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Adaptation and mitigation: trade-offs in substance and methods

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Abstract

Adaptation to climate change and mitigation of climate change are policy substitutes, as both reduce the impacts of climate change. Adaptation and mitigation should therefore be analysed together, as they indeed are, albeit in a rudimentary way, in cost-benefit analyses of emission abatement. However, adaptation and mitigation are done by different people operating at different spatial and temporal scales. This hampers analysis of the trade-offs between adaptation and mitigation. An exception is facilitative adaptation (enhancing adaptive capacity), which, like mitigation, requires long-term policies at macro level. Facilitative adaptation and mitigation not only both reduce impacts, but they also compete for resources.

Keywords: Adaptation; Mitigation; Climate change

1. Introduction

For a long time, it was politically incorrect to speak about adaptation to climate change, because it presumably implies accepting defeat in the battle against evil emissions (Burton, 1994). This has changed, perhaps because scientists repeatedly pointed out that climate change cannot be altogether avoided even if we try very hard (Parry et al., 1998; Wigley, 1997), and perhaps because the current US administration made it blatantly clear to everyone that not everybody is going to try equally hard to reduce greenhouse gas emissions.

As a consequence, adaptation has now established itself at the political agenda with a vengeance. At the moment, a flurry of consultants and academics are advising governmental and international bodies on what to do about adaptation,[1] typically treating adaptation as something novel. However, adaptation to change is an everyday fact, as is adaptation to weather variability (Burton et al., 1993). Adaptation to climate change is an historical and prehistorical fact (Lamb, 1982). Self-serving advisors also kept adaptation, together with mitigation, at the national and international agenda. This has led to demands for an integrated analysis of and policy for mitigation of greenhouse gas emission and adaptation to residual climate change.

This paper argues that adaptation and mitigation should be kept largely separate. It also looks at a few exceptions where adaptation and mitigation should be integrated, and warns that the results are even more politically incorrect than seeing adaptation as accepting defeat in mitigation; in fact, we should embrace adaptation in triumph, at least for some impacts.

This paper is built up as follows. Section 2 briefly reviews the literature on impacts and adaptation, so as to set the scene for the main argument. Section 3 discusses adaptation in more detail, particularly focusing on its role in decision analysis. Section 3 argues that adaptation and mitigation are substitutes,[2] but that making the trade-off in practice is not at all trivial. Section 4 treats of facilitative adaptation, a small

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[1] This observation is based on informal observations by the author, who knows many of these advisors personally.

[2] The more mitigation, the less adaptation is needed; and the more adaptation, the less mitigation is needed.

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part of all adaptation, but one that is comparable to mitigation. Section 5 looks at the trade-off between mitigation and facilitative adaptation, arguing that mitigation and adaptation are not only substitutes, but may also compete for resources. Section 6 concludes.

2. Impacts and adaptation

One cannot study the impacts of climate change without also studying, or at least making assumptions about, adaptation. Adaptation matters, reducing impacts in many cases, and frequently turning negative impacts positive; however, adaptation may also increase impacts, and turn positives into negatives (Rosenzweig and Parry, 1994; Darwin and Tol, 2001).

Tol et al. (1998) review the impacts literature, attempting to distinguish between adaptation and residual impacts. They also classify studies as to their assumptions about adaptation. Surprisingly, in 1998, there were still many studies that do not consider adaptation. Essentially, these studies assume that the impacted system does not respond to climate change, an assumption that may well be fairly unrealistic. Unfortunately, one can still find such studies today (e.g., Arnell, 2004; van Lieshout et al., 2004). Other studies include arbitrary adaptation. Essentially, adaptation is included in a ''what if'' scenario, such as, ''what if planting dates are a week earlier than before'' (e.g., Iglesias et al., 1996) or ''what if we build dikes everywhere'' (e.g., Hoozemans et al., 1993). Adaptation is *arbitrary* because there is no evaluation of the realism or desirability of the level and type of adaptation. A few studies include a behavioural model of adaptation, postulating either motives or rules of behaviour and using these to assess how a system would respond to the impact (see, e.g., Fankhauser (1994) and Yohe et al. (1995, 1996) for motivation-based models; see, e.g., Nicholls (2004) for a rule-based model). Yet other studies, again only a few, include statistical models of adaptative behaviour, measuring rather than postulating motives or behavioural rules (e.g., Mendelsohn et al., 1994; Yohe and Tol, 2002). Finally, a small but increasing number of studies look at past and current adaptation, using the rich yet descriptive methods of anthropology, sociology, political science, social geography and history (e.g., Cohen et al., 2000; Downing et al., 1997; Miller et al., 1997; Tol and Langen, 2000; Tol et al., 2003).

