enhance economic growth, as with improvements in transportation and telecommunication or reduced morbidity, estimates of these economic growth spillovers should also be added to the project's benefits.

The expected climate loss reductions and spillover benefits will then have to be given monetary values. This is likely to be relatively easy for some sort of benefits (e.g., property, stock-in-trade or crop-loss prevented), but more difficult for others (e.g., death and morbidity prevented, ecological damage avoided). It may not be necessary to resort to exotic "revealed preference" (contingent valuation) techniques[17] for estimating them, as monetary proxies often exist. In some cultures, compensation is required, for example, for murder, wrongful death or injury, and these values could be used directly. Ecological damage that affects tourism could be monetised via the value to the local economy of the lost tourism. It should be noted that it is very hard to compare op-

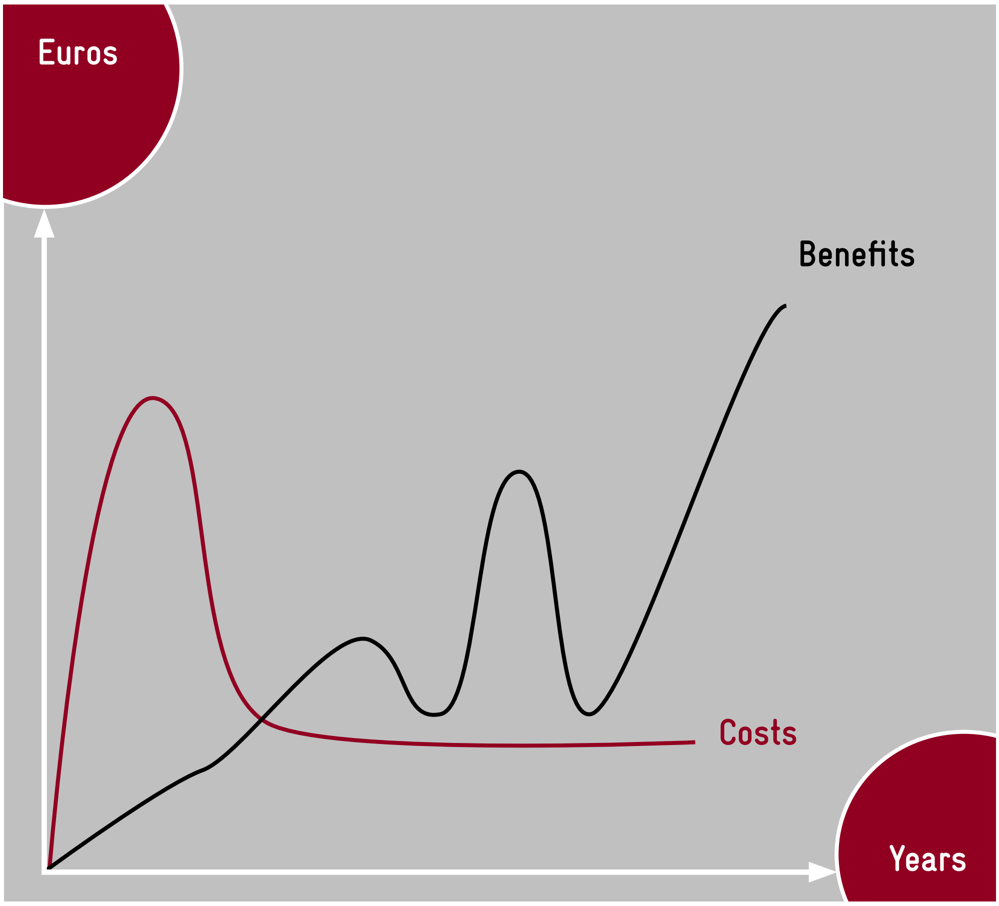
[16] Non-monetised costs, in the sense that they are not valued by the market are frequently referred to as "negative externalities", i.e. being "external" to the market. Similarly, non-monetised benefits are often referred to as "positive externalities". These externalities, even if they cannot be assigned monetary values, should not be ignored in the project appraisal process. At a minimum they should be presented prominently in side tables.

tions that have significant non-monetised benefits (or cost for that matter), particularly if they are of very different kinds (e.g., involving the loss of coral reef ecosystems on the one hand, and an increased incidence of malaria on the other).

