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Climate change adaptation in developing countries: issues and perspectives for economic analysis

Muyeye Chambwera

Jesper Stage

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ABOUT THE AUTHORS

Muyeye Chambwera is a Senior Researcher and Economist for the Sustainable Markets Group at IIED.

Address: International Institute for Environment and Development, 3 Endsleigh Street, London WC1H 0DD, United Kingdom
E-mail: Muyeye.Chambwera@iied.org

Jesper Stage is an Associate Professor in economics at the University of Gothenburg, Sweden.

Address: Department of Economics, University of Gothenburg, PO Box 640, 405 30 Gothenburg, Sweden
Email: Jesper.Stage@economics.gu.se

Sustainable Markets Group
International Institute for Environment and Development (IIED)
3 Endsleigh Street
London WC1H 0DD, UK
Tel: 44 20 7388 2117 (international); 020 7388 2117 (UK)
Fax: 44 20 7388 2826 (international); 020 7388 2826 (UK)

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1 Key points

Adaptation to climate change needs to be seen as an integral part of a country's development planning, rather than as a separate issue, and adaptation measures that lead to better overall development outcomes are preferable to ones that focus exclusively on adapting to climate change impacts while ignoring other stresses.

As part of this mainstreaming, economic evaluation of alternative adaptation measures should entail cost/benefit analysis (broadly defined) of those measures, relative to a baseline that includes the effects of climate change if no adaptation is carried out.

All other development planning should also include the effects of climate change as a baseline, rather than assume a false status quo scenario.

Evaluation methods that implicitly compare adaptation measures with an imaginary baseline where climate change is not taking place run the risk of biasing policy towards less costly adaptation, or towards not carrying out adaptation measures at all, rather than towards those measures that yield the highest net benefits. Thus, such methods should be used only with great care.

Governments and policymakers cannot consider their own adaptation measures in isolation; they need to incorporate the fact that their policies will affect the behaviour of firms and households, and include estimates of these changes in behaviour when they compare the effects of different adaptation measures.

Impacts on agriculture are likely to be an extremely important part of the overall impact of climate change in developing countries. In many developing countries, own production of food is still an important part of farming, making economic analysis complicated.

Ricardian analysis entails using current production patterns in regions with different climates to predict how farmers are likely to adapt when the climate shifts. Used wisely, this method can probably provide the best guide to assessing autonomous adaptation on the part of farmers. This can help inform development planning in agriculture by identifying possible constraints to adaptation.

Most estimates of the welfare impacts of climate change made so far have used willingness to pay (WTP) measures. However, the fact that developing countries have not caused the problem implies that the appropriate welfare measure is willingness to accept (WTA) rather than WTP. Given the huge changes involved for many of the people who will be affected, this means that the welfare losses may be considerably higher than the WTP measures indicate.

The standard toolbox used in cost/benefit analysis is still useful for assessing adaptation measures, provided that the correct baseline is used.

2 Introduction

This paper is intended to provide some guidance to the policy-oriented researchers' work on valuing climate change adaptation in developing countries. The paper is not intended to be exhaustive, merely to indicate some issues that it may be useful to consider when designing studies to value the impacts of climate change in practice in developing countries. Practitioners are well advised to consider also the huge existing literature on climate change adaptation and on valuation.

The economics of adaptation touches on several levels, from the global to the local. At the global level, policies that support effective adaptation at the local level require credible evidence from the local level, taking into account the microeconomic dynamics of those who need to adapt to climate change. At the local level, the separation between climate change adaptation and development is less evident, whereas at the global level the separation is possible. These differences make it complex to tackle the economics and the policies in one generic model or approach. There is clear value in giving climate change focused attention because of its urgency. The anthropogenic nature of the causes of climate change also justifies the separate attention that climate change receives in the global climate change processes. This paper acknowledges this, but does not focus on these issues. It rather focuses on the economic issues at play in developing countries where adaptation is most needed, and where a host of other constraints have to be addressed at the same time.

The objective of this paper is to develop a framework for analysing the costs and benefits of climate change adaptation in developing countries and the specific contexts in which these could be applied in potential IIED work on the economics of adaptation. This framing is based on earlier conceptual work, for example by Stern (2006) on the economics of climate change, and on measures of adaptive capacity, for example by Vincent (2007), as well as issues arising from these initial studies. It is also informed by IIED's work in identifying adaptation issues prioritised in seven least developed countries. Rather than prescribing a rigid framework, it presents just one of the several approaches for taking the economics of adaptation to the country and local level, an area that is lacking in the literature.

The paper begins by confirming the current state of knowledge on climate change. It then discusses the conceptual issues involved in cost/benefit analysis of climate change adaptation. Following this, it deals with some specific issues involved in analysing adaptation in developing countries, notably the importance of subsistence and near-subsistence production. After an overview of the current state of the literature, the paper considers potential future work in this field based on work being undertaken by IIED. The paper ends by reviewing some potential conclusions.

3 The state of climate change knowledge

There is now general consensus on the reality of climate change (Reid and Huq, 2007), with scientific evidence of its anthropogenic drive getting stronger (IPCC, 2007; Stern, 2006). From studies informing its Fourth Assessment, the Intergovernmental Panel on Climate Change (IPCC) has been able more confidently to express the influence of regional temperature changes on many physical and biological systems. For example, the number and size of glacial lakes in the Arctic and Antarctic regions have increased owing to the melting of glaciers; hydrological systems have been affected; and there have been changes in terrestrial ecosystems, such as poleward and upward shifts in plant and animal ranges (IPCC, 2007).

Anthropogenic carbon emissions have been an important driver of these temperature changes. Between 1970 and 2004, greenhouse gas (GHG) emissions caused by human activities increased by 70 per cent (IPCC, 2007). Emissions of carbon dioxide (CO_2), the most important GHG, grew by about 80 per cent between 1970 and 2004 and by 28 per cent between 1989 and 2004. The IPCC Fourth Assessment (2007) claims that it is 90–99 per cent likely that the rise in global temperature seen since the mid-19th century has been caused by human activities. There have also been advances in the knowledge pertaining to the impacts of climate change in different sectors and geographical zones. The key sectors for which general impacts are expected are:

- freshwater resources
- ecosystems
- food, fibre and forest areas
- coastal systems and low-lying areas
- health
- industry, settlement and society

In terms of the geographical aspects of climate change, impacts have generally been characterised for Africa, Asia, Latin America, Australia and New Zealand, Europe, North America, the polar regions, and small islands. GTZ (2007) also characterised the vulnerability and adaptive capacity of developing countries by region – Africa, Asia, Latin America and small island states. In developing countries, risks are higher in agriculture, fisheries and other components that constitute the livelihoods of rural populations (Adger *et al.*, 2003). With impacts on so many sectors, climate change is a threat to global security and indeed to the attainment of developmental goals such as the Millennium Development Goals; see, for example, Oxfam (2007).

The IPCC projects that global GHG emissions will increase by 25–90 per cent (measured in CO_2 equivalents) between 2000 and 2030. This will cause further warming and induce changes in the global climate system during the 21st century (IPCC, 2007). Even if GHG concentrations were to be stabilised immediately, climatic processes and feedback timescales will make anthropogenic warming continue for centuries.

The climate change discourse focuses on mitigation and adaptation. Given the nature of the known impacts of climate change, it is highly desirable to minimise it through efforts that slow down its main driver – emissions of GHGs. However, past emissions are already having unavoidable climate change impacts. Current emission levels are also still high and will continue to be so for several years before stabilisation. Their impacts on climate require adaptation now and in the years to come.

Mitigation refers to interventions or policies to reduce emissions or to enhance the sinks for greenhouse gases. Thus, mitigation is a key long-term solution to addressing climate change and minimising its negative impacts in the future. Significant efforts and resources are currently devoted to mitigation. Various instruments are in place at global, regional and national levels to promote mitigation, including those that involve private sector participation. However, the imminent impacts can be addressed only through adaptation, because mitigation cannot reverse the impacts of past and current emissions or of unavoidable future emissions.

Adaptation, according to Adger *et al.* (2003), is the adjustment of a system to moderate the impacts of climate change, to take advantage of new opportunities or to cope with the consequences. The Stern Review (Stern, 2006) relates adaptation to building resilience, and recognises that it will be a key response to reduce vulnerability to climate change. Adaptation is not limited to discrete projects (Leary, 1999), such as dams and sea walls. It includes a wide range of adjustments by entities such as households, firms and other institutions in response to the effects of climate change and variability. These include such activities as managing natural resources, input mixes in production, and changes in laws, programmes, policies and investments. According to Metroeconomica (2004), adaptation to climate risks is important for the following groups of stakeholders:

- managers of businesses that are currently affected by weather or climate directly or indirectly
- those making decisions with long-term consequences for land use, built assets or population groups
- infrastructure and business areas that are sensitive to climate changes
- contingency planning
- those agents who want to gain an 'early-mover' advantage on climate change business opportunities.

Dealing with the unavoidable impacts of climate change requires adaptation, but adaptation has its own limits: it can address only known impacts and only in the near term. Moreover, although all societies are fundamentally adaptive, some sectors are more sensitive and some groups are more vulnerable than others. Climate change is a global problem, but the need for adaptation is higher among developing countries (Reid and Huq, 2007; Adger *et al.*, 2003). Here, societies are more vulnerable owing to their geographical location (for example, being prone to drought, floods and so on), their reliance on resources sensitive to climate change and their low adaptive capacity.

In the short term, mitigation and adaptation will not substitute for each other; that is, current reductions in emissions will not avoid the necessity to address the effects of climate change that are already being felt. However, the need for adaptation in the long term can be reduced by current mitigation. The reality of climate change is that it will be around for the foreseeable future because of the emission levels associated with the developmental and lifestyle paths to which the world is already committed, and from which we cannot withdraw immediately.

It is recognised that the solution to human-induced climate change ultimately lies in mitigation. However, it is also recognised that stabilising emissions, or reducing them to levels that do not affect climate, will not happen immediately. For a considerable period into the future, the world will therefore be exposed to climate change impacts resulting from past, present and future emissions. With the slow pace of mitigation, adaptation to climate change is the only option, especially in those areas and among those groups that are most vulnerable – the poor and developing countries. Stern (2006) acknowledged that these poor countries and communities would also be affected earlier than the richer countries and emphasised the need for accelerated adaptation in low-income countries, yet it is in these countries that adaptation is least easy.

