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Sharing the Burden of Adaptation Financing: An Assessment of the Contributions of Countries

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Summary

Climate change may cause most harm to countries that contribute least to greenhouse gas emissions. This paper identifies deontology, solidarity and consequentialism as the principles that can serve as a basis for a fair international burden sharing scheme of adaptation costs. We translate these principles into criteria that can be applied in assigning contributions of individual countries, namely historical responsibility, equality and capacity to pay. Specific political and scientific choices are discussed, highlighting implications for international burden-sharing. Combining historical responsibility and capacity to pay seems a promising starting point for international negotiations on the design of burden-sharing schemes. From the numerical assessment, it is clear that UNFCCC Annex I countries carry the greatest burden under most scenarios, but contributions differ substantially subject to the choice of an indicator for capacity to pay. The total financial contribution by the Annex I countries could be in the range of \$55-68 billion annually.

Keywords: Adaptation Financing, Burden-Sharing, Historical Responsibility

JEL Classification: F55, Q54

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Sharing the burden of adaptation financing: An assessment of the contributions of countries

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Abstract

Climate change may cause most harm to countries that contribute least to greenhouse gas emissions. This paper identifies deontology, solidarity and consequentialism as the principles that can serve as a basis for a fair international burden sharing scheme of adaptation costs. We translate these principles into criteria that can be applied in assigning contributions of individual countries, namely historical responsibility, equality and capacity to pay. Specific political and scientific choices are discussed, highlighting implications for international burden-sharing. Combining historical responsibility and capacity to pay seems a promising starting point for international negotiations on the design of burden-sharing schemes. From the numerical assessment, it is clear that UNFCCC Annex I countries carry the greatest burden under most scenarios, but contributions differ substantially subject to the choice of an indicator for capacity to pay. The total financial contribution by the Annex I countries could be in the range of \$55-68 billion annually.

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1. INTRODUCTION

As recognition of observable and irreversible changes to the climate system grows, the scope of international climate policy has broadened from mitigation to include adaptation as a way of dealing with damage caused by climate change. A post-2102 global climate agreement will need to pay special attention to adaptation and its potential role in modifying climate vulnerabilities in different countries and to the distribution of adaptation costs (Ott et al., 2008). Climate vulnerabilities are not evenly distributed and the greatest vulnerabilities lie in countries that have contributed the least to historical greenhouse gas (GHG) emissions (IPCC, 2007). The potential scale of climate damages and the possible costs of adaptation are increasingly becoming apparent (Oxfam International, 2007; UNDP, 2007; Behrens, 2008). Hence, the question of how to share the burdens of adaptation costs has become an urgent international policy question (Baer et al., 2008) even though it has received limited attention in comparison to mitigation (Paavola and Adger, 2006; Grasso, 2007; Grasso, 2006).¹

In broad terms, whereas mitigation efforts (emission reductions) are concentrated in richer countries, adaptation effort is likely to be needed in poorer countries, with financing expected to come from richer countries. For adaptation, the primary burden-sharing problem will be to allocate funding responsibilities to richer countries to fund adaptation efforts in poorer countries².

But devising such a burden-sharing scheme raises many complex questions (Gupta, 1997). These include: Who is responsible for causing the climate change problem? Who should be held responsible for possible damages that result? Should those responsible for contributing to damage compensate those who suffered them? Should they assist in helping them to adapt so as to reduce these damages? What would be a fair division of liability and compensation? What is the capacity of countries to contribute to international financing? Answers to these questions need to draw on insights from political, legal and economic theory, be rooted in climate science and pass certain ethical tests.

¹ Ringius et al. (2002a) do address adaptation, damage and mitigation costs as a basis for burden sharing in their 'second fairness framework'.

² An equally important question raised, but not addressed here, is how to distribute these funds.

Against this background, this paper establishes a conceptual framework for allocating responsibilities for international financing of adaptation efforts related to climate change. Beyond a conceptual framework for allocating responsibility internationally for financial support for adaptation, we also quantify potential contributions by (groups of) countries, taking account of different design criteria for international adaptation financing schemes. Our approach provides insights into how shifting weights across design criteria in financing schemes will affect international burden-sharing of adaptation costs.

By focusing on a conceptual framework for ‘applied distribution rules’, we provide an in-depth application of the framework applied by Klinsky and Dowlatabadi (2009), who argue that the distributive justice implication of climate policy depends on ethical positions taken with regards to the definition of the climate problem, measurement of the imposed burden, and the applied distribution rules. Our specific approach to adaptation allows us to (partially) fill the gap on evaluative modelling as identified by Klinsky and Dowlatabadi (2009).

The next section analyses the relevant literature on ethical and legal principles and investigates how these principles can be used to specify some practical policy guidelines. We argue that a principle of strict liability cannot yet be applied to climate risk and propose instead a principle of responsibility, combined with an indicator related to the ‘capacity to pay’ of different countries. Seven scenarios are developed using this hybrid ‘Common But Differentiated Responsibility’ and respective capabilities (CBDR) approach and we model the distribution of costs, including a sensitivity analysis around key design criteria. Section 3 investigates what these guidelines may mean to specific countries and regions, including the Netherlands. Section 4 concludes.

2. FROM PRINCIPLES TO PRAGMATIC POLICIES

2.1 ETHICAL PRINCIPLES APPLIED TO ADAPTATION BURDEN-SHARING

Clearly, the aggregate global costs of adaptation to climate change impacts should be fairly distributed among countries (Adger et al., 2006) and a variety of fairness principles have been suggested in different disciplines (Sen, 1992; Young, 1994; Paavola and Adger, 2006; Klinsky and Dowlatabadi, 2009). Given the use of different vocabularies, this is a potentially confusing area and we start by reviewing some relevant concepts.

Using fairness as the starting point, several guiding principles are at hand to distribute aggregate, global adaptation costs among countries. Ikeme (2003) presents a distinction between deontological and consequential justifications. Bouwer and Vellinga (2005) further point to the role of solidarity as a guiding principle. Figure 1 shows that these ethical principles can be translated into ‘policy principles’ that may form the basis of pragmatic policy choices in relation to burden-sharing. These are an expansion on the classification proposed by Heyward (2007). The combination of the three policy principles results in an assessment of ‘Common But Differentiated Responsibilities’ (CBDR), which we argue may function as a practical basis for developing proposals for distributing adaptation costs.