The expected benefits and costs of each proposed adaptation option will inevitably appear as streams of annual benefit and costs. The expected benefits will perhaps be non-existent in the near term, but then are likely to become positive and increase in future years as the impacts of climate change intensify. Conversely, the anticipated costs of a proposed project could very well be significant initially, but decline markedly in later years (see Figure 3). This, in particular, is likely to be the case when one is dealing with physical infrastructure enhancements, where there is initially a large capital outlay and then mostly annual operating and maintenance expenses.

Benefits and costs over time

Figure 3



[17] These techniques involve administering questionnaires to sub-samples of the relevant population to elicit the value they place on alternative hypothetical states of their world with respect to such things as longevity, morbidity and the environment. It is not clear how well such estimates obtained in one setting can be transferred to another setting, particularly if different countries and cultures are involved. The reliability of value estimates derived from contingent valuation is hotly debated and when done well, these studies tend to be very expensive. An extensive literature exists on these topics.

In any case, the benefit and cost streams for any one option are likely to differ markedly in shape, as will those of the different options being considered. In order to make them comparable, the normal procedure is to convert the streams of benefits and costs to present values by means of discounting which makes use of some measure of the time-value of money.[18] This could be some interest rate that might be a measure of the opportunity cost of funds, or a derived social time-preference rate.[19] What exactly the discount rate should be, is usually specified beforehand by the agency sponsoring the analysis, and should not be left to the discretion of the analyst.

Once the present value of the benefits [PV(B)] and costs [PV(C)] of each potential project have been calculated, the costs can then be subtracted from the benefits to obtain the present value of net benefits [PV(NB)] for each of the projects. From the economist's perspective, this is a measure of the social surplus (welfare) that the project would generate and, clearly, the bigger it is the better. If projects are ranked in descending order of their PV(NB) and are then funded by starting at the top and working down the list until the budget is exhausted[20], the social surplus generated by that budget would be maximised. This is the recommended approach to determining which projects should be financed.

Given the sensitivity of the PV(B) estimates to projections of the adverse impacts of climate change and projections of the effectiveness of the proposed adaptation measures in mitigating them, these estimates of PV(B) are bound to be highly uncertain. To the extent that the cost estimates include significant local outlays and spillover effects, this is also likely to be true of the PV(C) estimates. One way to deal with this uncertainty in the context of project selection is to do a sensitivity analysis of the ordinal ranking of the projects with respect to components of PV(NB) estimates that are deemed to be the most uncertain, or suspect. If the ordinal ranking of the projects turns out to be very sensitive to small changes in the PV(NB) of these projects, it would be worthwhile to refine the underlying benefit and cost estimates for these projects.

At this point, it seems appropriate to mention the widely used benefit-cost ratio (B/C), which is calculated as PV(B)/PV(C). Clearly, the more the ratio exceeds "1", the better. While showing that a particular project has a high B/C might be a convenient way for enlisting political support for it, using benefit-cost ratios is not the best way to allocate a budget among alternative investments. This is an issue of scale and replication. Ordinally ranking projects by their benefit-cost ratios and proceeding down the list until the budget is exhausted, is not likely to produce as large a total social surplus as using the present value of net benefits. This is because the projects with the highest B/C may be quite small in terms of their budgetary expense, as well as being unique and, therefore, not replicable. The object of the whole exercise is to maximise the surplus of total social benefits over costs from the available budget, not to get the highest return per euro/dollar

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18 We can represent the present value of benefit as $PV(B)=\sum_t B_t/(1+r)^n$ and the present value of cost as $PV(C)=\sum_t C_t/(1+r)^n$, where 't' refers to the number of future years and 'r' is some interest rate representing the time value of money. Occasionally, the annual streams of benefits and cost are presented as "annualised" benefits and costs, which are obtained by dividing the present value by an annuity factor.