Tol et al. (1998) also estimate the share of adaptation costs in total economic damages, the remainder being residual damages. Depending on the study, adaptation covers some 7–25% of total damages for a doubling of the atmospheric concentration of carbon dioxide. The total economic damage ranges from 1 to 2% of world income (Pearce et al., 1996), so adaptation costs ranges from 0.1 to 0.5% of GDP. The study of Tol et al. (1998) has not been updated.

3. Adaptation in decision analysis

Estimates of the total economic impact of climate change (as in Pearce et al., 1996) are useful input to, among others, global cost-benefit analysis (CBA) of greenhouse gas emission reduction. Global CBA (e.g., Manne et al., 1995; Nordhaus, 1991, 1993; Peck and Teisberg, 1992; Tol, 1999) addresses the question ''If the world were ruled by a benevolent dictator, a philosopher-queen who is in control of the entire planet and is up to speed with the latest scientific insights, what would she do about climate change?''

On the one hand, this is a silly question as there is no such dictator. On the other hand, real politics can impossibly deliver a better result, so CBA provides a useful yardstick to measure real policies against. Our philosopher-queen, if she were a utilitarian in the broad sense of that word, would balance the marginal costs of emission reduction with the marginal benefits of reducing climate change; the marginal benefits would result from balancing the marginal costs of adaptation to climate change with the marginal residual damages.[3] So, a global CBA, or a national CBA for that matter, yields insights into the trade-offs between adaptation and mitigation, at least in principle.

Practice is different, however. As noted above, the treatment of adaptation in climate change impact studies is far from perfect. This makes the quantitative results of the published CBAs suspect.

But there are deeper difficulties as well. The first is a mismatch of scale. Mitigation is primarily a matter of national governments in the context of international negotiations. Adaptation is primarily a matter of local managers of natural resources, and individual households and companies, in the context of a regional economy and society. Even though individuals will mitigate their emissions, the incentives to do so are to be provided by their governments. A CBA on mitigation should therefore resolve the national and international scale well. On the other hand, the incentives to adapt are already in place, although they may be distorted, and need not be created by governments. A CBA on adaptation should therefore resolve the local scale well. At the local scale, an analysis about how much to abate is pointless, as only a tiny share of emissions can be reduced.[4] The implication is that models that support decisions for mitigation and models that support decisions about adaptation necessarily operate at different resolutions.[5] This holds for CBA as well as for other forms of decision support.

[3] All studies estimate that optimal emission abatement is fairly small. There are a few apparent exceptions to this, but these studies are either technically flawed (Azar and Sterner, 1996; Hasselmann et al., 1997) or assume unrealistically high impacts (Manne and Richels, 1998). See Tol (1998) for a further discussion.

[4] Local mitigation is often defended under the slogan ''think global, act local''; the equivalent slogan for adaptation would be ''think local, act local'' (which really is not much of a slogan).

[5] Public health is an exception.

The second difficulty is a mismatch of client. A CBA on mitigation addresses, first and foremost, the Ministries of Energy and Finance and, to a lesser extent, the Ministries of Transport, Agriculture, Forestry and, perhaps, Environment. A CBA on adaptation is addressed at local water managers, farmers, health officials, coastal zone managers, tourist suppliers, architects, or energy suppliers; decision makers on a national level would only sideways be involved. This implies that decision criteria, parameters and reporting are different for a CBA on adaptation than for one on mitigation. Again, this holds for other forms of decision support as well.

The third difficulty is a mismatch of time scale. A CBA on mitigation looks at short-term action because of potentially detrimental long-term developments. A CBA on adaptation looks at short-term action in the context of short- to medium-term developments. Again, this implies that, in practice, a CBA on mitigation would be done very differently than one on adaptation.

