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Mitigation versus adaptation: the political economy of competition between climate policy strategies and the consequences for developing countries

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Abstract

So far, the dominant paradigm in international climate policy has been mitigation while adaptation has been a low-key issue. However, with LDCs starting to push for adaptation side payments it has recently gained importance. The allocation of funds and the definition of adaptation activities are currently being discussed. The most outstanding difference between mitigation and adaptation is that mitigation activities contribute to a global public good whereas most forms of adaptation are club goods. Technical adapation such as building sea-walls can be distinguished from societal adaptation, e.g. different land-use patterns. Generally, there is a trade-off between mitigation and adaptation strategies as resources for climate policy are limited. The choice between mitigation and adaptation strategies depends on the decision-making context. While mitigation will be preferred by societies with a strong climate protection industry and low mitigation costs the voters‘ quest for adaptation is linked to the occurence of extreme whether events. The policy choice in industrialised countries feeds back on the situation in developing countries. Adaptation in industrialised countries enhances the adaptation need in developing countries through declining mitigation activities. Unless this adaptation is financed by industrialised countries, developing countries will be worse off than in a mitigation – only strategy.

Zusammenfassung

Bisher hat sich die internationale Klimapolitik auf die Emissionsvermeidung konzentriert, während die Anpassung an veränderte klimatische Bedingungen eine untergeordnete Rolle gespielt hat. Durch die Forderung der ärmsten Entwicklungsländer nach Unterstützung bei der Anpassung hat sich die Aufmerksamkeit für diese Thematik in jüngster Zeit jedoch erhöht. Zur Zeit wird über die Alloziierung von Geldern und die Definition von Anpassungsaktivititäten verhandelt. Der größte Unterschied zwischen Emissionsvermeidung und Anpassung liegt in der Tatsache, dass es sich bei ersterem um den Beitrag zu einem globalen öffentlichen Gut handelt, während letzteres den Charakter eines Clubguts trägt. Hierbei kann zwischen technischer Anpassung, z.B. Deichbau und gesellschaftlicher Anpassung unterschieden werden. Ein Beispiel für letzteres ist die Nicht-Bewirtschaftung von Küstenregionen. Zwischen Anpassungs- und Vermeidungsaktivitäten besteht aufgrund begrenzter Ressourcen ein Zielkonflikt. Welche Strategie bevorzugt wird hängt u.a von der Stärke der Klimaschutzindustrie eines Landes sowie von dem Auftreten extremer Wetterereignisse in der Vergangenheit ab. Entwicklungsländer bevorzugen eine reine Vermeidungsstrategie auf Seiten der Industrieländer.

1. Introduction

1.1. International climate policy

Anthropogenic climate change has become one of the most salient international policy issues during the last decade. As the scientific case for global warming has become much clearer, a sequence of international agreements has been concluded. The long-term aim of the U.N. Framework Convention on Climate Change (UNFCCC) signed in 1992 is to avoid "dangerous" climate change. It did, however, not introduce concrete policy instruments to mitigate greenhouse gas emissions, apart from a non-binding goal that industrialised countries should return CO_2 emissions to 1990 levels by 2000. Eventually, only few OECD countries reached this goal. In contrast to the UNFCCC, the Kyoto Protocol (KP) of 1997 sets legally binding limits for greenhouse gas emissions of industrialised countries that were to amount to a reduction of about 5.2% between 1990 and the commitment period 2008-2012. However, the elaboration of the detailed rules for the application of cross-border cooperation in greenhouse gas reduction via the so-called "Kyoto Mechanisms" and the rules for carbon sinks has taken four years and almost led to failure of the whole process. Another blow was the declaration of U.S. president Bush that he would not ratify the Protocol. Nevertheless, in July 2001 the Bonn Agreement clarified the major outstanding policy issues and made ratification of the Protocol more likely. However, the KP targets were considerably weakened by the introduction of new sinks.

1.2. Mitigation and adaptation

Until now, the dominant paradigm in climate policy has been mitigation, i.e. the reduction of greenhouse gas emissions to achieve stabilisation of greenhouse gas concentrations in the atmosphere and subsequently a cessation of further warming. The architecture of the international agreements reflects this by setting absolute emission targets that were indicative in the case of the UNFCCC and shall be legally binding under the KP. The dominant view is that the targets will be strengthened during subsequent commitment periods. However, so far no long-term concentrations target

has been agreed upon; only the EU endorsed a target of stabilising concentrations at 550ppm in the long run.

As the major greenhouse gases are global pollutants without direct local impacts, mitigation is a global public good with extensive possibilities for free riding. Thus many observers of climate negotiations have argued that mitigation commitments will not go beyond business-as-usual. The KP commitments were certainly stronger but the Bonn Agreement considerably weakened them and without the US, the overall Annex B target is business-as-usual if efficient redistribution of the available "hot air"[1] is made (Jotzo/Michaelowa 2001).

There is widespread discussion which forms of mitigation are preferable. While emission reduction at the source through renewable energy, fuel switch or demand-side efficiency increase is universally accepted, sequestration in vegetation or geological formation has attracted controversy. The question of vegetation sinks was the apparent reason for failure of COP 6 at The Hague in 2000.