19 The latter is derived using such concepts as "social welfare functions" and the "marginal utility of income", as well as expectations about the wealth of future generations and the number of relevant future generations (see the Stern, 2006; Technical Annex 2).

20 This process may be facilitated and made more appealing to decision-makers by segregating out the portion of annual costs not borne by the donor agency and treating them as offsets against the corresponding annual benefits.

spent; doing the former implies starting with the largest increment in the PV(B) over PV(C) and working down the list until the available funds are exhausted.

Limits to project appraisal methods

Now, this is all a lot easier said than done. As mentioned before, accurately predicting climate change impacts is difficult. Coming up with good estimates of the uncertainty surrounding these impact estimates is likely to be even more difficult. Parallel problems are associated with predicting the success of the various adaptation options. This is especially likely to be true the further one gets away from physical infrastructure enhancements and into human capital development or incentive approaches. Estimating the benefits of economic incentive options may present the greatest difficulty, since they rely on voluntary action. Even the effectiveness of fiat approaches will depend on enforcement effort and expected penalties, which are often hard to predict ex-ante. The ease of monetising benefits will also vary depending on the type of climate change impact one is considering, for example, property and crop loss are a lot easier to monetise than the loss of life or ecosystem damages.

Another problem inherent in benefit-cost analysis generally is related to the discounting necessary to compute present values. The largest benefits, particularly those associated with adaptation projects, are likely to occur 10, 20 or 30 years into the future as climate change intensifies and impacts manifest themselves, whereas the greatest costs will tend to cluster in the first few years after project initialisation. However, it is the nature of discounting that any significant discount rate will greatly reduce future monetary sums. Even with a relatively low discount rate, say of 3%, a sum 25 years out will have lost over 50% of its value. At an 8% discount rate, this same reduction in value would occur by the 10th year. This effect tends to bias benefit-cost analysis against projects that deliver the bulk of their benefits in the more distant future in favour of less costly projects, regardless of the absolute magnitude of the future benefits they deliver.

In light of the complexity of doing full-fledged benefit-cost analyses and the predictable discounting effect on future benefits, cost-effectiveness analysis could be an alternative. It would obviate the need to monetise benefits, avoid much of the discounting problem[21], and get around some of the difficulties in predicting the timing of climate change impacts. However, since it is hard to compare very dissimilar benefits (the "apples and oranges" problem), cost-effectiveness analysis presupposes that the attention can be focused on the mitigation of a single category of climate change impacts. It will thus not be very useful in allocating resources among projects that deal with different sorts of climate impacts.

[21] This would, however, not get around the biases discounting would still introduce with respect to costs. A project with the same total cost as another would appear cheaper, the greater the portion of those costs that are shifted to future years.

8

Concluding remarks

Developing countries are for various reasons most vulnerable to the adverse effects of climate change: they are geographically located in areas which are projected to be hit hardest by negative climate change impacts, they rely mainly on climate-sensitive natural resources, and have a low adaptive capacity due to a lack of financial and human resources, infrastructure and good governance. Even though societies have always adapted to spatial and temporal climate variations, for example, by migrating to other locations, changing crops, or adjusting or relocating their settlement structures, most of the poorer countries and people will not be able to deal with extreme changes in climate.

Therefore, development cooperation assistance will play a major role in helping developing countries adapt to climate change. An important step in doing so is to integrate climate change adaptation in development strategies, plans and projects. This will, on the one hand, make development investments more efficient if the exposure of an investment portfolio to climate risks is reduced. On the other hand, targeted interventions, such as measures aimed at enhancing the adaptive capacity of developing countries, will take these countries a long way towards preparing for the effects of future climate change.

