Chapter 1

Putting Climate Change Adaptation in an Economic Context

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Adaptation to climate change is now widely recognised as an equally important and complementary response to greenhouse gas mitigation in addressing climate change. Adaptation consists of deliberate actions undertaken to reduce the adverse consequences, as well as to harness any beneficial opportunities. A wide range of adaptation measures can be implemented in response to both observed and anticipated climate change. How much adaptation might cost, and how large its benefits might be, are issues that are increasingly relevant both for on-the-ground projects, as well as in a global context where trade-offs might need to be considered between the costs of climate policies and the residual damages resulting from climate change. This chapter provides a context for examining adaptation costs and benefits, and discusses key issues related to the timing of adaptation decisions as well as how such decisions could be affected by the uncertainty surrounding the impacts of climate change. It also moves the discussion beyond cost estimation to examining market and regulatory mechanisms that can be used to incentivise adaptation actions. Such mechanisms have so far received little attention in the context of adaptation.

Introduction

Adaptation to climate change is now widely recognised as an equally important and complementary response to greenhouse gas (GHG) mitigation. Both mitigation and adaptation help to reduce the risks of climate change. Mitigation – through the reduction in sources or enhancement of sinks of greenhouse gases – reduces all impacts of climate change. Adaptation – through adjustments in human and natural systems to actual or expected climatic changes – can be selective. It can reduce negative impacts, and take advantage of the positive. Even the most stringent mitigation efforts cannot avoid further impacts of climate change in the next few decades, which makes adaptation essential, particularly in addressing near term impacts.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) defines adaptation as any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007). The process of adapting to climate and climate change is both complex and multifaceted. As such it is very difficult to do adaptation analytical justice, and a number of typologies have been developed to classify adaptation activities. For example, adaptation measures have been classified according to: timing (anticipatory *vs.* reactive); scope (local *vs.* regional, short-term *vs.* long-term); purposefulness (autonomous *vs.* planned); and adapting agent (natural systems *vs.* humans, individuals *vs.* collective, private *vs.* public).

While societies have a long record of adapting to the impacts of weather and climate, many regions and sections of the society remain poorly adapted even to current climate. Further, climate change poses novel risks often outside the range of historical experience. These include: increases in mean temperatures and sea levels; changes in precipitation patterns; melting of glaciers and permafrost; and changes in the intensity and/or frequency of weather extremes such as droughts, heat waves, floods and hurricanes. There are now some examples of adaptation measures that also incorporate considerations of climate change, but progress remains limited in both developing and developed country contexts (Agrawala and van Aalst, 2008; Gagnon-Lebrun and Agrawala, 2007).

In planning for these observed and anticipated impacts of climate change it is important that adaptation efforts rest on a sound economic basis. How much adaptation might cost, and how large its benefits might be, are issues that are increasingly relevant both for on-the-ground projects, as well as in national and global contexts where trade-offs might need to be considered between the costs of climate policies and the residual damages resulting from climate change.

There are significant analytical and policy challenges associated with economic assessments of both mitigation and adaptation. However, the boundaries of mitigation measures are more clearly defined, the literature on mitigation costs is much more comprehensive, and there is a clear metric (reduction in GHG emissions) for assessing the effectiveness of such measures. In contrast, what does and does not fall within the purview of adaptation is much more ambiguous, the literature on adaptation costs remains sparse and contested, and there are no accepted metrics for assessing the effectiveness of adaptation policies and measures.

Unlike mitigation, which has to be co-ordinated internationally, adaptation decisions are largely decentralised. They will be made to a large extent in well-established decision-making contexts, such as corporate investment or local government planning. Some adaptations will have a public good character and as such may be provided by the state (local authorities or national governments). In making these adaptation decisions the authorities will apply traditional decision support tools, such as cost-benefit analysis, cost-effectiveness analysis and multi-criteria analysis.

Other, perhaps most, adaptation decisions will be taken by private agents, such as individuals and firms. The more sophisticated actors among them will base their decision on the investment appraisal techniques of corporate finance. They may, for example, calculate the net present value of an adaptation investment, analyse its risks and returns or determine the return on capital employed. What these decisions have in common is that they are based, loosely, on a comparison of the advantages and disadvantages – the costs and benefits – of a certain course of action (Mendelsohn, 2000). In addition to the level and type of adaptation, decision makers will also have to determine the timing of their action. Both sets of decisions – level and timing – will be taken under considerable uncertainty about the precise impacts of climate change. Finally, because adaptation is a decentralised process, there is the question whether, and if so how, economic agents need to be incentivised to adapt. This is a question for public policy.