When climate changes, its impacts on human societies can be reduced through adaptation measures. As mitigation on the relatively limited scale currently defined by the Kyoto Protocol will only have minor and long-term influence on warming rates, a certain degree of climate change is inevitable. Some observers (Parry et al., 1998) have argued that successful adaptation is a much more powerful strategy to reduce impacts of climate change than mitigation.

Adaptation has been a relatively low-key issue during most of the period of climate negotiations but recently gained importance. In the 1996 Second Assessment Report of the IPCC, adaptation only covered less than 5% of the pages of the Working Group II report on impacts, adaptations and mitigation (Kates 2000, p. 5). In the Third Assessment Report of 2001 mitigation has got its own report (Working Group III), while impacts and adaptation are lumped together in the Working Group II report (McCarthy et al 2001) with a relatively balanced treatment of adaptation in each chapter on a geographical region and human-ecologic system. Many developing country negotiators, especially from LDCs have started to realise that they are unlikely to profit

1 "Hot air" refers to the situation that country targets are higher than business-as-usual emissions the due to the economic collapse in the countries in transition. This difference can be sold through the "Kyoto Mechanisms" and is likely to cover the shortfall of all other industrialised countries.

from mitigation action through the CDM and thus look for other avenues to get advantages from the international regime. Thus they have increasingly concentrated on side payments for adaptation. In the KP, a tax on CDM projects was defined whose revenues were to finance adaptation measures. The Bonn Agreement set the tax at 2% and set up an adaptation fund that shall get a considerable share of the funds paid by Annex II countries (i.e. the high income countries of the OECD) to the developing countries. However, it was not possible to negotiate binding shares of funding. 410 million $ per annum were pledged voluntarily by a subset of Annex II countries. The detailed allocation of these funds to the different funds to be established under the Bonn Agreement remains open and a thorny question for future negotiations.

It is unclear which activities belong to adaptation and the term is still being defined (Mc Carthy et al 2001, p. 883ff, Smit et al. 2000). The impacts of climate change span a wide range and so far can be forecast only with considerable uncertainty. Among the most relevant negative first-order impacts are sea-level rise, melting of mountain glaciers, changes in precipitation, especially heavy precipitation events, and thus droughts and floods, and possibly changes in storm intensities. Second order impacts are changes in biological variables which then have consequences on humans. Table 1 shows human systems that undergo impacts and characterises critical impacts:

Table 1: Human systems and impacts of climate change

System	Negative impacts	Positive impacts
Water resources	Decreased availability in many water-scarce regions, especially sub-tropics and small island states	Increased availability in some water-scarce regions, e.g. parts of South-East Asia
Agriculture and forestry	Reduced crop yields in most tropical and subtropical regions; and in mid latitudes for strong warming	Increased crop yields in some mid-latitude regions for low to moderate warming Potential increase in timber supply from appropriately managed forests
Fisheries	Decreases in commercial (mainly cold water) fish stocks in some areas	Increases in commercial (mainly warm water) fish stocks in some areas
Human settlements, energy and industry	Widespread increase in risk of flooding, landslides and avalanches Permafrost melting directly destroys physical infrastructure Increased energy demand for space cooling in low and mid latitudes Decreased hydro power potential and waterway transport capacity in areas with lower water availability and decreased glacier areas Loss in attractiveness as tourist destination in low and mid latitudes and many mountain areas	Reduced energy demands for space heating in mid and high latitudes Increased hydro power and waterway transport capacity potential in areas with higher water availability Gain in attractiveness as tourist destination in higher latitudes and some mountain areas
Insurance and financial services	Increase in payments due to damages	
Human health	Increase in number of people exposed to vector- and water-borne diseases	Reduced winter mortality in mid and high latitudes

Source: systems classifications and impact data from IPCC (2001, p. 4, 6), own additions

Adaptation is mainly related to extreme events. There are different aspects of adaptation. Generally, adaptation can be done by individuals in a spontaneous manner or governments can implement adaptation actions / grant incentives for individuals to

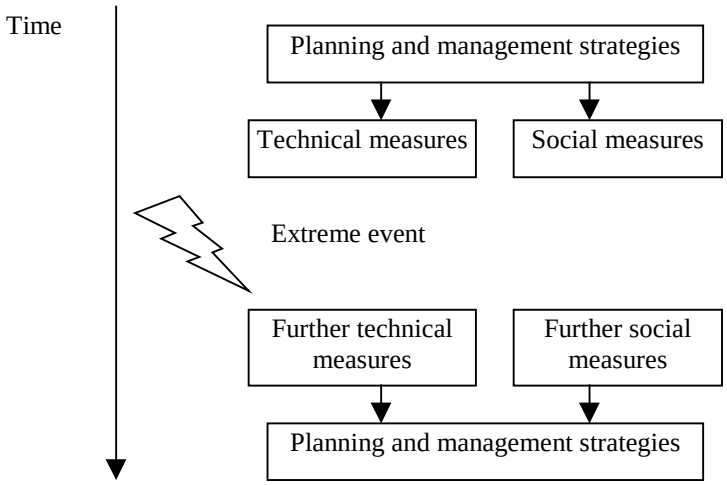
act in a certain way. Moreover, two principal avenues of adaptation can be distinguished:

- direct technical adaptation of physical infrastructures: e.g. raising sea-walls and levees on rivers, changing of harbour infrastructure, changing types of vessels used on rivers with a more variable seasonal runoff regime, developing transferable infrastructure for coastal defence (Adger, 2001, p. 924), planting protective forests against rockfalls in thawing mountain environments. Usually, this infrastructure has the character of a club good. Either a government provides the infrastructure directly or it sets incentives to put the infrastructure in place.