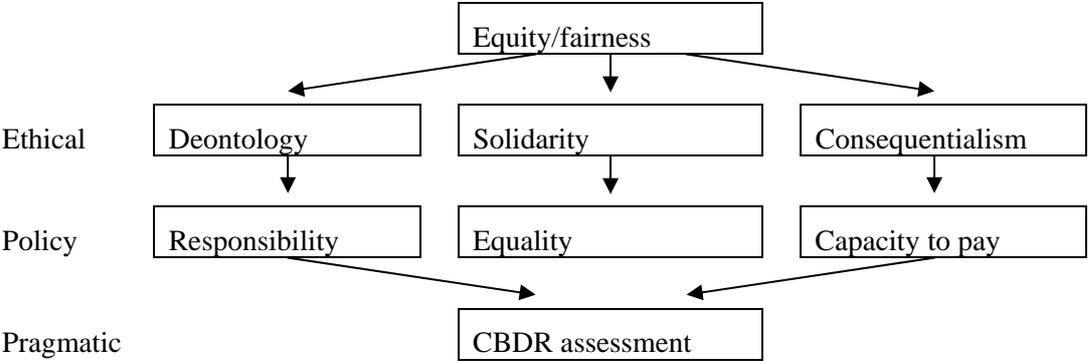


Figure 1. General principles of fairness translated into policy principles.

2.2 FROM DEONTOLOGY TO RESPONSIBILITY

The deontological principle can be traced back to Kant (Ikeme (2003), Low and Gleeson (1998)). Kant reasons that people can and should be held responsible for the consequences of their actions. Recent approaches related to the distribution of environmental damage have adopted the deontological principle as a basis (see for example Cullet, 2007; Faure and Nollkaemper, 2007). The ‘no harm’ principle applies the deontological perspective in an international legal context (the sovereignty of states does not include a right to harm other states³), the polluter pays principle (PPP) takes an economic point of view (the polluter bears the costs of achieving acceptable environmental quality, thereby avoiding harm) and the precautionary principle defines the duties of states in avoiding irreversible harm to others,

³ As (Tol and Verheyen, 2004) explain, the ‘no-harm’ principle further implies that when harm is done, causing states are obliged to redress or compensate the damage.

even in the absence of full scientific certainty. Those approaches have been incorporated in many international treaties, including the United Nations Framework Convention on Climate Change (UNFCCC).

A key principle in domestic environmental policy is the polluter pays principle as adopted by the OECD(OECD, 1972). This states that victims of pollution have a right to a certain acceptable state of the environment. Polluters must pay for measures to ensure that the environment returns to (or remains in) this acceptable state. If environmental quality cannot be returned to this state, as is the case for climate change impacts, the PPP may be extended to include the principle of compensation (Fischhendler, 2007). Here the polluter bears responsibility for compensating for the damage caused. This extension of the PPP draws on principles in international law, such as the principle of limited sovereignty (no harm) as embodied in the Rio Declaration (Birnie and Boyle, 2002).

There are difficulties in attributing damage experienced (or anticipated) at one place to polluting activities occurring in another place, especially in the case of climate change where polluters are widely distributed around over the world, where future impacts are related to past emissions and where impact assessment is still scientifically immature (Birnie and Boyle, 2002; Faure et al., 2007; Voigt, 2008). Drumbl (2008, p. 10) points out that for harm that is “too indirect, remote, and uncertain” causation cannot be established and therefore “falls outside the scope of the reparative obligation”.⁴ In other words, since specific impacts of climate change cannot (yet) be attributed to specific emissions of greenhouse gases by polluters, there is no basis for liability claims (yet). Another complexity is the question of which actor should be held responsible: states, operators or individual citizens? States, as such, are not emitters of greenhouse gases, but they may have the power to regulate emissions and have taken on international legal obligations to do so (see for example Faure et al., 2007; Cullet, 2007; Klinsky and Dowlatabadi, 2009). Despite these evident problems, this paper focuses on the responsibility of nation states for their greenhouse gas emissions, because this is the level at which international climate agreements are negotiated and because it avoids the problems of attributing emissions to individual consumers and producers.

⁴ Note that some climate scientists argue that establishing a causal relationship between specific emissions and specific damages may be within reach (Allen, 2003; Allen and Lord, 2004; Stott et al., 2004).

How then should we frame the problem of historical responsibility? Irreversible changes in the climate system are being caused by past emissions and these are projected to continue into the future (van Vuuren et al., 2008). These changes go beyond the historical variability of climate, with each increment of climatic change assumed to be associated with some damage. This suggests that a direct and limited application of the polluter pays principle, which assumes that mitigation will bring the environment back to an acceptable state, is not feasible.⁵ The extent to which such damages remain ‘acceptable’ – the standard set by the polluter pays principle – is the subject of ongoing debate about the definition of ‘dangerous’ climate change – the standard set in the UNFCCC (Gupta and van Asselt, 2006).

If all damage is assumed to be unacceptable to some degree, we need additionally to draw on the principles of liability (for damages) and compensation. Compensating victims for damages caused by climate change is one extension of the polluter pays principle with respect to adaptation costs. Attempts to apply this principle to climate change have been limited to assigning property rights to GHG emissions (as in emissions trading), but ignore the question of historical responsibility for climate change (Tol et al., 2004; Tol, 2006). Here the idea of ‘due diligence’ plays a central role in international legal debates. As Rao (2002) explains, due diligence means a state should do everything within its capabilities to take measures that are “appropriate and proportional to the degree of risk of transboundary harm.” To determine whether a state has acted with due diligence, two factors need to be taken into account: its capabilities to act; and the degree to which the harm could or should have been foreseen (Voigt, 2008). The first factor refers to the responsibilities of states – states with greater capabilities must accept more responsibility. The second factor holds that the state is no “absolute guarantor of the prevention of harm” (Birnie and Boyle, 2002, p. 112), but must exercise foresight in assessing potential harm caused by its actions. A related debate on when industrialized countries should be held responsibility for (attribution date) is presented in section 3.1.

In the UNFCCC, due diligence is associated with the application of the precautionary principle. According to the treaty, states should act in a precautionary way, but “policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into

⁵ Note that the notion of a low-stabilisation of atmospheric greenhouse gas concentrations implies that it may be possible to bring about an acceptable climate in the future (see den Elzen et al., 2007).

account different socio-economic contexts” (UNFCCC, 1992). Voigt (2008) and Birnie and Boyle (2002) argue, however, that due diligence and precaution are ill-defined in international law and their interpretation can differ from court to court. Thus, although GHG emitting countries may be taken to domestic or international courts to test their liability for damages, the outcome is at present unpredictable (Farber, 2007; Faure et al., 2007) but litigation in many related areas is taking place and relevant precedents are being created (Verheyen, 2005).