National governments, donors and international organisations will need to step in where the adaptation measures taken by individuals prove to be inadequate or insufficient. This relates, for example, to the generation and dissemination of relevant climate risk information: effective adaptation will in all cases require easily understood and reliable information about the risks of climate change at levels of geographical specificity appropriate to the constituencies of the decision-makers. Particularly in developing countries with low literacy rates, disseminating easily comprehendible information about climate risks and potential adaptation options is key to minimising adverse climate impacts. Also, where adaptation by individuals and businesses will be constrained by the availability of funds and the lack of organised markets for credit and insurance, governments will need to help organise markets by providing essential information and necessary regulation, or by inducing voluntary adaptive behaviour via the provision of suitable incentives. These can take the form of taxes, subsidies, licensing and zoning requirements or marketable development rights. While economic incentive approaches are voluntary, they must exist within a framework of enforced laws and regulations. At the most basic level, these might involve clearly defined property rights and fairly adjudicated contracts. Complexity and uncertainty will raise transaction costs, which in turn, will inhibit the desired voluntary behaviour.

While it seems that developing countries are making a lot of progress in assessing their vulnerabilities to climate change, they seem to be having problems in identifying and developing adaptation options (Tearfund, 2006).[22] Therefore, development assistance might be most valuable in helping these countries develop options and design projects for dealing with their highest priority climate threats.

In general, emphasis should thereby be given to "no-regrets" adaptation measures. As a country's poverty is likely to be the biggest constraint to its ability to prepare for climate change impacts, it is very important to pay attention to the complementarities that often exist between adaptive capacity and economic development: enhancing one will often enhance the other. Development-adaptation complementarities can be exploited by taking measures such as enhancing literacy and governance; diversifying away from reliance on a single resource-dependent industry (thus reducing vulnerability to climate change and under-employment, and raising labour productivity); implementing efficient irrigation systems (thus increasing crop yields and reducing agricultural vulnerability to drought); or establishing well-functioning insurance markets to facilitate private adaptation and reduce the need for self-insurances, thereby freeing up capital for productive investments.

Prioritising adaptation options is a great challenge for development cooperation agencies: they will have to identify the countries/regions that are most vulnerable to climate change and, at the same time, have the lowest capacity to adapt. This could be done by creating some sort of ordinal index of vulnerability or adaptive capacity which is based on data elements such as a country's GDP per capita, elevation above sea level, number of severe hurricane/typhoon landfalls in the last decade, health professionals per thousand of population, and others. Another way to prioritise adaptation options would be to extract information regarding primary vulnerabilities or preferred adaptation strategies from the National Communications prepared by Non-Annex I countries or the NAPAs by Least Developed Countries. Furthermore, in figuring out which countries to help, especially until adequate information becomes available to predict the future impacts of climate change, it may be recommendable to focus the provision of assistance on those countries which suffer the most from observed/historical climate variability due to their geophysical vulnerabilities and their limited response capabilities. Also, priority for involvement might be given to adaptation assistance in countries where the donor is already heavily involved in development assistance.

More knowledge about the economics of adaptation, particularly the costs and benefits of available options, is necessary for development partners in implementing the most efficient adaptation measures. They will need to identify those options where the total benefits from any adaptation activity exceed its total costs and, where possible, the benefits from the last euro/dollar spent on each adaptation activity are equalised. Project appraisal methods such as benefit-cost analysis and cost-effectiveness analysis can be useful for doing so, however, they are very data- and labour-intensive and presuppose that one is dealing with a complete set of fully formulated projects, including complete information about the effects of all adaptation options. The greatest difficulty in doing project assessments will most likely involve coming up with good estimates of expected climate change damage. Probably, second in difficulty will be projecting the effectiveness of non-engineering adaptation measures. They are more likely to be the source of erroneous project rankings than the selection of the "wrong" discount rate, and should receive the most analytical attention.