- societal adaptation, i.e. enhancing the resilience of a society through planning or provision of (non-infrastructure) options to cope with climatic stresses. Actions in this context are e.g. changing the operation mode of glacier-fed hydro-power stations, developing and using new seed varieties in agriculture and forestry, switching crops or land uses, introduction of rapid drought-reaction plans, changing land use regulation in areas prone to flooding, public provision of insurance. Governments can only provide information, finance R&D or give financial incentives; the final success of adaptation depends on the rate of uptake by economic actors, i.e. their behaviour. Empirical studies show that this rate is low in situations of general political-economic uncertainties and low direct incentives (Eakin 2000). Bryant et al. (2000, p. 184f) stress the different aggregation levels relevant for societal adaptation and differentiate between autonomous responses and conscious public policy. They also stress the role of perception of climate change and the need for adaptation by the different actors; in the case of Canadian farmers, this was felt to be very low (ibid., p. 192).

IPCC (2001, p. 59) differentiates between anticipatory and reactive adaptation but this distinction is not clearcut. Most adaptation tries to be anticipatory; if it has not proved to be sufficient there will be reaction (see Figure 1).

Figure 1: Adaptation over time



Most forms of adaptation are club goods (Mendelsohn 2000) or public goods on different scales, but rarely on the global level. Some of them can be combined with mitigation. Examples for the land-use and health sector will show the different scales and characteristics of adaptation (see Tables 2 and 3).

Table 2: Adaptation in land use

Adaptive action	Type of adaptation	Scale	Link to mitigation
Coordinated plant breeding	Social	Global, if crop is globally used, otherwise regional	None
More efficient irrigation	Technical	Regional	Positive due to lower pumping needs
Diversification	Social	Local	None
Protective forestry	Technical	Local	Positive
Provision of crop insurance	Social	Regional	None
Protection against flooding	Technical	Local	None

Table 3: Adaptation to avoid health impacts

Adaptive action	Type of adaptation	Scale	Link to mitigation
Reducing heat stress though better building infrastructure	Technical	Regional	Positive (higher insulation, more efficient buildings) to negative (higher energy consumption for cooling)
Reducing heat stress through behavioural change	Social	Regional	Positive to neutral
Reducing disease vectors	Technical	Regional	Negative (energy use for vector control, emissions from wetland conversion)
Decreasing exposure to disease vectors	Social	Regional	None
Reducing water-borne disease	Technical	Local	Negative (energy use for water treatment)
Decreasing exposure to water-borne disease	Social	Regional	None

As the examples show, mitigation and adaptation are strategies that are generally not complementary. Spending money on adaptation means that it is not available for mitigation. This trade- off between adaptation and mitigation has also been the perception for a long time. Many participants of national and international climate policy processes felt that adaptation could be used to displace mitigation activities and thus avoided discussions of adaptation (Kates 2000, p. 6). For future climate policy, this competition will become important, but so far the choice between mitigation and adaptation has been rarely addressed in the policy literature. The first ones to explore the issue are Kane/Shogren (2000) and Lempert et al. (2000). Kane and Shogren use a complex model of endogenous risk to explain interactions between adaptation and mitigation (see discussion below). They rightly state that there can be tradeoffs across time and space but do not address systematically how far both options are complements

or substitutes[2]. Lempert et al. argue that intertemporally, choices between mitigation and adaptation should be readjusted as knowledge about climate change improves.

What so far has not been addressed in detail but sometimes been mentioned in a passing way (e.g. Tol et al. 2001, p. 131) is the impact of the power of different actors on the allocation of funds to mitigation and adaptation and the design of measures. Using public choice theory, it is possible to explain which strategy is more attractive depending on the decision-making context.

2. The public choice framework

I use a simple public choice set of political actors and assume that each group of actors maximises its expected utility. I distinguish between the following groups (see also Michaelowa 1998):

- companies
- emitters, i.e. all companies emitting greenhouse gases
- climate protection industries, i.e. companies that sell goods whose use leads to emission reduction
- providers of adaptation infrastructure, i.e. building companies. They can belong to the categories of emitters.
- NGOs
- environment
- development
- media
- voters
- politicians, organised in parties
- bureaucrats

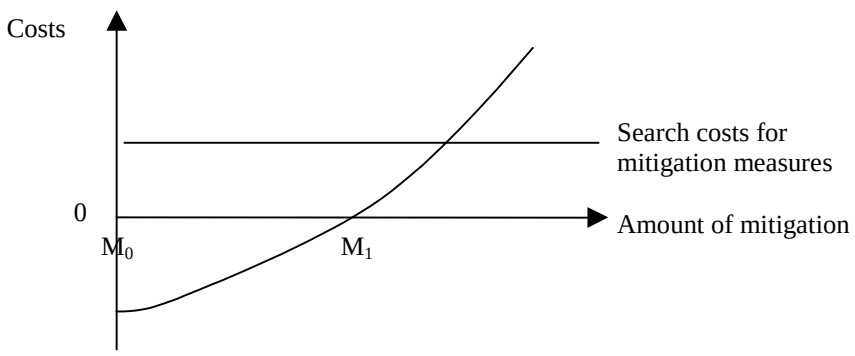
2 They assert that in US agriculture adaptation and mitigation are substitutes as losses in productivity due to climate change would be counteracted by using more energy-intensive inputs. However, an adaptation strategy could well reduce energy intensity by e.g. using less inputs in a diversification strategy.

