Equitable access to sustainable development

Contribution to the body of scientific knowledge

A paper by experts from BASIC countries
Harald Winkler, T. Jayaraman, Jiahua Pan,
Adriano Santhiago de Oliveira, Yongsheng Zhang,
Girish Sant, Jose Domingos Gonzalez Miguez,
Thapelo Letete, Andrew Marquard
and Stefan Raubenheimer

2011
BASIC expert group: Beijing, Brasilia, Cape Town and Mumbai
ISBN 978-0-620-52066-9

Printed on recycled paper

Preferred citation

Please cite this paper as:

BASIC experts, 2011. Equitable access to sustainable development: Contribution to the body of scientific knowledge. BASIC expert group: Beijing, Brasilia, Cape Town and Mumbai

Contents

Preface *v*

Equitable access to sustainable development: Contribution to the body of scientific knowledge **1**

1. Introduction 1
2. Equitable access to sustainable development 2
3. Carbon budgets and equitable distribution 5
4. Overoccupation of the atmosphere by Annex-I countries GHG emissions 6
5. Two broad frameworks 9
6. Operationalising equitable distribution of carbon space through criteria 11
7. Comparing approaches 15
8. Conclusion: the need for an equity-based reference framework 20

The importance of historical responsibility in the context of the international regime on climate change **23**

Equitable access to sustainable development: Carbon budget account proposal **35**

1. Introduction 35
2. Principles and approach 37
3. Methodology 40
4. Results 42
5. Implications for support by developed countries for their developing counterparts 44
6. Discussions 46
7. Conclusion 49

Appendix 1: Carbon budget account: An indirect measurement 50

Appendix 2: Carbon budget account with consideration of technological improvement and spill-over effects 52

Equitable access to sustainable development: An Indian approach **59**

1. Introduction 59
2. Basic features of equitable access to sustainable development 59
3. Operationalising equitable access to sustainable development 63
4. Equitable access and financial and technological transfers 73
5. Conclusion 76

A South African approach – responsibility, capability and sustainable development **78**

1. Introduction 78
2. Approach and principles 78
3. Methodology 82
4. Results 86
5. Implications for support by developed countries for developing countries 88

Preface

The synthesis chapter of this paper was written collectively by Harald Winkler, T. Jayaraman, Jiahua Pan, Adriano Santhiago de Oliveira, Yongsheng Zhang, Girish Sant, Jose Domingos Gonzalez Miguez, Thapelo Letete, Andrew Marquard, and Stefan Raubenheimer. It is based on discussions (including also several other experts) attending meetings of the BASIC Expert Forum over six meetings from July 2010 to October 2011. The authors of the country chapters are experts from the respective countries, and indicated by name or organisation in the respective chapter.

Equitable access to sustainable development: Contribution to the body of scientific knowledge

A JOINT PAPER BY EXPERTS FROM BASIC COUNTRIES

1. Introduction

The climate negotiations are at a cross-roads. Negotiators seek to craft a shared vision for long-term cooperative action, including a long-term global goal for emission reductions.[1] Action is needed in two core areas – adaptation and mitigation. These in turn depend on the means of implementation – finance, technology and capacity-building. The ultimate objective of the Convention has been specified in relation to temperature increase – keeping temperature increase to below 2°C above pre-industrial levels now has wide political support. But it has not been possible to translate temperature into specific mitigation goals. It has not proved possible to even set an aggregate goal for emission reductions by Annex I countries –in either the long or medium term.

Meanwhile, the emissions gap grows.[2] The pledged commitments and actions have little chance of limiting temperature increase to 2°C. In Copenhagen, leaders of many countries could not agree on the long-term goal, because there was not a paradigm for equitable burden-sharing. BASIC Ministers made clear the reason: ‘A global goal for emission reductions should be preceded by the definition of a paradigm for equitable burden sharing.’[3] They put this challenge squarely in the context of sustainable development, and a few months later ‘reaffirmed that equitable access to sustainable development will be the core of and foundation for any climate change agreement and that this will be the prerequisite for setting up any global emission reduction target’.[4]

Ministers of the BASIC countries reflected the linkage between the physical dimension of carbon space and development when they ‘reaffirmed their support for the aspirational objective of keeping global temperature increase well below 2°C, bearing in mind that social and economic development and poverty eradication are the first and overriding priorities of developing countries.’[4] While there are different views on the temperature goal, there is agreement among all developing countries on the priorities of socio-economic development and fighting poverty.

BASIC experts have met and discussed equity over several meetings in 2010 and 2011. They were mandated by Ministers in February 2011 to 'prepare a synthesis document on the issue of equitable access to sustainable development to be considered in the next BASIC meeting.'[5] This publication presents the richness of approaches among BASIC experts, and the introductory joint chapter synthesises the many common elements, while respecting differences. Drawing on four chapters, the joint chapter develops an equity-based reference framework.

2. Equitable access to sustainable development

Limiting dangerous anthropogenic interference with the climate system by curbing the emissions of greenhouse gases (GHGs) to levels that prevent an unacceptable increase in global temperatures appears is a preeminent global issue. No country acting on its own can solve this issue. The ratification of the UNFCCC by the vast majority of countries confirms the global acceptance of this fact.

Issues that cannot be dealt with independently by countries suffer from under-provisioning and the difficulties in making progress on concerted global action to control global warming confirms this in telling fashion. As developing countries are well aware, overcoming the barriers to under-provisioning of global public goods,[1] in particular the atmosphere, in an unequal world requires constant effort in every instance.

An outstanding benefit of the acceptance of a global public goods character is the development of objective criteria for its definition. Such objective criteria, as the landmark study, 'Global public goods'[6] has noted, would provide developing nations the means for a more equitable allocation of resources that matter to them. It would also enable apparently conflicting agendas, especially between the global North and the South, to be more comparable and therefore negotiable.

In the particular case of limiting global warming, the broad realization of its sustainability character has not yet been matched by an adequate analysis of the objective criteria required in its definition. Particularly in terms of equity and the resolution of the apparent conflict between equity and sustainability, there is a strong need to fill the gap in defining these criteria and providing a specific, operational meaning to the concept of equity.

While developing countries may consider the need for equity and sustainability to be obvious, the criteria for equity and sustainability, or indeed the very necessity for both, are not immediately apparent to all in an unequal world.

It is the aim of this paper to pursue this task of deepening and clarifying the objective criteria in defining the global public good character of the control of global warming. As we proceed to the details of this effort, we also note that the search of objective criteria merits consideration not only in resolving the outstanding gap between Northern and Southern perceptions on what needs to be done. It also provides the

---

1 For the purposes of this study, a global public good and global commons will refer only to resources which are not within the sovereignty of nations.

basis on which the global South would also attend to its due responsibilities in the matter of ensuring a globally sustainable future.

We begin with a consideration of the meaning of 'equitable access to sustainable development'. The concept has three essential parts – access to carbon space, sustainability and time for development – elaborated further in the following section.

2.1 Access to atmospheric space

There can be no doubt that from the point of view of sustainability GHG emissions, particularly carbon dioxide, have to be reduced by humanity as a whole. But implicit in the principle that no nation has a right to unrestrained GHG emissions or to cause harm to the world as a whole through unrestrained greenhouse gas emissions is the larger concept of the atmosphere as a common space shared by all nations in the world, that must be considered under both past and future perspectives.[7] The limitation on the use of this common space is a limitation on the availability of the atmosphere (and in reality the full global system of the geosphere and biosphere) as a sink for GHG emissions.[8]

In this perspective, the various aspects of equitable access to sustainable development that we have already indicated become immediately relevant. On the one hand there is the need to equitably share a scarce resource, namely carbon space, that is essential for developing countries for their developmental needs. On the other hand it is also clear that developing countries cannot immediately slow down their need for atmospheric release of GHG emissions because of the technological and financial costs and also because of unavailability of technologies less intensive in terms of GHG emissions, especially in developing countries, that might be associated with a less carbon-intensive economy. It is clear that this need for carbon space is not equivalent to a right to pollute. This issue is explored further in section 6.2. Developing countries need access to global sinks or equivalently ways to discharge emissions in relation to their developmental needs and not because they seek to perpetuate a high-carbon regime of growth.

In determining how equitable access to the global atmospheric commons is to be guaranteed, the question of the past use and access to this commons is a matter that depends on the particular case at hand. Considering that there are past gross inequalities in respect of climate change in an unequal world, clearly there is a need to account for this in assigning the rights of equitable access in the future.[9] This is the essence of the concept of historical responsibility and is a general feature of all of our proposals. We need to consider the past in addressing the future.

Once the principle of equitable access is accepted, the next question is how to operationalize this principle. A variety of approaches are obviously possible in determining how this is to take place and have been discussed in the literature. The criteria are elaborated in section 5.

2.2 Time for development and support

If one dimension of equitable access to sustainable development is access to carbon space, another dimension is closely tied to it. It is time for sustainable development. This balance is reflected in the objective of the Convention itself: 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'.[10] What is often forgotten is the second sentence of Article 2, which specifies conditions under which this should be achieved – including time-frames related to ecological, social (food) and economic dimensions – in other words, time for sustainable development. In reducing greenhouse gas emissions, development rights must be respected.[11]

How does equity relate to time for sustainable development? It provides time to make the transition to a low carbon and climate-resilient economy and society. Time for development is important to all developing countries, in that all still need to address the overriding priorities of poverty eradication and development.