Formally, the dilemmas of climate change adaptation in developing countries were recognised at the Seventh Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2001 in Marrakesh (Adger *et al.*, 2003). There is still much to do in order to stimulate adaptation, including some detailed economic analyses. Our attention therefore focuses on adaptation, because mitigation is already receiving a lot of attention, including private sector initiatives. Climate change poses a huge threat to the development of poor countries and the livelihoods of their people, especially those of the very poor. It puts at risk many of the gains made so far. It is with this in mind that we also focus on adaptation in developing countries. We note that developed countries are less vulnerable than developing countries because they are better resourced and there is already significant adaptation going on in developed countries.

4 Conceptual framework for economic analysis

In general, adaptation to climate change presents itself as an economic problem because it addresses the bigger problem of allocating scarce resources to attain sustainable development. Ignoring climate change by not building adaptive measures will eventually damage economic growth and other aspects of human and natural wellbeing, and threatens to reverse the gains made in these areas over the past several decades. The risks posed by climate change to development will be managed more efficiently by putting them in the mainstream of development (GTZ, 2007).

The impact of climate change on human, environmental and economic systems is a cost that can to some extent be avoided by applying appropriate adaptation measures, but there are costs associated with these (Stern, 2006). However, the resources put into adaptation represent an investment, which should be decided upon in relation to the competing demands for the available resources. This presents actors with a basic economic problem of how much to invest in adaptation, given the expected outputs or benefits. Limited resources have to be allocated or reallocated among several alternatives so as to maximise welfare. This problem confronts actors at all levels, from local to global. Decisions range from household-level welfare to global sustainable development perspectives, including the need to attain the Millennium Development Goals. According to Stern (2006), the decisions have to deal with long time horizons, incorporate risk and uncertainty, and examine possibilities of major irreversible changes.

The economic dimension of climate change adaptation has also been expressed in welfare terms by Stern (2006). In this perspective, climate change damage associated with moving from an existing to an altered climate represents a welfare loss, which is reduced by adaptation. Ingham *et al.* (2006) put the welfare dimension in a dynamic setting involving choices about how much to adapt and mitigate, given the costs and benefits, in order to maximise welfare. Decisions have to be made about whether or not it is worthwhile to adapt, given the consequences, the level and the timing of adaptation. The other common question on the economics of adaptation is how much it will cost to adapt (see, for example, Oxfam, 2007). In view of this, key adaptation decisions are being, and will continue to be, taken that require economic backing. Adequate economic knowledge is required (GTZ, 2007; Stern, 2006), and it is necessary to generate sound economic information and methods to aid these adaptation decision-making processes.

Before undertaking economic analyses, there has to be a client to whom this is valuable. There have been several statements on and prominence given to the need for an economics of adaptation, ranging from general economic analysis to specific analysis, such as estimating the costs and benefits of adaptation (for example, Stern, 2006; IPCC, 2007; European Environment Agency, 2007; Fankhauser, 2006; Oxfam, 2007). This suggests that there is a demand for economic data.

Various stakeholders have different needs, including global stakeholders (such as the UNFCCC and donors), national governments, local authorities, communities, households, businesses, researchers and academics. For one entity, economic analysis is necessary to determine whether or not it is worthwhile doing any adaptation at all. For another entity, economic analysis can be used to prioritise or choose the most appropriate adaptation option. In some cases, economic data may be needed to raise awareness about the likely impacts of climate change , for example on an economy or its sectors, thereby emphasising to government the urgency of planning adaptive measures to avoid the costs of climate change.

Needless to say, countries have to consider climate change in their development strategies, because climate change will be an important constraint on the choices that are likely to be available to many countries. Similarly, other stakeholders will need to take climate change into account when carrying out long-term planning. However, there is nothing unique about climate change in this regard; developing countries are subject to many internal and external constraints and stresses that affect their choice of development strategies, positively or negatively. Changes in terms of trade, natural disasters, wars and other external factors, as well as internal factors such as weak institutions, corruption and domestic strife, all affect the portfolio of choices available, and all need to be considered when a country determines its development strategy. It may seem unnecessary to value the costs and benefits of a country's adaptation policy separately from the costs and benefits of other development policies that the country is pursuing, because in practice the adaptation policy will be part of an overall policy. Similarly, it is reasonable to assume that, even though firms and households will consider the need to adapt to climate change in their overall strategies, they will not do this in isolation from other decisions. Firms will presumably seek to maximise their profits regardless of the weather, and climate change will be only one of the many factors affecting their production and investment decisions. The same will presumably be true of households' consumption and savings decisions.

There are, however, at least two reasons to consider climate change adaptation separately from other issues affecting development, both of which are related to the way in which the international debate on climate change is framed. In international climate policy discussions, the estimated future costs of climate change impacts on individual countries are an important component in the debate on the allocation of emission rights and compensation criteria. Similarly, the costs and benefits of climate change adaptation have become an important part of the discussion in development aid. A developing country's capacity for providing credible estimates of the future costs of climate change, including the costs of adaptation to climate change, is therefore likely to affect its flows of development assistance, emission rights allocations and compensation for climate change impacts. It is, thus, in a developing country's interest to consider the climate-change-related costs and benefits of its development strategy separately from the costs and benefits of other components of its development strategy, at least when discussing its development strategy with other countries.

This discussion suggests that the valuation of climate change adaptation may be difficult in practice. Many decisions that incorporate climate change as part of the background will, nonetheless, not necessarily be seen as explicit climate change adaptation. In this context, it is useful to consider two components of climate change adaptation that are frequently discussed separately in the literature: autonomous adaptation and planned (or policy-driven) adaptation (Stern, 2006). Autonomous adaptation refers to adaptation decisions made not by government agencies but by private firms and households in order to adjust to the realities of climate change. Planned adaptation refers to decisions that are made by government bodies.

Adaptation is also characterised by the nature of the responses by the agents identified above. These include discrete projects such as the construction of dams and sea walls, as well as a wide range of behavioural adjustments that households, firms and institutions make in response to the direct and indirect effects of climate change and variability (Leary, 1999). These adjustments can also be autonomous or planned (Stern, 2006). The management of resources, the methods and mixes of inputs used in production, the choices of household purchases and leisure activities, laws, programmes and policies, and investments are some of the areas where decisions are made by the different players at the different levels.

Table 1: Examples of adaptation types

Type of response to adaptation	*Autonomous*	*Planned or policy driven*
Short run	Making short-run adjustments, e.g. changing crop planting dates Spreading the losses, 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. 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 sea walls Avoiding the impacts, e.g. land-use planning to restrict development in floodplains or in areas of increasing aridity

Source: Stern (2006).

Both autonomous and planned adaptation will involve short-run and long-run responses, as shown in Table 1. Looking at these adaptation categories, it is clear that they will not consist exclusively of explicit adaptation decisions. Firms will presumably seek to maximise their profits and households their utility, no matter what the climate situation and no matter what planned adaptation policies are being carried out. The climate and the planned adaptation will affect what choices firms and households can make, and hence also affect their behaviour, but they will not affect their overall objectives; they will affect only how successful firms and households are in reaching those objectives. Similarly, governments will presumably seek to maximise the welfare of their citizens regardless of the climate, and will (mainly or exclusively) carry out planned adaptation policies when the expected welfare effects of these policies are positive, even if this means that not all possible climate change adaptation is carried out.

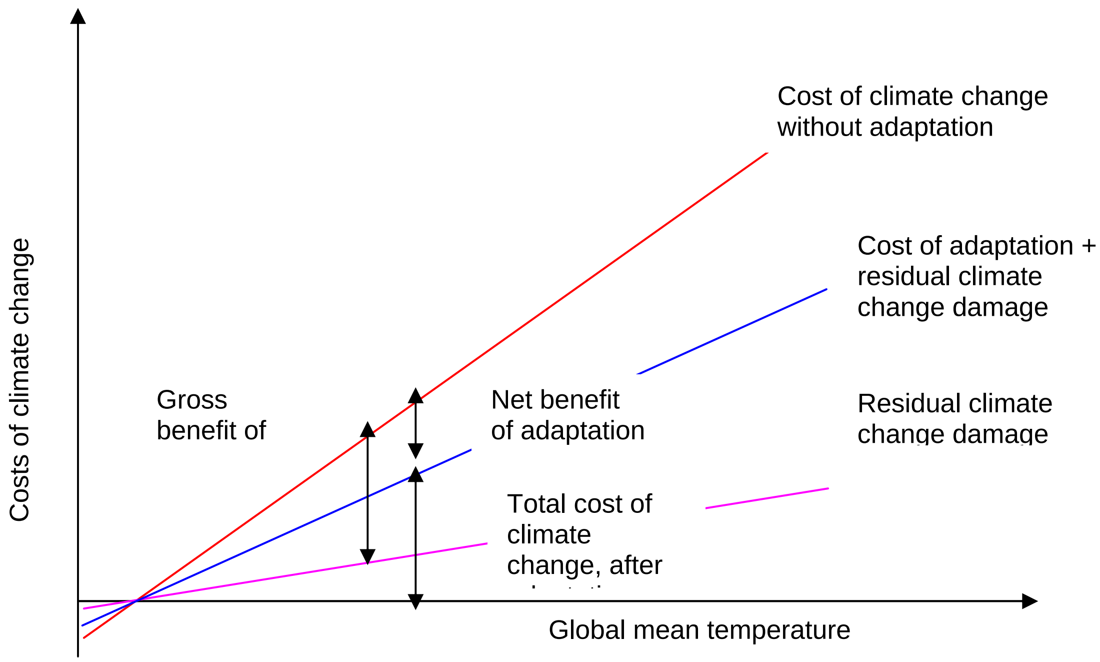
In practice, this means that cost/benefit analysis, in a broad sense, is likely to be the only framework within which it is meaningful to assess climate change policies (Metroeconomica, 2004; Lecocq and Shalizi, 2007b; Agrawala and Fankhauser, 2008). Most other frameworks, such as cost-effectiveness analysis, will work well only when the adaptation policy is the main or single government policy objective; in practice, this is rarely the case. Moreover, in practice there is considerable risk that cost-effectiveness analysis and other partial methods will lead to the adaptation measures, and their costs, implicitly being compared with the current status quo rather than with the climate-change-affected 'no adaptation' outcome that will prevail if nothing is done. For cost/benefit analysis, where the correct procedure is to compare the alternatives actually available, the appropriate approach is to compare adaptation measures with the outcome that will prevail in the absence of adaptation (Lecocq and Shalizi, 2007b). Thus, comparing adaptation measures with the current status quo is explicitly incorrect, which is not the case with other methods where there is no explicit alternative option being considered. When adaptation is only one goal among many, the best way of comparing different outcomes or policies will be to compare their overall welfare effects. This can ensure that climate adaptation is seen as an integral part of development policy, rather than as a costly and unnecessary extra.