In sum, in international law states have a duty to avoid causing harm to other states. Since, historical greenhouse gas emissions are causing irreversible global damage and although ‘reparative obligations’ are in their infancy, *historical responsibility* is a good point of departure for a practical approach to burden-sharing on global adaptation costs, instead of using the more loaded and narrow term of *liability*.

2.3 FROM SOLIDARITY TO EQUALITY

Bouwer and Vellinga (2005) point to solidarity as a guiding principle for burden-sharing in international climate policy. There are many social and international public goods for which the solidarity principle holds. For instance, it is the duty of all citizens to uphold the law. Likewise, in international law, every state equally must respect human rights. A practical interpretation of solidarity is not straightforward, as it is a context-based principle. The concept does, however, provide a direct link to the related notion that any agreement should be ‘egalitarian’. Ringius et al. (2002b) argue that a common starting point in (international) negotiations is that all parties have equal responsibilities to address the problem at hand. From a moral point of view, as Shue (1999) explains, the most just division of costs thinkable would be to share all costs equally among all parties. Thus, the solidarity principle states that responsibilities should be divided equally.

Burden sharing of adaptation costs based on equality considerations has received less attention. Possible options include attributing adaptation costs to countries on the basis of their share in world population, or scaling adaptation costs to the geographical size of a country. Both measures are problematic: the former leads to a large burden for the developing countries, and may call for developing countries to finance the adaptation costs of more developed countries; the latter assumes that size and impacts are correlated. We conclude that

while equality may be a generally useful guiding principle, it has no practical relevance for a narrower assessment of burden sharing regimes for adaptation financing.

2.4 FROM CONSEQUENTIALISM TO CAPACITY TO PAY

The principle of consequentialism suggests that responsibilities for dealing with climate change should be based on the capacity-to-pay of countries to share the burdens of climate change (Ikeme, 2003). If there is an agreement on burden-sharing according to capacity to pay, then there is less need to go through the complex technical and political process of establishing responsibility for greenhouse gas emissions and for the damages that might result. Capacity to pay approaches that take the relative wealth of a country as a starting point also imply that countries should not bear unacceptably high costs. Müller et al. (2007) provide an excellent overview of different indicators that can be used to assess the capacity to pay perspective. The system of financial contributions of individual member states to the United Nations (the UN Scale of Assessment (UN, 2007)) is commonly agreed, through the General Assembly, to be based on the principle of capacity to pay.⁶ In broad terms, countries' contributions are determined by their recent level of Gross National Income, with corrections for external debt and low per capita income. The exact procedure and the level of assessment can be retrieved from the resolution (UN, 2007).

3. POLICY CHOICES AND 'COMMON BUT DIFFERENTIATED RESPONSIBILITIES (CBDR)' SCENARIOS

3.1 ASSESSING HISTORICAL CONTRIBUTIONS TO CLIMATE CHANGE

The historical contribution of different countries to climate change is a key aspect of establishing responsibilities of countries for adaptation funding. It is, however, difficult to disentangle historical and current contributions, because historical emissions may have long-lasting effects on climate conditions in the future for two main reasons. First, the atmospheric lifetime of most greenhouse gases is (very) long (Montenegro et al., 2007). Second, lags in the climate system imply that past emissions continue to change the climate in the future as a result of effects not directly related to the long lifetime of greenhouse gases (IPCC, 2007).

⁶ In a sensitivity analysis in Section 4 below, we look at current Gross Domestic Product (GDP) levels as an alternative.

Although difficult, attempts have been made to use historical responsibility for assessing the contributions of countries to international climate change financing mechanisms. A proposal made by the Government of Brazil (the ‘Brazilian proposal’) in 1997 was the first and most influential of these attempts (UNFCCC, 1997). The proposal led to a model inter-comparison exercise on the ‘Attribution of Contributions to Climate Change’. The conclusions of this analysis are described in UNFCCC (2002), and in greater detail in the scientific literature (e.g., den Elzen et al., 2002; Andronova and Schlesinger, 2004; Höhne and Blok, 2005; den Elzen et al., 2005b; Trudinger and Enting, 2005). A follow-up exercise was carried out by the Ad Hoc Group on Modelling and Assessment of Contributions to Climate Change (MATCH).

Given the complexity of allocating historical responsibility for greenhouse gases and their associated damages, we build on the work of the MATCH group (den Elzen and Schaeffer, 2002; den Elzen et al., 2005a; Trudinger and Enting, 2005; Rive et al., 2006; Müller, 2008). This group looked at alternative methods of assessing historical responsibility, identifying a set of key parameters that determined the outcome (see Table 1). These are each discussed below.

Table 1. Specifications of scenario parameters.

Choices in constructing CDDR scenarios	
Basic needs	Full responsibility, limited responsibility
Causal attribution	Producer-based
Gas mix	CO ₂ , all GHGs [CO ₂ , CH ₄ , N ₂ O]
Indicator	GWP-weighted cumulative GHG emissions, temperature increase
Sectors	All anthropogenic emissions (incl. LULUCF), Energy and Industry only
Timeframes	<i>Attribution start date</i> 1750, 1900, 1950 and 1990
	<i>Attribution end date</i> 1990, 2005, 2050 and 2100
	<i>Evaluation date</i> 2005, 2050, 2100, 2500

First, it is sometimes argued that a distinction should be made between emissions that serve a basic need, such as emissions for cooking and heating, and emissions that can be regarded as ‘luxury’ (Müller et al., 2007). Accounting for emissions on the basis of ‘full responsibility’ attributes all emissions to individual countries, whereas limited responsibility deducts a given amount of ‘basic allowances’. Second, there is the question of whether emissions (and consequently climate impacts) should be attributed to the source of the emission, or to the

destination of the good or service responsible for the emission, i.e. whether *causal attribution* should be to producers or to consumers. It is customary to attribute emissions to the source - the United Nations Handbook on Environmental Accounting (UN et al., 2003) also adopts this custom. From an ethical perspective it may, however, make sense to attribute emissions to the destination of the goods, i.e. to consumers. For instance, a large proportion of Chinese emissions are related to the production of goods consumed in OECD countries (Wang and Watson, 2008; Peters et al., 2007; Weber et al., 2008). However, international trade data does not typically contain information on emissions embedded in produced goods. This makes it extremely hard to approximate emissions of specific regions and countries on a consumer-basis.