The challenge of global warming is compounded by fact that we live in an unequal world.[9] Achieving 'equity in the greenhouse'[12] will require common effort while taking into account different circumstances. Slowing the growth of emissions and making societies more resilient to the impacts of climate change. For those developing countries with a high dependence on emissions-intensive sectors, it means time to make the transition to other sectors, with lower emissions. For developing countries that have not followed a high-emissions path, the challenge is to avoid increasing their emission in the first instance – 'tunnelling through' to a higher level of well-being without increasing emissions. The more sustainable the development path, the lower the emissions.The more diverse the economy and society, the more resilient to the impacts of climate change. If there is no fair distribution of mitigation effort or carbon budget, it becomes likely that none will act. If none act, then the world will not keep temperature below 2°C – and the impacts will be worst for the poor. Fairness is integral to the adaptation response to climate change and discussions of equity should be extended to include the equity dimensions of adaptation (see section 7.4).[4] As the BASIC Ministers have emphasized, 'equitable access to carbon space must be considered in the context of sustainable development, the right to which is at the heart of the climate change regime, and which demands the implementation of ambitious financing, technological support and capacity building.'[3]

How is time for development related to the notion of access? It is related through the support that is needed – the finance, technology and capacity development – that will assist developing countries in putting their development on a more sustainable path. The analysis conducted by experts from BASIC countries has considered equity in support quantitatively (section 7.2). Before considering these elements, our starting point is consideration of the remaining global carbon budget and how it should be distributed fairly.

3. Carbon budgets and equitable distribution

There is support for focusing on cumulative emissions as the primary indicator of global sustainability in relation to climate change by some researchers. These developments also naturally fit in with the idea of defining equitable access to sustainable development, including in relation to the global atmospheric commons in terms of the cumulative emissions that are permitted for various regions in future, and without exceeding 2°C.[13]

In the cumulative emissions approach,[2] taking into account the total carbon dioxide emissions that have already taken place, for a given maximum temperature rise (above pre-industrial temperatures, that is), the gross amount of carbon dioxide that the world can now emit between 2000 and 2049 can be estimated. As a consequence of various scientific uncertainties, for a given amount of emissions the consequent maximum temperature rise can be predicted only in terms of probability (expressed as the likelihood that the maximum temperature will not be exceeded). The results for varying amounts of gross carbon dioxide emissions are summarised in the table below. We also present the allowed cumulative emissions for the period 2000-2049 for all GHG emissions.

The future global carbon budget depends on the probability with which we wish to adhere to a target for maximum temperature rise. A remaining budget of 1000 Gt has a roughly 25% probability of exceeding the 2°C limit (we are not considering political acceptability). On the other hand, a choice of 1440 Gt of CO_2 seems reachable (even if only with substantial effort) but this immediately raises the probability of exceeding 2°C to a mean value of 50%.

Table 1: Future global carbon budgets remaining in relation to probabilities of exceeding 2°C above pre-industrial levels

Indicator	*Emissions*	*Probability of exceeding 2°C*	
		Range	*Illustrative default case*
Cumulative total CO_2 emissions 2000-49	886 Gt CO_2	8-37%	20%
	1000 GtCO_2	10-42%	25%
	1158 Gt CO_2	16-51%	33%
	1437 Gt CO_2	29-70%	50%
Cumulative Kyoto-gas emissions 2000-49	1356 Gt CO_2equiv.	8-37%	20%
	1500 Gt CO_2equiv.	10-43%	26%
	1678 Gt CO_2equiv.	15-51%	33%
	2000 Gt CO_2equiv.	29-70%	50%

Source: Meinshausen *et al.* (2009) [14]

2 In a later chapter, an approach to historical responsibility, according to the Brazilian proposal, is explained.

It is clear from Table 1 that there is no completely unambiguous answer as to how much the world can emit for the period 2000-2049. It must be remembered that even in the present, between 2000 and 2007, the cumulative emissions of CO_2 (excluding LULUCF) amount to 210 Gt CO_2. It is therefore very unclear whether a budget of say 1000 Gt of CO_2 is feasible.

Even if this uncertainty can be progressively narrowed eventually in the IPCC's Fifth Assessment Report (AR5) or later, the precautionary principle enjoins us to act on these results. A possible mediation between the 1000 Gt and 1440 Gt of CO_2 ranges is clearly the possibility that while the 1440 target is the accepted one, we may examine technological advances a decade or a decade and a half later to see whether much sharper transitions to a low-carbon developments are indeed within reach.

Fair process is as important as a fair outcome. A formula that does not address the concerns of all countries will not be readily accepted in a multi-lateral process. A 'formula-plus' approach would be more practical, in which the equitable distribution of carbon space as outlined here is a reference point for the negotiating process. In the negotiations, the heterogeneous resource endowments and other national circumstances of particular countries would be taken into account politically, thereby adding the 'plus' to the formula. The equity-based approach may be used not only at the start, but also as an ongoing reference for review of what countries should achieve in an ideal world.

4. Overoccupation of the atmosphere by Annex-I countries GHG emissions

4.1 Unsustainable past and a sustainable future with equity

Before we proceed further it is important to examine in detail the total national carbon budgets as well as what they have at their disposal with regard to the future. To get a better view we will aggregate the individual nations to the level of regions. We present below the share of the Annex-I and the non-Annex-I countries in the cumulative emissions till the year 2000 based on the various choices of the specified initial year.

Table 2: Shares of cumulative emissions by Annex I and non-Annex I countries

	Entitlements – 1850-2000 (%)	*Contribution to stock – 1850-2000 (GtC)*	*Shares of cumulative emissions by Annex I and non-Annex I countries*
Annex-I	20%	210.03	79%
Non-Annex-I	80%	55.44	21%
Total	100%	265	100%
Starting year 1850, excluding historical LULUCF, data source: CAIT[15]			

It is clear that the Annex-I countries have emitted significantly more than non-Annex-I countries. This remains true whether we take into consideration initial years that are far more recent, such as 1970, or start from the beginning of the Industrial Revolution – perhaps 1850. This fact is recognised in the second sentence of Article 3.1, which follows the principle of equity and CBDR&RC: ‘Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.’[10]

If we take into account the relative populations of the two regions of the world in 2000, the extent of over-occupation is striking. The IPCC recognised this reality in its Fourth Assessment Report, as well as acknowledging the trends in future emissions:

> In 2004 UNFCCC Annex I countries held a 20% share in world population, produced 57% of world Gross Domestic Product based on Purchasing Power Parity (GDPppp), and accounted for 46% of global GHG emissions (p. 3) … CO_2 emissions between 2000 and 2030 from energy use are projected to grow 40 to 110% over that period. Two thirds to three quarters of this increase in energy CO_2 emissions is projected to come from non- Annex I regions, with their average per capita energy CO_2 emissions being projected to remain substantially lower (2.8-5.1 tCO_2/cap) than those in Annex I regions (9.6-15.1 tCO_2/cap) by 2030. According to SRES scenarios, their economies are projected to have a lower energy use per unit of GDP (6.2 – 9.9 MJ/US$ GDP) than that of non-Annex I countries (11.0 – 21.6 MJ/US$ GDP). [p.4][16]

Developing countries, including all of the BASIC countries, take seriously their responsibility for the future. In shaping that future, we cannot ignore the inequities of the past. It is evident that the over-occupation by the Annex-I Parties is so severe that even if they were to stop emitting tomorrow that would still not leave enough carbon space for the developing countries. This is clearly articulated in the Indian approach – because even though by way of entitlement they have 1 607 Gt CO_2 at their disposal, the available cumulative emissions to keep below 2°C amount to only 1 195 Gt CO_2. This demonstrates clearly that bare equity based on carbon space cannot be attained directly. The Chinese chapter of this publication suggests that, as some of the developed countries have used up all the emission budgets and nothing is left for the future, considerations will have to be made to ensure that fundamental necessity emissions for people in the rich countries should be guaranteed as well.

These figures also demonstrate unambiguously that the claim of developing country Parties to carbon space cannot be interpreted as a right to pollute. Developing countries are committed to sustainability. Sustainable development for developing countries is not a matter of choice. In terms of atmospheric space, the developed nations have occupied more than four times their fair share.

Even if developing countries will not be able to achieve their equitable share, the actual amount that they will physically be able to access depends on how much the Annex-I parties have to reduce emissions – and the extent to which they pay for any shortfall or remainder. We turn to this issue in the next section.

4.2 Implications for ‘who picks up the remainder’

Developing countries, who have generally less than their fair share of emissions space, take responsibility for the future. Many developing countries, including all BASIC countries, have pledged to slow down their rate of emissions increase – expressed either as a deviation below BAU or a reduction in the carbon intensity of GDP.

The ranges identified in the IPCC AR4 have laid the basis for broad agreement that developed countries need to reduce emissions in absolute terms, while emissions for developing regions would be relative ‘deviations below baseline’.[17] The implicit assumption, however, is that developing countries have to pick up the remainder – the difference between the global pathway required to keep temperature below 2°C above pre-industrial levels and what Annex I can do. This is inequitable.

If one nation takes away more than its equitable share, this inevitably reduces the share of the others. Whether in sharing the resource or the effort of mitigation, if one does less, the other has to do more.[18] Expressed in terms of a carbon budget, if one country gets a share of the remaining budget, another cannot have it. If Annex I countries commit only to a fixed reduction, then developing countries will have to do more. Framed in terms of a carbon space approach, if developed countries claim a larger share of the remaining space than is fair, then not enough is left for non-Annex I countries. An equitable approach has to turn the formula around, as shown in Figure 1.