This is complicated in practice, unfortunately. In many cases, the economic effects of climate change are highly uncertain (for discussions of the implications of this in practice, see, for example, Tol, 2003; Tol and Yohe, 2007; or Clarke, 2008)); in many cases, the exact benefits of adaptation measures are also uncertain (see, for example, Lecocq and Shalizi, 2007a). Thus, any evaluation of adaptation measures will have to be made using an uncertain baseline scenario where no adaptation measures are carried out. The alternative is to evaluate adaptation measures against the status quo, which will tend to bias evaluations towards less costly measures and towards measures that would increase welfare in the absence of climate change but would not necessarily do so in its presence.

The Stern Review developed the main framework for analysing the costs and benefits of climate change adaptation. The framework is based on intertemporal benefit/cost analysis in a welfare economics framework. We present this framework first, and in some detail.

With the science of climate change as the point of departure, an increase in the global mean temperature leads to climate change, whose impacts represent a cost to society (the costs of climate change), as depicted in Figure 1. Adaptation reduces these costs, but not completely, such that there will always be residual damage costs. The difference between the cost of climate change without adaptation and the residual cost of climate change after adaptation is the gross benefit of adaptation. Including the cost of adaptation reduces the benefit to the net benefit of adaptation. Figure 1 presents the costs of adaptation against the global mean temperature. Empirical analyses will involve time changes and changes in other factors that also change over time, thereby complicating this model.

Figure 1: The costs and benefits of adaptation



Source: Stern (2006).

Noting that the economics of climate change is shaped by the science, the structure of Stern's (2006) economic analysis is developed from the scientific underpinnings. The approach emphasises three themes, which feature throughout: uncertainty, risk and equity. It incorporates risk and uncertainty by presenting the trade-offs facing those planning adaptation under uncertainty (see Table 2). The stakes and risks are very high for the planner when both the cost of planning for climate change and the risks are high, and mistakes under these scenarios are costly. This reinforces the need for credible analyses and demonstrates the links between economics and the science of climate change.

Table 2: Risk and uncertainty in adaptation planning

Cost of planning for climate change	*Risks of climate change*	
	Low	*High*
Low	Low risk	Plan for climate change
High	Do not plan for climate change	High risk

Source: Stern (2006).

As a benchmark for evaluating the costs and benefits related to climate change, let us consider a counterfactual situation where no climate change is expected, and where firms and households make their decisions based on the assumption that no climate change will take place. Now let us introduce climate change of a certain magnitude into the discussion. In the absence of any adaptation, autonomous or planned, the net welfare effect on society would almost certainly be negative;[1] many agents will be making decisions that would have been appropriate without climate change but that are no longer appropriate with climate change. Clearly, it is unlikely that firms and households will act in this way in practice. Even if there are no government adaptation measures, many firms and households will change their behaviour as a result of climate change, and as a result of this autonomous adaptation they will be better off than if they had ignored climate change in their decision-making. In many countries, however, the net effect of climate change will nonetheless be that aggregate social welfare is lower than it would have been without climate change. This remaining difference may be seen as the net cost of climate change to this society, after adjusting for autonomous adaptation.

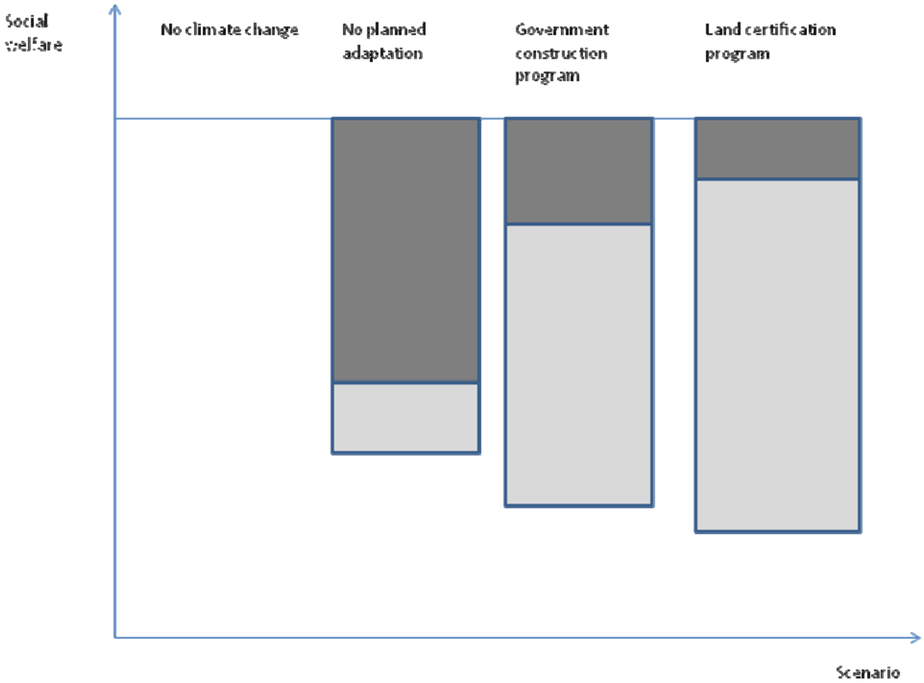
If government also changes its behaviour in order to adapt to climate change, we will have both planned and autonomous adaptation. The decisions made by the government will affect the portfolio of choices available to private agents and will also affect which of these choices the private agents choose to make (Lecocq and Shalizi, 2007a). Hence, the government's planned adaptation measures will have indirect effects on private agents' autonomous adaptation measures. A government policy may lead to less autonomous adaptation, by making autonomous adaptation less necessary or by reducing the number of available options, or to more autonomous adaptation, by making a wider range of autonomous adaptation decisions profitable to firms or households. This means that, when evaluating a potential planned adaptation policy, one also needs to predict the response of private agents to this policy. The net impact, again, can be seen as the overall net cost of climate change, given this planned adaptation policy. A government choosing between different potential planned adaptation policies can thus do so by looking at which policy leads to the highest social welfare and, hence, the least loss compared with the counterfactual scenario in which climate change does not occur.

Let us consider a concrete example (see Figure 2). Suppose that, in the absence of any adaptation measures, agricultural production in a region is expected to decrease as a result of the increased incidence of flooding caused by climate change. Suppose that it is known that the loss of production would be greatly reduced if farmers were to dig ditches to reduce the risk of flooding. Further suppose that frequent land reallocations mean that farmers can reasonably expect that the land will soon be redistributed so that, if they dig ditches, most of the future benefits of this will accrue to someone else. In this situation it is likely that, if there is no planned adaptation, autonomous adaptation (in the form of digging ditches) will be limited and that the welfare losses associated with climate change will therefore be large,

[1] In theory, one may envisage a situation in which many agents are extremely constrained in their available choices by external factors and where climate change, by sheer accident, makes many agents better off because the choices to which they are constrained are more appropriate with climate change than without it. The likelihood of this happening in practice is limited, however. Even in cases where countries gain from climate change, this will mainly be because climate change makes new choices available, not because it makes the old choices more appropriate.

because the only autonomous adaptation actually taking place will be in the form of minor changes in farming practices. The welfare losses are illustrated in the ‘no planned adaptation’ scenario in Figure 2; the entire grey area shows the welfare loss that would occur if no autonomous adaptation were to take place; the light grey area shows the part of this welfare loss that is avoided thanks to the autonomous adaptation that does take place, and the dark grey area shows the welfare loss that remains.

Figure 2: Illustrating welfare effects of adaptation decisions



Source: Authors

One potential policy measure in order to reduce the overall welfare loss might be government construction projects aimed at digging ditches. This would make better crop choices possible for the farmers and hence lead to more autonomous adaptation, so that the welfare gain compared with the situation without planned adaptation might be substantial even with the cost of paying workers to dig the ditches. In Figure 1, this is shown as a larger grey area overall than in the ‘no planned adaptation’ scenario (because carrying out the government construction programme is more expensive than not carrying it out) but a smaller remaining welfare loss once autonomous adaptation is included, because the benefits of adaptation would also be greater; the net result would be a welfare gain compared with the scenario where no adaptation takes place.

Another potential policy measure might be to increase farmers’ security of tenure through land certification or titling schemes. This would make the farmers more likely to dig ditches of their own volition, and would thus also increase overall welfare compared with the scenario where no planned adaptation takes place. In addition, a land titling or certification scheme might affect farmers’ overall investment and soil management strategies and have additional positive impacts on production, further reducing the net effect of climate change.

