Differentiating (Historic) Responsibilities for Climate Change

Summary Report

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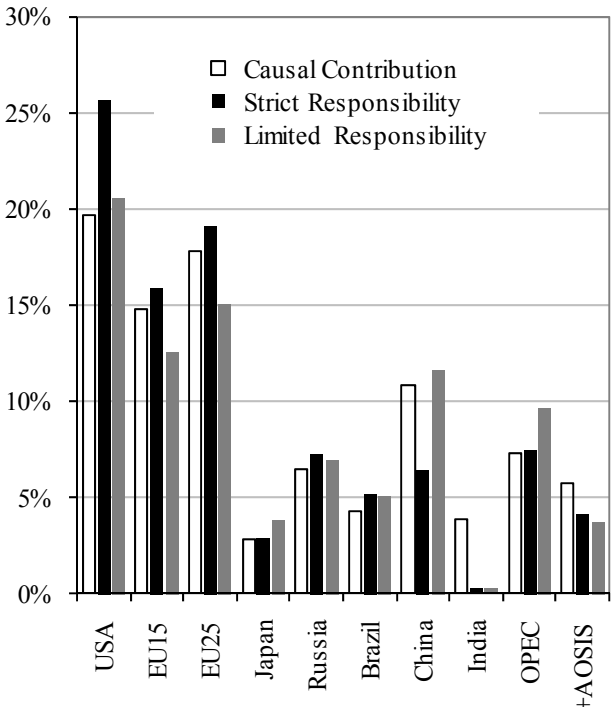
Summary for Decision Makers

The *ad hoc group for the modelling and assessment of contributions of climate change* ('MATCH') was formed in response to the decision of the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UN Framework Convention on Climate Change (UNFCCC) in November 2002 to invite the scientific community to continue their work on a burden sharing proposal based on the concept of 'historic responsibility,' originally put forward by Brazil in 1997.[6] The MATCH work has been primarily concerned with establishing shares in the causal contributions to changes in global mean temperature.

This Report is meant to complement the work of MATCH by re-directing the focus on the notion of moral responsibility, and by putting forward a methodology for establishing the relevant differentiated responsibilities.

The Report recognises two distinct kinds of responsibility, namely strict (or unlimited) responsibility, and limited responsibility, which are based on, but different to, cumulative historic emissions of the greenhouse gases CO_2, CH_4 and N_2O (incl. those from land use change and forestry).

Causal Contributions: For reference, we calculated shares in cumulative historic emissions of the greenhouse gases CO_2, CH_4 and N_2O (incl. from land use change and forestry), as a relative measure of causal contributions. According to this methodology, industrialised countries (as listed in Annex I to the UNFCCC), have up to the present causally contributed 54.5% to the climate change problem.



Shares in Causal Contribution to, and Moral Responsibilities for Climate Change

However, one of the key messages, of this Report is that causal contribution – while an important indicator of (environmental) relevance to the problem – must not be confused with moral responsibility for it. The latter will have to take into account limiting factors, such as ignorance of the harm done, which have no place in the scientific assessment of causal contributions. As shown in the figure depicting the shares in causal contributions to moral responsibility for climate change, the differences between the two can be significant. India, for example, with a causal contribution of 3.9% has a significant relevance to the problem, but has minimal moral responsibility – as we shall presently see – regardless of whether one considers strict or limited moral responsibility.

Strict Responsibilities are in part determined by causal contributions as reflected in historic emissions since 1890, and in part by population size and the level of global greenhouse gas emissions that are seen to be harmless – here taken to be the current level of global ocean sinks (estimated at $7GtCO_2eq$/annum) – and allocated on a per capita basis. In other words, in order to determine a country's share in the strict responsibility for the climate change problem, it is allocated a part of the harmless global emissions on a per capita basis. This 'basic allowance' is then subtracted from the

[6] See UNFCCC 1997

country's historic emissions, with the remainder (if any) determining its share in strict responsibility for the problem.

According to this methodology, industrialised countries (as listed in Annex I to the UNFCCC), are at present jointly strictly responsible for 64% of the climate change problem. As illustrated in the figure, the largest portion of strict historic responsibility has to be attributed to the US with 25.6%, followed by the EU15 (15.9%), OPEC (7.4%), Russia (7.3%), China (6.4%), Brazil (5.2%), the 76 countries of AOSIS and the LDC group (4.1%), Japan (2.8%), and finally India with next to no responsibility (0.3%). India's very low share (compared to its causal contribution of 3.9%) is due to the large population of India and the fact that the basic allowances were allocated on a per capita based 'lump sum' thus, as it were, allowing the not so poor to benefit from the surplus basic allowances of the poor.

Limited Responsibilities. According to Aristotle, moral responsibility ('blame') can be limited because of ignorance or circumstances beyond ones control. For the purposes of this report, these conditions were applied as follows. First it was assumed that there was a time before which governments could not be blamed for not knowing about the problem, and second that very poor people have a morally justified need to emit a certain amount of greenhouse gases, over and above the harmless level (they have a right to overcome their poverty and, presently, can't do so without these emissions).

There can be no doubt that after the start of the negotiations in 1990 that led to the UNFCCC, no government could reasonably plead ignorance of the climate change issue. While one might argue that they should have known even earlier, we have chosen to use this undisputable upper bound to implement Aristotle's epistemic condition by restricting the limited responsibility calculations to post-1990 emissions. The justified need to grow, in turn, was implemented through the introduction of individual 'subsistence allocations' of $2tCO_2eq.$ per poor inhabitant (the average per capita energy emissions of the developing world), which were allocated to every inhabitant surviving on less than \$1 a day, replacing the above-mentioned basic allowance, if that was less (in this case less than $2tCO_2eq.$).[7] Subsistence allowances are for 'subsistence emissions' only. In contrast to the basic allowances, a surplus therefore cannot be transferred outside the eligible community, i.e. the inhabitants with less than \$1 a day.

Numerically, the epistemic constraint – i.e. disregarding what happened before 1990 – turns out to have by far the stronger impact, relative to the strict responsibility figures, than the introduction of subsistence emissions under these poverty parameter values. Their combined effect is a shift of responsibility of 9 percentage points away from Annex I to the developing world, chiefly absorbed by China (+5.1 percentage points). With the exception of AOSIS+LDC overtaking Japan, and China advancing to third place, the ranking remains the same as under the strict conception: US (20.3%), EU15 (12.4%), China (11.5%), OPEC (9.5%), Russia (6.8%), Brazil (5%), Japan (3.8%), AOSIS+LDC (4.7%%), and India (0.6%).

We do not wish to engage here in a debate on which of the two conceptions of responsibility – with the chosen parameter values – is more appropriate, not least because the answer may well depend on what one wishes to do with the results. However, the rather large difference between the responsibilities at the two extremes of the scale *under both conceptions* does, we believe, give pause for thought as to what sorts of burdens can justly be demanded in any application of the UNFCCC *principle of common but differentiated responsibilities*, whether in the context of the Brazilian proposal or beyond. This is not to say anything about the environmental relevance of the emissions of these countries to the climate change problem, but merely about the just distribution of burdens/costs of, for example, addressing these emissions.

[7] According to WRI *EarthTrends*, (http://earthtrends.wri.org/index.php), the per capita CO_2 emissions (excl. LULUCF) of the developing world in 2002 was $1.98tCO_2$

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Introduction

The Brazilian Proposal and MATCH

As part of the negotiations of the Kyoto Protocol, the delegation of Brazil presented an approach for allocating reductions of greenhouse gas emissions among OECD countries and economies in transition (the Annex I Parties) based on the effect of their cumulative historical emissions of greenhouse gases (GHGs) included in the Kyoto Protocol, from 1840 onwards, on the global-average surface temperature (UNFCCC 1997).

Although it was not adopted during the Kyoto negotiations, the Brazilian Proposal did receive support, especially from developing countries, and the Third Conference of the Parties (COP.3) requested the Subsidiary Body on Scientific and Technical Advice (SBSTA) to further study the methodological and scientific aspects of the proposal. This led to continued debate and analysis (e.g. den Elzen et al. 2002; Andronova and Schlesinger 2004; den Elzen et al. 2004; Höhne and Blok 2005; Trudinger and Enting 2005; Rive et al. 2006; Rive and Fuglestvedt 2007).