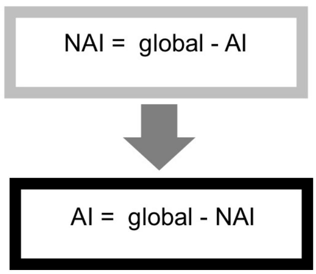

Figure 1: Turning around the formula

With the formula corrected, the question becomes: If non-Annex I countries were to achieve substantial deviations below baseline, and the lowest assessed stabilization levels are to be achieved to avoid worse impacts, then how much do Annex I countries have to reduce their emissions from 1990 levels? For notional levels of non-Annex Imitigation action, Annex I has to reduce by between –52% and –69% below 1990 by 2020, only dropping to a domestic –5% with commitments to offset payments through the carbon market.[18]

Politically turning around the implicit formula provides a better basis for an equitable burden-sharing paradigm that also addresses distributional issues, and we can then fully understand the real requirement for Annex I as a group’s absolute reductions. If this appears politically unacceptable to AI, the zero-sum nature of mitigation burden-sharing between Annex I and non-Annex I implies that non-Annex I countries would have to pick up the remainder. The same would apply if the Annex I Parties do not comply with their mitigation commitments. That would be unacceptable and inequitable, as would lead to higher levels of impacts on developing countries, who are the most vulnerable. The mitigation gap is wide.

5. Two broad frameworks

The first principle stated in the Convention (Article 3.1), that Parties should protect the climate system, benefiting inter-generational justice and 'on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities'.[10] Two broad approaches to operationalising the principle of equity and CBDR&RC are a resource-sharing budget approach and an effort / burden-sharing approach.The first can be considered sharing the resource equitably, that latter fairly sharing the effort. Both can be linked to each other.

5.1 Resource-sharing budget approach

In this approach, it is the resource in terms of the total global carbon budget that is shared among nations. The resource represented by the total remaining carbon budget (outlined in section 3) is to be divided among all nations starting with an appropriate formula for equitable access.

The Indian and Chinese chapters operationalise this aspect of equity in the following manner. These approaches share two common steps: (1) setting the global carbon budget that includes historic and future budget compatible with the temperature control target; and (2) allocating the global budget among all countries according to per capita equal accumulative emissions. The third step is somewhat different but complementary in the two approaches.

The global carbon budget has two components, the historical part and the future carbon budget and it is the sum of the two that is referred to as the global carbon budget. The historical part is given by the total carbon dioxide emissions from the specified starting year until 1999. The future global carbon budget is estimated by both the maximum temperature increase as well as the probability that this increase will be achieved as described earlier. Since these results are for the period 2000-2049, we have chosen 1999 as the end of the historical component. This is the first step.

This global carbon budget is then divided on a equal per capita basis based on the global population in a given base year. Every nation's total entitlement for cumulative emissions is then determined by the relative share of the country's population in the global population in the given base year. This total entitlement, we reiterate, for every nation is for the entire period from 1850 to 2049.

The future national carbon budget, or the remaining entitlement for the period 2000-2049, is then estimated by subtracting its actual historical emissions from its total entitlements. The future carbon budget from any later year (after 2000) to 2049 can be determined by further subtracting the actual emissions from 2000 up to that year.

Calculating entitlements and future carbon budgets by this method, it is clear that the Annex I countries have considerably exceeded their entitlement for the entire period 1850–2049. As a result the remaining entitlement for these countries for the period

2000–2049 is actually negative. This has important implications that are discussed in somewhat different ways in the two approaches.

The Indian approach focuses on calculating the future physical availability of carbon space to developing countries, within the global carbon budget and the reduction of emissions by Annex I countries. It is clear from these calculations that even if the Annex-I countries reduce their emissions rapidly, their over-occupation of the global atmospheric commons is so severe that most developing countries will not be able to attain their fair entitlement to carbon space. It specifically calculates the extent of this deficit for various countries and regions.

The Chinese approach, in a complementary way, points out that as a result of the negative entitlements of the Annex-I countries for the period 2000–2049, there are many developing countries with large positive entitlements. Thus, any nation to fulfil its requirement of carbon space, over and above its future entitlement, will have to collaborate with countries with large positive entitlements through open and compatible international collaborating mechanisms. A South-South cooperation mechanism is discussed in section 7.3.

5.2 Effort / burden-sharing approach

A second approach to operationalising equity and CBDR&RC is to focus on sharing the effort required to reduce emissions compared to future trends. Effort-sharing is crucial to solving the problem of global warming.

Defining fair shares of effort requires assessment of 'business-as-usual' (BAU) trends in emissions. While baselines are always projections and a function of the assumptions made, they do represent a critical aspect – the global trend of emissions growth. The IPCC's Fourth Assessment stated clearly that most emissions have come from Annex I countries in the past, but equally clearly that future emission will come mainly from non-Annex I countries, while their per capita emissions are nonetheless projected to stay below Annex I levels (see section 4.1).

The effort-sharing approach considers the emissions trends globally (using IPCC scenarios). It then allocates the effort to get to a desired future emissions pathway on the basis of equity – operationalised through different criteria. The global mitigation burden is defined by the difference between one of the IPCC scenarios and a required global pathway. The area under the required global pathway is equivalent to the future global carbon budget. The burden-sharing approach, however, focuses on the effort required in 'bending the curve' of future emissions trends down towards the required pathway. Historical cumulative emissions is one of the critieria considered in this approach, but it does not carry forward historical portion of the global carbon budget in the way defined in the resource-sharing budget approach.

The Brazilian chapter is based on the so-called Brazilian proposal, described in a document submitted by Brazil in May 1997[21] during the Ad-hoc Working Group on the Berlin Mandate that led to the adoption of the Kyoto Protocol. It was the first proposal by a Party to the Convention containing elements in a possible Protocol with objective criteria that had historical responsibility of Annex I Parties in terms of their contribution to the average global temperature increase as a basis.

In the Brazilian Proposal there is no use of scenarios or global projected emissions pathways that prejudge the relative future contribution of emissions by countries as the mitigation effort or burden shall be agreed upon politically. The proposal also established an objective criterion to share the burden in accordance with historical responsibility of Annex I countries. This proposal can be generalized and historical responsibility can be reviewed and updated periodically (e.g. every 5 or 10 years) depending on actual emissions pathways of each and every country (and therefore without resorting to any type of future projection) in order to establish an updated burden sharing regime periodically as time goes by and Parties develop their emissions pathways.

The Brazilian proposal is based on a different approach, recognizing the fact that a direct metric related to global warming is the global average temperature increase. Limiting global warming is essentially limiting the increase in the global average temperature by establishing a mitigation burden to be periodically reviewed. Consequently, the main issue is how to share the burden. The criterion for the sharing of the burden among Parties becomes a natural consequence of the fact that, given the emissions over a period for Parties, it is possible to assign relative responsibilities to individual Parties according to their respective contributions to climate change, as measured by the induced change in temperature. This proposal addresses the central question of the relationship between the emissions of GHGs by Parties over a period of time and the effect of such emissions in terms of climate change, as measured by the increase in global mean surface temperature. The increase in global mean surface temperature is roughly proportional to the accumulation over time of the radiative warming. The radiative warming is, in turn, proportional to the atmospheric concentration of the GHG. It follows that the temperature increase itself is proportional to the accumulation of the atmospheric concentration of the GHG. It is to be noted that the uncertainties remaining in the present knowledge of the absolute value of the predicted temperature change, as reflected for instance in the margin of uncertainty in the climate sensitivity (the change of temperature resulting from a doubling of the carbon dioxide concentration is known to be within the range 1.5–4.5 °C), does not affect the conclusions about the relative contribution of countries.

6. Operationalising equitable distribution of carbon space through criteria

Both of the broad approaches need to be operationalized. A key step is to identify criteria which can be approximated quantitatively, which form the basis of calculations. We examine in this section approaches based on historical responsibility, the per capita principle and sustainable development.

6.1 Per capita

The criterion in this approach to equity is that it must sensibly distinguish between nations of different sizes, recognizing that larger nations need proportionately greater amounts of carbon space. The essence of the Indian approach is to share the global carbon budget in an equal per capita distribution of cumulative emissions, inclusive of emissions in the past (from some specified initial year) and possible emissions in the future (up to some specified target date. In the chapter by Chinese experts (CASS/DRC, based on two previous studies, Pan & Chen (2009)[19] and DRC (2009)[20]) per capita accumulative emissions are used as a basis with respect to the principle of carbon equity in allocating global carbon budget.

The per capita approach deals with both the equity aspect and with this need to distinguish the size of nations. In this approach, equitable access is defined by carbon space being equally assigned to all individuals across the globe. These are then aggregated at the level of each nation and become the definition of the equitable share of global carbon space for individual nations. Such a per capita allocation of global carbon space can be based on flows or stocks. Currently per capita allocation based solely on flows is widely considered to be unsatisfactory and it is per capita allocation based on cumulative emissions that is under discussion.

Many people might think that the populous developing countries, such as China and India, will benefit greatly from the per capita principle. But this is not the case. The per capita principle merely allocates a low carbon growth model to China and India, since, according to the principle, their per capita accumulative emissions can reach only the world average level in the future – much lower than the current high level of real emissions in the industrialised countries.The views above are reflected in the per capita-based approaches.