[22] That is, with the exception of many of the Caribbean and Pacific Island Nations, which appear to be much further along in the process than most other developing countries.

Annex 1

Glossary: Clarifying Terms

Climate change adaptation:

• According to the IPCC, adaptation is broadly defined as any "adjustment in natural or human systems in response to experienced or future climatic conditions or their effects or impacts – which may be beneficial or adverse" (Smit et al., 2001).

• A narrower definition of adaptation is used, for example, by Huq et al. (2003): "Adaptation to climate change includes all adjustments in behavior and economic structure that reduce the vulnerability of society to changes in the climate system."

These definitions seem to exclude actual climate disaster-response activities (e.g., relief, rehabilitation, reconstruction, compensation and liability) per se[23] , but do seem to include activities aimed at enhancing the capacity to provide these remedies.

Adaptive capacity:

This concept can most usefully be defined as "a country's capacity to plan, prepare for and implement adaptation initiatives" (Huq and Klein, 2003). The factors that determine a country's adaptive capacity include its economic wealth, access to credit, available technologies and infrastructure, the education, information and skills of its population, as well as the nature of its governmental institutions and community networks.

Efficiency:

This term has a unique meaning in economics and its application to adaptation. Efficient adaptation requires that the sum of the benefits from the adaptive action exceed the sum of its costs (Mendelsohn, 2000). These are not only the pecuniary benefits and costs received or borne directly by the private (individuals and firms) and public sectors, but also opportunities forgone, externalities and non-pecuniary effects, especially as they relate to ecosystems.
Another aspect of efficiency relates to the allocation of funds among activities. From this perspective, efficiency calls for the equalisation of the benefits derived from the last euro/dollar spent on each activity. (This concept will be hard to apply rigorously to a basket of discrete, non-replicable projects.)

Equity considerations:

Equity, as it relates to climate change, concerns the distribution of benefits and costs across and within countries and over time, as well as to concepts of fairness. Thus far, the contrast between the industrialised countries that have benefited the most from the unrestricted release of GHGs and the countries that will inevitably bear the most severe consequences of the resulting climate change has received the most attention.[24] However,

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[23] The Pew Center on Global Climate Change, however, defines adaptation as including the remediation of residual or un-avoided climate change damages (see Burton et al., 2006).

[24] This has been a major argument by developing countries for seeking relief from mitigation requirements in international treaties.

with respect to climate change adaptation measures, it is also important to consider who will benefit from a particular measure and who will bear its (financial and other) costs. For instance, who will benefit from a new sea wall versus who will have to pay for it or have their property condemned to allow its construction? Internationally, notions of fairness will very much affect the willingness of the rich to help the poor adapt to climate change. Intra-nationally, they will very much affect the ability of a society to engage in public (collective) adaptive actions.

The concept of inter-generational equity is also relevant to discussions about climate change impacts and who should pay for their abatement. It refers to expectations about the relative wealth of future generations and to the belief that the environment should be passed on from generation to generation undiminished, so as to allow a standard-of -living that is at least as high as it is in the present (cp. the concept of sustainability or sustainable development).

The long run versus the short run:

From an economist's perspective, these terms relate to the time it takes for the factors of production (labour and capital) to respond to changes in how they are rewarded with respect to wages, interest rates, opportunities and risks. This is a time continuum associated with a particular set of economic circumstances, and has no fixed meaning in terms of weeks, months or years. In the shortest of short runs the supplies of labour and capital are fixed, whereas in the longest of long runs, all labour and capital are completely mobile and will fully respond to small changes in their compensation.

Public goods:

In contrast to "private goods", "public goods" are those goods and services that will be inadequately supplied by the private sector because, by their very nature, those who do not pay for them cannot be excluded from consuming them and one person's consumption will not reduce the amount of them that is available to others. Sometimes this is referred to as having "non-rival" benefits. The associated "free rider problem" – the tendency of consumers to let others finance the provision of the good or service since they cannot be excluded from consuming it – tends to confound cooperation among individuals in providing these good and services, usually making that a task for government.