Companies and media maximise expected profits. Politicians try to maximise their utility by remaining in office as long as possible. NGOs and bureaucrats maximise their budget. Voters maximise their expected utility from policies.

3. Interest group constellations concerning mitigation

Reduction of greenhouse gases will have a different degree of attractiveness to the different interest groups outlined. I assume that the benefits from mitigation in the form of avoided climate change accrue with long lags and thus are not relevant for today´s decision-making due to discounting. Mitigation can technically be done in a multitude of ways but in general, the marginal cost curve for mitigation measures has the following shape (see Figure 2). Social mitigation is possible through voluntary restriction of consumption but leads to strong problems with free riding. It is thus very improbable to happen and will therefore not be discussed here in detail.

Figure 2: Marginal mitigation costs



This curve has a segment of so-called “no regret” measures, i.e. measures that are profitable. While this is doubted by neoclassical economists, empirical studies show the existence of such measures, albeit made less attractive by search costs due to the risk of using a new technology (Hourcade/Shukla 2001, p. 507). The functional form will thus be: $c_M = ax^b - d$

Emitters maximise $\Pi = (p - c - \bar{c}_M)x - C - C_s$, with p=average sales price, c= average variable costs, $\bar{c}_M$ = average mitigation costs, C= fixed costs and C_s = search costs. Autonomously, emitters will stay at point M_0 as the movement to M_1 entails non-recurring internal short-term search costs to the employees, shown by the horizontal line. Under the impact of a political decision to mitigate compared to business-as-usual, the companies incur search costs anyway as they have to look for mitigation options. They will thus be able to shift to point M_1 and reap benefits (BP 2001). Beyond point M_1, profits will decrease. A decrease in profits leads to a reduction in jobs. Depending on the type of instrument chosen, overall costs for emitters will differ. If a market instrument is applied, costs will be minimised. Instruments that entail subsidies or just obfuscate the fact of remaining on a business-as-usual track (such as the voluntary agreements in many countries, see Rennings et al. 1997), are preferred by emitters.

Climate protection industries will monotonously increase their profits with rising sales: $\Pi = (p - c)x - C$; with p=average sales price, c= average variable costs, and C= fixed costs. An increase in profits leads to an increase in jobs. Sales are positively correlated to the domestic *and* global mitigation compared to business-as-usual. Thus even in a domestic no-mitigation case, climate protection industries may grow.

Environmental and developmental NGOs try to maximise their budget by defining a clear profile and visible actions. They profit from blunt mitigation instruments.

Media maximise sales and will report on climate change issues when they feel that this can boost sales due to the attractiveness of an event for readers such as a weather catastrophe or a controversial negotiation session with colourful NGO protests. There is a feedback circle between voter interest in climate change and media reporting.

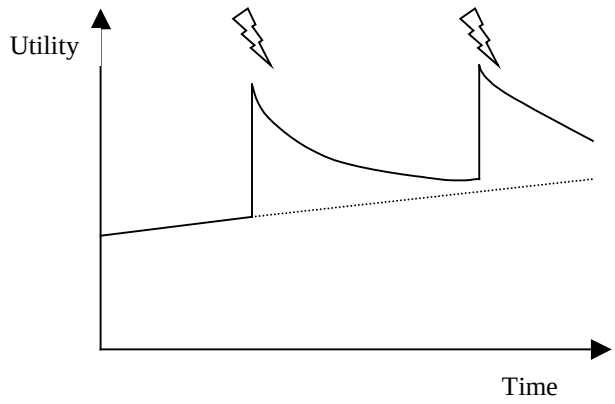
Voters´ preference for avoiding climate change is likely to be proportional to income. Experience has shown that interest in environmental policy rises with income as the basic needs have been saturated. Then, utility will be positively influenced by mitigation policies. Voter utility is also positively correlated with the number of jobs in the economy. Utility will not be constant over time but be influenced by the perception of the threat of climate change. Perceived utility of mitigation policies will be high if (see Figure):

- an extreme weather event just has taken place

- a new alarmist report on the science of climate change has been issued

It will diminish over time unless new events come up.

Figure 3: Voter preference for mitigation



Two extreme weather events cause a deviation from the preference path that would be slowly rising due to rising real income; the number of jobs is assumed to be constant.

Due to the costs of procuring information, voters will tend to perceive relatively blunt instruments more strongly than elaborate ones.