A follow up exercise is now being carried out by an *ad-hoc group for the modelling and assessment of contributions of climate change* (MATCH) (Höhne and Ullrich 2003) to improve the robustness of calculations and more rigorously assess the uncertainties and methodological choices.

Motivation of this Report

While the MATCH process concentrated on the *causal contribution* of emissions originating from the territory of a country, the present Report turns the focus on the *moral responsibilities* for climate change. It turns the issue from a technical question into a moral question on the interpretation of the results of the MATCH group.

In the past, the distinction between historical contribution and responsibility for climate change has not always been clear and our intention is to explicate and clarify this distinction in this Report.

Furthermore, it had been criticised that the past work on historical contributions for climate change, by focussing on the technical, natural science aspects, neglected the ethical and interpretational aspects. Discussions of the earlier work showed a clear demand for more discussion on these normative and moral aspects. We intend to contribute to this demand with this Report.

The Conceptual Framework

Contribution versus responsibility

Climate impacts – be they anthropogenic, due to natural variability or anything else – will inevitably have a large multitude of causes, each causally *contributing* to the impacts in question. The (moral) responsibility for climate impacts will also typically be shared by a number of actors. The key difference between being morally (partly) responsible for, and (causally) contributing to is that the former is a blameable matter which only makes sense if the impacts are anthropogenic, while the latter is not. The 1628BC eruption on the Aegean island of Thera (Santorini),[8] it has been argued, led to an average global cooling of 1.5°C over the following one hundred years,[9] which, in turn, has been put forward as one of the key contributing factors in the downfall of the Minoan civilization during the first half of the 16th Century BC,[10] but it would be considered odd to hold the mountain morally responsible, let alone wishing to punish it accordingly.

The problem is that in the case of *anthropogenic* impacts – i.e. impacts brought about by man-made greenhouse gas emissions – the difference, while remaining, is sometimes not quite as self-evident, a fact that has led to considerable confusion. There is, of course, a link between a moral agent causally contributing to an impact and being morally (partly) responsible for it,[11] but that does not mean that the two are the same. Indeed, their difference becomes clear when considering that they generally imply – as will be shown below – different shares. The share of someone's causal contribution to an impact is generally not the same as their share in the moral responsibility for it.

However, to demonstrate this, we need to begin by briefly considering the way in which causal contributions are attributed, in which their relative shares are defined. For the present purposes, it is quite sufficient to focus on the methodology adopted in the MATCH project.

The MATCH project modelling has focussed on determining the causal contribution of greenhouse gas time series to certain climatic impacts, in particular to changes in mean global temperature. One of the key outcomes of this work has been that the degree to which any such given sequence contributes to climate change impacts is not uniquely determined but varies with the type of impact: one and the same emission time series might contribute 10 percent to a change in global mean temperature, but only 5 percent to sea level rise. The lesson thus has to be that one really cannot speak of causal contributions to climate change *per se*, at least not if one is intent on specifying numerical shares thereof.

The advantage of focussing on the effects of emission time series on certain climate parameters was, of course, the purely scientific nature of the exercise which was meant to safeguard the discussions from being dragged into normative or even moral debates. Of course, even in the context of establishing shares in causal contribution, normative issues could not be completely avoided. One of the key normative decisions which was generally not even recognised as such was the way in which emission time series were associated with

[8] See Manning (1999).
[9] 1647BC: +0.65ºC, 1559BC: –0.9ºC, relative to present. See Petit *et al.*, (1999).
[10] '... the eruption on Thera could have lowered annual average temperatures by 1 to 2 degrees across Europe, Asia and North America. ... the summer temperatures would have dropped more - suggesting years of cold, wet summers and ruined harvests' Cecil (2001).
[11] Although moral responsibility can exist even in the absence of causal contribution (see discussion of duty-based responsibilities below).

particular countries. It is one thing to say that this and that series of emissions has contributed a certain percentage to the increase in global mean temperature over the 20th Century, and quite another to say that the United States of America have done so. The former is purely scientific, but uninteresting; the latter involves a normative decision of how to identify 'the emissions of the US' (at a given time) and can lead to rather heated debates. The implicit assumption of the MATCH team was that (a) the (anthropogenic) emissions associated with a country for a given period are those emitted over its sovereign territory, and (b) the sovereign territory is changing over time.[12]

There are a number of problems with this traditional conception, not least the well-known fact that it does not lend itself easily to accommodate 'bunker fuel' emissions from international travel and transport which cannot easily be identified as coming from a sovereign territory, particularly if they are emitted over international waters. Another, lesser known problem with this sort of traditional sovereignty based definition is that it does not lend itself to take account of joint contributions and responsibilities, short of pooling the sovereignty of the territories in question. We shall discuss this shortcoming briefly in the context of Article 4 of the UNFCCC, which we believe can be interpreted as implying joint North-South responsibility over the (increments in) emissions in developing countries since the Convention was signed in 1992. For the rest of the Report, we shall however follow the traditional sovereign territory definition of countries' 'anthropogenic' emissions, both for determining their relevant causal contributions and moral responsibilities.

Types of Responsibility: A loosely Aristotelian Framework

To be responsible for something harmful is to be worthy of blame for it.[13] Aristotle contends that *blame* and praise are bestowed on *voluntary* actions, while *involuntary* ones are *pardoned*. The key to responsibility for actions is thus their voluntary status, for which he gives two necessary conditions:

> "First, there is a **control condition**: the action or trait must have its origin in the agent. That is, it must be up to the agent whether to perform that action or possess the trait — it cannot be compelled externally.
>
> Second, Aristotle proposes an **epistemic condition**: the agent must be aware of what it is she is doing or bringing about"[14]

However, ignorance *per se* seems to be slightly too easy for pardoning, which is why the condition is usually strengthened insofar as the agent *could have reasonably been expected to know*.

Aristotle's conception of 'responsibility' is based in his theory of virtue, which concerns 'passions and actions.' But there are other theories which see the concept rather in the context of duties, in particular in derelictions of duty, which are not (necessarily) actions but equally liable to give rise to blame. Figure 1 is an attempt at representing the interplay between the distinctions of voluntary/involuntary, harmful/harmless, agency-/duty-based, and the type/level of blameworthiness (responsibility) attached to their combinations.

Aristotle's conditions on assigning blame to actions (and, *eo ipso* agents) are about whether they are carried out voluntarily or involuntarily – i.e. they are about the difference between categories II and III (or rather III.a) in Fig.1. However, as illustrated in the same figure, blame can also be assigned or withheld regardless of this distinction. If, for example, the

[12] Data take in to account changing geographical borders, but only for energy and industrial CO_2. Other sources are based on current territory.
[13] Strictly speaking it is either blame- or praiseworthy, but in the present context the former suffices.
[14] Eshleman 2004. See also Aristotle 1908: III.1-5, 1110a-1111b4.

effects of an action are *harmless* (category I), then clearly no blame should be attached to it, even if it was voluntary. Moreover, there are situations where, contrary to Aristotle conditions, 'strict' blame (responsibility) is handed out simply on the ground that the effects are harmful, regardless of whether the harm was done voluntarily or involuntarily (category III.b).