It is therefore not practical to look at the trade-offs between adaptation and mitigation, as no study can do right to both.

Instead, CBA studies like Manne et al. (1995), Nordhaus (1991, 1993), Peck and Teisberg (1992) and Tol (1999) make the trade-off between the costs of emission reduction on the one hand and the costs of adaptation plus the residual damages on the other hand. The costs of adaptation and the residual damages of climate change are lumped together in a single "damage function". Hope et al. (1993) are among the very few to explicitly implement adaptation in their model.

4. Facilitative adaptation

The exception to above-mentioned impracticality and mismatches is the trade-off between mitigation and *facilitative* adaptation. The "adaptation science" literature (Burton, 1997; Fankhauser et al., 1999; Kelly and Adger, 2000; Klein et al., 2001; Smith and Lenhart, 1996) distinguishes many forms of adaptation, including anticipatory and reactive adaptation[6] and planned and autonomous adaptation, where planning is supposed to happen at the same level as the analysis (typically governments and multilateral organisations), while adaptation below the analysis level is taken for granted. [7] Facilitative adaptation is probably a form of planned, anticipatory adaptation but, instead of the central government going in and telling farmers when and what to plant, doctors what pills to proscribe, or households how high to turn on their air conditioners, facilitative adaptation comprises those government actions that allow households, companies and lower authorities to adapt better, that is, to make appropriate planting decisions, medical prescriptions, and air conditioning investments.

I believe that, in most cases, facilitative adaptation implies the government doing less, not more. For instance, a water market is inherently a more flexible and therefore more adaptable way of allocation water than a system of seniority rights. Another example, subsidies reduce the incentives of farmers to switch crops, as it severs the link between productivity and profitability.

Facilitative adaptation is often referred to as enhancing adaptive capacity (Smit et al., 2001). Adaptive capacity is the ability of a system to respond to a change (in this case, climate change). Adaptive capacity is generally believed to be determined by technological options, economic resources and their distribution, human and social capital, and governance. Although there is a wealth of anecdotic evidence, this hypothesis has yet to be rigorously tested, and the relative strengths of the determinants of adaptive capacity have yet to be estimated (cf. Yohe and Tol, 2002).

Facilitative adaptation is done at the national level, in developing countries often with support of multilateral organisations. The scale is therefore similar to that of mitigation. The client is different, but one could argue that cabinet and parliament decide both mitigation and facilitative adaptation. A comparison of the two is therefore meaningful.

5. Trade-offs between mitigation and facilitative adaptation

One question a comparison of mitigation and facilitative adaptation could address is how much the need for facilitative adaptation falls if mitigation is increased. That question is difficult to answer as climate change is so uncertain. Moreover, facilitative adaptation has many other benefits. A society that is more robust to climate change is probably also more robust to climate variability, and a society that can adapt to climate change is probably also better in adaptation to socio-economic change. Facilitative adaptation is about making society more robust and more flexible—and even if there were no climate change, societies have to be robust and flexible to withstand other changes, many of which are more rapid than global warming. In most cases, climate change is only a minor co-benefit to facilitative adaptation. For example, one does not want to develop a malaria vaccine because of climate change, but because malaria is a nasty disease; and even though climate change is an additional reason to invest in a malaria vaccine, one would hardly invest less if climate change would not be there. Similarly, one does not want to use drought resistant crops because of climate change, but because drought is a current problem in many places of the world; climate change is only a minor reason to invest in further developing such crops.[8]

[6] Even though before and after is hard to define in a continues process such as climate change.

[7] Again, it is hard to define the level of decision making in all but the most centrally organised and anarchistic countries.

[8] An anonymous referee pointed that, in many cases, vulnerability to climate change is used to raise the political profile of certain afflictions. This is a valid political strategy.