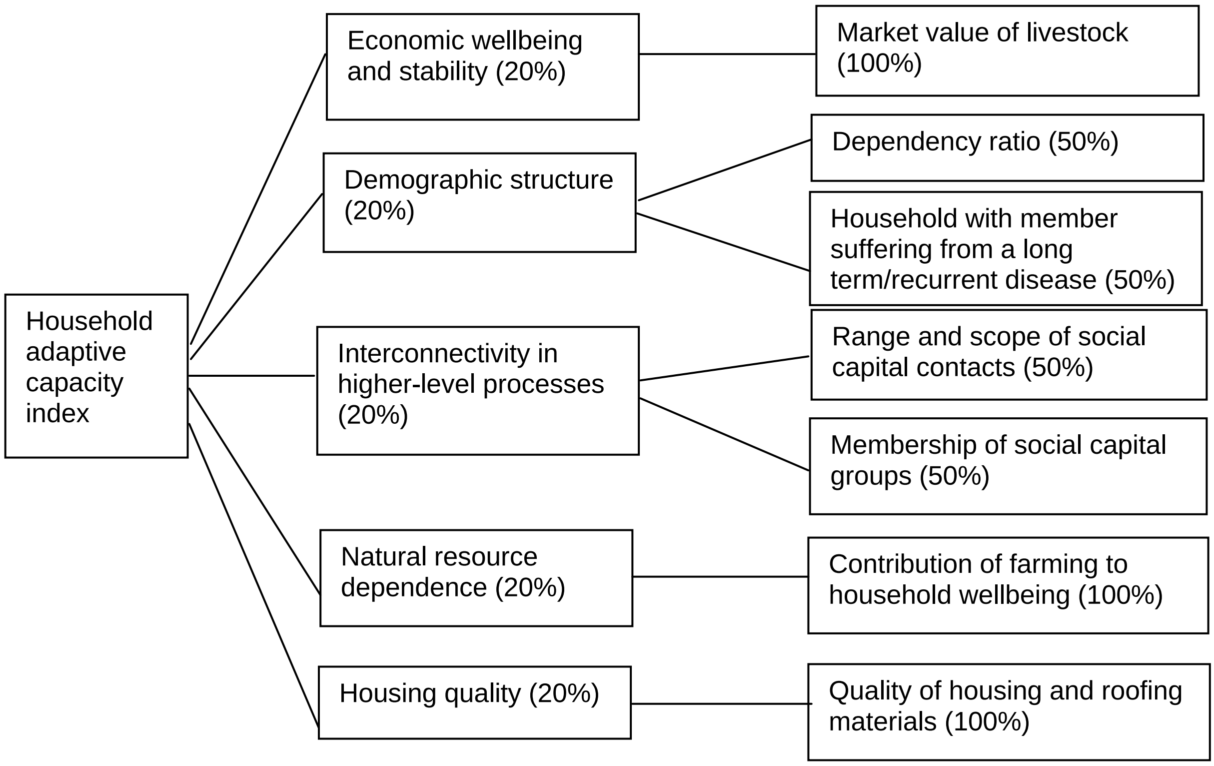
Which of these two planned adaptation measures would have the best overall impact on social welfare would depend on the relative costs of construction workers in the first scenario and of government surveyors in the second, but would also depend on the estimated magnitudes of the impacts on farmers’ autonomous adaptation behaviour. In Figure 2, the scenario in which tenure security is improved is the best, but one might also imagine a scenario in which land titling is sufficiently expensive that government-funded construction of ditches would be more attractive.

We may note that, in this example, many would consider a land titling scheme not as a climate change adaptation measure but, rather, as a component of overall agricultural policy. However, if the expected net effect of land titling were positive without climate change, the government would presumably already have carried it out. It is only the additional effect of climate change that makes the expected net present value of the titling scheme positive, by increasing the importance of enhanced adaptive capacity on the side of the farmers. More broadly, given the uncertainty associated with climate change projections in general, and with many country and regional projections in particular, several measures that improve firms' and households' adaptive capacity are likely to become attractive as a means of insurance against the worst-case outcomes.

A separate but related issue is that of proactive versus reactive adaptation; that is, whether countries should undertake measures aimed at handling anticipated but uncertain future problems of climate change, or whether they should wait until the problems have appeared and their extent is known with greater certainty (Lecocq and Shalizi, 2007a). Obvious arguments for waiting would be that, the later the adaptation costs are undertaken, the lower the present value of those costs will be, and that waiting will provide more information on the actual magnitude of the problems. An obvious argument against waiting would be that delaying adaptation may lead to far greater adaptation costs at the point when the costs are realised. A less obvious argument (made, for instance, by Lecocq and Shalizi, 2007b; Mathews, 2007; and Chhibber and Laajaj, 2008) is that introducing new technology tends to have spillover effects on human capital formation that can enhance growth; thus, given that the adaptive technology will need to be introduced at some point in any case, it may be better to introduce the technology earlier and hence get the spillover benefits sooner.

Vincent (2007) gives the main factors that constitute the adaptive capacity of a country, and their proportions, as: economic wellbeing and stability (20 per cent), demographic structure (20 per cent), global interconnectivity (10 per cent), institutional stability and wellbeing (40 per cent) and natural resource dependence (10 per cent). Does adaptation have to address all these? If they are not addressed, interventions may not have long-lasting impacts. How can they be factored into the costing of adaptation, and in what form are the benefits observable?

Figure 3: Structure of household adaptive capacity index



Source: Vincent (2007).

It is possible to get indications of adaptive capacity from national-level indices but the task is more complex at the local level, and indices will change from one area to another in the same country and from household to household. Vincent (2007) also provides the main elements that constitute the structure of a household adaptive capacity index (see Figure 3), which is useful for carrying out analyses at the local level. Again, representing the costs and benefits of providing these to a level of acceptable adaptive capacity is an issue that analyses at the local level are confronted with.

5 Issues related to valuing the impacts of climate change

It is expected that climate change will have impacts on most parts of society in most of the countries of the world, and many organisations are already carrying out projects aimed at assessing the costs and benefits of climate change and of various adaptation strategies. The added value of having IIED involved in this work too lies in IIED's traditional focus on marginalised communities. In the context of climate change valuation, many of the studies carried out so far have focused on impacts on GDP and on components of GDP, to the exclusion of impacts on other components of social wellbeing (Halsnæs and Verhagen, 2007). Although these measures can be useful as indicators of countries' overall capacity to adapt to climate change, they provide only an incomplete picture, especially for developing countries.

In many developing countries, a large part of agricultural production, and frequently also other primary production such as fishing, is a subsistence or near-subsistence activity, carried out by households and buffeted by numerous stresses and constraints that are not part of the formal economy. This means that this production, although crucial for the livelihoods of many people in developing countries, is often completely ignored in economic statistics. Even when it is included in economic statistics, the monetary value of this production is frequently low. This means that, if climate change affects the subsistence component of the primary sectors in developing countries, the impacts on many people's livelihoods may be devastating without having much impact on GDP. Thus, a recent study of possible climate change impacts on Namibia (Reid *et al.*, 2008) concluded that, even in the worst-case scenario studied, overall GDP might fall by only 5 per cent or so – yet half of the population would have their livelihoods destroyed and would have to find new means of survival, leading to almost unthinkable strains on social cohesion. Focusing on GDP alone can give a completely misleading picture even in a middle-income country such as Namibia, not to mention lower-income countries. For countries where subsistence production is important, the impacts of climate change on this production will have to be modelled explicitly in order to give some idea of what the overall impacts on livelihoods will be.

In this section we therefore focus on impacts on marginalised groups living at subsistence or near-subsistence levels. We begin the section, however, by discussing some other issues that have been raised in the debate and that have a bearing on the valuation of climate change in developing countries. Some of these are common to any economic analysis of climate change; others are likely to be especially important in developing countries. This overview is not intended to be exhaustive but aims merely to mention some of the issues.

5.1 Data availability

The economic case for climate change adaptation and any planned activity is backed by data. Data are required for several purposes, including raising resources for adaptation and determining whether or not it is worthwhile to undertake adaptation, how much to invest in adaptation, the cost-effective methods of adaptation, and so on. The IPCC's Fourth Assessment also recognises the need for a good understanding of the costs, barriers and limits to adaptation, which are not well established at the moment. In fact, according to Stern (2006), adaptation is an issue because it has costs associated with it, and these can be properly established by data on how much adaptation is going to cost. The first issue therefore is the state of the data available on the economics and, more specifically, the costs and benefits of adaptation.

One of the most difficult issues that economists have had to deal with is the estimation of the costs of climate change. This is at the core of the economics of the subject. Because cost is the major barrier to effective adaptation, most of the early work has focused on estimating how much adaptation is going to cost. This is required in mobilising resources and determining whether or not it is affordable and worthwhile. Attempts have been made to address this (for example, Stern, 2006; IPCC, 2007) by providing estimates of the expected losses owing to climate change and of the costs of adaptation. Figures are mostly provided as percentages of global GDP. The usefulness of global estimates has been challenged by, for instance, Meyer and Cooper (1995) and Huq (2006) because of the abstract level at which they are applied. According to Huq (2006), for example, the use of global costs and benefits of adaptation (often expressed as a share of global GDP) presupposes a global decision maker, whereas in the real world this does not exist. These figures make little sense at national and lower levels; neither do they show the distribution of the costs and benefits. The first issue, therefore, is about the usefulness of global estimates in reflecting the resources required without specifying where these are required most and where the net benefits are higher. If cost is expressed as a share of GDP, it changes from country to country, especially between developed and developing countries and between emitting countries and the victims of climate change in vulnerable places.

Most of the existing estimates of costs and benefits are based on very few case studies, and figures from isolated, highly dissimilar areas are grossly aggregated to provide global figures. Not considering the methods and details captured when arriving at location-specific figures, the differences in regions and countries expose them to climate change impacts and risks differently, and the costs of adaptation take on very different shapes. For example, different countries that are subject to sea-level rise, floods or droughts require different adaptation measures to different levels. It is therefore not accurate to aggregate estimates from a few countries to a global level by using population, GDP or area. Similarly, adaptation in some countries requires a focus on awareness whereas in others it requires infrastructural measures.

Until recently, there have been few credible estimates of the costs and benefits of adaptation in developing countries, and many of the estimates now being developed remain highly speculative (Stern, 2006). This is a reflection of both the attention given to the economics of climate change in these countries and the limited applicability of existing methods to developing-country contexts. This is complicated by the fact that adaptation itself in developing countries is complex, cutting across the social, economic and developmental sectors of these countries. The need for adaptation is stronger and more urgent in developing countries, where vulnerability is higher and the impacts will be experienced sooner (Stern, 2006). For example, in Africa, one of the most vulnerable continents, between 75 and 250 million people are expected to be exposed to water stress by 2020 because of climate change. Similarly, freshwater availability in Central, South, East and Southeast Asia is projected to decrease by the 2050s. Adaptation in developing countries alone, however, will cost tens of billions of dollars according to Stern (2006). More accurate data are required from these countries and regions.

The figures available on the same factor change from one source to another. This is to be expected, given the methods used and the areas to which the base figures pertain. It is, however, a reflection of the fact that the data are still improving and more factors are being taken into account in coming up with the estimates. For example, National Adaptation Plans of Action (NAPAs) provide cost estimates for only the most urgent and immediate adaptation, ignoring both current and future adaptation costs that are not classified as urgent. Oxfam (2007) identifies some of the areas with high but hidden adaptation costs, such as protecting ecosystems, preventing gender inequality, providing global public goods such as research and documentation, and addressing unknown impacts.