Third, concerning the *gas mix* taken into consideration, alternative choices can have major impacts on responsibility for individual countries. Since the pattern of industrial production has differed across countries, the share of individual countries in the emission of particular gases varies widely across gases.. We restrict ourselves to the three main greenhouse gases CO₂, CH₄ and N₂O, as the effect of the remaining Kyoto greenhouse gases is in most cases marginal (den Elzen et al., 2005a).

Fourth, concerning the *climate change indicator* selection, it should be noted that - as with any indicator - there is a trade-off between accuracy of measurement (early in the cause-effect chain) and accuracy of impact (late in the cause-effect chain). Choosing temperature increase as an indicator may be more accurate in terms of impact (although even then it is a proxy measure), but very uncertain in terms of measurement, while for cumulative emissions as an indicator the opposite holds. For those indicators that are not 'forward-looking' (radiative forcing, temperature increase and sea-level rise), a time gap between attribution and evaluation dates enables delayed, but inevitable, effects of the attributed emissions to be taken into account. This method therefore tends to shift the weight toward long-lived gases and towards more recent emissions (den Elzen et al., 1999). An extreme choice as climate change indicator is the use of climate damages. The major advantage of using damages as a climate change indicator is that this is the only indicator that would quantify the economic impacts of a climate change. However, estimation of damages produces major uncertainties compared to other indicators because impacts due to anthropogenically-caused climatic changes would need to be estimated and valued, now and in the future, opening-up complex discussions, such as the choice of an appropriate discount rate, and the value of life and property.

Fifth, a significant choice relates to the choice of the sectors to be included: including or excluding emissions from land use changes, in addition to emissions in energy and industry. There are fundamental differences between emissions from the combustion of fossil fuels in energy and industry and emissions from land use, land use change and forestry (LULUCF). Thus, it becomes a political choice whether or not to include land use emissions. Moreover, the geographical spread of historic land use change emissions differs substantially from the geographical spread of emissions from burning of fossil fuels. Including total (fossil and land-use change) GHG emissions decreases the OECD share by 21%-points and increases the Asia share by 14%-points, when compared with fossil fuel CO₂ emissions alone. Significant measurement problems may arise when land use change emissions are included in the analysis. One especially sensitive issue could be the question of how to treat deforestation and land use change during periods of colonialism in parts of Asia, Africa and Latin America. Should these emissions be allocated to the modern independent state, or to the colonising state? Due to lack of appropriate data we follow the convention of the database as described in Appendix I, but this pragmatic solution does not imply an ethical preference.

Finally, with respect to the time period of analysis, there are three choices to be made. The first two choices are the *start date* and *end date*, which define the time interval for the emissions that will be attributed to regions (hereafter referred to as the attribution period, i.e. start date – end date). Emissions that occurred before or after the attribution period are included in the climate model but not attributed (see Figure 2). The third choice is the *evaluation date*, which is the time for which attribution is performed. Usually the indicator is assessed at the end of the attribution period. The evaluation date may, however, be any later date (see Figure 2). This would allow consideration of the long-term effects of emissions, but would only be relevant for indicators that have time-dependent effects – i.e. in the cause-effect chain from concentrations onwards, due to the inertia of the climate system.

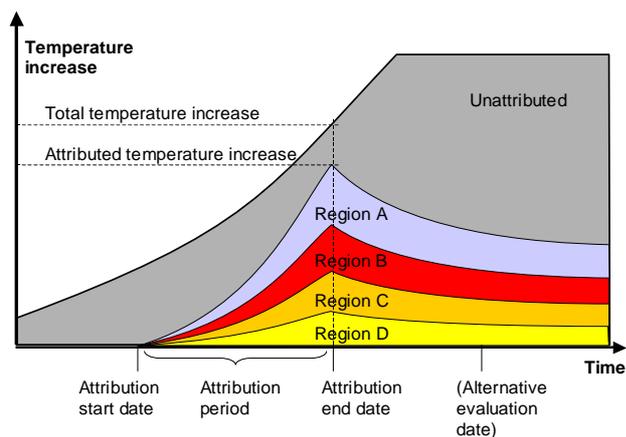


Figure 2. Schematisation of the impact of time period choices on attributed temperature changes. Source: Den Elzen et al. (2005a).

The complexity of identifying and disentangling historical contributions to climate change could be an important complicating factor in the allocation of responsibilities between countries and regions. Today the industrialized countries, notably the EU, USA, Japan and Russia, carry the main responsibility for past human contributions to atmospheric greenhouse gas concentrations (den Elzen et al., 2005b; Srinivasan et al., 2008). For this reason, many developing countries have argued that they should not be penalized for historical emissions by rich countries (Najam et al., 2003). However, it should be noted that relative contributions to climate change are changing, notably due to the rapid industrialization of China and to a lesser extent India and other developing countries. Therefore, in the future responsibility will be shared by the historically large emitters, as well as the new developed and the rapidly developing countries (Botzen et al., 2008).

3.2 A LIMITED SET OF CBDR SCENARIOS

The options described above, in combination with the technical/scientific options outlined in Appendix I, produce a highly complex set of choices for policymakers. The many different combinations of options each lead to specific outcomes. This section provides a restricted set of concrete formulas which we designate 'common but differentiated responsibility' (CBDR) scenarios.

These scenarios include as many GHGs as possible (specifically CO₂, CH₄ and N₂O), include LULUCF and the most recent fossil energy emissions (2005), because they all contribute to the problem of climate change and should be considered in a *fair* distribution of its burden based on responsibility. We set the evaluation date to 2005 to avoid interactions with

projected future emissions, as these cannot be part of a historical responsibility assessment. As outlined in section 2.4, we adopt the UN Scale of Assessment (2007-2009) as the indicator for capacity to pay. In the numerical calculations we have assumed an equal balance between *responsibility* and *capacity-to-pay* by giving both an equal weight to countries' contributions in the CBDR assessment (see Baer et al. (2008) for a similar approach).⁷

Variations are brought into the scenarios by changing (i) the start date for when countries can be held responsible for their past emissions, (ii) the indicator of climate change (temperature change or cumulative emissions) and (iii) full or limited responsibility (for all emissions, or only 'luxury' emissions). Table 2 shows seven CBDR scenarios in total.

