GENERIC ASSESSMENT OF THE COSTS OF RESPONSE STRATEGIES

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Summary

This article outlines the main definitions and cost concepts for climate change response strategies. The response options include adaptation measures that aim at reducing the damage of climate change, and mitigation measures that reduce greenhouse gas emissions or enhance carbon sequestration. It is suggested that a broad decision-making framework be used where the costs of adaptation and mitigation policies are balanced in relation to the expected damage of climate change.

A general overview is provided of adaptation and mitigation measures including those related to institutional and technical capacity building, technical projects in the energy sector, transport, industry, and land-use sectors, and behavioral and social policy options.

In particular, mitigation measures and related costs have been extensively covered and reviewed in the international literature and some of the methodological and empirical results of this work are referred to. The main source of information is the Intergovernmental Panel on Climate Change, which has assessed the literature on social and economic dimensions of climate change.

Mitigation costing estimates seems to depend very much on a number of critical assumptions that are highlighted in this article. These assumptions include population and economic growth, technical change, implementation issues, ancillary benefits of climate change policies, timing of the policy efforts, and the possibilities of international collaboration about greenhouse gas emission reduction policies.

1. Introduction

This article will consider response options to climate change including those related to reduced greenhouse gas (GHG) emissions and/or enhancement of sinks, which in the following will be termed *mitigation measures,* and those related to adaptive response to climate change impacts, which will be termed *adaptation measures.*

The article will outline the main concepts relevant to mitigation and adaptation cost assessments, provide a generic overview of adaptation and mitigation options, review critical assumptions in costing studies, and summarize the main conclusions of international studies as to costs.

Mitigation cost assessment has been extensively covered in the international literature, in contrast to adaptation assessments, which primarily have included more general conceptual discussions and a number of studies for the agricultural sector and water systems. This article therefore will emphasize the costs of mitigation measures, and will consider adaptation costing studies in a more general way.

2. Definition of Key Concepts

Response options include adaptation measures and mitigation measures and the key concepts related to the definition of these measures are outlined below.

Adaptation is the adjustment of ecological, social, and economic systems in response to actual or expected climatic stimuli, their effects or impacts. It refers to changes in processes, practices, or structures to moderate or offset potential damage or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities, regions, or activities to climate change and variability.

Successful adaptation depends not only on the quality of adaptive strategies but also on the nature of the adapting system. An improved understanding of the process of, and conditions for, adaptation is needed to enhance the adaptive capacity of the regions. The adaptive capacity depends on economic, social, institutional, and technological conditions that facilitate or constrain the development and deployment of adaptive measures.

Two sorts of adaptation are distinguished in the literature:

- Autonomous or spontaneous adaptations are those that take place, invariably in reactive responses, as a response to climate change impacts, without the direct invention of a public agency.
- Planned adaptations can be either reactive on climate change impacts or anticipatory (undertaken before impacts are apparent) and are initiated by public agencies to reflect collective needs.

Mitigation is the adjustment of natural, technical, economic, and social systems in order to reduce current or future GHG emissions or to enhance sinks (carbon sequestration in forestry and agricultural land, and marine systems). There are also a number of geo-engineering options, including carbon dioxide (CO_2) capture and disposal. These latter options, however, have only a limited capacity in relation to total GHG emissions.

Mitigation option includes all sort of behavioral changes related to the main economic and social forces driving GHG emitting production sectors, as well as technical options that reduce the GHG intensity of main emission sources.

The potential for climate change mitigation and the related costs depend on macroeconomic and sectoral development trends, as well as nationally specific resource endowments and institutional capacity for introducing mitigation options. The main critical assumptions in mitigation studies are the availability of low carbon emitting energy sources, carbon sequestration capacity, technical and institutional capacity, and implementation barriers. Other important factors are timing of mitigation policies and assumptions about international collaboration about emission reduction policies. International collaboration, for example, can imply that GHG emission reduction commitments of industrialized countries can be offset by GHG emission reduction projects in developing countries or countries with economies in transition through international climate change finance.

3. Decision-Making Framework

Mitigation and adaptation policies are different sorts of responses to climate change damage, and they should therefore be "balanced" in relation to the costs of these damage. It can, in other words, be said that the climate change damage that is expected to be avoided as a result of mitigation and adaptation actions should be considered a sort of a "metric," or measurement standard, for the minimum return that society and/or private agents will get on investments in response actions. The term minimum is used here deliberately, to emphasize that economic benefits of climate change damage over the long time frame of global climate change will reflect only part of the climate change impacts. This is because climate change will involve damage beyond what can be measured in economic terms and because estimates of climate change impacts are very uncertain.

The high degree of uncertainty about climate change impacts is first of all a consequence of the complexity of climate modeling and impact estimates, which reflects the long-term nature of the problems and the many components of the system.