As discussed earlier, adaptation can be planned or autonomous. The data currently available do not identify this distinction. Selecting the ideal mix of the two is likely to be important in developing countries, and the cost and effectiveness of each approach is also an important consideration that merits economic analysis. The economic data required for designing such a policy mix are currently unavailable.

In order to assess the net costs and benefits of adaptation over time and the costs of climate change with and without adaptation, the impacts need to be projected into the future. There is also the need to build a projected baseline without climate change and without adaptation (European Environment Agency, 2007). It is complex enough to project the impacts of climate change on some key trends such as yields; projecting their trends without climate change and with and without adaptation is even more complex. As climate change adaptation progresses, economic analyses will shift from merely estimating the costs and benefits of adaptation to including other aspects such as monitoring and evaluation of progress. This will require advance planning and collection of data to build baselines.

The general conclusion from the data available is that more specific and robust economic estimates are required to include both current and future needs. The next step in estimating the costs (and benefits) of adaptation is to go to real places and focus on the realities of those areas. The information generated should also be tailored for use in particular countries and localities and not just the global audience. Even in the specific countries themselves, the costs and benefits of climate change and adaptation make greater sense when applied to appropriate units that stakeholders deal with, such as the different sectors, instead of just global figures. NAPAs are one such attempt to take the analyses down to the country level.

5.2 Baseline development scenario

Any attempt to estimate the economic impacts of climate change needs to take into account the fact that many of the physical impacts of climate change are expected to appear only with considerable time lags. This means that comparing the counterfactual ‘no climate change’ scenario with the counterfactual ‘climate change but no adaptation’ scenario and with the actual ‘climate change and adaptation’ scenario, and doing this for several different possible outcomes of climate change, is a very tall order. Predicting the economic impacts of climate change along the lines outlined above entails predicting the future trajectory of an entire economy a century or more into the future, and doing so for a series of different scenarios and policies. Moreover, because the economic impacts of climate change on a particular country will depend crucially on the impacts and policies in other countries, this needs to be done for the entire world economy and, ideally, for the most important individual countries as well. One need only consider the state of the world economy a century ago, and imagine what types of projections would have been made then, in order to realise how difficult this endeavour is likely to be.

This does not mean that such an undertaking is pointless; the policies that we undertake today will have impacts on the future course of climate change, and the fact that it is extremely difficult for us to predict that future course is not an argument for not doing our best to consider these impacts when designing our policies. In addition to this, there is the moral problem that many of the impacts of climate change will be felt by people who have not contributed much to the problem. The fact that it is difficult to predict exactly how large are the future problems that the rich countries are causing for people in the poor countries is not an argument for ignoring those problems, either in policy design or in discussions of compensation.

5.3 Valuation techniques

The details of adaptation economics eventually run into the valuation and quantification of key inputs and outputs of adaptation, such as the impacts of climate change and the costs and benefits of adaptation. For example, the methodology for costing climate change impacts involves identifying and quantifying impacts, converting physical impacts into monetary units, calculating the resource costs of adaptation options, weighing the costs and benefits of adaptation options and choosing the preferred option (Metroeconomica, 2004). Most of these calculations involve non-market factors such as lives, adaptive capacity, and environmental goods and services. There are difficulties in placing a monetary value on climate change damage, because the costs are often long term, uncertain and unknown in advance (Meyer and Cooper, 1995). In the developing countries this is even more complex because of the interrelatedness and multi-use attributes of some factors. Not only are values difficult to estimate, but there are also controversies about the notion of expressing the values of other factors in monetary terms. Several techniques have been proposed in the literature for valuing different impacts, including market-based techniques such as replacement cost and non-market techniques such as hedonic pricing, travel costs and contingent valuation. Recognising the costs and time involved in carrying out primary studies for non-market values, Metroeconomica (2004) recommends the use of the benefit transfer approach, which transfers values from existing studies to the climate change context. This, however, can introduce errors, especially for developing countries. Benefit transfer from one country to another (or even within a country) needs to be done with great care, given how many other factors are likely to vary. Valuation is an issue that has especially confronted the field of environmental economics, and it inevitably confronts climate change adaptation economics.

The benefits of adaptation go beyond the sectors to which the adaptation effort is directed to other sectors (European Environment Agency, 2007). These ancillary benefits can be easily omitted from valuation studies, thereby underestimating the benefits of adaptation. If these pertain to the impacts of climate change, the costs can also be underestimated. This raises a related issue of the boundaries of analysis in an area with several spillover effects in the costs of climate change and the benefits of adaptation.

Another related issue is the manner in which to express the costs and benefits of climate change adaptation in different countries and at different levels, even if this does not require expressing them in a common unit. For example, one may express costs and benefits in terms of the share of GDP, which makes sense at the national level for decision-making, but at lower levels this may not make sense because the stakeholders do not operate on this basis. In the literature, some costs and benefits are expressed in terms of global GDP. This is applicable to only a limited extent because a specific share of GDP has different implications for different economies. It may stimulate some countries to act, but maybe not all. At the global level, the costs of adaptation have also been expressed as a share of development assistance, but this makes sense only to the donor community and not to recipient countries or communities. In addition, the different ways in which the figures are expressed makes it difficult to compare the different estimates, because they pertain to different reference units and the way they are arrived at.

5.4 Uncertainty

One of the barriers to adaptation is uncertainty and imperfect markets (Stern, 2006). Uncertainty about the future climate scenarios and their impacts is a major challenge to any economic analysis. This is compounded by the long-term nature of climate change. It presents difficulties in determining the types of adaptation required and when they will be required. Climate is not the only changing variable; other non-climatic variables, such as the adaptive capacity of society, are also constantly changing, both positively and negatively (O'Brien, 2004). Moreover, social and technological progress may reduce or accelerate the known impacts of climate change.

The issue that uncertainty raises is the extent to which economics remains a reliable decision tool. Efforts are therefore required to address this in the methodology so that the results of economic analyses are reliable and do not lead to wrong adaptation decisions, such as mal-adaptation (adaptation activities are undertaken when they are actually not required). Similarly, the ability to capture catastrophic events in the economics of adaptation needs to be well developed in the discipline. Capturing uncertainty in economic analyses is complicated by the fact that uncertainty is inherent in the science of climate change. This implies using scientific assumptions in addition to economic assumptions, which may undermine the reliability and robustness of the estimates.

Temporal uncertainty is compounded by spatial differences in the impacts of climate change that are inadequately understood. The impacts of climate change vary from one location to another, even in the same country. For instance, as global temperature rises, some regions in the same country are likely to receive higher rainfall whereas others are expected to receive lower rainfall. This makes economic analyses over larger scales less precise. If more accurate local-level analyses are to be carried out, what would be the appropriate spatial disaggregation?

5.5 Discounting

Analysing phenomena that span long periods of time requires determining the cut-off point for the model, given the knowledge available. The costs of climate change and the benefits of adaptation pertain to causes and effects that take place in very different time periods. These need to be captured in the analyses. The costs of adaptation can be related to specific time periods; an example is the development of adaptive capacity, which may span long periods of time.

Economic analysis uses discounting to address benefits and costs that occur in different time periods. Discounting gives current decision makers the monopoly to decide the state of the world in periods that they may not live in. However, we assume the rationality and objectivity of current decision makers.There is no consensus in the scientific community on the appropriate discount rate to use. Most analyses that employ discounting choose a discount rate through a combination of theoretical objectivity and ethical discretion. There is no universal discount rate, and assumptions about discount rates differ from country to country, with the time period involved and whether a study is local, national or global. Most benefit/cost analyses are criticised for the discount factor used. In fact, there are major debates on the Stern Review centred on the choice of the discount factor.

To illustrate the variation in discount rates by source, Ackerman (2007) analyses the criticism of Stern's choice of discount rate. The analysis shows that, apart from Stern's discount rate of 1.4 per cent, the UK Treasury's Green Book recommends 3.5 per cent, Partha Dasgupta suggests a range of 2–4 per cent and Martin Weitzman suggests 6 per cent (Ackerman, 2007). These differences arise because of the assumptions made about the rate of pure time preference and the wealth of current (compared with future) generations. There is by now a considerable debate on discounting climate change impacts (for some examples, see Arrow *et al.*, 1996; Stern, 2006; Nordhaus, 2007; Brekke and Johansson-Stenman, 2008; or Sterner and Persson, 2008). The key issue for any economic analysis is to use a discount rate that makes reasonable assumptions that are likely be accepted by other economists and that give plausible results. Looking at the debate on this issue within climate change and elsewhere suggests that there will not be one correct answer. However, researchers and analysts need to note that this debate is taking place and take it into consideration in their studies. Some kind of sensitivity analysis, using a range of different discount rates, will likely need to be applied in most studies.

5.6 Income elasticities

In the absence of climate change, many of the countries that are currently poor would have experienced considerable increases in average income over the coming century. It is to be hoped that this income growth will happen even with moderate climate change, although, if the more extreme climate change scenarios come to pass, any future increases in income will be in question.

Increased income means, among other things, that the demand for most goods and services will increase. This will affect the production of many goods and services and hence have general equilibrium effects. This, in turn, means that the economic impacts in different scenarios become even more complex to estimate. In addition to this, demand will increase for 'goods' where production cannot easily increase, such as environmental goods (Krutilla and Cicchetti, 1972). This means that, if climate change is expected to lead to, for instance, losses of pristine nature, this nature should be valued not at the value currently attached to it by a country's inhabitants but, rather, at the value that it is expected that future inhabitants would have attached to it given the expected income increases under the counterfactual 'no climate change' scenario. In practice, this means that, if environmental valuation approaches are used (which is likely to be necessary), income elasticities will need to be estimated so that future welfare losses can be estimated.

This also means that to the extent that climate change is expected to lead to losses of life – through catastrophic weather events, through reduced overall carrying capacity or for other reasons – the appropriate value of the statistical life measure for losses of life at a specific time is the one that would have prevailed at that time at the income levels in the 'no climate change' scenario. This will normally be a higher value than the one currently used in the country (Pearce *et al.*, 2006).

5.7 Relative prices

An issue that is linked to that of income elasticities, but still deserves separate mention, is that of relative price changes. The income increases in the different scenarios studied will all have general equilibrium effects and hence lead to different relative prices for many goods. In addition to this, there is the matter of losses of productive land (and perhaps land area in general) owing to climate change, which will lead to additional relative price changes. If land becomes scarcer as a result of climate change, this will in itself lead to relative price changes, with attendant general equilibrium effects (Sterner and Persson, 2008).