Equity can only be achieved if the loss of equitably allowed carbon space for the majority of developing nations is made up by providing access to technology and finance that can compensate for this loss of carbon space in the medium and short terms. This is closely related to the other aspect of equitable access to sustainable development as we discuss below (section 6.3 and further in 7.2).

6.2 Historical responsibility

Another important criterion in an equitable approach is the one of historical responsibility. This concept has broad application, and at this point we might differentiate between local pollutants and GHG emissions. In the case of urban atmospheric pollution or water contamination, emissions have been used as a measure of responsibility of the polluters. Such a procedure is appropriate as, when the residence time of the pollutant is relatively short, the concentration of the pollutant is proportional to the emission. Emissions levels give a good measure of the level of mitigation needed, as any effects are associated with the concentration of these (short-lived) pollutants. However, in the case of climate change, this notion cannot be applied due to the long-lived nature of GHGs. Sharing the burden of mitigation climate change is the central issue in the UNFCCC process and these considerations highlight the problem of regarding current anthropogenic emissions of GHGs as the central issue in the climate change debate. But historical emissions and the long-term consequences from this are equally crucial.

In order to enhance the full, effective and sustained implementation of the Convention, quantifying the relative responsibility of developed countries in relation to developing countries based on their contribution to the increase in global mean surface temperature must be part of the equation, especially considering that UNFCCC Parties recognized the need to hold the increase in global average temperature below 2°C above pre-industrial levels as the long-term goal, consistent with science and on the basis of equity.[3] The current concentration of GHGs in the atmosphere is a result of past emissions since the beginning of the industrial revolution. Current generations are bearing the burden of past interference with the climate system, resulting from human activities during the last two centuries, primarily in the developed countries. In a similar manner, current human activities around the world will impact the future climate. The limits to the growth of emissions which are necessary will however impact the developing countries in their pursuit of development. The developed countries are therefore responsible for this extra burden on developing countries, and hence in mitigation efforts it is the developed nations who must take the lead. This is clearly recognized in the Convention itself in the second sentence of Art 3.1.

Historical responsibility is at the centre of the Brazilian approach to the question of equity. In this approach (detailed in the country chapter), the responsibility of specific countries to temperature increase is determined by the methodology of the double accumulation process. The following table provides an example of this method for some countries and compares it to the historical responsibility determined only through accumulative emissions.

Table 3: Contributions to temperature increase based on the Brazilian approach and historical data

	1850 – 2005CO_2(energy)	*1850 - 1990CO_2(energy+cement)*
Country	*WRI CAIT (%)*	*Brazilian proposal (%)*
China	8.39	3.05
India	2.22	0.90
South Africa	1.10	0.21
Brazil	0.80	0.32
BASIC	12.51	4.48
Non Annex I	26.48	10.35
Annex I	73.52	89.65

3 We also recognize the need to consider, in the context of the first review the need to strengthening the long-term global goal on the basis of the best available scientific knowledge, including in relation to a global average temperature rise of 1.5°C.

The future mitigation effort under this approach would be shared by agreement among Parties in accordance with their relative historical contribution to temperature increase, as actual emissions would evolve as time goes by in each and every country. The relative historical contribution would vary along time and the mitigation burden would be reviewed and updated periodically. The historical responsibility approach emphasizes the need to focus on equity in terms of contribution by Parties to global average temperature increase rather than on emissions flows alone. Mitigation discussions that focus only on flows and changes in future flows miss the dimension of historical responsibility.

The per capita-based approaches take into account historical responsibility in terms of the accumulative emissions from each nation.

6.3 Capability and indicators of sustainable development

Countries' respective responsibilities to protect the climate system vary. The Convention urges countries that have greater capabilities to act towards the common good by making a greater contribution to the effort.

In Tianjin, BASIC Ministers 'recognised diversity of views on more ambitious aspirational objectives. Ministers believed that the resolution to this issue links directly to reaching a political understanding of equity. Ministers reaffirmed that equitable access to sustainable development will be the core of and foundation for any climate change agreement and that this will be the prerequisite for setting up any global emission reduction target. This must take into account historical responsibility of developed countries, the need for space and time to achieve sustainable development in developing countries, and the need for the provision of adequate finance, technology and capacity building support by developed countries to developing countries.'[4]

Operationally, sustainability, in the term sustainable development, cannot be reduced solely to the duty of developing nations to proceed along a low-carbon pathway of development. Those countries that have developed unsustainably in the past have a primary responsibility to develop a global low-carbon economy and society. However, developing nations too will need to do their part, to preserve sustainability. as they proceed with poverty eradication and erasing their development deficit.

The South African chapter of this publication takes the approach of principle-based criteria. It uses criteria to allocate the carbon and development space available globally to 2049, drawing on the principles outlined in the UNFCCC. These principles are enshrined in Articles 3.1 – responsibility and capability to protect the climate system, and 3.4 – the right of Parties to sustainable development. In this approach, action to protect the climate system, interpreted as sharing the global mitigation burden (measured in terms of a baseline defined by one of the IPCC scenarios) is allocated according to historical responsibility for emissions, and capability to mitigate, which is quantified not only in terms of GDP, but also in terms of level of development.

7. Comparing approaches

7.1 Comparing future carbon budgets

This section compares future carbon budgets, based on the approaches presented in the country chapters. In the analysis, experts of those countries from BASIC countries used a common set of key parameters, except for the Brazilian chapter that uses a different approach.

Table 4: Key parameters used in analyses

Global budget	Historical 1850 – 1999 1970 – 1999	 965 Gt CO_2-eq 574 Gt CO_2-eq
	Future (2000-2049)	1440 Gt $CO_{2\text{-eq}}$
Historical starting point		1850, 1970
Population		Static – population for 2000
LULUCF		Results reported with and without LULUCF
Financial transfer		estimates made, assuming carbon price of \$20/t $CO_{2\text{-eq}}$ and \$50

While 1850 as a base year for historical responsibility is well known, 1970 is more uncommon. However 1970 is around the period when the first intimations of global warming were being discussed globally and countries such as the United States had already begun investigating its strategic implications for their future.

The results of the analysis according the approaches described in this chapter are reported in Table 5, Table 6 and Figure 2. In particular, the future carbon budgets are reported for BASIC countries, drawing results from the different approaches. For the purposes of this paper, the Brazilian approach based on historical responsibility has applied only to the past (see section 6.2). It could in further work be used to allocate future carbon budgets. Table 5 reports results with a starting year of 1850 and only without LULUCF in the past.

Table 6 reports future carbon budgets for the BASIC countries and various regions. The results from the Indian and South African approaches are reported with and without consideration of LULUCF in the historical period from 1970. For the future allocation of budgets, LULUCF is taken into account.

Table 5: Comparing carbon budgets according to various approaches (Gt CO_2-eq for the period 2000- 2049, starting year 1850, excluding historical LULUCF)

		Approach to equitable access to sustainable development		
		Carbon budget account proposal (CASS/DRC, China)	*The Indian approach (TISS)*	*A South African approach – responsibility, capability and sustainable development (ERC)*
Carbon budget for country / group	Brazil	61	61	113
	China	427	429	399
	India	388	391	236
	South Africa	7	7	29
	∑BASIC	883	887	777
	Non-Annex I	1675	1720	1917
	Annex I	-239	-282	-474
	World	1436	1438	1443

Note: Small differences in the world total from the global carbon budget for 2000-2049 are due to differences in data for some smaller countries and/or rounding errors.

Table 6: Comparing future carbon budgets according to various approaches to equitable access to sustainable development (Gt CO_2-eq for the period 2000- 2049, starting year 1970)

		Carbon budget account proposal (CASS, DRC China)	*The Indian Approach (TISS)*		*A South African approach – responsibility, capability and sustainable development (ERC)*	
		Without historical LULUCF	*With LULUCF*	*Without historical LULUCF*	*With LULUCF*	*Without historical LULUCF*
Carbon budget for country / group	Brazil	52	36	52	52	107
	China	363	377	358	357	364
	India	333	341	330	231	229
	South Africa	8	11	8	31	28
	∑BASIC	754	765	747	671	727
	Non-Annex I	1432	1454	1447	1616	1817
	Annex I	9	-14	-7	-173	-374
	World	1440	1440	1440	1443	1444