Policymakers aim at getting an absolute majority of votes. They thus have to introduce policy measures in a way that leads enough voters to perceive utility offered by their party is higher than those of the other parties. Devising policy measures needs time and attention which entails an opportunity cost as the policymakers cannot use this time to be available to the voters. If emitters provide (often biased) information to policymakers the opportunity costs will be reduced.

Bureaucrats want to maximise their budget, which is proportional to the administrative complexity of the bundle of policy instruments they oversee. They thus will favour relatively intransparent instruments. Both policymakers and bureaucrats will tend to develop a bundle of mitigation policies geared towards the different interest groups.

The policy outcome depends on the following factors:

- intensity of the voters´ preference for mitigation, which partly depends on the time lag since the last occurrence of an extreme weather event

- relation between marginal mitigation cost of emitters and marginal climate protection industry gain;

The following situations are possible (see Table 4)

Table 4: Mitigation policies under different policy factors

Name	Voter preference[1]	Marginal mitigation cost	Marginal climate protection industry gain
Strong mitigation policy	High	Low	High
Subsidy-oriented mitigation policy	High	Equal	
Mitigation lip service	High	High	Low
Efficiency-oriented mitigation	Low	Low	High
Some low-cost mitigation	Low	Equal	
No mitigation	Low	High	Low

[1] Extreme weather events cause a temporary shift from low to high values

Currently, no country fully exhibits the characteristics of the first line. Denmark may be the most close case. Several countries can be found in the second line, inter alia Germany and the Netherlands where perceived marginal mitigation costs are high[3], and the UK where they are low. The third line applies to most other EU countries and Japan. Line four is a rare case which may be found in some states of the U.S. such as California but also in some developing countries like Costa Rica. It can be explained as follows: voters have no interest in mitigation policy but climate protection industry

3 Objectively, German mitigation costs are much lower than in the Netherlands but the German emitters´ lobby is stronger.

profits from measures. Policymakers do not have to show voters a big bundle of activities and will implement efficient measures as they

Canada is a good example for line five but also several developing countries such as China fit here. Most countries of the world, however, remain in line six.

4. Stakeholders in adaptation

Adaptation policies are much more diverse than mitigation. In contrast to mitigation policies, there are direct individual and local benefits due to the reduction of potential damages from climate change. However, as the baseline damage cannot be measured exactly, these benefits are difficult to quantify. Besides the direct benefits, some types of adaptation policies also have positive externalities by strengthening overall resilience of a society. The benefits accrue to differing groups depending on the type of adaptation action. So far, adaptation literature has been slow to look at the different interests but first calls for this are being made (Adger 2001, p. 927). However, they are still defined in terms of "vulnerability" of specific interest groups seen from an objective angle and do not look for the subjective interests. The poorer and less educated people are, the higher their vulnerability. Thus "policies that lessen pressures on resources, improve management of environmental risks and increase the welfare of the poorest members of society can simultaneously advance sustainable development and equity, enhance adaptive capacity and reduce vulnerability to climate and other stresses" (IPCC 2001, p. 7). Some first forays into an interest group analysis can be found in the criteria set of Mortsch and Mills (1996) to assess adaptation options where they ask inter alia whether policymakers, bureaucrats and voters are supportive. They also ask who pays and who benefits from the measure. Loë and Kreutzwiser (2000, p. 171ff) discuss the issue of transnational adaptation in a case study on the Great Lakes and mention the adaptation options of different interest groups .

Benefits from technical adaptation of infrastructure accrue to all people living in the area under threat from the climate change-related hazard (e.g. floods, rockfalls). Some mitigation measures such as hydropower stations may have adaptation benefits – here flood control is improved. Societal adaptation benefits much less defined groups and can have significant externalities, especially in earlier stages of a policy. In the case of

development and use of new seed varieties for agriculture and forestry besides the farmers in your jurisdiction, farmers in similar climate zones can use the new varieties. Implementation of early warning systems for extreme events can also have a positive externality if the system can easily be transferred to another location. The more specific adaptation policies become, the smaller the group of addressees and the less relevant the externalities.

In the case of societal adaptation policy, it is unclear whether adaptation has actually occurred unless you can force the target group to behave accordingly. Adger (2001, p. 922) argues that many adaptation activities will be spontaneous and depend on perceived and actual risks. Spontaneous activities are likely to be started by individuals and depend on their economic resources (McCarthy 2001, p. 895); later governmental action may supplement them. Reilly and Schimmelpfennig (2000) argue for totally unconscious social adaptation due to path dependency[4]. The capacity for such spontaneous adaptation would be proportional to institutional capacity, e.g. to do research or to ensure an open and efficient market in goods and ideas. The different determinants of adaptive capacity and their relation to government action are shown in Table 5.