Table 2. Overview of the CBDR scenarios.

Scenario	Name	Description
1	Full historical contribution to warming	<i>including all GHG emissions from 1750; indicator: temperature change; full responsibility</i>
2	Historical contribution to warming (default case)	<i>including all GHG emissions from 1900; indicator: temperature change; full responsibility</i>
3	Historical contribution to emissions	<i>including all GHG emissions from 1900; indicator: cumulative emissions; full responsibility</i>
4	Protocol contribution to warming	<i>including all GHG emissions from 1990; indicator: temperature change; full responsibility</i>
5	Protocol contribution to emissions	<i>including all GHG emissions from 1990; indicator: cumulative emissions; full responsibility</i>
6	Limited responsibility protocol contribution to emissions	<i>including all GHG emissions from 1990; indicator: cumulative emissions; limited responsibility</i>
7	Present contributions to emission levels	<i>including all GHG emissions for 2005; indicator: cumulative emissions; full responsibility</i>

⁷ There is no standard for combining the two criteria, responsibility and capacity to pay, in an assessment. Clearly, different weights would imply different quantitative results. The equal weights used here indicate most clearly that there is no ethical basis to emphasise one objective over the other.

A comprehensive approach would argue that countries are responsible for the effects of all their past emissions on the climate system. CBDR scenario 1 sets the start date at 1750, the date from which emission data is available, such that all known emission levels are attributed to individual countries and form the basis for a full responsibility to global warming. CBDR scenario 2 ignores emissions that have occurred between 1750 and 1900. Compared to scenario 1 this scenario has the same goal of compensating for climate change damages caused by individual countries. The reliability of the underlying emission data has, however, improved by setting the start date to 1900. As not all impacts of past emissions have revealed themselves through increases in temperature it can be argued that it is fairer to distribute the adaptation cost based on cumulative emission levels, as this indicator does not have a time lag. This is the basis for CBDR scenario 3.

Knowing about climate change might not be sufficient to establish state responsibility. A more convincing argument is that countries could have acted from the moment they started to negotiate on how to address the problem. In the case of climate change, international negotiations started around 1990. Therefore, in CBDR scenario 4 countries are assumed to be responsible from 1990 onwards for the effects their emissions caused on global average temperature up to now. In the same vein CBDR scenario 5 uses 1990 as a starting date, but determines historical responsibility on the basis of cumulative emission levels over the 1990-2005 period. As a variation to scenario 5, CBDR scenario 6 also takes into account that not all emission levels cause damages. Hence, countries cannot be held responsible for emissions associated with basic needs during the attribution period. We adopt a total level of 'basic needs' emissions of 7 GtCO₂eq, equal to the current sink of CO₂ by the oceans (Müller et al., 2007). These harmless emissions are translated to a per capita basis.

Alternatively, it can be argued that countries can be responsible only from the moment that an international agreement (on adaptation financing) comes into force. Hence, the adaptation regime should only look at recent contributions to climate change. By adopting this approach of sharing the total burden over current emissions, scenario 7 shifts attention more towards prevention of new emissions (i.e. if the regime only looks at the emissions in the previous year, new emitters need to cover all the associated adaptation costs for this year). As these new emissions have had limited time to affect the climate system, emission levels are taken as an indicator of climate change.

4. CONSEQUENCES FOR WORLD REGIONS AND COUNTRIES

This section aims to provide quantitative insights into the implications of different parameter choices on the attribution of adaptation costs to specific groups of countries across the range of the CBDR scenarios. We use for the climate attribution calculations generated by the MATCH climate model, as described in den Elzen et al. (2005a) combined with a historical emissions dataset at the level of 192 UN countries, as described in Höhne et al. (2008) (see Appendix I). These calculations are further extended by our own calculations for contributions according to the capacity to pay. We start by discussing the results of the restricted set of CBDR scenarios set out in Section 4.1 and conduct a sensitivity analysis in section 4.2.

4.1 RESULTS FOR THE CBDR SCENARIOS

Figure 3 gives the contributions to the CBDR capacity-responsibility index for selected countries and country-groups (more details presented in Table 3). We focus in the figure on two main groups (Annex I and non-Annex I) and a selected set of countries or world regions: USA, European Union (EU-25), Japan, Russia, Brazil, China, India, the Organization of Petroleum Exporting Countries (OPEC), the Alliance of Small Island States (AOSIS), and the group of Least Developed Countries (LDCs). The overall difference between the CBDR scenarios shows interesting patterns, especially because the scenarios take into account both the historical responsibility and capacity to pay. The figure shows that in general the choice of CBDR scenario affects the assessed responsibility of countries only marginally. In most CBDR scenarios, the burden placed on the group of Annex I countries amounts to about 70%.

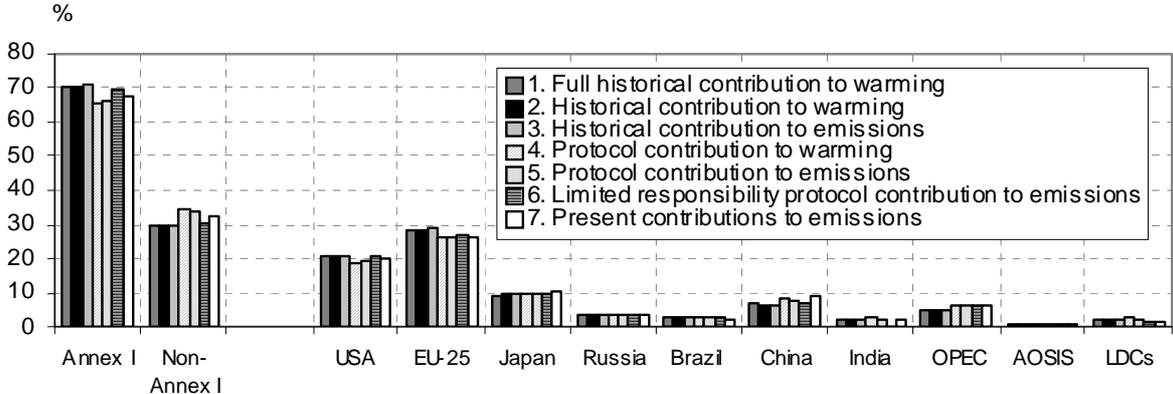


Figure 3. Contributions in the CBDR scenarios using a capacity-responsibility index.