Risk pooling:

The pooling of risks is the basis of all forms of insurance; it allows many individuals or groups to share the costs of a risky event. The persons affected by the event benefit from the contributions of the many others that are not affected by the event, and thus receive compensation greater than their individual premium payment. This assumes that there is a low covariance of the risks faced by individuals or groups within the risk pool. Since disasters are, almost by definition, "mass covariant events" which frequently affect whole geographic regions, the effective pooling of disaster risks is difficult, thus making it hard to design disaster insurance schemes that are not heavily subsidised.

Risk transfer:

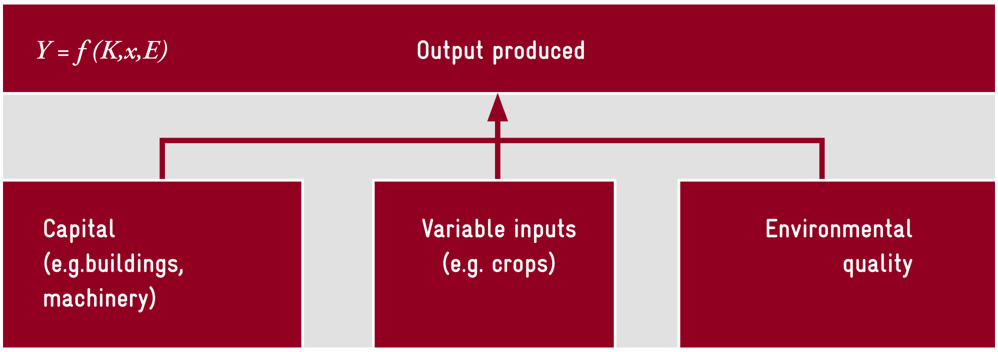
Risk transfer is formally defined as the shifting of the burden of a loss to another party by means of legislation, contract, insurance or some other means. Traditionally, this involves social programs such as safety nets and calamity funds, as well as conventional insurance policies that protect against specific types of loss (e.g., collision, flood, hail, etc.). It also includes reinsurance which involves the transfer of a portion of the risk from the insurer to a second insurer who has no contractual relationship to the insured party, thus facilitating a broader pooling of risks and reduction of the expected loss faced by any one insurer. More recently, as the term has been applied to natural disasters, it has come to include such mechanisms as catastrophe bonds, catastrophe pools, weather index-based insurance and micro-insurance schemes.

Annex 2

Adaptation actions with fixed and variable capital stock and differences between short- and long-run adaptations

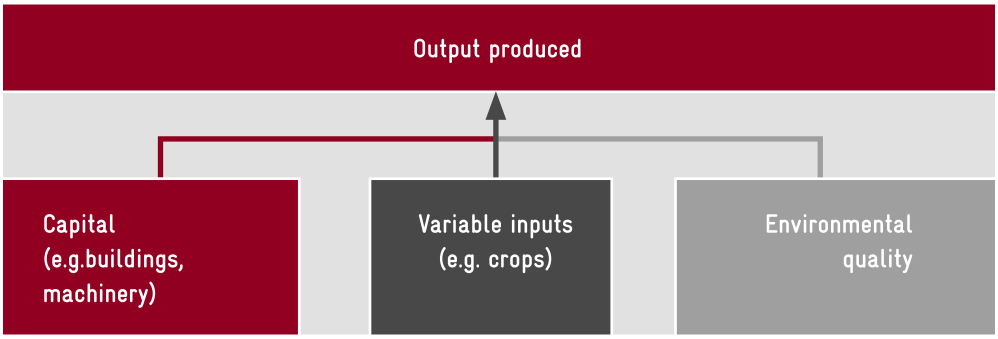
The difference between short-run and long-run adaptation decisions can be explained using the following illustrative diagram. In any given year, the output of an economy is generated using three types of inputs, capital K, variable inputs to production and environmental quality E.