The costs and benefits of adaptation

The comparison of costs and benefits, while straightforward conceptually, raises a plethora of methodological issues including valuation, discounting as well as aggregate versus distributional consequences. Such issues are hardly unique to adaptation, but the challenge of addressing them is particularly acute in this context. One reason for this is the nebulous nature of many adaptation actions, which are often embedded within responses undertaken by innumerable private and public actors to a broader set of social and environmental stimuli. For example, farming practices, land use planning and infrastructure design might all reflect some considerations of current climate and anticipated climate but it might not be feasible to cost the climate component, as such decisions are also simultaneously conditioned by a whole range of other (and often more influential) factors. Separating the costs of adapting to climate variability and climate change adds a further layer of complexity, as few examples of adaptation are as cut and dry as building the next increment of a sea wall to protect against climate change induced sea level rise.

Adaptation costs might increase several-fold if, in addition to measures that directly reduce climate damages, actions to increase baseline "adaptive capacity" – for example, investments in nutrition, education and health services – are also included within the purview of adaptation. Delineating the boundaries of adaptation to the climate component, therefore, is not straightforward.

Moreover, while adaptation can reduce negative impacts of climate change, there will nevertheless be residual damages. This is because, as the IPCC Fourth Assessment Report notes, there are biophysical, social, and economic limits with regard to the level and rate of climate change that different systems can adapt to (IPCC, 2007, Chapter 17). The gross benefit of adaptation is the difference between the climate damages with and without adaptation. Adaptation, however, will also entail costs. Consequently, these costs need to be deducted from the gross benefits to arrive at the net benefits of adaptation (Stern, 2006, after Fankhauser, 1998).

Table 1.1 helps to illustrate these issues. The starting point is the recognition that adaptation to climate phenomena is a part of everyday life. Today's society is adapted to the current climate through measures ranging from farmland irrigation to flood protection infrastructure. This current state of affairs is represented in the top-left quadrant of the table. In the illustrative example of Table 1.1, society is spending an amount of 90 units on adaptive measures – for example, a flood protection system. Included in these costs are both monetary components (*e.g.* capital costs) and non-monetary components (*e.g.* the impact on the environment). This level of adaptation is sufficient to prevent most adverse climate effects, but not all. There is a residual damage of 50 units, for example due to occasional extreme flooding. There is no climate change, and hence no climate change impact yet. Current adaptation is preferred over extended adaptation, because the additional cost of more comprehensive protection (150-90=60) are higher than the additional benefits of reduced flood damages at the margin (50-20=30).

The calculus changes with climate change (associated, for example, with a higher frequency of storms and floods). Under a changed climate, the extra costs of adaptation (150-90=60) are more than offset by the reduced costs of climate change (200-120=80). In this particular example, the climate change benefits alone are sufficient to justify adaptive action, but the extra reduction in ordinary climate impacts (50-20=30) is an important ancillary benefit. The ancillary benefits occur because the extended protection system will reduce the impact of both climate change-induced and ordinary floods.

Obviously, the example of Table 1.1 is simplistic and ignores important complications, such as uncertainty and continuous change. However, it helps to flesh out two important issues: the costs of adaptation have to be measured against current adaptive measures; and many adaptive measures may have climate change as well as non-climate-change-related benefits, although distinguishing between the two will not be possible in practice.

Table 1.1. **A hypothetical classification of adaptation costs and benefits**

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

Source: Adapted from Table 2.1 in Fankhauser, S., (1998), "The Cost of Adapting to Climate Change", Working Paper No. 16, Global Environment Facility, Washington, DC.

The timing of adaptation

The long-term nature of climate change makes timing an important part of adaptation decisions. This is particularly the case for strategic and anticipatory means of adaptation. Like decisions about the level of adaptation, timing decisions will be based on the relative costs and benefits of taking action at different points in time. In particular, decision makers will compare the present value of adaptation now with the present value of adaptation at a later stage (Fankhauser *et al.*, 1999). The present value of taking action now consists of the cost of adaptation (for instance, the cost of building and maintaining a sea wall), plus a stream of residual climate damages, since adaptation will not be perfect. The present value of acting in, say, ten years includes ten years of unabated climate impacts, the discounted adaptation cost ten years from now, and a stream of residual damages thereafter.