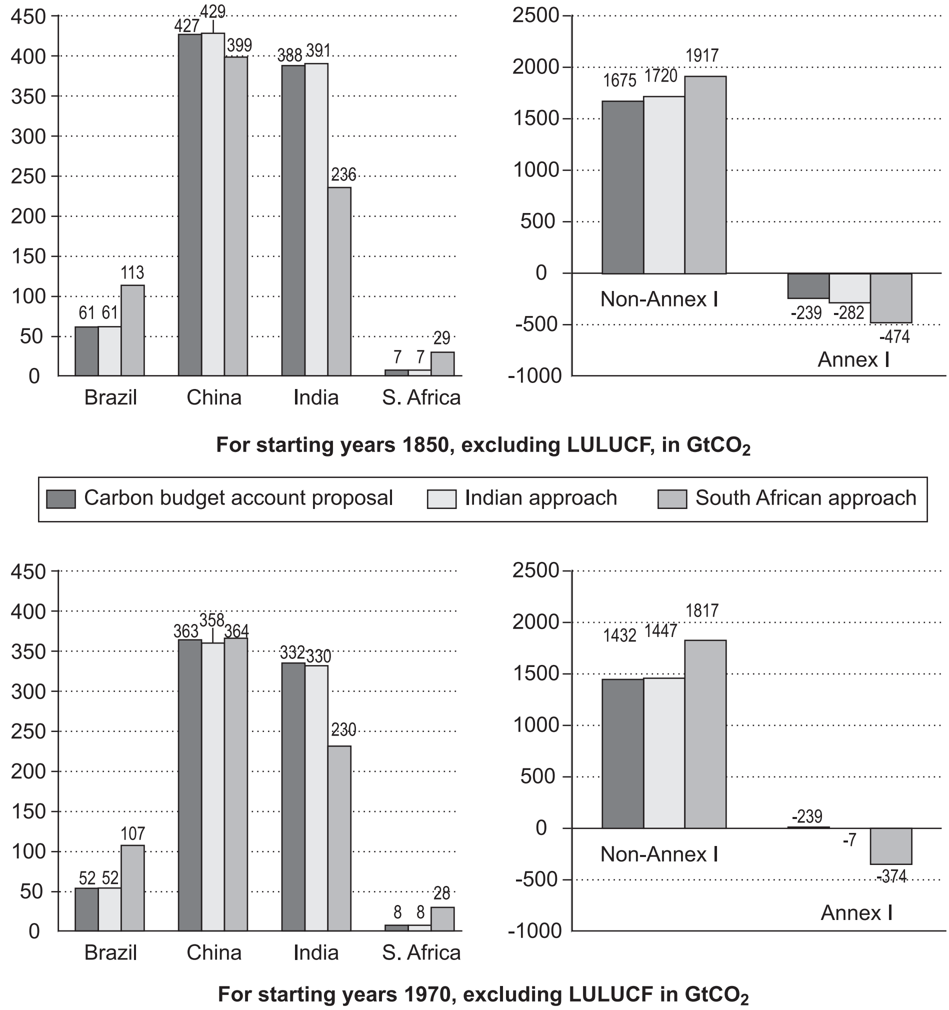

Figure 2: Comparing future carbon budgets according to various approaches to equitable access to sustainable development

The following general conclusions can be drawn from the comparison in the tables and figures:

- The first conclusion is that developed nations are in deficit with respect to their budget even up to 2050. Developed countries taking the lead (Article 3.1)[10] therefore has a continued and clear meaning – sharp and immediate reduction commitments are required by the Annex I countries.
- For developing countries as a group, the major problem is that they are unable to achieve their entitlements under any global sustainability constraint. Hence, most individual developing countries will be unable to physically access their equitable share of the future carbon budget.

- The future carbon budgets for the Annex I and non-Annex I groups are very similar, across somewhat differing methodologies.

7.2 Equity in support – finance, technology and capacity development

Equitable access to sustainable development is about both about access to carbon space and time for development. The allocation of the global mitigation burden must be fair, but there must also be equity in the question of 'who pays?'.

It is clearly thought that the critical issue for developing nations is the gap between their equitable share of the global carbon space versus the physical share that will be accessible to them. This gap has to be bridged by appropriate financial and technology transfer.

The financial flows implied are large. Three of the chapters in this publication quantify the scale using the carbon space approach for two carbon prices, assuming \$20 and \$50 / t CO_2-eq. Using the CASS /DRC approach (with 1900 as starting point), the financial flows from Annex I to Non-Annex I would reach 8.04 trillion dollars at a price level of 20\$/tCO_2 and 20.1 trillion dollars at a price level 50\$/tCO_2 respectively as a one-time payment. However, if year 1970 is used at the starting point, the historical deficit of Annex I over 1970–1999 will be substantially reduced as compared to the numbers under the starting years 1850 and 1900. The chapter by Chinese experts also considers (in Appendix II) the merits and demerits of discounting historical emissions. It reports lower financial transfers for two methods, depreciating the real CO_2 emission in the past, or depreciating the price of carbon directly. In the chapter by Indian experts, financial transfers are estimated by a similar method. However, the quantum of financial transfers varies because of a different choice for the year in which the carbon deficit of Annex I countries is calculated.

The chapter by South African experts also reports estimates of the scale of financial transfers consistent with equity. It assumes that any portion of developed countries' emissions budget that is negative would *have* to be purchased by paying for mitigation in other countries. The results scale linearly with the assumed carbon price. A higher finance requirement for Annex I results from an earlier starting year and from the exclusion of LULUCF. The average finance requirement ranges from a minimum of \$231 billion per year (average at \$20 / t CO_2-eq, starting year 1970 and including LULUCF), and a maximum of \$2 058 billion per year (maximum at \$50 / t CO_2-eq, 1850 and no LULUCF). The maximum required in any given year significantly exceed the average.

Given the large mitigation gap, a political agreement on the question of 'who pays' is fundamental. Funding enhanced mitigation in developing countries from international sources seems to be an essential method for bridging that gap.The scale of funding agreed in the Copenhagen Accord and confirmed in a Cancún decision is \$100 billion per year by 2020.

Equity is about the emissions gap and the finance gap. The analyses here suggest that, in any equity-based approach, the financial transfers required are much greater than those that have been agreed.

7.3 South-South cooperation in determining national carbon budgets

A single allocation formula for equitable access to sustainable development does not satisfy the needs of all developing countries. It is clear that South-South cooperation is the key to resolving this issue. The Chinese approach considers collaborative approaches and cooperation mechanisms at a larger scale.

If one considers the cumulative emissions of all countries, it is clear that there are some countries in the global South whose cumulative emissions today have already reached 50% or more of their entitlements for the entire period 1850-2050. These countries are in this special situation for particular historical reasons. In applying the equitable access principle it is clear that the needs of these countries must be included: a type of 'formula-plus'. A natural prescription for this formula-plus approach is revealed by the actual data.

A closer analysis of data reveals that the extent of overuse of carbon space by these countries is actually small in absolute terms. It is clear that their requirements for carbon space may be met by mutual adjustment and cooperation among developing countries. At the same time the overall principle of equitable access that is true for a significant majority of developing countries can be preserved.

Among the emerging economies a total of ten countries have currently utilised more than 50% of their total entitlement for the period 2000-2049. Their contribution to stock, however, is only 58.2 Gt CO_2, amounting only to 3.36% of the total. Their future entitlement is however limited to 19.6 Gt CO_2.

Among the smaller economies there are similarly 18 countries whose current stock contribution is 27.1 Gt CO_2 (1.22% of total). Even though their future entitlement is limited to only 1.2 Gt CO_2, providing for more for this group should be feasible within a paradigm of south-south co-operation.

Once the national carbon budget is determined for a given country, it can draw up its mitigation roadmap for its own, formulate its policies to meet the basic needs of its people and at the same time cut its emissions, and assess whether it will be able to keep its own carbon budget in balance. If not, it will have to adjust its emissions reduction policy, or acquire carbon emission quotas from other countries through various ways, for example, through international transfer of carbon budget, through bilateral or multilateral negotiations, or through flexible international cooperation. Step number 3 in the CASS/DRC approach is the designing and establishment of cooperation mechanisms among countries, in particular between countries with surpluses and those with deficits in their respective national accounts.

7.4 Equity in adaptation

The discussions in these chapters have focused on equity in mitigation and finance. This clearly does not exhaust all aspects of equity in acting on climate change. Equity in the shared vision for long-term cooperation is an essential element of the pursuit of equity in all aspects of climate change and the starting point for the consideration of equity in other dimensions. Equity applies, as noted at the outset, to a broad set of issues related to sustainable development. Other aspects of equity, such as equity in adaptation, should follow the same basic thrust of equity in the shared vision for long-term cooperation. Operationally, content would be different, but also interrelated. Failure to deal with mitigation in a way that keeps temperature below 2°C will increase the adverse effects of climate change. This has a multiplier effect on costs of adaptation. Insufficient investment in mitigation, due to both the emissions and finance gap, will increase the costs of adaptation – particularly for poor countries and communities. Infrastructure development is an integral aspect of adaptation, but would require sufficient carbon space for its realisation. The equity-based reference framework should therefore link mitigation, adaptation and their respective costs.

Adaptation is an issue of development. Development is an issue of emission space, which in turn is an issue of equity, equitable access to sustainable development.

8. Conclusion: the need for an equity-based reference framework

The equity-based reference framework outlined in this draft paper is presented to Ministers for their consideration. Given that Parties agreed in Cancun 'to work towards identifying a timeframe for global peaking of greenhouse gas emissions based on the best available scientific knowledge and equitable access to sustainable development, and to consider it at its seventeenth session',[22] the BASIC experts believe this synthesis is timely. A framework of equitable access to sustainable development must be the foundation of any further consideration of global peaking and related issues should take place.

The review of adequacy, the scope of which will be defined at COP-17, 'should be guided by the principles of equity, and common but differentiated responsibilities and respective capabilities and take into account'.[22] This equity-based reference framework could be the basis to review what countries are doing and to motivate an increase in the level of ambition.

More generally, Ministers might consider an equity-based reference framework. It would constitute a normative dimension in the climate regime:what countries should ideally do. It would not provide the end point for a negotiation. Rather, it can provide a reference point that is not purely based on political power and willingness to pledge, but based on what is required by science, what is good for development and what is fair. It also satisfies the precondition for setting a long-term global goal for emission reductions and to the means needed for sustainable development consistent with such a goal.