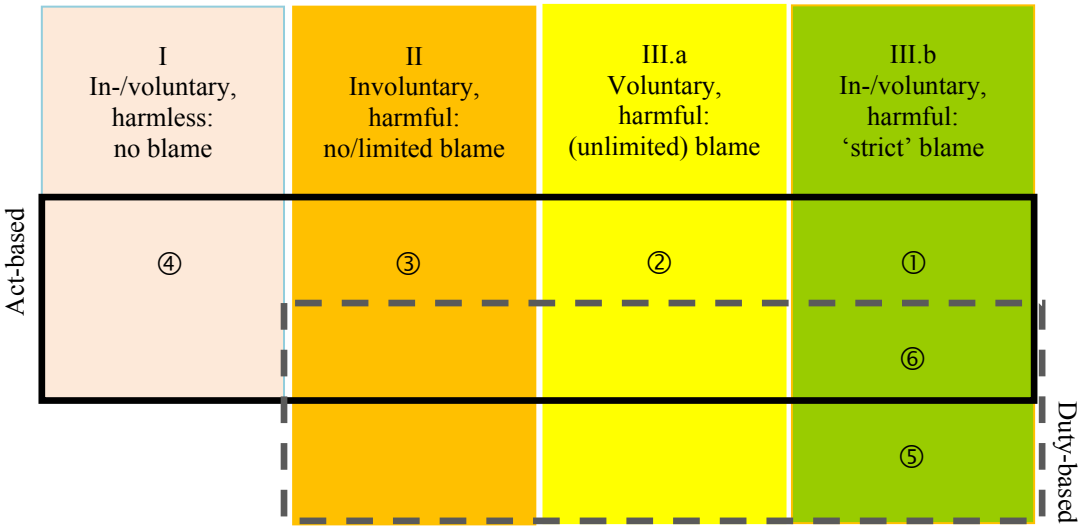


Figure 1. Categories of blame/responsibility

Act-based blame. In the context of climate change, blame/responsibility is usually seen as applying to certain acts, namely the emission of greenhouse gases – i.e. it is act-based. For example, if someone drives a car, and if the emissions resulting from this act are deemed to be harmful, then they may be judged to deserve unreserved blame just because the emissions are harmful (strict blame, ① in Fig. 1), or because they drove voluntarily, in the full knowledge of the harmfulness of the emission and without coercion (unlimited blame, ②). If, however, they can plead reasonable ignorance or coercion, then they may get a (limited) pardon (no/limited blame, ③). Finally, if the emissions in question are classified as harmless, then no-one can justly be blamed (no blame, ④).

Duty-based blame. What is not usual is to consider blaming someone for certain harmful emissions not because they were actively engaged in emitting, but because they had duty to prevent them. Thus if two individuals, say Jane and John, enter a contract that Jane is to reduce her emissions and that John is to bear her additional costs, then it can be argued they both have a joint-duty to reduce Jane's emissions, and that if the reduction does not occur, that they could be jointly blamed. The blame may, of course, not lie equally. Jane may have wished to reduce but did not receive the money to do so, or John may have wished to pay for Jane's emission reduction, but Jane having no inclination to do so. The point being that John might have to take responsibility for a certain amount of emissions, even though they were not actually emitted by himself (⑤), while Jane may not have to take responsibility for the whole of the emission increment she failed to reduce, because there was a joint dereliction of duty (⑥).

Differentiating Contributions and Responsibilities

Methodologies

Causal Contribution Shares: The MATCH Methodology

As mentioned earlier, the methodology of the MATCH project was designed to establish the relative causal contributions by countries to changes in global average temperature. The MATCH percentage figures for countries shares in contributing to these changes are determined by the anthropogenic emissions that have historically been emitted from their sovereign territory. As was mentioned, these percentage shares are themselves relative to the type of impact chosen, and they depend on the sequential order of the emission series in question. However, to simplify the calculations, it is possible to use the sum of the historic emissions – or rather their relative size – as a reasonable approximation for their relative causal contributions. Instead of using the MATCH project modelling techniques, we have therefore opted to simply use the aggregate historic country emissions – using the 1995 Global Warming Potentials (GWPs) for different gases as used under the Kyoto Protocol – emitted between 1890 and the present (2005) as determinants of the contribution as well as responsibility shares in question. The proportion between countries historic emissions since 1890 is used as a proxy measure of the relative size of their contribution to climate change impacts.[15]

Responsibility Shares: The Allowance-based Methodology

The issue of how to measure and compare responsibilities has been controversial for some time, not least with respect to comparisons between the 'large emitters,' such as the US and China. In a recent newspaper article, the IEA chief economist was reported to predict that "China may overtake the United States as the world's biggest source of greenhouse gases within months", however, he also "accepted that on a per capita basis, people in rich countries still emit far more than individual people in China. … Historically, China has also contributed little to the present build-up of greenhouse gas emissions in the atmosphere."[16]

The problem with either aggregate (i.e. country-wide) or per capita emissions measures is that, while they may capture some facet of the relevant notion of 'responsibility,' they both fail in capturing others. The percentage shares derived from the aggregate figures clearly capture the causal contribution aspect of responsibilities, but they cannot, by definition, reflect other potentially relevant country aspects, such as population size. Per capita emission figures, on the other hand, do reflect population size, but they are unable to reflect causal contributions, with the effect of assigning the same responsibility to both China and Latvia with 0.8tC/cap, but a 500-fold difference in aggregate emissions.[17]

Not surprisingly, there is no general answer to whether responsibility should be measured in absolute (single parameter) or in relative (multi parameter) terms. There are cases of, say, emission-based responsibilities which should be quantified in absolute terms, i.e. in terms involving only one parameter, namely physical emissions. In other cases, it may be necessary to relativise these figures in terms of other relevant parameters, such as population sizes – when talking about group/country responsibilities – or wealth/economic production.

[15] We would like to emphasise, however, that our methodologies could easily be adapted to be used with the full MATCH modelling techniques

[16] John Vidal, "China could overtake US as biggest emissions culprit by November," *The Guardian*, London, UK, 25 April 2007.http://www.guardian.co.uk/china/story/0,,2064725,00.html

[17] Data Source: http://cait.wri.org/

Traditionally, these relativisations have been operationalised by simple parameter divisions such as the well-known per capita and per unit of economic output (GDP) measures.

Aggregate – i.e. country or regional – responsibility for climate change (impacts), we argue, *does* need to be relativised in the sense that it has to be measured in multi parameter terms, including – apart from emissions – the size of (certain) populations. However, the traditional operationalisation in per capita terms we find over-simplifies the situation. Instead we propose a (bottom-up) allowance-based methodology which generalises both the traditional absolute and per capita measures.

The idea is that allowances may be allocated to emitters which they can use against their emissions in calculating their level of responsibility. It is, in general terms, analogous to the system of tax allowances used in most countries in differentiating the tax burden. There can be different kinds of such 'climate change responsibility allowances', depending on the (moral) justification for why they should be allocated. For example, if a certain level of (greenhouse gas) emissions is deemed to be harmless, then one would have to allocate what we call '*basic allowances*' to cover these harmless emissions, on grounds of the fact that no-one should be held responsible (blamed) for a harmless activity.

Other allowances could be allocated on the basis of basic needs, in turn justified by way of the Aristotelian 'control condition' that one cannot be held responsible for what is not in ones control. We have implemented this kind of allowance by looking at '*subsistence allowances*,' based on the assumption that poverty eradication is an over-riding moral aim, and that in present circumstances it can only be achieved through activities which generate a certain amount of emissions. There may, of course, be other (basic) needs-based allowances which might have to be considered, such as the need to keep the ambient temperatures within certain boundaries in order to survive (note 'survive' and *not* 'live in luxury'). The Aristotelian epistemic condition that one should not be held responsible for actions which one could not have reasonably been expected to know were harmful – note, incidentally, that mere ignorance is not sufficient – could also be used to justify the introduction of what might be called 'epistemic allowances.' The main difference between these Aristotle-based allowances and the above-mentioned basic kind is that while the latter can be seen as 'certificates of harmlessness', the former are merely 'responsibility wavers' applied to emissions which would otherwise have been counted as harmful and blameworthy. The main consequences of this is that while basic emissions should be transferable, these 'responsibility wavers' should not, and that the latter ought to be used only as 'back-up' to the former, should both be issued, and not as complement.

