INTEGRATED ASSESSMENT OF POLICY INSTRUMENTS TO COMBAT CLIMATE CHANGE

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Contents

Summary

Integrated assessment of climate policy is a relatively new and rapidly expanding field of research. Most integrated assessments are carried out by means of comprehensive models with contributions from various disciplines in order to analyze consequences of, or to evaluate, alternative climate policies. It is difficult to classify the integrated assessment models, but one may distinguish between models that emphasize the description of atmospheric responses and impacts on terrestrial systems of greenhouse gas emissions, and models with an elaborated economic module that aim at evaluation of policies. The models are therefore subject to different strengths and weaknesses. Models emphasizing the physical laws usually base policy choices on assumptions without considering political or economic responses of the policy. Hence, their strength is to assess the impacts of alternative scenarios. Models with a basis in macroeconomics can, on the other hand, be used to evaluate policies. Usually they have a more rudimentary representation of the effects of climate change but nevertheless need to transform impacts into values. This involves substantial difficulties, including those related to the uncertainty of climate change. The results from these studies are, therefore, of a preliminary aptitude, but crucial for the understanding of alternative options to respond to the highly uncertain threat of global warming.

1. Introduction

Integrated assessment is a collective concept for studies that aim at a comprehensive assessment of the effects of environmental change induced by human activities. Integrated assessments are characterized by attempts to draw on approaches and results from various disciplines in order to bring consistency to studies of the various aspects of a given problem. For example, an assessment of the impacts of climate change on agriculture will have to be based on assumptions about emissions of greenhouse gases and the resulting change in weather conditions. The emissions depend on social factors, such as general economic growth, the advancement of technology, and population growth. Emissions are likely to change the weather conditions but depend on which greenhouse gases are emitted and the rate of increase in the emissions. Moreover, the effects are sensitive to land-use and land-cover change and, thereby, to the effects on agriculture of climate change. An analysis of the effects of climate change on agriculture should therefore consider all these interdependencies in a simultaneous assessment of all the relevant factors.

Due to the emphasis on the interrelationships between different aspects of environmental problems, a common feature of integrated assessments is the aim to be a device to assist in decision making. Integrated assessments are usually worked out with numerical models. Some models emphasize the description of relationships with an accent on data, and some are used to provide numerical illustrations of certain aspects of the problem. Bringing a variety of widely different effects into a simultaneous system usually requires input from various disciplines.

Despite the aim of being comprehensive, however, the different studies put unequal weight on the various aspects of climate change and there is indeed a wide range of possibilities. It has, therefore, been claimed that the development of integrated assessment models ought to be like biodiversity: The more diverse, the better. With reference to the existing integrated assessment models, one may nevertheless classify the models into models with an elaborated physical representation of the atmospheric system, and models with an elaborated representation of macroeconomic relationship.

Integrated assessments have a relatively short history, and arise from the increasing focus on transboundary environmental pollution since the mid 1970s. In the beginning, attention was paid to the pollution of sea, rives, and lakes and to transboundary air pollution, acid rain in particular. After the Rio summit in 1991, the major development of integrated assessment can be found in studies related to climate change. Among the reasons why integrated assessment has emerged in the wake of the increasing concern for transboundary environmental problems, we mention the following.

First, there is usually a long time lag between the impulse and the effect, because the effects are results of the accumulation of impulses. Emissions of greenhouse gases, for example, lead to higher concentrations of the gases in the atmosphere. There is a natural decay of the concentrations over time, but it is small for most of the greenhouse gases. Hence, a continuous flow of emissions results in a steady increase in the concentrations. In the long run, the concentrations change significantly as a result of anthropogenic emissions. An increase in the concentrations of greenhouse gases increases the atmosphere's ability to absorb reflection of radiation from the earth, which causes the greenhouse effect. Because of the time lag, it is impossible to say how the emission of a unit of, for example, carbon dioxide (CO_2) affects the temperature without considering future emissions of various gases. But future emissions will partly depend on what the effects of climate change are. To say anything about these, one has to bring in expertise on meteorology, ocean currents, terrestrial systems, etc. In other words, to assess the impact of current emissions of greenhouse gases, one needs to know future emissions but the impact of future emissions depends on the impact of current emissions. To take this interdependency into account, an integrated assessment is needed.