Table 3. Contributions (%) for specific countries and regions in the CBDR scenarios using a capacity-responsibility index.

	Country	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Annex I		70	67	70	70	65	66	69
	Australia	1.6	1.9	1.6	1.6	1.8	1.7	1.9
	Canada	2.5	2.6	2.6	2.6	2.5	2.5	2.7
	Japan	9.6	10.3	9.7	9.8	9.7	10.0	10.2
	New Zealand	0.3	0.2	0.3	0.3	0.2	0.2	0.2
	Russia	4.1	3.3	4.1	3.9	3.7	3.5	3.9
	Ukraine	0.9	0.5	0.9	0.9	0.8	0.7	0.7
	USA*	20.7	20.0	20.4	20.8	19.0	19.5	21.0
EU-25		28	26	28	29	26	26	27
EU-15		26	24	26	26	24	24	25
	France	4.2	3.8	4.2	4.3	3.8	3.9	3.9
	Germany*	6.1	5.7	6.2	6.3	5.6	5.7	5.9
	Italy	3.1	3.3	3.2	3.2	3.2	3.2	3.3
	Netherlands	1.2	1.3	1.3	1.3	1.3	1.3	1.3
	Spain	1.8	2.1	1.8	1.9	1.9	1.9	2.0
	UK	5.1	4.2	4.9	5.1	4.2	4.2	4.3
Non-Annex I		30	33	30	30	35	34	31
Rest-OECD		3.7	4.4	3.7	3.7	4.0	4.1	4.1
	Mexico*	1.8	1.9	1.8	1.7	1.9	1.9	1.9
	Turkey	0.5	0.6	0.5	0.5	0.6	0.6	0.5
Brazil, China, India		21	23	21	21	23	22	20
	Brazil	2.7	2.2	2.8	2.6	2.9	2.7	2.9
	China*	7.1	9.5	6.7	6.7	8.1	8.0	7.1
	India	2.2	2.0	2.1	2.1	2.7	2.1	0.5
OPEC		4.9	6.0	5.0	4.9	5.9	5.9	6.0
	Indonesia*	2.0	2.1	1.9	1.9	2.1	2.3	2.4
	Nigeria	0.4	0.4	0.4	0.4	0.6	0.5	0.4
	Venezuela	0.5	0.4	0.6	0.5	0.6	0.5	0.6
AOSIS		0.8	0.9	0.9	0.9	0.9	1.0	1.0
	Cuba*	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Maldives	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LDC		2.4	1.8	2.4	2.3	2.6	2.2	1.7
	Afghanistan	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Congo*	0.3	0.3	0.3	0.3	0.4	0.0	0.0
Rest World		9.0	8.4	9.1	8.9	10.0	9.3	8.9
	Argentina	0.6	0.4	0.6	0.5	0.7	0.6	0.6
	South Africa*	0.5	0.7	0.6	0.6	0.6	0.6	0.7

* Country with highest contribution in the group (according to scenario 2).

In general, choosing a later attribution start date (e.g. present or 1990 instead of 1900 or 1750) reduces the relative contributions of industrialised countries ('early emitters'), emphasizing the shift in heavily emitting countries over time (compare CBDR scenarios 1, 2, 4 and 7). The more recent rapid increase in emissions in China and India is also apparent; highlighting how fluctuations in emission profiles in combination with specific start dates affects the attribution of responsibilities. Switching from increases in temperature to cumulative emissions as an indicator of climate change affects assessed historical responsibility to a limited extent in

most cases (compare CBDR scenario 2 with 3 and 4 with 5). CBDR scenario 6 clearly shows that with limited responsibility the contributions of LDCs are substantially reduced. It also decreases the total contribution of non-Annex I, in particular for India and China due to their large population.

4.2 SENSITIVITY ANALYSIS

This section investigates the degree to which each of the parametric choices related to responsibility and capacity affect countries contributions by varying a single parameter at a time. We use the default case CBDR scenario 2 as a reference, in line with the choices of the default cases made in other studies (den Elzen et al. (2005a) and Höhne et al. (2008)). In the selection of the parametric choices related to responsibility indicators we choose those that are most relevant and of major influence based on the detailed discussions in den Elzen et al. (2005a), i.e. the end-date, the greenhouse gas mixture and including or excluding CO₂ emissions from land-use change and forestry. For the choices on the capacity to pay we focus on the cases similar to those reported in Baer et al. (2008). A more elaborate sensitivity analysis is reported in Dellink et al. (2008).

Varying the end date and the evaluation date

By extending the attribution (and evaluation) period, i.e. applying different attribution end dates in 2005, 2020, 2050 and 2100 (Figure 4), predicted future levels of emissions (using SRES scenario A1B) and their consequent impact on climate change are also taken into account. This has a strong impact on the relative contribution of most regions to increases in temperature. Choosing a point further into the future lowers the relative contributions of Annex I regions, like USA and Russia, and raises those of non-Annex I regions, especially those with expected fast-growing emission levels after 2005, specifically India and China.

The responsibility of developing regions for the rise in temperature will increase when high economic growth is combined with high emission increases. Note that future attribution end dates attribute the effect of emissions from a future emissions trajectory, not just historical emissions. Thus, while these projections shed light on the expected shift in contributions across regions over time, they are fundamentally uncertain. Using a different emission

scenario will have a strong influence on a region's relative contribution to temperature change in 2100 (den Elzen et al., 2005a).

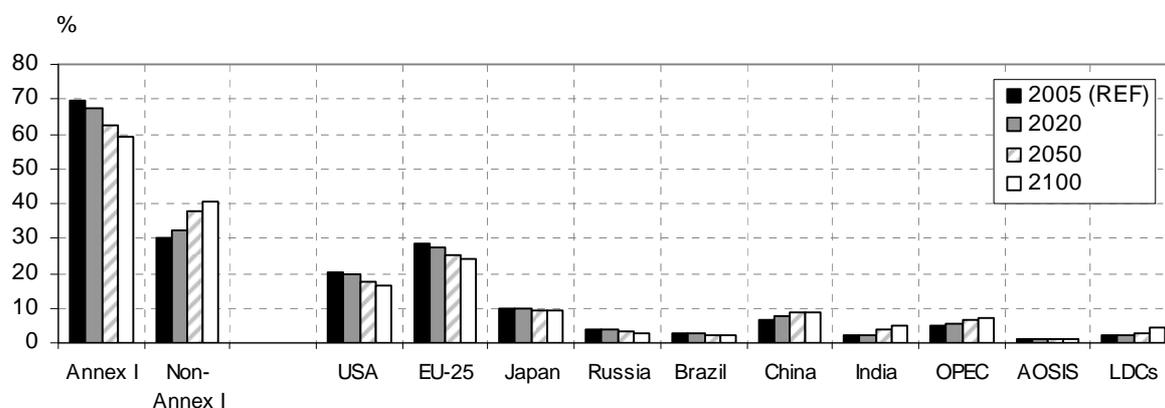


Figure 4. Impact of end-date on contributions in CDR scenario 2.