This paper is the result of intensive work. It is an approach that is applicable to all countries. It should be understood as flexible, and further work may be undertaken by experts from BASIC countries in collaboration with experts from other countries, particulary from other developing countries. The approach is intended to accommodate the legitimate concerns of developing countries, in particular least developed countries and small islands developing countries. Further work may also consider the implications of consumption-based approaches for the analyses presented in this paper.

References

1. UNFCCC (2007) Bali Action Plan. Decision 1/CP.13. Bali, Indonesia.
2. UNEP (2010) The emissions gap report: Are the Copenhagen Accord pledges sufficient to limit global warming to 2°C and 1.5°C. A preliminary assessment. UNEP, Nairobi.
3. BASIC (2010) Joint Statement issued at the conclusion of the Fourth Meeting of BASIC Ministers. 26 July. Rio de Janeiro.
4. BASIC (2010) Joint Statement issued at the conclusion of the Fifth Meeting of BASIC Ministers. 11 October. Tianjin.
5. BASIC (2011) Joint Statement issued at the conclusion of the Sixth Meeting of BASIC Ministers. 25 February. New Delhi.
6. I. Kaul, I. Grunberg, M. A. Ster (1999). (eds), Global public goods: International cooperation in the 21st Century (Oxford University Press).
7. Global Commons Institute (2000) Climate Change - a global problem. Global Commons Institute.
8. E. Ostrom, J. Burger, C. B. Field, R. Norgaard, D. Policansky (2000). Revisiting the Commons: Local lessons, global challenges. Science 284, 278-282.
9. A. Agarwal, S. Narain (1991). Global warming in an unequal world: A case of environmental colonialism Center for Science and Environment, 1991.
10. UNFCCC (1992) United Nations Framework Convention on Climate Change. United Nations, New York.
11. P. Baer, T. Athanasiou, S. Kartha (2008). The Greenhouse Development Rights Framework: The right to development in a climate constrained world EcoEquity and Christian Aid, 2008.
12. H. E. Ott et al. (2004). South-North dialogue on equity in the greenhouse: A proposal for an adequate and equitable global climate agreement Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH in cooperation with Wuppertal Institute for Climate, Environment and Energy, Germany and Energy Research Centre (ERC), University of Cape Town, South Africa, 2004.
13. T. Kanitkar et al. (2010) Meeting equity in a finite carbon world: Global carbon budgets and burden sharing in mitigation actions in Global Carbon Budgets and Equity in Climate Change, June 28-29, 2010. Tata Institute of Social Sciences, Mumbai, pp. 47.
14. M. Meinshausen et al. (2009). Greenhouse gas emission targets for limiting global warming to 2°C Nature Letters 265-279.
15. WRI (2009) Citation: Climate Analysis Indicators Tool (CAIT) Version 6.0. Washington D.C.
16. IPCC (2007) Climate Change 2007: Mitigation of Climate Change. Summary for policy makers. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva.
17. IPCC (2007) Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC working Group I Technical Support Unit, Bern.

18. H. Winkler, S. Vorster, A. Marquard (2009). Who picks up the remainder? Mitigation in developed and developing countries. Climate Policy 9, 634–651.
19. J. Pan, Y. Chen (2009). The carbon budget scheme: An institutional framework for a fair and sustainable world climate regime. *Social Science in China* **5**, 83-99 ([潘家华、陈迎（2009）.碳预算方案：一个公平、可持续的国际气候制度框架.中国社会科学.).
20. DRC (2009) Greenhouse gas emissions reduction: A theoretical framework and global solution, Chapter 17 in Ross Garnaut, Ligang Song and Wing Thye Woo (eds) China's New Place in a World in Crisis: Economic, Geopolitical and environmental dimensions. pp.389-408. (http://epress.anu.edu.au/china_new_place/pdf/ch17.pdf). The Australian National University E-Press and Brookings Institution Press.
21. Brazil (1997). Proposed elements of a protocol to the UNFCCC, presented by Brazil in response to the Berlin mandate, FCCC/AGBM/1997/MISC.1/Add.3 UNFCCC, 1997.
22. UNFCCC (2010) Decision 1/CP.16: The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention. Document FCCC/CP/2010/7/Add.1. United Nations, New York.

The importance of historical responsibility in the context of the international regime on climate change

JOSÉ DOMINGOS GONZALEZ MIGUEZ[1] and ADRIANO SANTHIAGO DE OLIVEIRA[2]

Causes of climate change are difficult to attribute, as observed warming is of the same magnitude as natural climate variability. Natural changes in climate result from interactions between the atmosphere and ocean, as well as from variations in the sun's energy output and in the amount of material injected into the upper atmosphere by explosive volcanic eruptions.

According to the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 4AR), warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.[3]

Climate change, as defined in the United Nations Framework Convention on Climate Change (UNFCCC), refers to a change of climate that is attributed directly or indirectly to human activity and altering the composition of the global atmosphere, in addition to natural climate variability observed over comparable time periods.

According to IPCC 4AR most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.[4]

Unlike ozone-depleting substances, greenhouse gas emissions don't need to be phased out. Stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system would be sufficient, once a stable level has been scientifically defined. The stabilization of

---

1 Ministry of Science and Technology of Brazil.
2 Ministry of Environment of Brazil.
3 IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
4 IPCC, 2007, reference i.

concentrations requires that emissions eventually drop well below current (or 1990) levels.

According to UNFCCC, policies and measures on the mitigation of climate change will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention, recognizing that the return by the end of the past decade to earlier levels of anthropogenic emissions of greenhouse gases would contribute to such modification with the aim of returning individually or jointly to their 1990 levels these anthropogenic emissions of greenhouse gases. To some extent, this aim was replaced as well as postponed by the quantified emission limitation and reduction commitments of reducing 5% of their aggregate emission in 1990 by a five years period centered in 2010 contained in the Kyoto Protocol first commitment period (there is no expiration date for the Kyoto Protocol). However, as announced in Bangkok in October 2009 and confirmed in Barcelona in November 2009, some relevant developed countries have manifested a strong intention to abandon the Protocol. They apparently want to join the United States, and establish a new agreement, which would represent the substitution of the internationally legally binding regime that is Kyoto, to focus on national efforts in a new 'politically binding' agreement. In addition, if there is no second commitment period of the Kyoto Protocol, there will be no incentive for compliance with the Annex I commitments for the first commitment period. This represents a further delay of 10 years in combating climate change and further postponement of actions.

Moreover, when the pledges by individual developed countries in aggregate are compared to 1990 base year, the overall emission reductions range from 16 to 23%, according to the UNFCCC secretariat data distributed in 2009 at Barcelona (11 to 18% if the USA is included, according to an estimate of the Alliance of Small Island States). This is a very low level of ambition and well below the minimum level proposed by the IPCC for Annex I Parties (in the range from 25 to 40%). In addition, a substantial part of this pledge would be achieved by means of the use of mechanisms that would imply shifting the burden of solving global warming to developing countries.

In the case of urban atmospheric pollution or water contamination, emissions have been used as a measure of responsibility of the polluters. Such a procedure is appropriate as, when the residence time of the pollutant is relatively short, the concentration of the pollutant is proportional to the emission. Emissions levels give a good measure of the level of mitigation needed, as any effects are associated with the concentration of these (short-lived) pollutants. However, in the case of climate change, this notion cannot be applied due to the long-lived nature of greenhouse gases (long lifetimes in the atmosphere). Sharing the burden of mitigation climate change is the central issue in the UNFCCC process and these considerations highlight the problem of regarding current anthropogenic emissions of greenhouse gases as the central issue in the climate change debate. But historical emissions and the long-term consequences from this are equally crucial.

The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. There is no doubt that this increase is largely due to human activities, in particular fossil fuel combustion.

According to the IPCC , the primary source of the increased atmospheric concentration of carbon dioxide since the pre-industrial period results from fossil fuel use, with land-use change providing another significant but smaller contribution. Fossil carbon dioxide emissions are estimated to range from 72% to 92% of the global emissions of this gas in the 1990s. Carbon dioxide emissions associated with land-use change are estimated to range from 8% to 28% over the 1990s, although this estimate has a large uncertainty.[5]

According to IPCC 4AR, since 1970, greenhouse gas emissions from the energy supply sector have grown by over 145% while transport emissions grew by over 120% – by far the two sectors with the largest greenhouse gas emissions growth. Industry sector's emissions grew by close to 65%, LULUCF by 40% while the agriculture sector (27%) and residential/ commercial sector (26%) saw the slowest growth between 1970 and 2004.[6]

According to IEA's Key World Energy Statistics 2009, energy derived from fossil fuel usage accounted for approximately 81.4% of the world's energy output in 2007. It is estimated that CO_2 emissions will increase by 130% by 2050 in the absence of new policies or supply constraints. IEA also estimates that approximately 30% of CO_2 emissions are from coal fired power stations, however other industrial processes, such as natural gas stripping, steel making, cement production and alumina refining, account for close to 50% of CO_2 emissions.[7] Energy will continue to come from existing fossil fuel based power stations and industrial facilities because of their long lifespans. Renewable energy technologies are fundamental to mitigate climate change, but alone they are not able to produce the required energy output by the world. This perpetuates the need to use fossil fuels over the next few decades. Therefore, fossil fuel-based energy will continue to be part of world energy matrix.

The scientific information presented above shows clearly that the focus to combat climate change must be reducing emissions from fossil fuel use.