Apart from the question of what sort of allowances should be admitted to be counted against one's responsibility (for climate change), the key issue with this sort of methodology is, of course, how to allocate those that have been admitted. And while the answer is bound to vary depending on allowance types (allowances for countries, for firms, of individuals), there are cases where one could expect some relation between them. For example, if one is of the opinion that emission-based country responsibilities should in some way be related to the personal responsibilities of the inhabitants, then there would have to be some relation between country allowances and the personal allowances of inhabitants. Indeed, we believe that in the case of basic and subsistence allowances, a 'bottom-up' approach to country allocations – i.e. a definition of country allocations in terms of personal ones – is the most appropriate one. Note that this does not imply that country emissions have to be defined in the same way. In particular, this bottom up approach to allocating basic and subsistence allowances is perfectly compatible with the traditional definition of country emissions as the emissions originating from their sovereign territories.

In the case of epistemic allowances – meant to operationalise Aristotle's epistemic condition – there is no need to take recourse to such a bottom-up approach to country allocations, particularly if one adheres to the traditional definition of country emissions. All that is necessary, on either the personal or the country level, is to ensure that all the emissions which happened in justifiable ignorance of their harmfulness be covered by allowances (which, of course, still leaves the thorny issue when a particular emitter could have reasonably been expected to know about these effects).

As concerns personal basic allocations, it can be argued that they should be allocated on an egalitarian principle for the same reasons that support the per capita allocation of global emission permits. (Note, however, that the two are *not* the same: to be allocated an emission permit, *per se*, is not tantamount to being given a responsibility allowance for the specified amount of emissions, in the same way in which being given the legal licence to produce tobacco does not give one immunity with respect to the consequences of tobacco use!) The bottom-up methodology then implies that countries can disregard $b \times p_i$ of their emissions in responsibility calculations, where b is the global per capita figure of harmless emissions, and p_i is the population of country/region i. This illustrates how population figure enter the allocation-based country responsibility measures, and that they are quite different from the traditional per capita measures.[18]

The difference becomes even more marked if we consider some of the other population related allowances. Take subsistence allowances. While there are arguments for a differentiated allocation (in accordance to particular needs), it is clear that if they are equally allocated they would normally not be allocated to the whole population of a country, but only to those who are eligible by living below some poverty line. In other words, it is possible that the allocation of subsistence allowances to a country is dependent on population size, thus generating a (population) relative responsibility measure. But – unlike in the traditional per capita methodology – the populations in questions are not all inhabitants, but only special needs groups, namely the country's poor. The proposed allowance-based methodology thus manages to reflect certain population sizes in establishing country/regional climate change responsibilities without the danger of unjustifiably diminishing in-country responsibility differences – by letting the responsible (carbon) rich hide behind their (carbon) poor compatriots – as can happen in the case of the traditional per capita methodology.

From a moral point of view, there is an important difference between these two types of allowances. Basic allowances are, as it were, *certificates of harmlessness*, and we believe that on balance they should be transferable, in the sense that if someone emits less than their basic allowance, they should be allowed to transfer the surplus to other people who emits more for use on top of their own basic allowances. Subsistence allowances, by contrast, are responsibility wavers, handed out because of specific circumstances of the recipients, namely their poverty. Accordingly it would be wrong to transfer them, certainly beyond the specified recipient group. While it may be right for a rich person to reduce their responsibility by using surplus basic allowances from someone else, it certainly would not be right for that same person to claim a responsibility rebate through subsistence allowances.

[18] For example, if it is agreed that all the emissions in question are harmful, then the basic global per capita allocation $b = 0$, implying that the resulting basic country allocations are equally 0 for all countries regardless of their population size, and thus that the allocation-based responsibility measures are independent of population figures. Per capita measures, by contrast, reflect population size by definition.

Data

The calculations made in this Summary Report are based on data coming from a variety of sources.

Emissions

The same emissions dataset is used by the latest modelling effort of the *ad hoc group for the modelling and assessment of contributions of climate change*. It includes 192 countries for three sectors: energy and industry (CO_2, CH_4, N_2O), agriculture/waste (non-CO_2) and land use change and forestry (CO_2) from 1750 to 2100. It is derived with an algorithm that combines emission estimates from various sources in the following hierarchy: National submissions to the UNFCCC published in the GHG emission database (UNFCCC 2007); CO_2 emissions from fuel combustion as published by the International Energy Agency (IEA 2006);[19] emissions from CH_4 and N_2O as estimated by the US Environmental Protection Agency (USEPA 2006); CO_2 emissions from fuel combustion and cement production as published by Marland et al. 2003 as retrieved in 2006 and regional past data of Edgar/Hyde (Klein Goldewijk and Battjes 1995). The emissions of different greenhouse gasses are multiplied by their global warming potential and added up, leading to a single amount of carbon dioxide equivalent emissions.[20]

The source data takes into account changing geographical borders, but only for energy and industrial CO_2. Other gases and sectors are based on current sovereign territory. If a currently existing country did not exist over the whole period, emissions were backward extrapolated based on the country's current sovereign territory.

Population and Poverty

Historical population data are taken from the HYDE database (Klein Goldewijk 2007) and Penn World Tables (PWT 2006) and, where not available, the World Development Indicators 2006 (World Bank 2006).[21] Poverty headcount ratio (as % of population) at $1 and $2 a day and GDP data (PPP current international $) are obtained from the same source for calculating the size of poor populations.[22]

[19] This dataset was supplemented by process emissions from cement production from Marland et al. 2003 to cover all industrial CO_2 emissions.

[20] See Höhne et al. forthcoming, section 2.1 for a detailed description of the emission dataset including issues of completeness and uncertainty.

[21] Because population data for the years 1890 to 1959 are not obtainable for 29 small countries (making up 11 million inhabitants of approximately 3 billion worldwide in 1960), their emission allowances of these 70 years are not counted towards their total share. This leads to very slight increase in the share of LDC+AOSIS in the calculation of responsibility with emissions allowances 1890-2005.

[22] Poverty data of 24 least developed countries was unobtainable. For these countries, the poverty headcount ratios at $1 and $2 a day have been set to a level comparable to that of other LDCs (50% and 75%,respectively). The time series of poverty data is not complete for all countries. Poverty shares have therefore been extrapolated for the missing years using existing data.