Second, climate policy affects other environmental problems as well. The control of greenhouse gas emissions can be carried out by directly reducing the emissions or enhancing the capacity of carbon sinks. The consequences of these actions, however, cover a much broader spectrum than just reducing the greenhouse effect. Most of the possible measures to reduce emissions of CO_2 are related to an adjustment of energy use, either by reducing it or by replacing energy that has a high content of CO_2 (e.g. coal) with energy that has a lower content (gas). As a result, the emissions of pollutants are also affected. The social benefits of these reductions may substantially exceed the benefits related to global warming. Therefore, an evaluation of alternative policy options has to integrate local, regional, and global impacts, both in connection with the costs and with the benefits of the policy alternatives.

Third, those who cause the problem (“polluters”) live in a different country from those who suffer from the problem (“pollutees”). Although many non-integrated analyses of environmental problems focus on the fact that the people who cause the problem are not the ones who suffer, they are usually assumed to live in the same country. They are subject to a common political system where the authorities have the possibility of implementing policies to raise social welfare to the highest level possible. Thus, the authorities may implement policy measures to make polluters pay for the damage they impose on others, thereby ensuring an effective utilization of economic and environmental resources.

In the cases of transboundary environmental problems, there are no such opportunities. Policies to mitigate these problems require negotiated agreements between countries where the overall target of making the social welfare for the global community as large as possible is more or less inadequate. Agreements will depend on the negotiating power among the parties. What is considered fair differs substantially between countries. There is, therefore, a close link between environmental policy and issues of equity in these cases. In addition, the outcome of negotiations as well as the question of implementing policies in different countries cannot be analyzed properly without considering institutional conditions, both on the global and on the national levels.

Most integrated assessments of climate policy have focused on the interrelationship between emissions, atmospheric conditions, and impacts. In many cases, the concept of integrated assessment is limited to this class of studies. Generally they employ a methodology on which there is reasonable consensus, such as geophysics or economics, and they are usually based on models for the entire world. Sometimes there is a particular focus on certain regions, for instance when focusing on the impacts on terrestrial systems. However, these studies also include a more general representation of the world. The main difference between the models of this kind is the disciplinary focus of the methodology, mainly concentrating on economics, geophysics, or biology.

Integrated assessments of combined global, regional, and local effects of climate policy are often referred to as assessments of secondary or ancillary benefits. These studies do not aim at describing global interaction but at interaction between different environmental problems. The decision makers are thereby given evidence for priorities of alternative choices in environmental policy. Because of the local focus of these studies, the use of macro models is less extensive than in global studies. Most of the studies of ancillary benefits are, therefore, based on a "bottom-up" approach.

The least developed fields of research of integrated assessments, in terms of model-based studies, are related to negotiations and fairness. This should come as no surprise, considering the difficulty of establishing realistic numerical models of negotiations. Therefore, there is less consensus about appropriate methodologies. Conceptual models thus have a stronger position than in the other two fields of research. On the other hand, conceptual models are more difficult to integrate with other models. Below, we therefore focus on integrated models of emissions, atmospheric conditions, and impacts. The aim of this article is to discuss similarities and differences between models, and to raise some questions about strengths and weaknesses. It is not a survey of existing models. There are large numbers of surveys of integrated assessment modes (see Bibliography).

2. The Modules of Integrated Assessment Models

The need for comprehensive interdisciplinary research in the study of climate change relates to the fact that different disciplines can contribute significantly to the understanding of the various aspects of climate change or climate policy. Without putting the pieces together, however, one will always leave important information and knowledge behind. On the other hand, the need to select which issues to emphasize cannot be avoided. Because of the immature nature of integrated assessment models, issues of negotiations have been left aside to a large extent because it is difficult to model them. Ancillary benefits are also usually treated separately from climate policy. The main modules of the existing integrated assessment models of climate are displayed in Figure 1.