Table 5: Determinants of adaptive capacity and the relevance of income and government action

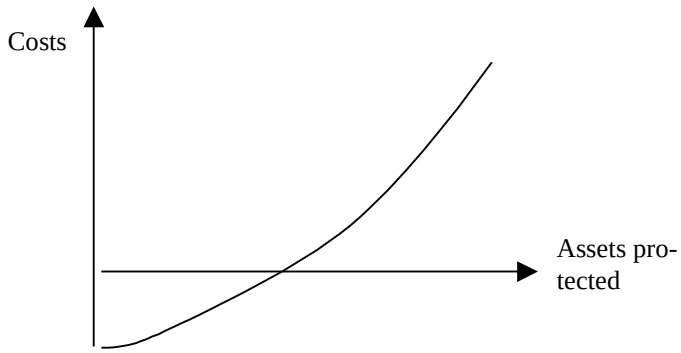
Determinant	Dependence on income	Relevance of government action
Economic resources	High	Medium
Technology	High	High
Infrastructure	High	High
Information and skills	Medium	High
Institutions	Medium	High
Equity	Low	Medium

Source: Determinants from McCarthy (2001, p. 895ff)

4 They use the example of a farmer buying new seeds on the basis of overall performance on the recommendation of his seed salesman; however performance of this seed has only become the best due to climate change.

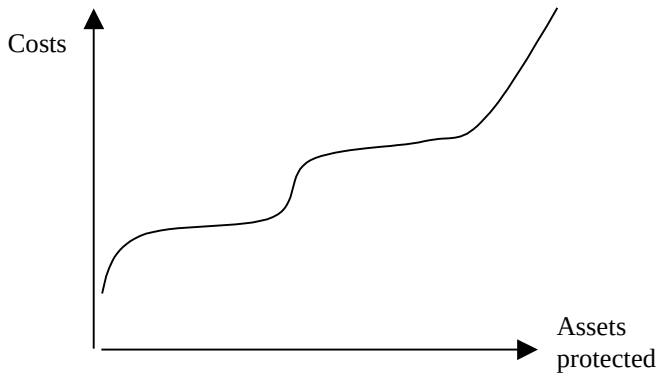
The cost function for technical adaptation costs is similar to the mitigation cost curve (see Figure 4).

Figure 4: Marginal technical adaptation costs



The more people and assets you protect, the higher the costs. There are no private no-regrets as any technical measure will have a positive cost but socially, some measures will produce side benefits. The cost curve may, however, become irregular if at a specific level a marginal addition in costs leads to a protection of a huge number of additional people due to the particularities of the geographical location (see Figure 5).

Figure 5: Irregular cost curve



This cost shape is likely to be prevalent in societal adaptation. If for example an agricultural extension service has to develop wheat seeds that are more likely to

withstand weather extremes expected under climate change, the marginal costs of spreading these seeds to an additional farmer are likely to be very small. Marginal costs thus first rise steeply and then become flat. After all farmers start using the seeds, the next step to develop barley seeds once again leads to steeply rising marginal costs. The marginal cost curve will thus exhibit steps. It does not start at zero because there are transaction costs if routines are changed. Transaction costs will be the lower, the higher existing institutional capabilities and human capital.

The situation is complicated if negative externalities of successful adaptation accrue on other societal groups (Kates 2000, p. 7, 12).

Emitters and climate protection industries will try to get free adaptation policies financed from the general budget. If this cannot be achieved, they will accept policies as long as their payment for adaptation equals their expected damage from climate change: $C_A = D$. D can be both positive and negative. If damages to one group equal advantages to another one due to shifts in an exploitable resource and information is lacking, efficient adaptation may be impossible to reach as shown by a study on Pacific salmon fisheries (Miller 2000).

Providers of adaptation infrastructure will monotonically increase their profits with rising sales: $\Pi = (p - c - c_M)x - C$; with p=average sales price, c= average variable costs, c_M = average mitigation costs due to the production of goods and C= fixed costs. An increase in profits leads to an increase in jobs.

Environmental NGOs will not be interested in adaptation measures unless they protect endangered ecosystems. They will criticise adaptation spending as distraction from limiting climate change through mitigation. Development NGOs will call for adaptation measures in developing countries but will be disinterested in domestic measures.

Media will be mainly interested in extreme events and catastrophes as long as they do not become too frequent. Technical and societal adaptation is a long process without news value and also will be much too complex to be attractive to readers. Thus media will not push for adaptation.

Voters will ask for government action to reach D = 0 but their willingness to pay will differ. Voter preference for adaptation will underlie similar changes as for mitigation,

with a stronger emphasis after an extreme weather event. This is underlined by the results of Bryant et al. (2000, p. 193) who saw a great impact of recent experiences on farmer behaviour in Canada. Technical adaptation will be more strongly perceived than the societal one. In non-democratic societies only damages of those will play a role who have an influence on government, i.e. the group closest to the governing oligarchy or dictator.

Policymakers can steer adaptation measures in a way that focuses on the voters of their specific circumscription. They will thus favour technical adaptation. Bureaucrats will on the one hand like technical adaptation due to the high budgets involved but will also be favourable to measures aiming at societal adaptation if these measures need strong discretionary input leading to high budget allocation and can be differentiated in many measures. If bureaucrats manage vulnerable systems, they will be interested in early technical adaptation.

The policy outcome depends on the following factors:

- intensity of the voters´ preference for adaptation mirroring expected damages from climate change and depending on the last occurrence of an extreme weather event

- relation between marginal technical adaptation cost and marginal societal adaptation cost – the former being proportional to the gain of providers of adaptation infrastructure

As both emitters and voters who expect high damages favour government intervention, the most likely outcome is a tax-financed provision of technical adaptation and subsidy programmes for societal adaptation of specific groups. The role of extreme events is very important. This can be underlined with empirical evidence. IPCC (2001, p. 61) states that extreme events often are catalysts for changes in water management.