5.8 Level, scale and boundaries of analysis

The economic data on climate change and adaptation are available at various levels, and it is difficult to reconcile all these data at any single level. The structures of analytical units are not uniform at all levels. Global data do not represent realities at lower levels, and local-level data do not add up to higher-level aggregates. For example, one cannot use global data on the cost of adaptation expressed as a percentage of global GDP in order to estimate the cost of adaptation in specific countries. Similarly, cost data from NAPAs may not give the best estimates of global aggregates.

National-level climate change economic analyses normally deal with sectors, which do not obtain at the local level. This challenges the ability to extend higher-level analysis downwards or to use local-level case studies at higher levels. It is, however, important that higher-level analyses match the reality on the ground; the challenge is to use suitable structural units that can be linked across all scales.

Linked to the level of analysis is the issue of the scale of analysis. Climate change affects large scales, including large landscapes that transcend national boundaries. Its impacts (nature and intensity), however, are locally specific. This complicates economic analysis, which should be aligned with relevant decision-making structures that operate within different boundaries. Economic boundaries such as sectors (for example, the health sector) do not correspond with geographical boundaries such as ecosystems or ecological zones. Analyses carried out at a particular scale should be able to stimulate decision-making. For example, an analysis that shows the cost of not adapting to be high over a region covering several countries, it may not result in action if it does not allocate the costs of inaction to specific countries. For an economic study to have a policy impact, its objective function should relate to a specific unit that is amenable to decision-making.

5.9 Capturing change

Technical, socioeconomic, political and environmental changes will take place during the long time horizons in which phenomena such as climate change occur, and such time horizons also influence adaptation (European Environment Agency, 2007). Although there is a perceived positive correlation between economic development and adaptive capacity, this will be difficult to forecast into the future, especially in developing countries. The pattern of development will also differ from country to country and from region to region, so that aggregated analyses will not capture these changes accurately. Changes in factors such as the populations and demographic structures of different countries challenge the reliability of economic analyses if not captured. In the future, for example, more people are expected to be living in urban areas than is the case now in many developing countries. The need for adaptation will shift; so will the costs and benefits. To give accurate estimates, economic models need to capture these expected changes.

5.10 Willingness to pay vs. willingness to accept

In cost/benefit analysis, practitioners normally measure the willingness to pay (WTP) to avoid an environmental degradation rather than the compensation that will make people willing to accept (WTA) the degradation, even in situations where WTA would be preferable on theoretical grounds. The WTP concept is usually easier to get across to survey respondents, and there is less risk that the results will be muddled by issues of loss aversion. The pragmatic argument is that, even in situations where WTA is the conceptually correct measure, the two measures tend to differ only slightly. Therefore, a correctly measured WTP is likely to be closer to the mark than an incorrectly measured WTA (Willig, 1976; Randall and Stoll, 1980; Mitchell and Carson, 1989).

When valuing the impacts of climate change in developing countries, however, the difference between WTP and WTA becomes crucial, in both practical and moral terms. Most inhabitants in developing countries have no share of the blame for the problem, which has almost exclusively been caused by inhabitants in the rich countries. The issue is therefore not how much inhabitants of poor countries are willing to pay to prevent climate change; the issue is how much it is reasonable that the rich countries should pay in compensation for the damage that they are causing to inhabitants of the poor countries. It is important that developing countries make this argument in negotiations over climate change, and hence it is important that the valuation exercises actually carried out in these countries should be undertaken with this argument in mind.

In addition to this moral argument, it is well known on theoretical grounds that the difference between WTP and WTA (correctly measured) is far larger for goods or services that play a major role in the lives of the respondents, and where there are no close substitutes, than it is for goods and services that play only minor roles. Hanemann (1991), in his seminal paper showing this, explicitly noted that ‘in the limit, WTP could equal the individual’s entire (finite) income, while WTA could be infinite’. For many people in developing countries, the WTP to prevent climate change is likely to be very limited, simply because their incomes are very limited. Per capita production losses caused by climate change are likely to be small in absolute terms, because per capita production is low, and hence those affected by climate change can pay very little even if they pay almost all that they have. This does not mean that the welfare impacts for these victims are likely to be small. Climate change can be expected to destroy the current livelihoods of huge parts of the populations in many developing countries. The correct measure of welfare loss is not those populations’ low WTP for preventing the destruction of their livelihoods; the correct measure is the level of compensation that will make those populations accept having their livelihoods destroyed. This WTA is likely to be considerably higher than the WTP, even if correctly measured; this means that the compensation that developing countries should demand in climate change negotiations should be correspondingly higher than the value of the production losses caused by climate change.

5.11 Valuation of the impacts on subsistence and near-subsistence production

In situations where all important markets function well, estimating the economic impacts of climate change is straightforward in principle, once one has estimates of the physical impacts and once the issues raised earlier in this section have been resolved. All one needs to do is to estimate the supply and demand functions of all goods and services as functions of various underlying parameters, predict the changes in these underlying parameters, and predict the impacts of these changes in underlying parameters on the production and consumption of various goods, including indirect general equilibrium effects.

Needless to say, this is a tall order in practice. When dealing with subsistence and near-subsistence production, however, the situation is even more complex because there are additional issues making the estimation of supply and demand functions less straightforward than usual.

The standard neoclassical assumption of separability between production and consumption decisions is frequently problematic for subsistence and near-subsistence production, and more generally for production decisions in situations where important markets are missing (Singh *et al.*, 1986; de Janvry *et al.*, 1991). In the absence of credit markets and markets for crop insurance, farm households in many developing countries will not necessarily grow the most profitable crops. Rather, they will choose to devote some (or all) of their land to low-risk, low-yield crops in order to ensure that they will survive even in worst-case scenarios in which many of the crops fail. Similarly, if markets for farm labour or important intermediate inputs, for example, are shallow or nonexistent, farmers will be constrained in their decisions by the amounts of labour or inputs that they can provide themselves. They will optimise, not with respect to the observed market prices (if any), but with respect to unobserved shadow prices that may be higher or lower than the observed market prices and that will often be specific to the individual household.

There is an ongoing debate about how such market failures affect the extent to which, and how rapidly, farmers in developing countries adapt to climate change, and what the policy implications of this are. Adger (1999, 2003) finds that social and institutional capital is crucial for farming communities' capacity to adapt. Eakin and Appendini (2008) argue that traditional autonomous adaptation to climate variability is more flexible than planned adaptation activities are likely to be. Shewmake (2008), studying South African farmers, argues that many of them are highly vulnerable to climate fluctuations as it is, and hence risk being affected substantially by additional climate change. Eakin (2005) studies climate vulnerability in Mexican farming, and finds that market integration per se makes little difference for coping capacity; even farmers who sell most of their produce may, because of limited access to, for instance, credit or insurance markets, remain highly vulnerable to climate fluctuations. Groom *et al.* (2008) study the role of risk aversion for farming strategies of ostensibly profit-maximising commercial farmers in Cyprus, and find that perceived risk matters considerably even for these farmers. Musango and Peter (2007) claim that neither policymakers nor farmers know how sensitive different agricultural activities actually are to climate fluctuations, and study the scope for adaptation strategies given these limitations. Nyong *et al.* (2007) argue that African farmers already have a rich set of coping strategies that policymakers and others can draw upon; Barrios *et al.* (2008), on the other hand, argue that historical experience demonstrates that African farmers have little capacity to cope with climate fluctuations.

Candel (2007), Maddison (2007) and Nhemachena and Hassan (2007) discuss the importance of access to insurance and access to credit for autonomous adaptation. Osgood *et al.* (2008) study the scope for introducing crop insurance among Malawian farmers as a means of helping them cope with climate change. Cunha (2007) provides a qualitative assessment of index-based micro-insurance products as a potential market solution for reducing the vulnerability of the poor to weather shocks and climate change more broadly, with recent examples from a few countries, for instance India, Malawi and Ethiopia. In these cases, index-based insurance is being tested as a tool to hedge the risks of drought. The limited participation in market transactions of this type by the most vulnerable groups is a critical condition for the success of market approaches. This, however, should not prevent innovative approaches, including market approaches, from being used to stimulate adaptation. Appropriate policy signals may be the key requirement for this to happen. In terms of undertaking economic analyses, traditional approaches such as cost/benefit analysis may not be appropriate in such cases. Rather, financial viability and institutional feasibility will be critical.

It is clear that, for many farmers, the capacity to undertake autonomous adaptation will be constrained by a number of factors – institutional, social, economic and others. This has several implications for the estimation of the economic impacts of climate change. One implication is that simply estimating supply and demand functions, without taking such issues into account, will lead to severe flaws in the results if these issues are in fact important; instead, behavioural economics will need to be considered (Brekke and Johansson-Stenman, 2008). In some cases, shallow or nonexistent markets will cause price responsiveness in other markets to be highly limited. In other cases, price responses may have the 'wrong' sign or the wrong magnitude, compared with what they would be if all markets functioned. In both sets of cases, welfare impacts can be estimated correctly only by using the shadow prices, rather than market prices, of important goods and services.

Another important implication is that, even if one believes that the general equilibrium effects of climate change will be important for a specific country (which they may well be), markets for various goods and services in that country may be so fragmented that one needs to consider them as a large number of separate, possibly interlinked, regional markets rather than as nationwide markets. This means that simulations using CGE (Computable general equilibrium) models, or other attempts to simulate nationwide general equilibrium impacts, will need to model impacts in a number of regional markets rather than impacts in a single nationwide market. Thus, Rosenzweig and Parry (1994), who attempt to model the global food price impacts of climate change, do so using a set of linked regional models rather than a single global pricing model.

A third implication is that there is a range of possible planned adaptation policies. One of the most important reasons climate change is expected to have more adverse impacts in poor countries than in rich countries is that people in poor countries have less scope to adapt to changes in their living conditions. One reason for this is, of course, their low income, but another is precisely that so many markets are shallow or nonexistent, and this leaves households and firms little room for manoeuvre. Policies that improve the functioning of shallow markets, or that create markets where these did not exist before, can improve the scope for households and firms to undertake autonomous adaptation. Hence, well-directed policies aimed at such market problems may be able to leverage limited planned adaptation interventions into huge improvements in autonomous adaptation (Lecocq and Shalizi, 2007a).