Table 1
Regional marginal costs of CO_2 emissions and marginal benefits of development aid on climate-change impacts in the period 2000–2009

	Marginal costs of CO_2 emissions[a]			Marginal benefits of development aid[b]			Cost-benefit ratio[c]		
	PRTP[d] = 0%	PRTP = 1%	PRTP = 3%	PRTP = 0%	PRTP = 1%	PRTP = 3%	PRTP = 0%	PRTP = 1%	PRTP = 3%
LA	1.10	0.66	0.25	0.05	0.08	0.06	0.9	2.3	5.2
S&SEA	0.03	−0.03	−0.06	−0.17	−0.08	−0.02	−99.9	63.9	8.1
CPA	0.01	−0.28	−0.42	−0.65	−0.41	−0.20	−1465.1	29.1	0.0
AFR	2.44	1.46	0.60	3.08	1.75	0.63	25.3	23.9	20.8

[a] Positive numbers are marginal costs, negative numbers are marginal benefits of carbon dioxide emissions.
[b] Positive numbers are marginal benefits, negative numbers are marginal costs of development aid; only the effects of aid on climate-change impacts are included.
[c] 20 × marginal benefits of development aid/marginal costs of CO_2 emissions.
[d] PRTP = pure rate of time preference, or utility discount rate. *Source*: Tol (2002).

Adaptation may, of course, also affect mitigation. An example is air-conditioning, which alleviates the indoor effects of summer heat but increases emissions of CO_2 as well as HCF-134a. Hamilton et al. (2004) show that climate change would reduce the global demand for tourism-related travel (as tourists from Northwest Europe would stay closer to home) and hence reduce CO_2 emissions. Berrittella et al. (2004) and Bosello et al. (2004a,b) study the effect of climate change impacts and adaptation on carbon dioxide emissions, and find only relatively minor effects. Although incomplete, it is hard to imagine that this feedback is particularly large.

A more interesting question is whether mitigation would help or hinder facilitative adaptation. Could it be that mitigation, which presumably strives to reduce climate change impacts, in fact increases them? Tol and Dowlatabadi (2001) look into this, focusing on malaria in Africa. As Africa has no obligations to reduce greenhouse gas emissions under the Kyoto Protocol, and is indeed unlikely to accept emission abatement targets any time soon, this may seem to be a peculiar analysis. However, economic agents typically export economic hardship: If a company gets into trouble, it protects its employees at the expense of its suppliers. Similar things happen internationally. Economic agents lower in the value chain are weaker, and they receive a disproportional part of the hardship. Internationally, at the bottom of the value chain are exporters of primary commodities, including most African countries. A reduction in economic growth in the OECD, caused by emission abatement, would have negative effects on the economic growth rate of Africa as well (Babiker et al., 2000).[9,10] And, lower economic growth would imply that there is less money to spend on health care.

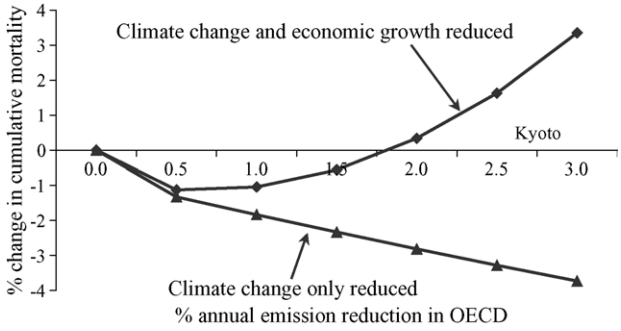

Fig. 1. The change in malaria mortality due to climate change in the 21st century as a function of emission reduction in the period 2001–2010 (as an annual percentage from baseline) in the countries of the OECD with (red line) and without (green line) trade and investment effects from the OECD on developing countries. *Source*: Tol and Dowlatabadi (2001).

Fig. 1 shows the trade-off, according to Tol and Dowlatabadi (2001). Annual emission reduction in the OECD is given on the *y*-axis, varying from zero to the average Kyoto targets. The reduction in total climate-change-induced malaria is on the *y*-axis. In one scenario, there is no influence from OECD growth on African growth. The Kyoto Protocol reduces climate-change-induced malaria deaths by some 4%. In the other scenario, OECD growth does affect Africa. Climate-change-induced malaria falls for moderate abatement policies, but increases for more aggressive emission reduction; Kyoto would *increase* malaria deaths by some 4%. Obviously, these numbers are very uncertain, but the qualitative result – there is a credible set of parameters for which greenhouse gas emission reduction may increase climate change impacts – is what matters.