The following situations are possible (see Table 6)

Table 6: Adaptation policies under different policy factors

Name	Voter preference[1]	Marginal societal adaptation cost	Marginal technical adaptation cost
Strong, balanced adaptation policy	High	Low	Low
Strong social adaptation policy	High	Low	High
Strong technical adaptation policy	High	High	Low
Prefer some damage to change	High	High	High
Reluctant balanced adaptation	Low	Low	Low
Some low-cost societal adaptation	Low	Low	High
Some low-cost technical adaptation	Low	High	Low
Little or no adaptation	Low	High	High

[1] Extreme weather events cause a temporary shift from low to high values; the preference is also proportional to expected damage

As so far almost no country has developed a dedicated adaptation strategy (the UK is just starting the exercise; UK Climate Impacts Programme/DETR 2000), it is not possible to give examples for every line. Generally, industrialised countries exhibit lower societal adaptation costs as the fixed costs for setting up institutions have already been incurred. Cases for line two may be the low-lying areas in the Netherlands and the UK. Line four applies to most small island states, line eight to most continental developing countries. Obviously, several situations may apply to different regions within a country.

5. Joint determination of mitigation and adaptation investments

Under an optimal strategy (see Appendix A.1), it is optimal to equalise the marginal benefits due to reduction of damages from climate change and the sum of marginal costs of mitigation and adaptation. The exact shares of each policy depend on the slopes of the cost curves.

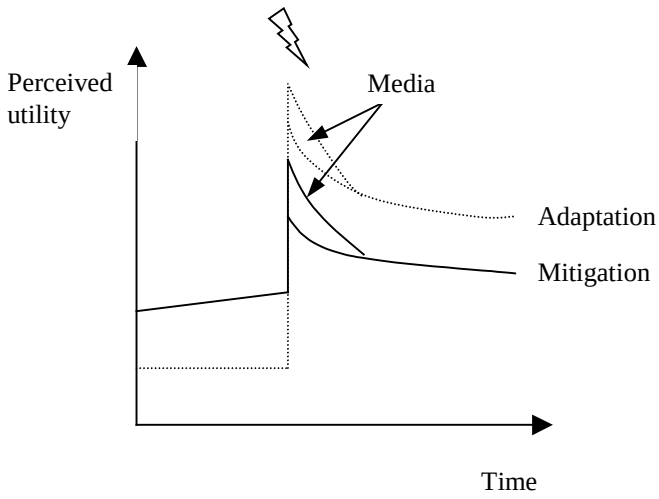
Kane and Shogren (2000) use an elaborate model that treats climate change as endogenous risk to come to the same conclusion. Thus they have a distribution function

for climate damages depending on the propensity of climate change to create damages and the current degree of knowledge about this propensity, i.e. expected damages. The latter is decisive for model results. The exact distribution of mitigation and adaptation effort depends on the second-order effects of adaptation on mitigation and vice versa, similar to cross-price effects[5]. If adaptation and mitigation are complements, an increase in expected damages leads to an increase of both adaptation and mitigation; if they are substitutes, the less productive one is crowded out.

5.1. Distortions through interest group action

The main driver is voters´ perceived preference for mitigation and adaptation which is both linked to the occurrence of extreme weather events. While perceived utility from mitigation is likely to be dependent on income, perceived utility of adaptation depends on perception of damage. It is thus likely that voters will press for both mitigation and adaptation if an extreme weather event has taken place but set a priority for adaptation if damages are perceived to be high. Voters´ preferences will be enhanced by the media feedback (see Figure 6). Perceived utility of voters does not take into account future generations.

Figure 6: Voter preferences for mitigation and adaptation



5 They assume that productivity of mitigation depends on the level of climate change damages; this can obviously only be relevant for mitigation options in the land use sector.

The existence of climate protection industry with low costs will increase the equilibrium amount of mitigation, especially if the potential for technical adaptation is low. Conversely, high costs of emitters coupled with a strong industry lobbying for technical adaptation will enhance the share of adaptation. NGOs will lobby for mitigation, shifting the equilibrium somewhat, depending on their influence. Societal adaptation has no strong lobby besides the bureaucrats and thus only becomes relevant under extremely high expected damages or unless a strong institutional culture exists that lowers transaction costs. Thus the following outcomes are conceivable (see Table 7):

Table 7: Mixes of mitigation and adaptation and strength of interest groups

	Expected damage	Income	Climate protection industry	Emitters´ mitigation costs	Costs of technical and societal adaptation	NGOs
Strong mitigation and balanced adaptation action	High	High	Strong	Low	Equal, low to medium	Strong
Strong mitigation, some adaptation	Low	High	Strong	Low to moderate	Medium to high	Strong
Strong adaptation, little mitigation	High	High	Weak	High	Technical: low to medium	Weak
Little mitigation and adaptation	Low	High	Weak	Moderate to high	Medium to high	Weak
Some basic adaptation	High	Low	Weak	High	Medium to high	Weak
Neither mitigation nor adaptation	Low	Low	Weak	High	Medium to high	Weak