The components of the climate system include the atmosphere, the oceans, the terrestrial and marine biospheres, the cryosphere (sea ice, seasonal snow cover, mountain glaciers, and continental-scale ice sheets), and the land surface.

Benefits in the form of climate change impacts avoided are somehow differently constituted for adaptation and mitigation policies. The purpose of adaptation policies is by definition to make climate change damage less harm full as a results of policies that enhance the capacity of natural, economic, and social systems to adapt to *given* climate change impacts. Mitigation actions, on the other hand, aim at *reducing* the atmospheric concentrations of GHGs and thereby the impacts of climate change.

3.1. Climate Change Damage Estimates

It is impossible to prevent further increases in atmospheric GHG concentrations from the present level of 360 parts per million volume (ppmv). This is because of the long lifetime of the gases: the most important GHG—CO_2—has a lifetime of over 100 years. If the atmospheric concentration is to remain below a stabilization level of 550 ppmv (double prehistoric concentration levels), the future global annual average emissions need to be below the current average global throughout the twenty-first century. In its second assessment report, the Intergovernmental Panel on Climate Change (IPCC) has assessed the damage of potential climate change that will arise from a doubling of the prehistoric concentration level, and the general results of this scenario is shown in Box 1.

Temperature increase	1^0C–3.5^0C
Global sea-level rise	15 cm–95 cm
World impact	1.5%–2.0 % of GDP
Developed countries	1%–1.5% of GDP
Developing countries	2%–9% of GDP
South and Southeast Asia	2.1%–8.6% of GDP
Range of damage cost estimates	US$5–$125 per tonne C

Box 1. IPCC climate change damage estimates for 550 ppmv CO_2 concentration (*Source*: J.P. Bruce, H. Lee and E.F. Haites, eds., *Climate Change 1995: Economic and Social Dimensions of Climate Change* (Cambridge, U.K.: Cambridge University Press, 1996))

Climate change damage is assessed as having a world impact on gross domestic product (GDP) in the range of 1.5% to 2.0% annual GDP loss, which must be considered relatively low. It must here be recognized that these economic estimates include only part of the potential climate change impacts because they primarily reflect average global estimates and are based on a very limited representation of regional and time-specific issues.

Relatively high damage is expected in developing countries even though global warming and sea-level rise in general will be less significant in those countries than in industrialized countries. The high level of damage expected in developing countries is a consequence of specific vulnerability of some areas, extreme events (cyclones,

flooding), and in particular the economic structure of developing countries where land-use sectors are important and there is little capacity to adapt to climate change. Furthermore, human health impacts are expected to be significant because of the poor nutrition and health infrastructure in developing countries. Valuation of human life becomes then the critical issues in estimating damage costs.

In conclusion it can be said that climate change is primarily a consequence of past and present emissions of industrialized countries, but damage will primarily occur in developing countries. Following that, the costs of GHG limitation policies will be high in industrialized countries while the benefits of control will be relatively few in this region.

4. Adaptation and Mitigation Costs and the Linkages between Them

Climate change puts society at risk. It is possible to prevent damage through mitigation and adaptation. A portfolio of mitigation and adaptation actions jointly determines climate risks and the costs of reducing them.

There are a number of interdependencies between the costs of adaptation measures and the costs of mitigation measures. This is because adaptation and mitigation measures have several side benefits, such as institutional capacity building, improved information, and enhanced planning capacity in relation to climate change issues that have implications on costs and benefits of the other policy area. Adaptation and mitigation policies can also imply changes in technical systems and human behavior with direct or indirect impacts on response costs.

Very few international studies have integrated adaptation and mitigation cost assessments. Sectoral work in agriculture, forestry, and coastal areas, however, has shown that mitigation cost estimates are sensitive to the inclusion of adaptation. Greater climate variability, for instance, can influence how adaptation affects mitigation in agriculture. Increased levels of risk directly induce nations to adapt more by switching their crop mix and crop varieties to those more tolerant of drier or wetter conditions; and by modifying weed control strategies. The magnitude of this adaptation depends on how risk affects the perceived marginal productivity of mitigation (e.g. more or less effective soil sequestration per acre); and how mitigation and adaptation work with or against each other.

These results suggest that more attention to the interaction of mitigation and adaptation, and its empirical ramifications, is worthwhile. The challenge is to capture in a reasonable way the interaction between mitigation and adaptation, and establish how this interaction can affect the estimated costs of climate protection.

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Biographical Sketch

Kirsten Halsnæs is an international expert on the economics of climate change and sustainable development implications of climate change policies. She has played a leading role in several international projects on economics perspectives of climate change policies in developing countries and has authored several key international publications on the economics of climate change mitigation, Kyoto flexibility mechanisms, as well as more general development perspectives of climate change policies. A major work is a recent book, *Climate Change and Sustainable Development—Prospects for Developing Countries*, co-authored with Professor Anil Markandya. Kirsten Halsnæs has been among the internationally leading economists in the work of the IPCC.