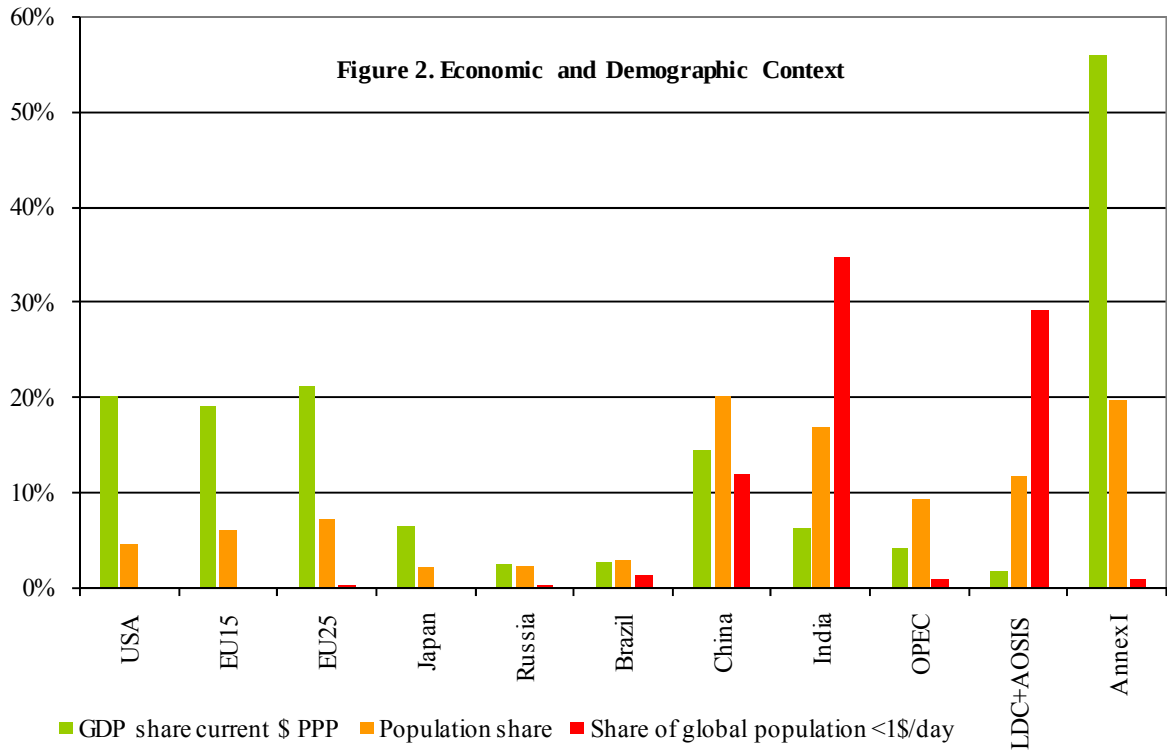
Results

Context

Causal contributions were calculated for all countries, but for expository reasons we have chosen to focus on six countries – three from Annex I: (Japan, Russia, and the United States) and three from non-Annex I (Brazil, China and India) – and five groups: the European Union before and after the 2004 enlargement (EU15, EU25), the Organization of Petroleum Exporting Countries (OPEC), the Alliance of Small Island States combined with the Group of Least Developed Countries (AOSIS+LDC, 76 countries), and the group of industrialised countries listed in Annex I of the UN Framework Convention on Climate Change (Annex I). In order to understand the contribution and responsibility figures to be discussed in the following two sections, it is important to appreciate certain basic economic and demographic facts about these entities, concerning their relative wealth and population sizes.

North-South Differences.

Figure 2 depicts three non-emission parameters for the year 2005 that are of interest in the subsequent analyses of contribution to and responsibility for climate change by these countries and country groupings, namely their share in global wealth (defined in terms of current PPP GDP), in global population, and in global poverty, measured in terms of the number of people living on $1 per day, or below. Not surprisingly, the developed and developing world (Annex I/non-Annex I; North/South) are not the same with respect to these three dimensions: While the 20% of the world population that lives in North (Annex I) owns 56% of global wealth, the South is home to 99.2% of the global very poor.



Countries and Groupings

Wealth. With around 20% each, the EU and the US both have the lion share of global wealth (measured in current PPP$ GDP), followed by China in third place, and Japan and India in (almost) equal fourth. At the other end of the spectrum, we have the 76 countries of the Small Island Developing States and the Least Developed Countries sharing 1.6% of global wealth.

Population. Unfortunately, the world's population is not distributed in proportion to its wealth, on the contrary. Accordingly there is a staggering discrepancy between per capita wealth across the North South divide, with the result that the 10 percent of people living in the 76 AOSIS+LDC countries are, on average, 33 times economically worse off than the average American.

Abject Poverty: The situation with abject poverty – defined here in terms of earning less than $1 (PPP)/day – is even more skewed. Three quarters of all people living in abject poverty live in either India, China, or AOSIS+LDC, almost half of which in India alone. These proportions will have some impact in our responsibility calculations, which is why it is important to keep in mind that they can change considerable depending on the level of poverty one considers. This issue will be re-visited below in the sensitivity analysis section, but just to give an example, and to give an idea of what these shares stand for in absolute terms, consider the fact that China's global share in abject poverty of 12% translates into 129m people, and India's 35% into 377m, while the population of those living below $2 (PPP)/day is 454m in China and a staggering 881m in India.

Differentiating Causal Contributions

According to the simplified methodology chosen for the purpose of this Report, the share of a country's – or group of countries' – contribution to climate change is given by their share in global historic GWP-weighted greenhouse gas emissions. However, to be able to calculate these shares, some further parameters need to be specified, such as the time frame, the types of emissions, and the countries or group of countries to be considered. For the purposes of this Report, the chosen time horizon is 1890,[23] and the emissions are those considered under the Kyoto Protocol.

Reference Case (RC) Contributions.

Historically, industrialised countries (as listed in Annex I) have contributed the majority of greenhouse cases, namely 54.5% – a figure which in the present simplified methodology represents their share in the causal contribution to the climate change problem. The causal contribution shares in detail, as represented in Figure 3, are (in descending order of magnitude) as follows: USA (19.7%), EU25 (17.8%), EU15 (14.8%), China (10.8%), OPEC (7.3%), Russia (6.5%), AOSIS+LDC (5.7%), Brazil (4.3%), India (3.9%), and Japan (2.8%).

These proportions can vary significantly depending on the sorts of gases and sources/sinks that are taken into consideration. For example, if emissions from land use, land use change and forestry (LULUCF), which are relatively uncertain, are excluded, Annex I contributions increase by almost a fifth (+10.2 percentage points), most of it absorbed by the US (+5.2%pts) and the EU(+4.3/3.7%pts), with chief beneficiaries Brazil (–2.3%pts), AOSIS+LDC (–2.3%pts), and OPEC (–2.9%pts). The last may seem somewhat surprising, but it is explained by the fact that the non-middle Eastern OPEC members tend to have lower

[23] Data before 1890 is less complete. Roughly 10% of the effect of total aggregated emissions is left out, when starting in 1890 instead of 1750, the start of industrialisation, see Höhne and Blok 2005.

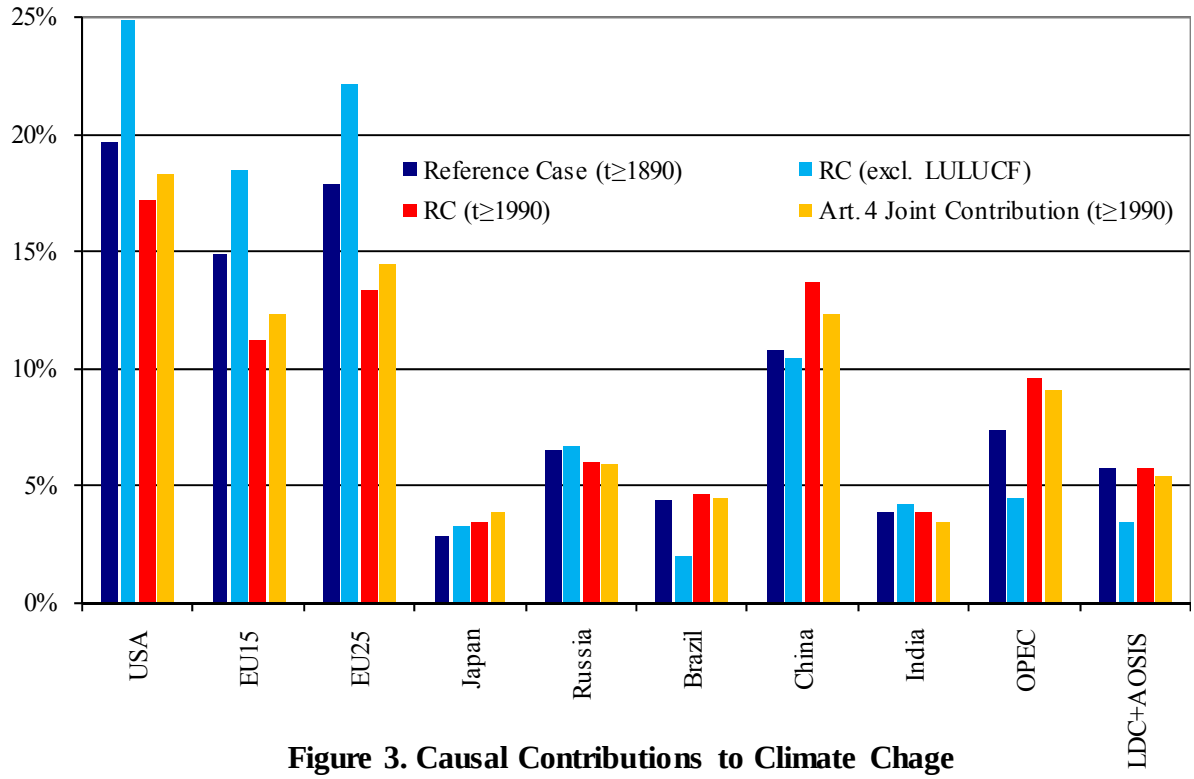


Figure 3. Causal Contributions to Climate Chage

contribution shares if LULUCF emissions are excluded, indeed, the share of Indonesia drops from 3.7% to 0.8% under this exclusion.