Tol (in press-a) does a similar analysis for the impacts of sea level rise. The costs of mitigation increase vulnerability to sea level rise, but much less so than in the case of malaria. Even though sea level rise responds more slowly to emission abatement than does malaria, mitigation cannot increase impacts. This is because economic growth would lead to an eradication of malaria, but not of sea level rise impacts.

[9] Emission reduction in the OECD would also lead to a reallocation of investments in energy-intensive production. However, the likely beneficiaries of this are found in Latin America and Asia, not in Africa (Tulpule et al., 1999).
[10] Other mechanisms through which emission reduction would affect developing countries are the reduced budgets for development aid and charity, and the reallocation of development money towards emission reduction (as has happened in, for example, the Netherlands and Germany).

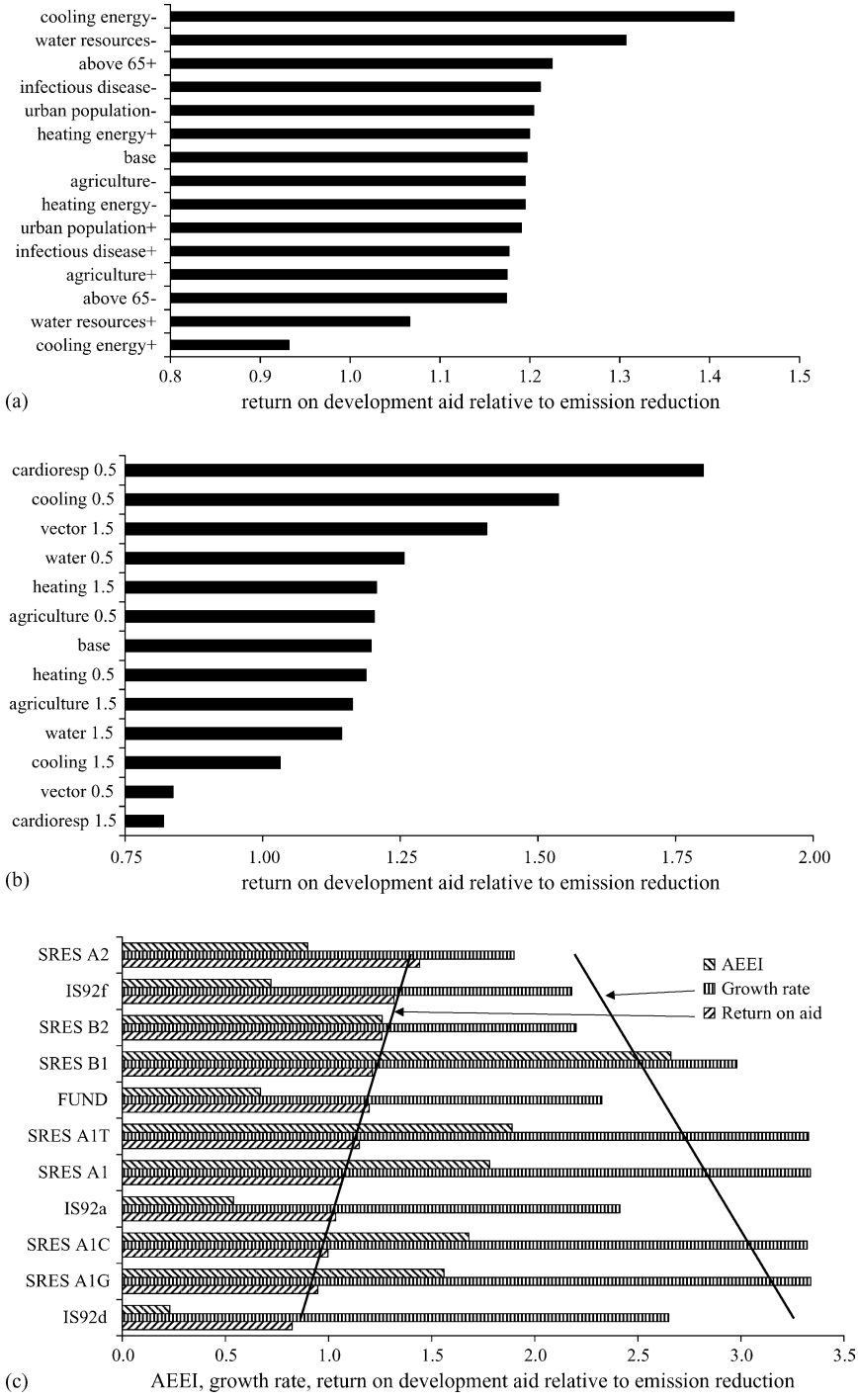

Fig. 2. The ratio of the net present value of the reduction in climate-change impacts due to a small increase in development aid and due to equivalent spending on emission reduction. A sensitivity analysis (a) around the sectoral impact of climate change; (b) around the growth factors of impact categories; (c) around the development scenarios. *Source*: Tol (2002).

Another interesting question is which part of the budget to allocate to mitigation and which part to facilitative adaptation. Schelling (1992, 1995) has long argued that greenhouse gas emission abatement would primarily benefit the grandchildren and great-grandchildren of the people living in currently less developed countries. He has wondered whether there are no better ways of helping them.[11] Tol (in press-b) analyses this question from the

[11] Schelling also wondered why we seem to be so concerned about them but largely indifferent to the fate of their grandparents and great-grandparents.

narrow perspective of climate-change impacts. Does a dollar spent on emission abatement reduce impacts more than a dollar spent on facilitative adaptation (read: development aid)? Table 1 shows the results for an emission abatement policy costing $1/tC, which is roughly the price of the Kyoto Protocol without the USA but with Russian hot air (Buchner et al., 2002).[12] Africa and Latin America would prefer money to be spent on development rather than on emission reduction—that is, their climate-change impacts fall further if money is invested in development rather than in abatement. Asian countries do not share this view. Fig. 2 shows sensitivity analyses around this issue for Africa. In most cases, Africa would prefer development to abatement, but not in all. The reason has to do with the relative sensitivity of different climate-change