A fourth implication is that estimating the economic impacts of climate change is likely to be orders of magnitude more complicated for many developing countries than for developed countries, even though the range of economic activities is smaller, precisely because autonomous responses are more difficult to predict in developing countries, where many producers and consumers will be responding to changes in shadow prices rather than in market prices. There is by now a considerable literature on modelling agricultural households (see, for example, Singh *et al.*, 1986, and Taylor and Adelman, 2003, for discussions of the literature). One thing that all these studies have in common is that they are highly data intensive. Modelling subsistence households well enough to estimate the economic impacts of climate change, even for a single agricultural region, is going to be a huge undertaking. Doing so for an entire country will be difficult in the extreme.

In practice, this means that less comprehensive methods for estimating the economic impacts of climate change are necessary. The most practical method (discussed in more detail below) is probably the Ricardian method. However, any analysis using this method (or other methods) will need to take into account the fact that many parameters are likely to be mis-estimated and that, as a result, the estimated economic impacts will be highly sensitive to limitations in the data. This is not a reason not to attempt to estimate economic impacts, but it does call for a great deal of humility in how the results are presented. Sensitivity analysis is always important in cost/benefit analysis, but even more than usual in this situation.

6 The current literature

Research on the economics of climate change adaptation in developing countries has been highly limited until recently, but the past few years have seen an explosive increase in interest. There are therefore undoubtedly works in progress and recently published working papers that are not covered by this review.

6.1 The overall economic impacts of climate change

A number of papers attempt to assess the overall economic impacts of climate change on one or several developing countries. The Stern Review (Stern, 2006) and the various DICE and RICE models (for example, Nordhaus and Boyer, 2003; Nordhaus, 2008) are, of course, seminal references, but there have been many prior and subsequent studies as well. Magadza (1994) estimates the impacts of climate change on a range of different economic activities in southern African countries, but does not consider general equilibrium effects of the projected impacts. The assumption is that little autonomous adaptation will take place and that, owing to poorly functioning political systems, planned adaptation will be limited and short term in character. Winters *et al.* (1998) use CGEs to model the impacts of climate change on agriculture, and the indirect general equilibrium effects of these agricultural impacts on stylised African, Asian and Latin American economies. The future sizes and structures of the three economies are projected using historical economic data and IPCC estimates. Planned adaptation is imposed exogenously. Neoclassical profit maximisation is assumed in agricultural production responses, although price responsiveness is varied to account for the fact that subsistence producers in Africa are likely to be less responsive to price changes. Ingham *et al.* (2005) use the expected utility maximisation framework, which captures behaviour to analyse adaptation and mitigation as a single economic problem set. Their starting point is that mitigation and adaptation are two alternative ways in which society can reduce the damage costs of climate change. They assume that a single global social planner chooses an optimal mix of adaptation and mitigation to minimise total social costs. Both mitigation and adaptation have a cost associated with them, and undertaking one reduces the need for the other.

On this basis they project a strong view that mitigation and adaptation are economic substitutes. Thus an economic optimisation problem can be solved by choosing the right mix of the two; that is, if the cost of adaptation falls relative to that of mitigation, the optimal response is to do more adaptation and less mitigation. Ingham *et al.* also incorporate uncertainty and learning, arguing that the rate at which agents can learn about the changing environment is a crucial determinant of the costs of adaptation. Callaway *et al.* (2006) use a programming model to study how water allocation between different economic activities in a South African river basin is likely to be affected by climate change. This study incorporates both planned and autonomous adaptation measures; however, because farming in this area is largely a commercial for-profit activity, the autonomous adaptation is, arguably, easier to model than in many other developing countries. Dasgupta *et al.* (2007) estimate the economic impacts of sea-level rise for the world's economies, They assume, however, that there will be no adaptation at all, planned or autonomous, making the estimates more of baseline projections than forecasts of actual economic impacts. GTZ (2007) presents some economic approaches to climate change adaptation, with a specific focus on developing countries. Starting with the characterisation of adaptation, the study focuses on an economic appraisal of adaptation projects. It presents cost/benefit analysis and cost-effectiveness analysis as the main tools. Its starting point is the framework developed by the Stern Review for comparing costs and benefits. However, it does not employ the tools empirically, leaving propositions at the abstract level.

Oxfam (2007) estimates the cost of urgent and needed adaptation for least developed countries and also for all developing countries, using existing figures from NAPAs and also from existing activities by nongovernmental organisations (NGOs) in specific countries. These figures are scaled up on the basis of population, GDP and land use to arrive at a range of global figures on the costs of adaptation. The Oxfam paper calls for more robust estimates of the economics of adaptation as a matter of urgency, and recommends a 'Stern Review' type of initiative, but focusing on examining the relationship between development and adaptation and providing stronger estimates on the costs and benefits of adaptation. Seo (2007) discusses how climate change might affect Latin American economies at the macroeconomic level, largely using geographical data as a basis for the discussion, but offers few firm conclusions. Bigano *et al.* (2008) use multi-country CGE models to assess the impacts of sea-level rise and changes in tourism flows on the overall economy. Reid *et al.* (2008) similarly use a CGE model to estimate the impacts of changed agricultural productivity and changed fish availability on the Namibian economy. The study assumes limited autonomous adaptation and almost no planned adaptation, and can most fruitfully be seen as a set of baseline projections for the outcome if no policy interventions are made. Calzadilla *et al.* (2009) use general equilibrium modelling to study the impacts of potential planned adaptation measures for sub-Saharan African agriculture, and find that measures to improve crop productivity (and hence increase the scope for autonomous adaptation by individual farm households) are likely to have a greater impact than measures to extend irrigation networks. Finally, Juana *et al.* (2008) study climate effects on water availability in South Africa and use a CGE model to estimate how this will affect the economy under different planned adaptation policies. These two studies are among the few to estimate the welfare impacts of climate change; both, however, estimate equivalent variation measures (WTP) rather than compensating variation measures (WTA) and thus underestimate the welfare losses caused by climate change.

6.2 The principles of climate change adaptation

Other papers discuss the principles of climate change adaptation. Tol (2005) argues that increasing developing countries' adaptive capacity through development aid is more fruitful than climate change mitigation. Halsnæs and Verhagen (2007) argue that focusing on the market outcomes of climate change risks missing the larger picture of climate change impacts on human wellbeing. Collier *et al.* (2008) discuss potential planned and autonomous adaptation in Africa, but are pessimistic about the scope for planned adaptation measures, at least by national governments.

6.3 Sectoral impacts

Apart from agriculture, there appear to be few studies of sectoral impacts. Spalding-Fecher and Moodley (2002) study health impacts in South Africa. Velarde *et al.* (2005) study impacts on protected areas in Africa and is one of the few studies to incorporate the effect of increasing income on the willingness to pay for protected nature. This effect is modelled, however, by using a range of different discount rates, and thus reweighting the values of all protected areas equally, rather than by using estimated income elasticities to estimate future changes in the relative values of the protected areas.

Many studies have, for obvious reasons, focused on agricultural impacts and impacts on production values. Mendelsohn and Dinar (1999) provide a useful subdivision by methodology: agronomic/agronomic-economic studies, agro-ecological zone studies, and Ricardian studies. The agronomic and agronomic-economic studies focus on examining what the implications of anticipated climate change will be on the yields of crops currently being grown in various parts of the world, and on potential other varieties of those crops. Examples of this literature include Rosenzweig and Parry (1994), who simulate global crop yields and feed these into a trade model in order to estimate price impacts; Matthews *et al.* (1997), who simulate impacts on rice yields in a number of Asian countries, though without any assessment of the economic implications; Parry *et al.* (2004), who use yield impact estimates for a range of crops to simulate price and livelihood impacts in a global economy model; Njie *et al.* (2006), who study yield effects in the Gambia under a range of different scenarios for planned adaptation, and the economic impacts in these scenarios; Lobell *et al.* (2008), who estimate crop yield impacts in a range of developing country regions, but without explicitly modelling the economic effects; and Reid *et al.* (2008), who use agricultural yield estimates as a starting point for simulating economy-wide effects in Namibia. We may note that the implicit assumption in these studies is that the only autonomous adaptation taking place will be that farmers currently growing some crop may switch to other varieties of the same crop, or may switch to different planting seasons. Other than this, any adaptation (autonomous or planned) has to be modelled explicitly in the analysis by incorporating additional ad hoc assumptions. Of the studies listed, only Njie *et al.* (2006) explicitly discuss the potential for planned adaptation policies in any detail.

In the agro-ecological zone studies, it is assumed that, when climate change leads to shifts in agro-ecological zones, this will lead farmers to adapt by switching from the crops that they currently grow to those crops that are currently grown in the zone that they are shifting into. This method appears not to have been widely applied in developing countries, although a recent set of World Bank studies of climate change impacts on African agriculture (Seo *et al.*, 2008b, 2008c, 2008d) can be seen as examples.

The Ricardian studies, finally, take their starting point in the Ricardian method developed by Mendelsohn *et al.* (1994). The assumption is that all farms choose their production portfolio so as to maximise their profits, given their characteristics – including the local climate. If climate change leads to a switch from climate state A to climate state B for farms in a particular region (for instance, less rainfall and higher temperature), farms in the region will adapt by switching to the production portfolio chosen by farms elsewhere that are currently in climate state B. The economic impact of the switch from A to B can then be estimated either by studying the change in net revenue that the switch in production will entail, or (more rarely in developing country applications) by using the hedonic pricing method, studying the difference in land values between the farms in the area and the farms that are currently experiencing climate state B. Applications of this method in developing countries include Mendelsohn and Dinar (1999), who study Brazilian and Indian crop yields and use Ricardian functions to estimate the impacts of a range of different temperature increases; Deressa *et al.* (2005) and Gbetibouo and Hassan (2005), who study South African agriculture; Timmins (2006), who studies a range of land uses in Brazil; Kurukulasuriya and Mendelsohn (2007a, 2007b, 2008) and Kurukulasuriya *et al.* (2007), all of whom use data from a set of African countries to study crop patterns and/or irrigation; Lotsch (2007) and Maddison *et al.* (2007), who also study African agriculture; Mendelsohn and Seo (2007) and Seo and Mendelsohn (2008a), who study livestock management and crop choice, respectively, in a range of South

American countries; Seo and Mendelsohn (2007a, 2007b, 2008b), who all study livestock management in African countries; and Seo *et al.* (2008a), who use the same data set to study crop choice and livestock management simultaneously in a number of African countries. Of these, Timmins (2006) and Maddison *et al.* (2007) are the only ones to use land values to assess economic impacts; all the others use price data for crops and livestock.