However, we believe that if one is talking of 'causal contributions to climate change' *tout court*, all (officially) recognised sources and sinks – including those from LULUCF – should be taken into account, which is why we chose our Reference Case for determining causal contribution shares.

Joint Contributions

As mentioned earlier, there are reasons to think that certain emissions, even though emitted over the sovereign territory of one country, should be given joint responsibility between different countries. The example put forward above was the case of emission increments in developing countries since 1992, when the world adopted the UNFCCC, and in particular its Article 4.

There may be other reasons as to why one might wish to introduce a joint responsibility for certain parts of 'sovereign' emissions, such as the ones embedded in exports. Indeed, a recent study which concludes that since 2004, net exports from China accounted for 23% of its total carbon emissions contends that:

> "… the extent of 'exported carbon' from China should lead to some rethinking by government negotiators as they work towards a new climate change agreement. It suggests that a focus on emissions within national borders may miss the point. Whilst the nation state is at the heart of most international negotiations and treaties, global trade means that a country's carbon footprint is international. Should countries be concerned with emissions within their borders (as is currently the case), or should they also be responsible for emissions due to the production of goods and services they consume?"[24]

[24] Wang and Watson 2007: 1.

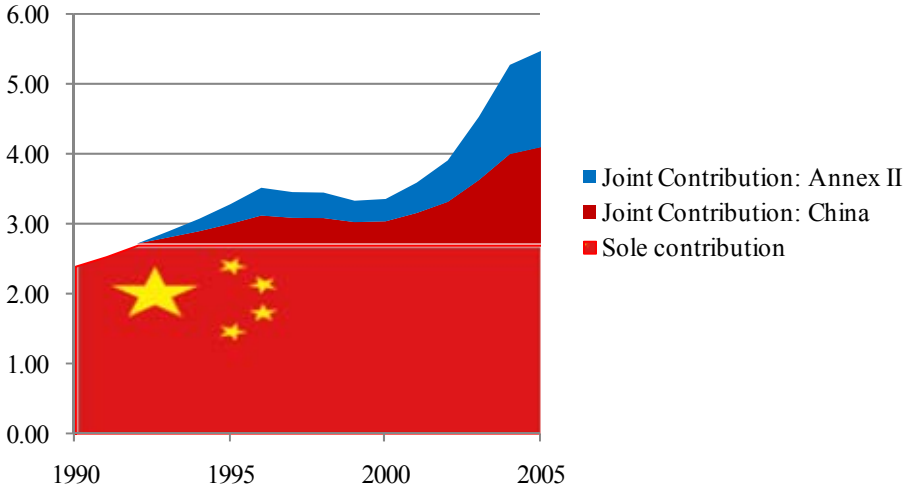


Figure 4: China's Joint Contribution

The method of determining shared responsibilities used in this Report is able to accommodate this sort of joint responsibilities by introducing 'joint contributions.' And while the actual calculations of responsibility shares below will all be based on the more traditional sovereign-contributions-only approach embodies in our Reference Case (incl. LULUCF), we felt it would be useful to just give an illustration of how the inclusion of such joint contributions might change the picture. The particular implementation of joint-contributions which is meant to reflect the duties under Article 4 simply assumes that, as illustrated in Figure 4 for China, the increment in emissions since and above the 1992 level are to be shared 50:50 by the countries in question and the rich industrialised (Annex II) countries[25] – divided among them in proportion to their GDP.

In order to have any significant variance from the sovereign country measures at all, we have also limited the time horizon to start in 1990. For the industrialised world, the switch to this sort of 50:50-joint contribution would mean in increase of 3 percentage points since 1990, most of it going in roughly equal to the US and the EU (+1%pt each), and benefiting mostly China (–1.3%pts). Given these differences would practically disappear if one were to use the Reference Case (beginning in 1890) we decided not to proceed along these lines for the moment.

Differentiating Moral Responsibilities

Strict Responsibility

Strict responsibilities, according to the adopted allowance-based approach, are determined by the level of aggregate historic emissions – representing causal contributions – and a per capita allocation of the global total of harmless emissions. There has been some debate in the literature as to how much could be globally emitted without imposing harm, particularly in the context of defining what has become known as 'ecological space.' MacGregor (2006), for example, explains his choice of 4GtCeq (14.7GtCO_2eq) as follows:

> "The earth's natural ecosystems (both land and sea) currently absorb roughly half of the anthropogenic emissions of CO_2, thus buffering us from the full climate impacts of our emissions. However, this is a 'moving target' since future changes in climate will affect this rate of natural absorption. This in turn

[25] As it happens, in 2004, the share of Chinese CO_2 (energy) emissions allocated to Annex II in this fashion is precisely the share of its embedded export emissions as calculate by Wang and Watson 2007.

influences the future rate of change of atmospheric CO_2 since the warmer climate accelerates decay of carbon in soils and leads to large release of CO_2, which causes further warming. Moreover, the population is projected to increase. The current size of the global natural carbon sink is estimated to be 3-5 billion tonnes of carbon (GtCeq) – approximately 2 GtCeq by ocean and 1-3 GtCeq by land, depending on differing rates of deforestation. A global level of 4 GtCeq is often used (Monbiot 2007; Retallack 2005)."[26]

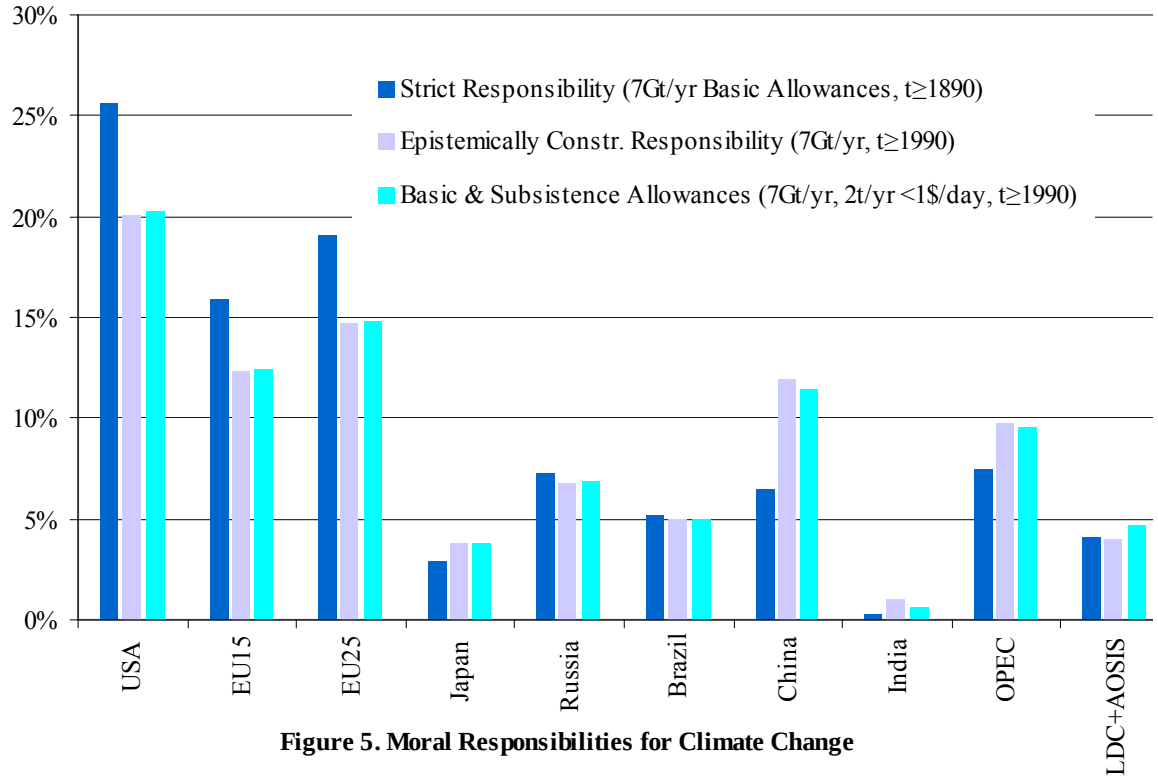


Figure 5. Moral Responsibilities for Climate Change

Agarwal, Narain and Sharma, in turn, contend that "terrestrial sinks are national property, but oceanic sinks, which absorb to the order of 2btC [7.3GtCO_2] per year, belong to human kind and are common global property."[27] We adopt 7GtCO_2 as the global total of basic allowances, for the present purposes to be allocated – in accordance with their global commons status – on a per capita basis.[28]

Numerically, this choice implies an overall industrialised country (historic) climate change responsibility of 64%. The largest single country share is that of the US with 25.6%, followed by the EU (19.1%, 15.9%), in turn followed by a cluster in the upper single digit range – namely OPEC (7.4%), Russia (7.3%), China (6.4%), Brazil (5.2%) – and finally a number of countries with low if not negligible responsibility: AOSIS+LDC (4.1%), Japan (2.8%), and India (0.3%).