Developed countries were responsible for 75% of CO_2 emissions from fossil fuel combustion in 1990 and OECD countries for 62% of these Annex I CO_2 emissions. It is also noted that per capita emissions in developing countries are still relatively low, owing to the industrialization process of developing countries that started in the middle of the twentieth century.

In 2004, per capita emissions in non-Annex I countries were four times lower than per capita emissions in Annex I countries (4.2 t CO_{2e}/cap in regards to the first one and

5 IPCC, 2007, reference i.

6 IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

7 http://www.iea.org/statistics/.

16.1 t CO_{2e}/cap regarding Annex I countries). In the same year, Annex I countries held a 20% share in world population against 80% share regarding non Annex I Countries.[8]

A method has been devised in the Bali Action Plan (adopted in December 2007 in Bali) to make a clear distinction of commitments of Annex I Parties and voluntary actions by non-Annex I Parties in accordance with the Principle of Common but Differentiated Responsibilities and further advance the implementation of the Climate Change Regime: paragraph 1b(i) for developed countries that are not Parties to the Kyoto Protocol (the United States of America is the only Party remaining with this status) in order to make comparable efforts to those Parties of the Protocol and paragraph 1b(ii) for developing countries in order to take nationally appropriate mitigation actions (NAMAs) enabled and supported by financing, technology and capacity building from developed countries. Both actions and support must be measurable, reportable and verifiable (MRV).[9]

An ethically relevant criterion for allocating responsibility to reduce the threat of climate change has been addressed in terms of the polluter pays principle and past contributions to climate change.

Developed countries argue that greenhouse gas emissions from fast developing key countries will equal the emissions from developed countries at some point in time between 2020 and 2030, according to IPCC scenarios. It is relevant to register that the UNFCCC notes that the share of global emissions originating in developing countries will grow to meet their social and development needs.

But the largest share of historical and current global emissions of greenhouse gases has originated in developed countries. According to WRI CAIT, Annex I countries held a 75% share in cumulative CO_2 emission (1850-2005) against 25% share regarding non-Annex I Countries for the same period.[10]

There is an impasse where developed countries look only at the future while forgetting past emissions, and developing countries look to the past and are concerned with their own future emissions. These concerns expressed by developing countries are linked to 'grandfathering' of greenhouse gas emissions of developed countries.

Considering the atmosphere, early action would reduce emissions or enhance sinks, decreasing future levels of greenhouse gas concentrations and contributing to mitigation of climate change. But the decision to use emissions as a basis for the climate change Convention is not contributing to solving the global warming problem from an atmospheric perspective.

The first approximation showed that the dependence of atmospheric concentrations on emissions over a given period of time is proportional to the accumulation of the emissions up to the year in question. It is necessary to take into account that the older the emission the smaller is its effect on concentration due to the exponential natural decay of greenhouse gases in the atmosphere, with a different lifetime for each gas. The

---

8 IPCC, 2007, reference iv.
9 Copenhagen: Key Issues Facing Developing Countries, Martin Khor mkhor@igc.org.
10 http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/6_china.pdf.

physics of radiative forcing indicates that the rate of deposition of energy on the surface (i.e. the warming itself) is proportional to the concentration of the greenhouse gases.

The increase in global mean surface temperature is roughly proportional to the accumulation over time of the radiative warming, which is in turn proportional to the atmospheric concentration of the greenhouse gases. It follows that the temperature increase itself is proportional to the accumulation of the atmospheric concentration of the greenhouse gases.

In order to contribute for solving the global warming problem from an atmospheric perspective, in 1997, Brazil has proposed[11] addressing the central question of the relationship between net anthropogenic emissions of greenhouse gases by Parties over a period of time and the effects of such emissions in terms of climate change, measured by the increase in global mean surface temperature.

The Kyoto Protocol uses emissions as a basis under which industrialized countries will reduce combined greenhouse gas emissions by at least 5% compared to 1990 levels by the period 2008–2012. This legally binding commitment promised to produce a historic reversal of the upward trend in emissions that commenced in these countries some 150 years ago.[12]

The outcome of the Kyoto Protocol (Annex B) established a different level of commitment for each country concerning quantified emission limitation or reduction (as a percentage of base year or period).

No attempt was made to establish objective criteria on how to mitigate climate change (by how much and for how long). Moreover, no explicit quantification has been made, through the Berlin Mandate process and discussions in Kyoto, of the effect that the overall greenhouse gas emission reduction would symbolize in terms of decreasing the rate of temperature increase. Actually, the emission reduction or limitation targets set at Kyoto will result in continued increase in the global mean surface temperature during the whole period of the Kyoto Protocol until 2012. Amazingly, the emission reduction effort does not reduce global warming caused by Annex I Parties, which is often misunderstood by the general public. It can be very easily demonstrated that the outcome of the Kyoto Protocol, emission reductions for all Annex I countries of 5 per cent on average in the period of five years centered around 2010 as compared to 1990 levels, represents an additional enhancement of the greenhouse effect as compared to the previous (and not legally binding) commitment of developed countries to stabilize their overall greenhouse gas emissions at 1990 levels by 2000, and maintain these levels until 2010.

Despite the facts given above, at present the Kyoto Protocol is the only legal instrument that is delivering real emission reductions from Annex I Parties and the task now is to build on this success by setting up the next steps for Annex I Parties, more ambitious quantified emission reduction commitments for the 2nd and subsequent

11. FCCC/AGBM/1997/Misc.1/Add.3 Proposed Elements of a Protocol to the United Nations Framework Convention on Climate Change, Presented by Brazil in response to the Berlin Mandate.
12. The Kyoto Protocol, UNFCCC, Introduction.

Commitment Periods. But the limitation and reduction commitments currently adopted and discussed are not related to future mean surface temperature increase.

The Convention on Climate Change is based upon two 'soft law' (or *jus cogens*) principles that countries adopt whereby political and moral commitments will be respected in good faith.[13]

Firstly, the precautionary principle which states that 'The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost.'

Secondly, the most important principle is that of common but differentiated responsibilities. Paragraph 1 of Article 3 of the UNFCCC states that 'The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.' The preamble of the UNFCCC acknowledges that 'change in the Earth's climate and its adverse effects are a common concern of humankind' and that 'the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions'.[14] It is also noted that 'the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs'.[15]

The responsibility for emissions is common, as the greenhouse gases are completely mixed in the atmosphere within approximately two weeks, leaving it impossible to attribute emissions directly to individual countries from which they originated. The large variety of greenhouse gases and infinite sources also leaves a question mark as to where the gases originated. Most importantly, the adverse effects of climate change are a common concern to humankind, making it difficult for any one country to act by itself to mitigate climate change if the rest of the world is not concerned with the problem. Some countries would have to accept a greater responsibility for global warming than others.

13. Direitos Humanos e Cultura: a Contribuição da Unesco nos anos 90, Candeas, Alessandro W. and Candeas, Ana Paula L.S., in Boletim da Sociedade Brasileira de Direito Internacional, Ano LI no. 113/118.
14. Climate Change Convention, Preamble, first and sixth paragraphs.
15. Climate Change Convention, Preamble, third paragraph.

UNFCCC Annex I illustrates that developed countries have committed to take the lead in combating climate change: only developed countries have assumed the commitment in the Convention of limiting their anthropogenic emissions of greenhouse gases with the aim of returning individually or jointly to 1990 levels of such emissions. These countries recognized that, by returning to earlier levels by the end of the decade, they would have made a significant contribution to modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention.

But for Annex I Parties that are not economies in transition (non-EIT Parties), total aggregate emissions excluding LULUCF increased from 1990 to 2008 by 7.9% and emissions including LULUCF increased by 8.3%.[16]

The differentiation between developed and developing countries is not apparent, due to a vague definition and criteria for distinction. The Convention lists the developed countries in Annex I, comprising OECD and industrialized countries of Eastern Europe and the Former Soviet Union. This simple selection criterion led to uncertainties for countries such Turkey, which was an OECD member, although its development level was still lagging behind most OECD countries. Including new developing countries as OECD members, such as the Republic of Korea and Mexico, deepens the difficulties of establishing objective differentiation criteria. They are not listed in Annex I and are not willing to accept the burden of developed country commitments,

This policy framework generates a new North–South antagonism as developing countries argue that industrialized countries are responsible for causing the change in climate. This is recognized in the preamble of the Convention where it is noted that ‘the largest share of historical and current global emissions of greenhouse gases has originated in developed countries’. The industrialization process, commencing for some developed countries during the industrial revolution, resulted in a large amount of carbon emissions from fossil fuel combustion (mainly from coal) during the end of the eighteenth century and the beginning of the nineteenth.

There is an understanding that historic responsibilities has already been addressed by dividing Parties to the UNFCCC into Annex I and non-Annex I countries while ascribing the quantified emission reduction commitments to the former under the Kyoto Protocol. But Annex I countries have been avoiding their historic responsibility partly by difficulties in meeting their agreed commitments (as registered above) through domestic actions combined with the use of Kyoto Protocol mechanisms in order to meet their commitments. In addition, recently new attempts have been made by developed countries to considered ‘emergent’ developing countries as developed countries, despite substantial social and economic indicators of differences among these developing countries and the developed countries.

The main focus of the discussion was increasingly an attempt to involve developing countries in sharing the burden of mitigating climate change. This is related to competitive problems in the economies of developed countries and the perception that

---

16. FCCC/SBI/2010/18.

the principle of common but differentiated responsibilities will further give advantage to the most advanced developing countries.