Figure A.2.1



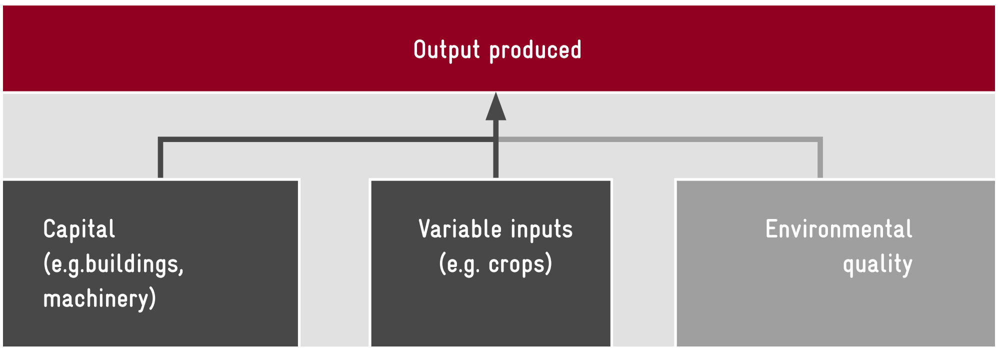
In the short run – and given a change in E due to climatic change and variability over a short period of time (e.g. one year) - the decision maker, who seeks to maximise the net profits of production, can respond only by changing variable inputs (shown as red in the diagram below).

Figure A.2.2



In contrast, in the long run (e.g. over 30 years), the decision maker can respond by changing both variable inputs and the capital stock to maximise profits given a change.

Figure A.2.3



Source: Stern, 2006.

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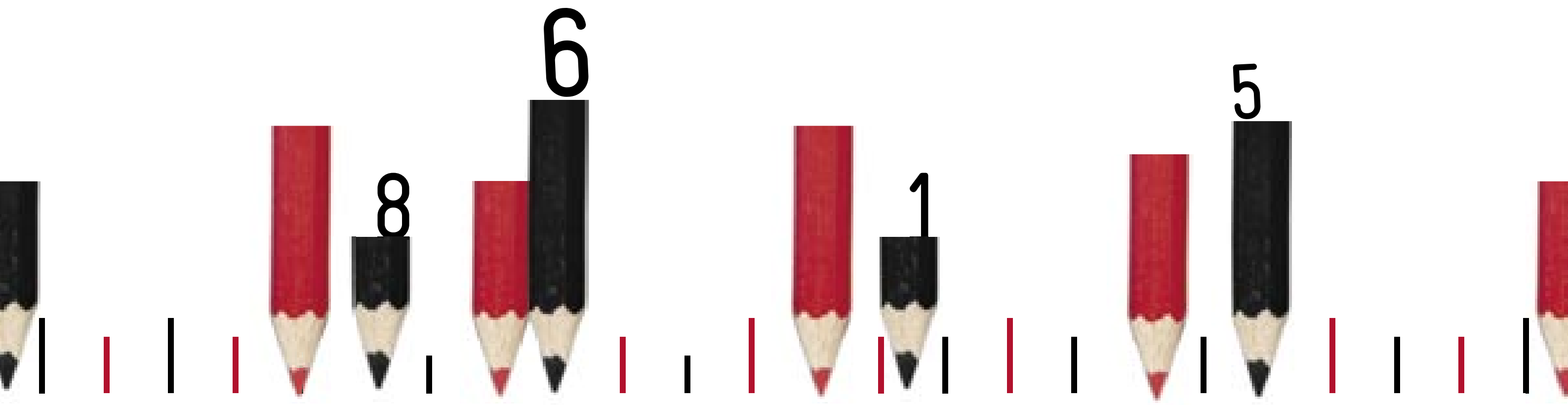

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