Varying the gas mix and the sector choice

We analysed the influence of including or excluding CO₂ emissions from land-use change and forestry, as well as the non-CO₂ gases CH₄ and N₂O. These emissions are significant for some countries, but also suffer from uncertainties compared to CO₂ from energy and industry with respect to reliability of historical emission data. Figure 5 shows the relative contribution to temperature increase in 2005 from emissions from 1900 to 2005 of all gases (including and excluding LULUCF), and for CO₂ only (including LULUCF or energy and industry only).

The difference with the default case is largest for countries with high emissions from deforestation and/or from CH₄ and N₂O in particular Brazil, China and India. Annex I countries usually have lower relative contributions when all gases and sectors are considered, which is most apparent for Japan. The most sensitive countries are those with a smaller industrial sector, but large emissions from agriculture and deforestation.

Thus, large developing countries have contributions that, in the default case, are of the same order of magnitude than those of most OECD countries (except the USA), but the main source of these contributions is different: they stem to a much larger extent from emissions due to land use change and deforestation.

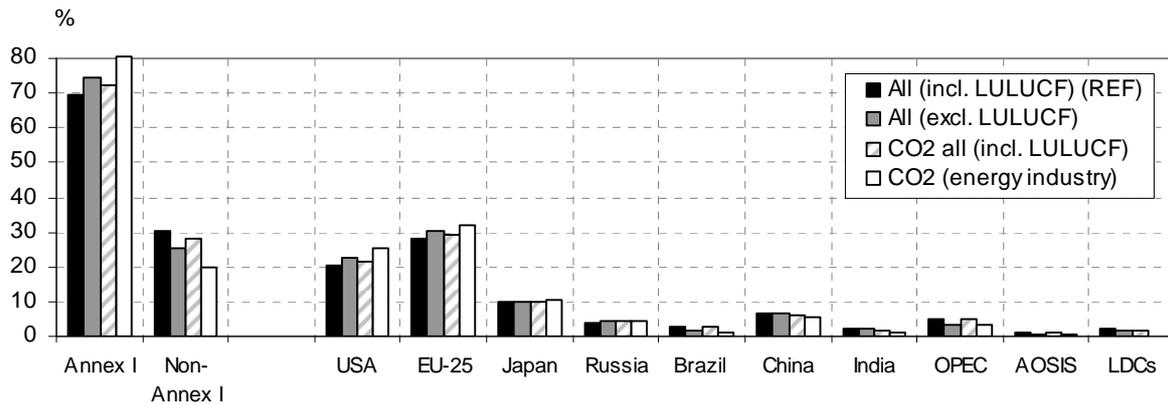


Figure 5. Impact of GHG mixture on contributions in CBDR scenario 2.

Varying the capacity to pay indicator

The variations above affect the contributions of countries based on historical responsibility. Alternative indicators for capacity to pay may also affect the results of the CBDR assessment. Therefore, we adopt current GDP (2005 level) as an alternative indicator of capacity to pay in this sensitivity analysis. As can be seen in Figure 6, this produces a decrease in the contributions from Japan and the EU-25, who have a relatively high contribution in the UN scale of assessment, and a clear increase in the contributions of China and India with fast-growing GDP levels. Furthermore, we present the results for the case that capacity to pay does not play any role in the assessment, i.e. a case where contributions are solely based on historical responsibility, leading to lower contributions for the Annex I countries in particular for Japan and EU-25, but substantially higher contributions for Russia. This provides a suitable benchmark to investigate the influence of using both responsibility and capacity to pay in the integrated CBDR approach, rather than adopting a single rule for the contributions.

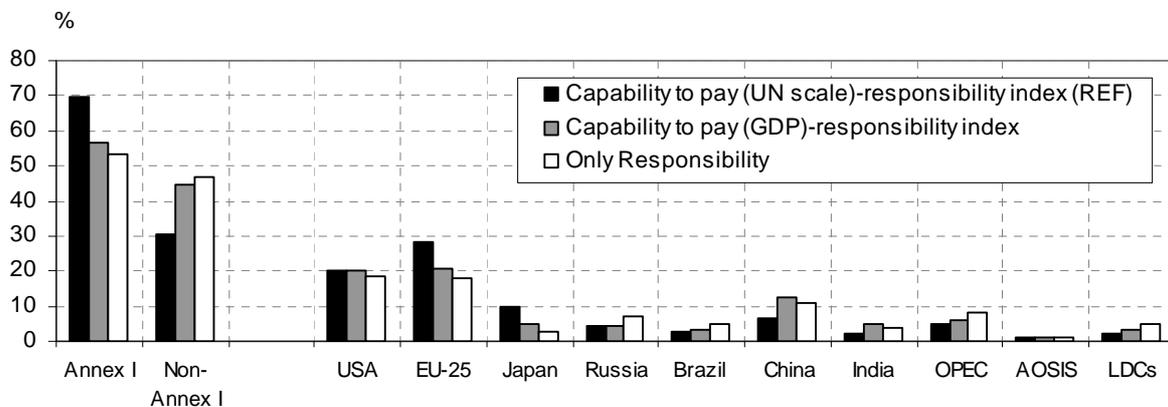


Figure 6. The impact of the capacity index on contributions in CBDR scenario 2.

5. CONCLUSIONS

As global impacts of climate change become observable and more serious, and given that a large part of the impacts will be experienced in less developed countries and regions, the issue of international financing of adaptation to climate change impacts has become more urgent. Adaptation has the potential for ameliorating, though not reducing to zero, the damages that could be caused by climate change. This paper set out a conceptual framework for allocating responsibilities for international financing of adaptation related to climate change, based on the historical contribution of different countries to climate change. We draw on ethical principles from philosophy, jurisprudence and economics. Using equity as the starting point, several guiding principles are available to allocate the costs of global adaptation efforts among countries: no harm; polluter pays; precaution; solidarity; and capacity to pay. These principles have been translated into policy principles which we term *responsibility*, *equality* and *capacity*. Although it is possible to adopt each one of these principles separately, we believe that a politically legitimate, and therefore politically feasible, approach would need to find a balance between historical responsibility and capacity to pay. Drawing on an already well-known principle in international climate policy, we call this approach *common but differentiated responsibility (CBDR)*.