6. Effects of the policy mix chosen on developing countries

We have seen that industrialised countries will prefer mitigation if they have a strong climate protection industry, relatively low mitigation costs and low damages. High damage countries will prefer adaptation, particularly if technical adaptation industries are strong, mitigation costs are high and NGOs are weak. Developing countries with low incomes will autonomously not be interested in mitigation unless its costs are very low or negative. They also do not have to reach an emission target under the current

form of the Kyoto Protocol regime. They thus will only do mitigation under the following cases:

- Companies or bureaucrats receive funding for CDM projects or find it attractive to unilaterally finance such projects and sell emission permits on the world market

- CDM projects show to emitters that a certain amount of no regret mitigation is available and can be exploited autonomously

Given the probability of damages from climate change, developing countries will start to invest in technical adaptation measures, especially after extreme events. This will be the case, if a minimum infrastructure exists and technical adaptation providers are active in the country. They will try to procure funds from industrialised countries. Bangladesh´ investment in cyclone shelters after the disaster of 1992 with aid funds from Germany is a nice example.

Societal adaptation is very difficult in the case of developing countries with a low institutional capacity and a high degree of inequality (McCarthy et al. 2001, p. 897f). Only if damages are extremely high, societal adaptation will be actively pursued. A striking case for anticipatory adaptation is Tuvalu´s government attempt to procure immigration rights from Australia and New Zealand in the case of sea-level rise and disappearance of the islands. New Zealand granted such rights while Australia refused (BBC 2001).

Overall, the growing recognition of the possibility to adapt to climate change by interest groups in industrialised countries reduces the investment in mitigation and enhances the adaptation need in developing countries. Unless this adaptation is financed by industrialised countries, developing countries will be worse off than in a mitigation – only strategy.

7. Conclusions

Mitigation of greenhouse gases and adaptation to climate change are two possible ways to react to the damages that are likely to be caused by global warming. So far, mitigation has been the focus of political activities. While mitigation is a global public good, adaptation is generally a club good. Actor preferences concerning mitigation and adaptation depend on income and are strongly influenced by the occurrence of extreme weather events. Mitigation will be preferred if there is a strong climate protection industry and emitters only face low mitigation costs. Due to the fact that technical adaptation leads to benefits for small, clearly circumscribed groups, these will ask for subsidy-financed programmes. Societal adaptation will be much less attractive but will also get some subsidies. A focus on adaptation in industrialised countries enhances adaptation needs in developing countries as future climate change will be stronger. As there is no climate protection industry and emitters face high costs, mitigation will not be done. However, for adaptation funds from industrialised countries will be sought, particularly if there are providers of infrastructure. Societal adaptation will only be addressed in case of high expected damages.

Overall, it is likely that adaptation policies will become more important relative to mitigation in the next years. Only if costs of mitigation are proved to be low and the climate protection industry becomes stronger in many countries, this trend could be halted. It will occur at any case in the developing countries, especially given the fact that under the Bonn Agreement transfers for mitigation under the CDM will be relatively small.

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Appendix

A.1 First-best optimal framework for decision on adaptation and mitigation

In a first-best world, the optimum mix of mitigation and adaptation policies can be determined as follows

The annual global wealth

(1) $W(x, M, A) = \Pi(x, M, A) - D_G(M, A)$

is maximised, with Π = profit, x = production, D_G = annual global climate change damages, M = annual mitigation, A = annual adaptation expenditures.

The profit function is

(2) $\Pi = (p - c - \bar{c}_M)x - C - C_s - c_A$,

with p=average sales price, c= average variable costs, $\bar{c}_M$ = average mitigation costs, C= fixed costs and c_A = adaptation costs.

The simple global damage function is dependent on the accumulated emissions in the atmosphere:

(3) $D(t) = \sum_{T-150}^{T} \frac{e(t)}{150 - t} - \sum_{T-20}^{T} \frac{A(t)}{20 - t}$,

with T = current year, e = annual emissions and A = annual adaptation expenses.

Mitigation costs are

(4) $C_M = ax^b - d$,

with x being the amount of production and b >0

Adaptation costs are

(5) $C_A = fy^g - h$,

with y being the protected assets and g >0.

Y depends on x as follows:

(6) $$y(t) = \sum_{T-50}^{T} \frac{x(t)}{50-t}$$

Annual emissions e depend on mitigation as follows:

(7) $$e_T = e_{T-1} - M \ .$$

Mitigation thus reduces D only over time.

A 2: Country table characteristics for mitigation policies

	Voter preference	**Status of climate protection industry**	**Status of emitters**	**Status of NGOs**	**Overall mitigation policy**
U.S.	High	Medium	Strong	Weak	Medium
Japan	High	Medium	Medium	Weak	Medium+
Scandinavia	High	Strong	Medium	Strong	Strong
UK	High	Weak	Medium	Medium	Medium
Germany	High	Strong	Strong	Strong	Medium+
Netherlands	High	Strong	Strong	Strong	Medium+
Cohesion countries	Medium	Weak	Medium	Weak	Medium-
EITs	Medium	Low	Strong	Weak	Weak
NICs	Medium	Medium	Strong	Weak	Weak+
DCs	Low	Low	Medium	Weak	Weak