As should be obvious from the above list, the Ricardian method has become the methodology of choice among economists studying the impacts of climate change on agriculture in developing countries, with an explosive increase in recent years in the number of studies undertaken. There is good reason for this. In the other two methods, any climate change adaptation has to be imposed exogenously, whereas the Ricardian method models autonomous adaptation by farmers endogenously. As noted earlier, there is considerable debate over how much farmers in developing countries can actually adapt to changed circumstances. Stern (2008) criticises Ricardian analysis and states that current temperature variation cannot be used to predict how – or if – we will cope with a shift in the entire spectrum of temperatures. Over the scope of several decades, however, it does seem likely that farmers will, at least to some extent, change their production patterns, and part of this is that they may switch to entirely new crops or new farming activities, rather than merely to new crop varieties.

This does not mean that there are no problems with the Ricardian method. As already noted, many farmers in developing countries are not profit maximisers now, and it is problematic to assume that they are. Some of the studies discussed above note that land values were problematic in their Ricardian analyses; some farmers would not or could not provide information on the value of their land, owing to poorly functioning land markets and insecure land tenure. Other studies note that a large share of farm production is for own consumption, but nonetheless proceed to use market (rather than shadow) prices to value the farm's entire production.

Farmers in developing countries choose their crops subject to a number of constraints, not merely climatic and agronomic but also institutional, social and economic, and these constraints need to be included in the analysis. Moreover, it is likely that many of these constraints will change in the decades to come, as a result of ongoing changes in the economy, and this should in principle be modelled if one wishes to forecast how production will actually change. Only a few of the Ricardian studies incorporate constraints on adaptation. Thus, most of these studies exaggerate farmers' potential for autonomous adaptation, and hence underestimate the impacts of climate change. Finally, we should note that, even if the Ricardian method may provide reasonable forecasts of production changes in areas where there are few constraints to autonomous adaptation, even in those areas the method does not provide accurate estimates of changes in welfare. The production losses caused by climate change can perhaps provide estimates of the WTP to avoid climate change effects, but not of the WTA.

Despite these caveats, the Ricardian method can provide a useful starting point for policy interventions. A Ricardian study can help identify the production patterns that farmers are likely to switch to, given the anticipated changes in climate, and policymakers and analysts can use these projections to identify policy measures that can make it easier for farmers to switch to these new production patterns. Using Ricardian analysis in this fashion – as a guide to designing policies for planned adaptation rather than as a prediction of autonomous adaptation activities – can help to make the adaptation to a new climate substantially less painful for rural communities.

7 Potential future work

An IIED workshop in January 2009 brought together economists from a number of developing countries (Bangladesh, Malawi, Nepal, Senegal, Sudan, Uganda and Zambia), in order to discuss the economic aspects of potential adaptation measures and how to value these potential measures. For all these countries, several of the issues highlighted in sections 3 and 4will clearly be important. Notably, agricultural production is important in many of the countries and (possibly owing to incorrect framing of the issues) adaptation has for long been seen as an unnecessary luxury item rather than as an integral part of development policy.

It is of course legitimate for a poor country to prioritise needs that are seen as more urgent, and perhaps to choose reactive adaptation measures once the impacts of climate change are known, rather than proactive measures now. If a country does, however, this it should be a conscious decision. In several of the cases discussed at the workshop, there is a clear risk that adaptation is seen as an extra activity and that countries' regular development planning, implicitly or explicitly, ignores climate change and assumes a false status quo baseline.

Donors should perhaps consider whether pushing climate change as the issue of the day in many development discussions has been a good or a bad thing for developing countries' readiness. Policymakers in developing countries are used to having donors pushing an issue for a few years and then moving on to some other issue; they are also used to drawing up strategies for the donors' issue of the moment, and then quietly dropping these strategies again when donor interest moves on. It is possible that many policymakers in developing countries see climate change in this light: as an issue that is of interest to donors at the moment but that will probably soon be replaced by something else. Donors would perhaps contribute more to developing countries' readiness by advocating the inclusion of climate change adaptation in regular planning, rather than by advocating separate climate change strategies in isolation from other policy.

The first priority should thus be to ensure that the baseline scenarios used in countries' economic planning include the anticipated impacts of climate change, with realistic timeframes for these impacts, and possibly also use several different scenarios with different ranges of impacts. In many cases the anticipated impacts may still be sufficiently far off in time that policymakers will continue to give priority to more urgent issues. This is not necessarily a problem, as long as there is an awareness of the likely future changes.

For all the countries involved, likely changes in agricultural production can be estimated using Ricardian analysis. This can then be used to assess how easy it will be for farmers to switch to the forecasted new production portfolios, given the current state of agricultural markets, land markets, credit markets, surrounding infrastructure, and so on. This should help clarify what policy interventions could make the switch easier.

For all the countries involved, assessments of welfare impacts using WTA rather than WTP should also be a goal. The Ricardian analyses can contribute to these assessments by providing realistic projections of how much farmers are likely to have to change their behaviour as a result of climate change.

All the country representatives also identified water as a potential future problem. Water scarcity is likely to increase in several of the countries, and water availability is likely to become more erratic with more volatile rainfall. The impacts of this on agriculture can be included in a Ricardian analysis. Agriculture is often the largest single user of water in developing countries, but changes in water availability will also affect numerous other sectors of the economy. Those countries that rely on hydropower for some or all of their electricity needs will see effects throughout the economy if no adaptation takes place. The economics of estimating the impacts of changed water availability are straightforward; the crucial point will be to ensure that government planning uses a realistic baseline that includes climate change. If planning in the water sector is done using an imaginary baseline where climate change is not taking place, on the other hand, infrastructure investments and other policy interventions will probably be seen as less urgent and will frequently be misdirected.

8 Summary and conclusions

The recognition of economics as tool that aids decision-making in climate change is a major step towards getting action to address the threats of climate change. However, economics is only useful to the extent that some of the issues highlighted above are taken into account. It is important for economic analyses to provide the appropriate information, based on the use of appropriate methods to generate relevant data. Some general perspectives identified from the issues discussed above can guide appropriate economic analyses in terms of the data required and the methodologies applied. We use the above sections to build these perspectives in this section.

The climate change debate is getting more and more focused. Decisions are being made on specific actions rather than generalities. For example, in the past, the focus has been to establish the scientific basis; now the debate is moving on to action, with adaptation being prominent on the agenda. Adaptation is linked with reducing impacts in real places. We therefore suggest economic studies and analyses that generate information where adaptation is required. Impacts occur in specific areas and therefore adaptation data from specific areas should form the basis of decision-making. The costs and benefits of adaptation are best estimated from real adaptation solutions that are possible with existing technologies that the most vulnerable can realistically access and afford. The need for higher-level economic data (national, global) is best met by data from real places. This involves recognising and costing locally based adaptation strategies together with those coming from outside.

In many developing countries, climate change adaptation has probably suffered from the fact that it has been regarded as a single issue, pushed by foreign donors, rather than as part of the background against which development planning has to take place. It is important to have realistic forecasts of expected climatic changes at the local and national level, and timeframes for these changes, to help mainstream adaptation into national policy. As long as such local and national forecasts are not available, climate change will probably continue to be seen as an unnecessary extra activity rather than as a crucial part of development planning. Thus, empirical economic studies should meet the needs of specific clients. These clients have to be identified to enable focused work, whether theoretical or applied. Clients at different levels have particular needs. Table 3 is an attempt to categorise the different clients by their level and to give examples of their needs from an economics perspective.

Table 3: Needs for economic data by client level

Level	*Clients*	*Needs*
Local	Households Community based organizations Businesses Local authorities	Cost-effectiveness of technologies for adaptation Multiple benefit strategies Costs of externally financed adaptation strategies Timing of adaptation
National	National governments NGOs	Impact on economies and other programmes, e.g. Poverty Reduction Strategy Papers Costs and benefits by sector Sectors to focus on Aligning adaptation with national priorities Financing adaptation
Global	UNFCCC Donors Other intergovernmental bodies International NGOs	Actual costs and benefits of adaptation Cost-effectiveness and best options Where to target: hard/soft adaptation/adaptive capacity, autonomous/planned adaptation, adaptation/development Raising adaptation funding
Specialised	Universities Research institutions	Theory and methods Data to test theories Refinements of methodologies Debate

Once such information is available, adaptation should become an integrated part of development planning, and adaptation measures should be assessed in the same fashion as any other development project or policy. Policymakers should judge whether they believe that these measures will make the country better off in the longer term, and pursue the measures if they believe that this is indeed the case. There is, mostly, no need for new economic tools to make such judgements; traditional cost/benefit analysis and the valuation methods already used in, for instance, environmental economics, health economics and water economics will largely suffice.

Shifts in agricultural production, including subsistence production, are likely to be important. Here, owing to the complex nature of many agricultural markets in developing countries, there *is* need to think about slightly newer tools. One such tool – the Ricardian method – has been developed in recent decades as a means of forecasting autonomous adaptation to climate change. Used wisely, this method can help inform policymakers about the future needs of agricultural policy: it can help forecast in what ways farmers will wish to adapt, and policymakers can use these forecasts to put policies in place that make this adaptation easier. Additional tools are likely to be needed in order to analyse the effects of the complicated interactions between weak institutions and poorly functioning markets on the impacts of climate change on agriculture in many developing countries.

On the whole, though, climate change should not be seen as a completely novel type of problem for economic analysis, although it is probably the most challenging one. A big problem in adaptation planning so far is precisely that climate change has been perceived as a separate issue, unrelated to other problems, rather than as one of many problems facing developing countries. Developing countries have always been buffeted by various shocks; climate change may be a new shock, but it is nonetheless only one (large) shock among many. Looking at it in this fashion, and evaluating adaptation measures with the same yardstick as any other development project, is a better way of mainstreaming adaptation into regular development planning. This does not mean that climate change is not an urgent issue. In fact, delaying action may lead to irreversible consequences. It is important that planning identifies those urgent adaptation actions and prioritises them and at the same time prepares to put in place measures and strategies for medium- and long-term adaptation, including preparing for unforeseen climatic impacts.

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