While it will not be surprising that individual SIDS and LDCs have really no historic responsibility for the climate change problem (on average 0.05%), what may be less expected is to find India at the very end of our responsibility spectrum. The reasons for the extremely low Indian responsibility share are its relatively modest causal contribution share of around 4%, and its rather large share in global population share (16.9%). The position of Japan in this strict responsibility scale also suggests that burden sharing according to responsibility

[26] MacGregor 2006:2.
[27] Agarwal et al. 1999:108.
[28] Strictly speaking, we should also have allocated basic allowances according to the sinks capacity of the respective sovereign territory, but given the uncertainties on how much these are, we decided to err on the side of caution and just consider oceanic sinks.

alone may not really be tenable, and that it would have to be complemented with some 'respective capacity' component, as referred to in Article 3.1 on the UNFCCC.

Limited Responsibility I: Epistemic Constraints (EC)

There has been a robust difference of opinion – more often than not along the North/South divide – whether it is fair to use this sort of strict historic responsibility, or whether countries should be granted mitigating circumstances, such as ignorance of the effect of one's actions. For the present purposes we have decided to implement this sort of Aristotelian epistemic constraint of full responsibility by excluding emissions before 1990 from the calculations, on the grounds that after that year, which saw the beginning of the UNFCCC negotiations, no government could reasonably plead ignorance of the problem.[29]

This plea for ignorance as mitigating circumstance does indeed shift the burden of responsibility significantly from industrialised to developing countries, with Annex I as a whole losing 10 percentage points. The US (20.1%) and the EU (12.3, 14.7) both lose just over a fifth of their responsibility relative to their historic strict responsibility shares, while China (12.0%) picks up about the same number of percentage points, but in this case this means almost a doubling of responsibility relative to the strict measure. In relative terms, by far the worst off is India (1%), which more than triples its responsibility under such a switch to ignoring most of the historic contributions. And yet it remains at the bottom of our responsibility scale, due to the extremely low base line. Indeed, the only change in the relative ordering of responsibilities between the countries/groupings considered here is China overtaking both OPEC (9.8%) and Russia (6.8%) to move directly below the US and the EU. However, the North/South picture is not quite as homogeneous as might be expected ("industrialised countries lose responsibility, developing countries gain"). Japan (3.7%), for one, gains a third in responsibility, while Brazil (5%), and AOSIS+LDC (4%) would actually be slightly better off. But, on the whole, the fact remains that in general a limitation of responsibility by considering only post-1990 contributions benefits industrialised countries.

Limited Responsibility II: EC with Subsistence Allowances

As mentioned earlier, Aristotle's conditions on limiting full responsibility lend themselves not only to justify these epistemic dispensations, but also a certain dispensation for subsistence emissions, or rather emissions needed to overcome (abject levels of) poverty. For the purposes of this Report, we have decided to implement these needs based dispensations as an additional constraint on the above-mentioned epistemic dispensation case. In other words, we shall continue to disregard pre-1990 contributions in this context. This leaves two parameters to be determined: who should be eligible for the subsistence allowances, and how much should they be. The former is, of course, itself restricted by data availability and completeness constraints (incidentally also a reason for restricting the time horizon). The most readily available data are listed in the World Bank Development Indicators, which contains figures for people living on less than $1 and 2$ per day. As to the question of how much should poor people be allowed to emit without incurring responsibilities, there are again certain practicalities to be considered. The fact is that, in the proposed allocation-based methodology, per capita subsistence allocations of less than the relevant global per capita basic allowance will not register, which – as will be illustrated in the next section – means that to have an effect at all on the shares calculated under the specified epistemic constraint at

[29] This is, of course, not quite the same as saying that they could not have reasonably been expected to know even before this – as referred to above – but for the sake of argument, we shall use 1990 in accordance with the principle of the presumption of innocence ("Giving the defendant the benefit of the doubt").

all, the subsistence allowance has to be greater than 1.2tCO_2eq.[30] Given that the per capita emissions of the developing world are currently estimated to be 3.7 and 2 tCO_2eq with and without LULUCF, respectively our decision was to allocate 2tCO_2 per poor inhabitant per annum, to be subtracted from the aggregate historic emissions (instead of the basic allowance)

In this case of 1$/day as 'poverty threshold' – referred to in the Summary for Decision Makers simply as 'Limited Responsibility' – the annual subsistence allowance of 2tCO_2eq. (which is larger than basic allowance per capita level) is used instead of the basic one for each inhabitant with an income of less than 1$ per day. The results, as could be expected, benefit developing countries more than developed ones, and yet the shift of half a percentage point in responsibility towards Annex I (53.8%) is clearly not compensating for the shift in the other direction due to the introduction of the epistemic constraint. As it happens, the situation is not much different at the level of the individual countries/groupings: the US gains 0.2 percentage points relative to the epistemologically constrained case, while India and China jointly loose nearly one (for individual shares, see Summary for Decision Makers). And the situation does not differ significantly if one moves the poverty threshold to 2$/day: The US gains another 0.6 percentage points, while China and India jointly loose 1.2 percentage points. In other words, the choice of poverty threshold – at the assumed level of 2tCO_2eq. for the subsistence allowance – is not a particularly sensitive one, certainly not in comparison to the effects of the chosen epistemic constraint, or the overall level of basic allowances.

[30] 16 (1990-2005) times the annual basic allowance budget of 7GtCO_2eq, divided by the sum of global annual population figures over the period = 1.2tCO_2eq.

Sensitivity Analysis

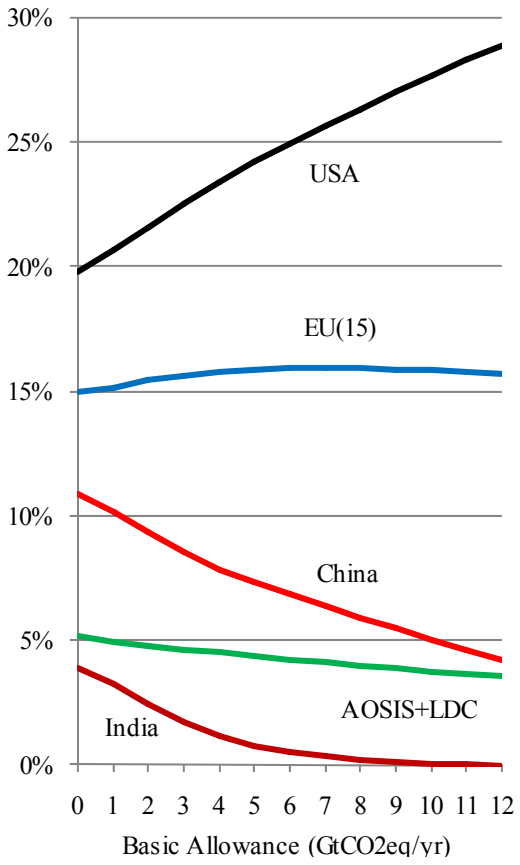
Strict Responsibility

The only parameter (apart from the choice of a per capita allocation – discussed above) is the over-all size of the overall basic allowance, i.e. the level of (annual) emissions deemed to be harmless. We therefore tested the sensitivity of this assumption for a possible range of values.