The timing decision thus depends on three factors. The first is the difference in adaptation costs over time. The effect of discounting would normally favour a delay in adaptation measures, and so would the prospect of potentially cheaper and more effective adaptation techniques that might be available in the future. However, there is also a class of adaptations where early action is cheaper. They include adjustments to long-term development plans and long-lived infrastructure investments, such as water and sanitation systems, bridges and ports. In each of these cases, it will be cheaper to make adjustments early, in the design phase of the project, rather than incur the cost and inconvenience of expensive retrofits.

The second factor is the short-term benefits of adaptation. Early adaptation will be justified if it has immediate benefits, for example by mitigating the effects of climate variability. It has been argued that changes in weather extremes will be one of the earliest signs of climate change, making adaptation to climate variability a potentially important early measure. Also in this category fall adaptations that have strong ancillary benefits, such as measures to preserve and strengthen the resilience of natural ecosystems. Another important example is health investments (for example, the development of a malaria cure), which have poverty-alleviation benefits that are at least as large as the climate change benefits.

The third component has to do with the long-term effects of early adaptation. Early adaptation is justified if it can lock in lasting benefits, for example by preventing long-term damage to ecosystems. Depending on these three factors, actors will decide to act earlier or later. However, unlike in the example in the previous section, they will have to make their decision under considerable uncertainty with regard to the magnitude and timing of the impacts of climate change. Under such circumstances, perceptions about the potential risks faced and benefits of adaptation become critical. Timely or effective adaptation will not occur if there is either a lack of perception in the mind of the actor of a need for action or a lack of perception of a benefit from the action (Hanemann, 2008). Timing errors can occur in both directions – premature or too late – and both will have implications for the costs and benefits of adaptation.

Dealing with uncertainty

Uncertainty about the exact nature of climate change impacts at the local and regional level (for example in terms of precipitation and storminess) makes it difficult to fine-tune adaptation measures. Adaptation decisions will be taken under uncertainty. Conceptually, this means that most of the adaptation benefits (avoided climate impacts) in Table 1.1 should be interpreted as expected benefits, that is, the probability-weighted mean over the range of possible outcomes. Risk-averse decision makers may pay more attention to negative outcomes, and if the potential cost of inaction is substantial, adaptation decisions may be based on the precautionary principle.

One set of adaptation measures that are easy to agree on, even in the face of uncertainty, are win-win measures. These are adaptations that are justifiable even in the absence of climate change. Many measures to deal with climate variability, for example long-term weather forecasting and early warning systems, may fall into this category. Schelling (1992) has argued that one of the best adaptation measures available would be (sustainable) economic development, and it is easy to agree that better health care, access to safe drinking water and improved sanitary conditions for the world's poorest households are clear win-win measures.

Fankhauser *et al.* (1999) have argued that given the prevailing uncertainties, the best way to account for potential climate change in current investment decisions may be to increase the flexibility and robustness of systems – allowing them to function under a wide range of climatic conditions and withstanding more severe climatic shocks.

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

Incentivising adaptation

Costing adaptation, by itself, is not enough. Raising money is important, but policies need to be in place to ensure that the money is well spent. Adaptation will comprise of thousands of actions by households, firms, governments, and civil society. Sustainable adaptation requires successful internalisation of both current and anticipated climate risks in the various decisions, while being mindful of the associated uncertainties. Despite a long record of dealing with climate variability there is considerable literature showing that many societies and sectors remain poorly adapted, even to current climate. Further, while there are now some examples of adaptation to long term climate change, progress in this direction has been more at the level of planning than actual implementation on the ground. There are clearly several bottlenecks here, not in the least, access to adequate financial resources and relevant climate information. Both financing and climate information have consequently been the focus of considerable attention.

What has received much less attention, however, is the role of market and regulatory mechanisms in scaling up and/or enhancing the efficiency of adaptation efforts. This is a particularly critical gap, given that a majority of actions are undertaken by private actors and also because the scope of the adaptation challenge will far exceed the public budgets available to address it.