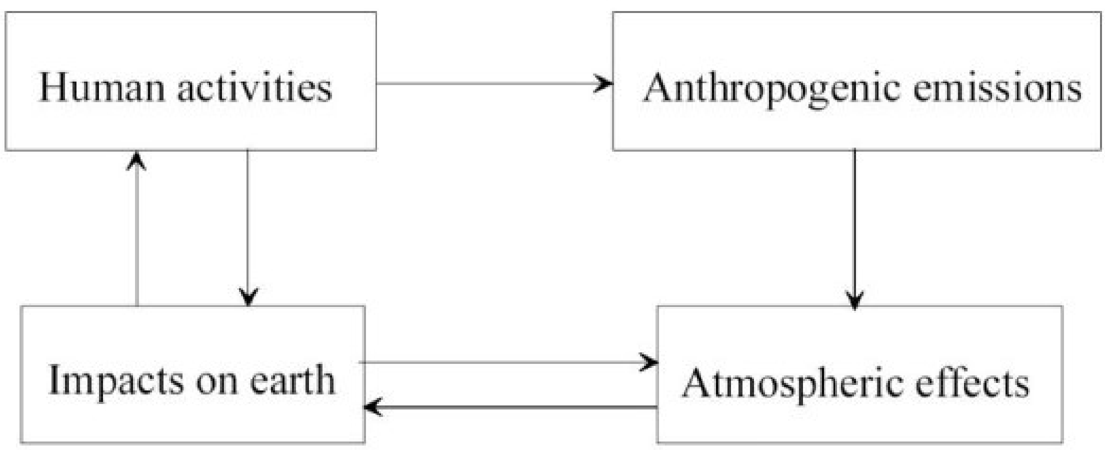

Figure 1. Main modules in integrated assessment models

Human activities consist of development, such as economic growth, political issues, land-use changes, technological change, and the development of population. These are the main determinants for the problem in focus, the future anthropogenic emissions of greenhouse gases. Apart from being necessary for analyzing the problem of climate change, they are also important in the evaluation of policies, and the possibility of comparing combating climate change with alternative political choices.

Most of the anthropogenic emissions of greenhouse gases can be related directly to human activities, primarily to energy use, but industrial processes and agriculture also contribute with large emissions worldwide. The emissions cause increments in the concentrations of greenhouse gases in the atmosphere, which increases the atmosphere's ability to absorb radiation reflected from the earth. Most of the atmospheric effect of greenhouse gases is, however, due to the natural balanced exchange of carbon between the earth and the atmosphere. Anything changing this balance has an impact on how anthropogenic emissions of greenhouse gases affect radiative forcing. For example, land-use changes affect the reflection of radiation from the earth directly, and carbon sequestration affects the natural sink of carbon.

Many studies of climate policy have excluded the issue of impacts on the earth because emission targets have always been the main focus of climate policy. However, the possible impacts are eventually the motivation for all climate policy. The modeling of impacts is difficult, comprising a wide range of possibilities, huge uncertainties and, not least, a large number of interdependencies with both atmospheric effects and human activities, exemplified by the creation of carbon sinks and land-use changes.

Important issues have been left out by the main modules shown in Figure 1, but it would be an immense task to model all the modules extensively. Different integrated assessment models therefore focus on the boxes to different degrees. Hence, some models emphasize human activities, such as economic modeling, others focus on atmospheric impacts, aiming at a realistic estimate of temperature change from a given emissions scenario, and others go into detail in the modeling of impacts. In some models, the different modules are represented as more or less balanced, without going into detail in any of them.

It is difficult to draw a borderline between "classes" of models without a lot of exceptions. One may perhaps distinguish between structural models, aiming first and foremost at a better understanding of certain interdependencies of climate change issues, and numerical assessment models that emphasize the accuracy of numerical estimates to a higher degree. Some claim that the complexity of integrated assessment models makes it difficult to understand what happens when the assumptions of an exercise are changed. Hence, there is a danger that the models just give "black box" answers to the questions of interest. Due to the high demand for numerical assessments, the latter trend is the dominant present integrated assessment model. Nevertheless, it may be useful to indicate the two different directions for the further development of integrated assessment models: more comprehensiveness and empirical detail on the one hand, and more complex structures on the other. Both are needed.

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Biographical Sketch

H. Asbjørn Aaheim (born 1951) is a senior research fellow at CICERO (Center for International Climate and Environmental Research), Oslo in Norway. He was educated at and graduated from the University of Oslo in 1978. From 1978 to 1993 he worked at Statistics Norway with resource accounting and analysis of oil production and energy markets. Since 1993 has been at CICERO, where he has been working primarily with cost-benefit studies of environmental policy. He was lead author of the second assessment report of the Intergovernmental Panel on Climate Change (IPCC) on the applicability of cost benefit analysis of climate policy. He has written several papers on multi-gas abatement of greenhouse gas emissions, and on ancillary benefits of climate policy. In recent years his orientation has been against the intertemporal aspect of climate policy, and decision making under uncertainty. He is also working with macroeconomic models, and development of integrated assessment models.