It could, for example, be argued that all greenhouse gas emissions are harmful, since a fraction of CO_2 stays in the atmosphere for several hundreds of years and that the basic allowance should therefore be zero. Another line of argumentation could be that the basic allowance should be levelled at 7 $GtCO_2eq$., the current sink of CO_2 by the oceans, (the default used here). A further line could be that the basic allowance should be set at the level allowed for stabilizing the climate system at a global temperature increase of 2°C, which we assume to be at 12 $GtCO_2eq$.

Figure 6 presents the change in strict responsibility as a function of the basic allowance from 0 to 12 $GtCO_2eq$. We observe that the strict responsibility of developing countries (with high population compared to emissions) decreases when the basic allowance in increased. For China it decreases by a factor of 2, for India it even declines to zero.[31] By contrast, the strict responsibility of developed countries (with low population compared to emissions) increases, e.g. for the US by a third.

Figure 6. Strict Responsibility: Basic Allowance Sensitivity (t>=1890)



Epistemically Constrained Responsibility

We also tested the sensitivity to choosing the cut off dates as of when emissions are accounted between 1890 and 1990 (keeping all other settings constant, i.e. 7$GtCO_2eq$ basic allowance for the strict responsibility).

Moving the cut off date from 1890 to 1990 decreases the relative contribution of countries developed countries (that started earlier with emissions), while it increases the relative contribution of developing countries. As recent emissions dominate the results, moving the cut off date after 1950 has a greater impact compared to moving the cut off date before 1950 (by the same amount of time).

[31] In contrast to the subsistence allocation model (discussed below), no domestic distinctions are made in this strict responsibility case between population segments, i.e. basic allowances are freely transferable within country.

Subsistence Allowances

The effect of subsistence allowances is determined by (a) relative size to the basic per capita allowance −the subsistence allowance is only granted, if it exceeds the global per capita level of the basic allowance, in which case it is used in lieu thereof, (b) the poverty threshold ($1 or $2/day), and (c) the level of the per capita subsistence allowance.

In order to avoid the misuse of subsistence allowances, countries are divided into poor and non-poor segments, treating each like sovereign moral agents, i.e. without allowance transfers between them. The aim of this is to prevent the non-poor from pardoning (parts of) their culpable emissions by illegitimately designating them to be 'subsistence emissions.' The culpable emissions of each segment are given by their emissions minus their allowances, and those of the country by the sum of those of the two segments.

The effect of these stipulations is that countries with large poor populations will generally have both a responsibility ceiling and floor under variations in the size of the subsistence allowance. The ceiling is determined by the basic allowance and applies in those cases where it is larger than the subsistence one. The floor is given by the responsibility of the non-poor segment − which is independent of the subsistence allowance level – and applies in those cases where the level of the subsistence allowance is large enough to cover all the emission of the poor segment of the population.

Figure 7. Subsistence Allowance Sensitivity (t>=1990)

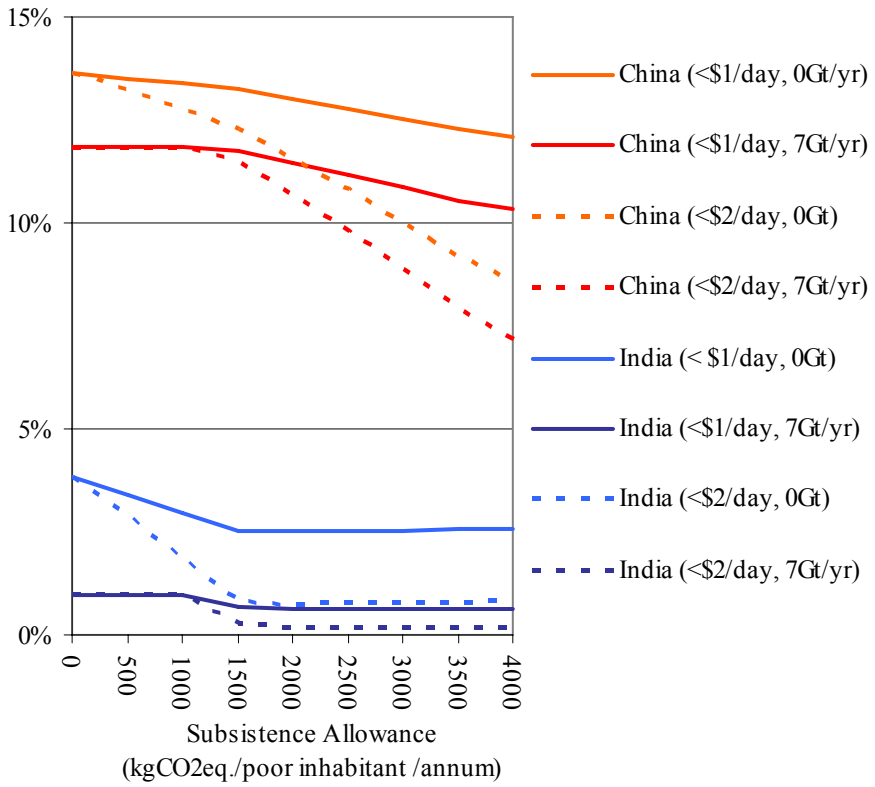


Figure 7 shows the effects on Chinese and Indian responsibilities of changing the poverty threshold (1$ and 2$ per capita and day) under variations of the subsistence allowance level from 0 to 4tCO_2eq./cap (around the chosen default of 2tCO_2eq./cap), for the default global basic allowance of 7GtCO_2eq., and – for comparative purposes – with no basic allowances (both focussing only on post-1990 emissions).

We observe that with a basic allowance of 7GtCO_2eq./y, the effect of the subsistence only starts to have an influence above 1tCO_2eq/cap. For China we observe that the responsibility share declines with increasing subsistence allowance. It declines much faster under the 2$/cap poverty definition compared to the 1$/capita definition. For India with a very high share of poor population, the floor of responsibility is reached at a substance allowance of around 1.5tCO_2eq./cap. This floor is higher for the 1$/capita case, since the share of poor population is lower. While for India the effect of the basic allowance is very significant, it is less so for China.

The values for no basic allowance and no subsistence allowance correspond to the causal contribution shares *post-1990*, which are not necessarily the same as those of the (post-1890) Reference Case contributions discussed earlier.

Concluding Remarks

The aim of this Report was to put forward and discuss a methodology for the numerical differentiations of responsibilities for climate change as opposed to calculating causal contributions to climate change. For expository purposes, this was done on the basis of aggregate GWP-weighted historic emissions as a proxy. Moving to fully fledged climate modelling techniques as used in MATCH could be done in the future, but would change the relative contributions and resulting responsibilities by at most 10%[i] for most countries.

This Report is not aimed to engage in a debate which of the two conceptions of responsibility ('strict' or 'limited') with the chosen parameter values is more appropriate, not least because the answer may well depend on what one wishes to do with the results. However, the order of magnitude difference in the responsibility of the two extremes of the scale under both conceptions does give pause for thought as to what sorts of burdens can justly be imposed, particularly given the discrepancy between the affluence and wealth of the exponents at either end of the spectrum of responsibilities we considered in this Report.[ii]

Indeed, it stands to reason that burden sharing on the basis of responsibility alone – as proposed in the original Brazilian proposal – without taking into account the second and lesser quoted element mentioned in Article 3.1 of the UNFCCC, namely 'respective capabilities', would not be appropriate. In other words, fair burden sharing would have to be based on a mixture between the responsibility shares discussed here and some differentiated index of capability.

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[i] Percent, *not* percentage points.

[ii] Affluence (GDP per capita, PPP): US = $41,890, India = $3,452. Wealth (GDP, PPP): India = $3.8tr, US = $12.4tr. (both in 2005). Source: World Bank 2006.