Establishing historical responsibility of different countries to climate change requires choices to be made about attribution. Many alternatives exist, all with particular merits. Which choices are adopted will be an outcome of a political negotiation, probably in the context of the UNFCCC. We analyse the arguments for and the quantitative consequences of alternative political choices in attributing responsibility and assess how this could influence the allocation of the burden of the international financing of adaptation.

The quantitative analysis shows that both the principles themselves, as well as the values of the key parameters chosen to express them (such as the end and evaluation date, the gas mix, whether land-use change is included and the capacity to pay indicator), have a marked influence on results. For the simple case in which contributions to global surface mean temperature increases are taken as the result of current emissions, the contribution of Annex I countries to climate change would be about 55%, with non-Annex 1 countries contributing the

balance. However, if we include *capacity to pay* as a criterion and use the UN Scale of Assessment measure (the CBDR scenario), the contribution of the Annex I rises to 68%.

We carry out two kinds of sensitivity analysis of CBDR as a basis for allocating historical responsibility: one around the construction of the CBDR scenario; and one varying parameter values around a default CBDR scenario. These show that in constructing a CBDR index the inclusion of a capacity to pay measure has the largest influence on outcomes. Furthermore, the start- and end-dates have a marked impact, with a greater contribution attributed to non-Annex 1 countries for later start dates and longer-term assessments. This is because of the growing importance of non-Annex 1 emissions over time. Varying the indicator of climate change (from temperature change to cumulative emissions), including land use change, and using CO₂ alone (rather than the full suite of greenhouse gases) have a similar effect of increasing the attribution of non-Annex 1 countries.

Assuming the costs of climate adaptation are \$100 billion per year (UNDP, 2007), the total financial contribution by Annex 1 countries could range between \$55-68 billion per year, depending on whether capacity to pay is based on GDP, or on the UN scale of assessment.

Finally, it is important to note is that the regional contributions as projected by these CBDR scenarios are hugely different than the estimated adaptation expenditures across regions. Thus, if an international burden sharing agreement regime is established based on one of these CBDR scenarios, a large transfer of wealth will be directed towards the AOSIS countries and LDCs in each of the CBDR scenarios, because they experience the largest impacts of climate change.

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APPENDIX I. MODELLING ASSUMPTIONS AND DATA CHOICES

For this analysis we combine the simple default model as used in the MATCH exercise (MATCH climate model), as described in detail in (den Elzen et al., 2005a), with a historical emissions dataset at the level of 192 UN countries, as described in Höhne et al. (2008) and briefly explained below.

MATCH climate model

This model is based on Impulse Response Functions (IRFs) for the calculations of concentrations, temperature change and sea level rise, and based on functional dependencies from the IPCC-TAR (Ramaswamy et al., 2001) for the radiative forcing (e.g., logarithmic function for CO₂). For the CO₂ concentration, the IRF is based on the parameterisations of the Bern carbon cycle model of Joos et al. (1996; 1999), as applied in the IPCC Third Assessment Report. For the concentrations of the non-CO₂ GHGs, single-fixed lifetimes are used. The total radiative forcing considered here consists of the radiative forcing from CO₂, CH₄ and N₂O plus direct and indirect radiative forcing from aerosols derived by the coupled ocean-atmosphere General Circulation Model HADCM3 (Stott, 2000). Surface temperature change is modelled using two-term IRFs also derived from the HADCM3 model. The contributions of individual emissions to concentrations, temperature change and sea level rise are calculated by separately applying all equations defined at global level to the emissions of the individual emitting regions. The assumption of linearity of these steps in the MATCH climate model ensures that the sum of the regional contributions is equal to the contribution of the global total. The relationship between concentration and radiative forcing is non-linear ('saturation effect'). Here, the normalised "marginal method" is used as default (taking the effect of small additional emissions normalized so that the sum of all contributions is the total effect, see also (den Elzen et al., 2005a). Here, we use the ECOFYS implementation of the MATCH climate model (see: Höhne et al., 2005; Höhne et al., 2008). This model calculates the contribution to climate impact indicators, including global temperature increase at the levels of 192 countries, using an historical emissions data set, as described in Höhne et al. (2008).

Historical emissions data

The historical emissions for the period 1750 to 2005 are compiled for three sectors: energy and industry (CO₂, CH₄, N₂O), agriculture/waste (CH₄, N₂O) and land use change and forestry (CO₂) from 1750 to 2005. Hydrofluorocarbons (HFCs and HCFCs), perfluorocarbons (PFCs) and sulphurhexafluoride (SF₆) were not included as historical emission estimates were not available on a gas-by-gas level, but these emissions only amount to about 0.5% of total cumulative historical emissions. Historical emissions are based on national emission inventories, submitted to the UNFCCC (UNFCCC, 2005). and, where not available, other sources. More specifically, the CO₂ emissions from fuel combustion are taken from the International Energy Agency (IEA, 2006). This dataset was supplemented by process emissions from cement production from (Marland et al., 2003) to be cover all industrial CO₂ emissions. Emissions from CH₄ and N₂O as estimated by the US Environmental Protection Agency (USEPA, 2006), covering the years 1990 to 2005. Historical CH₄ and N₂O emissions are derived from national emissions for 1990 extended backward using the regional growth rates of (Klein Goldewijk and Battjes, 1995). For LULUCF CO₂ emissions, we used a different approach (de Campos, 2007). The use of growth rates is not possible here as the estimates can be negative (removals). Hence we used the simple approach of taking the average between the two datasets that for the global total represent the two extremes: Houghton (2003) and IVIG (de Campos et al., 2005). To downscale from SRES regions to nations, a concept of “potential LULUCF sink” is used, simply assuming that the more a country has emitted from LULUCF in the past, the more potential it has to create a sink by reverting to the original biomes. As potential LULUCF depends on past emissions, this also prolongs the difference between Houghton and IVIG. A more sophisticated model should take into account climate feedbacks and changing demand for agriculture etc., this is just a first approximation for reasonable downscaling.

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