Across all sectors of the economy, private firms have a key role to play in adaptation. Engineering and construction, for instance, will be at the forefront of climate-proofing infrastructure and the housing stock. Telecommunications, information technology and the media have a key role to play in hazard monitoring and communicating risk. Agribusiness will be involved in securing food supplies in a warmer world. The banking sector will have to finance adaptation investments, while the insurance sector will provide risk coverage. Climate change might also pose risks to the global supply chain for many products, and might consequently need to be reflected in business planning. Even beyond the locus of firms and businesses, adaptation considerations also need to be better reflected in decisions made by individual actors. These decisions could be with regard to consumption of resources, such as water, whose scarcity might be exacerbated under climate change. Such decisions could also include investments, such as climate-proofing of homes and purchase of insurance, which might influence the vulnerability of individuals and households to climate change impacts.

In theory, such actions should be autonomous. Self-interest should be a sufficient incentive for such actors to undertake measures that reduce their vulnerability to climate risks or to exploit potential business opportunities. Like the activities of markets, these actions do not have to be directed centrally by a public authority. In fact this would be counter-productive, and probably impossible. However, as in the case of markets, governments have a role to play in providing an enabling environment that allows private agents to make timely, well informed and efficient decisions. Public policy also has a role to play in case private adaptations by one actor or set of actors create negative externalities on other sections of the society or the environment. Governments also have a role to play in providing adaptation as a public good where private actions might not occur due to externalities or other failures. Conversely, the scale and efficiency of many adaptations typically undertaken by governments could be enhanced through engagement with the private sector. Again, mechanisms need to be in place to catalyse such engagement and to ensure that it leads to the desired outcomes.

Focus of the remainder of this volume

This volume provides an assessment of both adaptation costs and benefits as well as the role of economic and policy instruments in facilitating adaptation. Chapter 2 of this volume first examines empirical estimates of adaptation costs and benefits in different climate sensitive activities and regions including coastal zones, agriculture, water resources, energy demand, infrastructure, tourism and public health. The chapter then assesses available aggregate cross-sectoral estimates of adaptation costs at the global level and in certain national contexts. An overall assessment is then provided of the key messages, strengths and limitations of the sectoral, national and global estimates of adaptation costs and benefits.

Chapter 3 examines the role of economic and policy instruments in incentivising adaptation. First, an overview of typical climate change impacts and adaptation strategies in key climate sensitive sectors is used to identify key policy instruments that could be used to facilitate adaptation. Next, three instruments are identified which could play a particularly key role in adaptation: insurance, price signals and environmental markets, and PPPs. Insurance is a recurring instrument within the context of adaptive responses in a number of sectors. Price signals and environmental markets might be critical to adaptation within the context of many climate sensitive natural resources, including water and ecosystems. PPPs could potentially play a very critical role in financing and enhancing the climate resilience of infrastructure, as well as in research and development for adaptation technologies in agriculture. These three instruments are discussed sequentially in the remainder of the chapter with a particular focus on their nature and current use, strengths and limitations, and relevance for adaptation.

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List of Abbreviations

ADB	Asian Development Bank
CDM	Clean Development Mechanism
CEE	Central and Eastern Europe
CGE	Computable General Equilibrium
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EEA	European Environment Agency
ENSO	El Niño Southern Oscillation
FDI	Foreign Direct Investment
FONDEN	*Fondo para Desastres Naturales*
fSU	former Soviet Union
GDI	Gross Domestic Investment
GDP	Gross Domestic Product
GHG	Greenhouse gas
GNP	Gross National Product
IMF	International Monetary Fund
IPCC	Intergovernmental Panel for Climate Change
LDCs	Least Developed Countries
MAF	Mean annual flow
MDB	Murray Darling Basin
MENA	Middle East and North Africa
MPCI	Multi-peril crop insurance
NAPA	National Adaptation Programmes of Action
NASFAM	National Smallholder Farmers' Association of Malawi
NGO	Non-governmental organisation
NOAA	National Oceanic and Atmospheric Administration (United States)
ODA	Official Development Assistance
PES	Payment for ecosystem or environmental services
PPP	Public Private Partnership
PFI	Private Finance Initiative
R&D	Research and development
ROH	Risk of hunger
SRES	Special Report on Emission Scenarios (of IPCC)
SSA	Sub-Saharan Africa

UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization
WUAs	Water user associations
WWF	World Wildlife Fund

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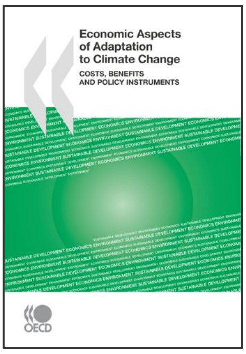
Economic Aspects
of Adaptation
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COSTS, BENEFITS
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