impacts, and the relative speed at which these are affected by development. This is also why different regions have different preferences. For instance, climate change has negative effects on both vector-borne diseases and heat-related cardiovascular and respiratory disorders. However, development would reduce the impact of vector-borne diseases – through improved health care and environmental management – but would increase the impact of cardiovascular and respiratory diseases—through changes in diet, urbanisation, and air pollution. As another example, climate change may decrease agricultural production and increase energy demand for cooling. Development would make agriculture less important, and air conditioning more important. The relative importance of the two impacts, and the relative pace with which they fall or rise with development determines whether development increases or reduces vulnerability, and hence the trade-off between development and abatement.

6. Conclusion

This paper makes three arguments. First, most adaptation is local. National governments and international organisation have little to do with adaptation, and should not try. Second, adaptation cannot be readily compared to mitigation, because most adaptation is done by different people, at a different spatial and temporal scale than mitigation. Although researchers like to talk about multi-scale, multi-stakeholder research of immediate policy relevance, reality is different. Third, mitigation takes resources away from adaptation;[13] for infectious disease related impacts in poor countries, money is better spent on adaptation than on mitigation. For other impacts, the reverse conclusion may be true.

These three arguments may seem a bit trivial to the novice in the climate policy debate. Yet, an international bureaucracy for adaptation is emerging, calling for the establishment of national focus points for adaptation and even adaptation ministries. Funding agencies have calls for proposals to study integrated policy strategies for adaptation and mitigation. The international adaptation fund is to be filled by a tax on mitigation. Greenhouse gas emission reduction, particularly through the clean development mechanism, is paid for by reducing development aid. If the analysis in this paper is correct, the recent developments on adaptation policy will be ineffective at best, but may do more harm than good.

[12] Alternatively, one may interpret the results of Table 1 as climate policy costing $20/tC and 95% of development aid being wasted.

[13] Emission abatement has two effects: it reduces the size of the economy, and it reallocated money towards mitigation. As a consequence, less resources are left for adaptation.

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