Discussions so far have been based on misleading assumptions, as it has been repeatedly reaffirmed that developing countries would account for the same amount of greenhouse gas emissions as developed countries between 2020 and 2030, based on IPCC scenario IS92a. The US Senate Resolution states that: 'greenhouse gas emissions of Developing Country Parties are rapidly increasing and are expected to surpass emissions of the United States and other OECD countries as early as 2015'. A USAID document on Climate Change[17] also states that 'Developed nations currently contribute approximately 73 per cent of anthropogenic emissions of carbon dioxide ... Despite the current disparity, the growth in emissions from developing nations is accelerating. The current rate of increase in carbon dioxide emissions from developing nations is approximately 6 per cent per year. If current growth trends continue, developing nations will account for half of annual greenhouse gas emissions by 2035.'

The future greenhouse gas emissions are only an estimate, therefore embodying all the uncertainties related to forecasting. A problem with this kind of emission forecasting is that it is based upon annual emissions, for which results do not correspond directly to responsibility for causing climate change. Responsibility has to be associated with the effect of emissions in terms of global warming.

The responsibility of both groups of countries (Annex I/non-Annex I) in terms of temperature increase, under the Convention, has never been estimated up to 1997. This is a natural consequence of the focus on annual emissions in the negotiations. Having neglected this issue in the IPCC assessments of climate change literature, the differentiated responsibility has been overlooked in IPCC documents so far. Moreover, because of the long-time residence of greenhouse gas in the atmosphere, the emissions of developed countries since the Industrial Revolution caused the vast majority of the problem: according to the Bern Model, around 20% of CO_2 emissions stays in the atmosphere for more than 800 years and about 10% stays for a very long timespan (for practical purposes considered to be 200,000 years due to the impossibility to estimate this lifetime).

The base year was established at 1990 for all Annex I countries under the Convention as a way to establish a baseline for a country's responsibility. Prior to 1990, nations were not aware of the existing problem and could not be blamed for their lack of knowledge. Under this rationale, countries are responsible for their role in greenhouse gas emissions only after 1990. This argument was aligned with the political interests of developed countries, which involved forgetting historical emissions and leveling the playing field ('grandfathering') in relation to newly industrializing countries (with high emissions in 1990) to maintain commercial competitiveness. Grandfathering implies that future generations will have to pay to enjoy a clean environment.[18] It is often ignored that new industrialized countries only started their industrialization processes in a robust pathway 40 or 50 years ago, that the increase in temperature is a

17. Climate Change Initiative 1998–2002, USAID, page 12.
18. Discounting and sustainability in applied IAMs, Gerlagh, R. IVM, The Netherlands.

double accumulation process, and that they have not contributed to current global warming. However, the Convention has provisions that can ensure that these arguments are flawed, especially in Article 4.2 (a) and preambular paragraph (18th paragraph) 'recognizing also the need for developed countries to take immediate action in a flexible manner … that take into account all greenhouse gases, with due consideration of their relative contributions to the enhancement of the greenhouse effect'.

The first problem faced in linking the causes (emissions) and effects (global warming) was the establishment of an objective criterion to measure climate change. It is therefore of central importance to establish a relationship between the net anthropogenic emissions and the resulting change of climate. Although it is anticipated that the change of climate would have a complex geographical distribution, it is important to have one unique measurement of global climate change.[19] The evident variable to measure climate change is the change in global mean surface temperature.

This criterion is closely connected to the physical reality of global warming, a property not applicable to absolute emissions, which are an instantaneous 'snapshot' of a situation in an arbitrary calendar year. Global mean surface temperature can be used as an indicator of global warming, and the designation of specific country responsibilities can be stated in terms of its individual contribution relative to total global mean surface temperature increase. This individual contribution temperature increase will take into consideration differences among countries in terms of starting points, approaches, economic structures, resource bases, the need to maintain sustainable economic growth, available technologies and other individual circumstances, as stated in Article 4.2(a) of the Climate Change Convention. The change in temperature is an objective measure of climate change, for it can be argued that the detrimental effects of climate change are somewhat proportional to it.

For example, there is a margin of uncertainty in climate sensitivity (the change of temperature resulting from a doubling of the carbon dioxide concentration is known to be likely within the range of 1.5 to 4.5°C). As these uncertainties are progressively reduced, improvements in the models can be achieved by updating the calibration constants of proportionality. This in turn will improve the accuracy of the absolute results resulting from the incorporation of available scientific knowledge without prejudice to relative contribution adjustment.[20]

Consistent with the position it has presented over the years, the Brazilian Government recently submitted its views to the UNFCCC on Shared vision for Long-Term Cooperative Action: the long-term global goal should be ambitious, based on the best science and updated accordingly. This updating should reflect progress in our knowledge of the potential effects generated by different levels of global temperature increase. The long-term global goal should be defined in terms of global temperature increase. Initially, this goal could be set at 2°C and updated according to progress in

19. Proposed Elements of a Protocol to the UNFCCC, presented by Brazil in response to the Berlin Mandate, submission dated 28 May 1997, FCCC/AGBM/1997/Misc.1/Add.3.
20. Brazilian Proposal, reference xvi.

scientific knowledge. To allow for this updating, the 2°C goal would be broken down into partial targets: initially, 0.2°C temperature increase per decade over ten decades. Every ten years, the partial target would be evaluated, with a view to possible redefinition, taking into account advances in scientific knowledge and the reduction of uncertainties. It is important not to attribute to science definitions which are not scientific, such as the identification of a specific global emission pathway as the sole pathway that can maintain global temperature increase below a certain level. Avoiding misleading definitions will be important to ensure that we advance towards what is needed: an ambitious long-term goal to control global warming.[21]

The Conference of the Parties, during its 16th Session convened in Cancun in the end of 2010, through Decision1/CP.16, recognized that deep cuts in global greenhouse gas emissions are required according to science, and as documented in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, with a view to reducing global greenhouse gas emissions so as to hold the increase in global average temperature below 2°C above preindustrial levels, and that Parties should take urgent action to meet this long-term goal, consistent with science and on the basis of equity. It also recognized the need to consider, in the context of the first review, strengthening the long-term global goal on the basis of the best available scientific knowledge, including in relation to a global average temperature rise of 1.5°C.

The use of global mean surface temperature as a proxy for global warming permits the formulation of a model to analyze the responsibility of individual countries. The Cancun Agreements give the opportunity to restart the consideration of global mean surface temperature as a proxy for global warming as Parties decided to hold the increase in global average temperature below 2°C above preindustrial levels as the long-term goal, consistent with science and on the basis of equity. The core of the model relates to a double accumulation process representing the essence of global warming. Accumulated emission increases concentrations and, for each annual level of greenhouse gas, the accumulation of radiative forcing increases (global mean surface) temperature.[22]

The current concentration of greenhouse gases in the atmosphere is a result of past emissions, since the industrial revolution (post-1750 period). Current generations are bearing the burden of past interference with the climate system, resulting from irresponsible human activities during the last two centuries, primarily in developed countries. In a similar manner, current human activities around the world will impact the future climate during the next two centuries. Any attempt to limit the global concentration level of greenhouse gases in the atmosphere will create concrete obstacles to the development of developing countries and are therefore completely unacceptable. This would increase the cost for economic growth, which would be unfair, taking into account that the current developed countries had no limitation during their

21. FCCC/AWGLCA/2009/MISC.4 (Part I).
22. Notes on the time-dependent relationship between emissions of greenhouse gases and climate change, Meira Filho, L.G. and Miguez, J.D.G., in press.

growth path in the past and now try to create a upper bound for the emissions of developing countries in the next few years.

Reconstructing the series of anthropogenic greenhouse gas emissions by sources and removals by sinks in all sectors allows the estimation of the relative share of total temperature increase attributable to an individual country. Hence, the estimation of the relative responsibility of a given country for causing global warming can be made regardless of the current uncertainty over the absolute temperature increase attributable to the greenhouse effect alone.

An example of this method was used in the Brazilian Proposal in 1997 and reproduced by WRI/CAIT (probably using a different methodology from the Brazilian Proposal) using updated information covering the period 1850 to 2005.

Table 1

Contributions to temperature Increase		
	1850/2005	*1850/1990*
	CO_2 (energy)	*CO_2 (energy+cement)*
Country	*WRI/CAIT %*	*Brazilian proposal %*
China	8.39	3.05
India	2.22	0.90
South Africa	1.10	0.21
Brazil	0.80	0.32
BASIC	12.51	4.48
Non Annex I	26.48	10.35
Annex I	73.52	89.65

This proposal provides a means to measure objectively the relative responsibility of each Party or each group of Parties in bringing about climate change. The Convention encompasses the all-important principle of a common but differentiated responsibility, and provides an objective criterion for the differentiation of responsibilities. Furthermore, it provides a means of quantifying the relative responsibility of developed countries in relation to developing countries based on their contribution to the atmospheric concentrations of greenhouse gases at the time of negotiation.[23]

Another important conclusion drawn from the Brazilian Proposal was that in 1990 emissions from developing countries (non-Annex I) correspond to 25% of global anthropogenic greenhouse gas emissions, whereas the non-Annex I relative share of the temperature increase in the same year corresponds to only 12% of global (mean

23. The estimation of initial concentrations for each individual country in 1990 can take into account the differences in starting points of each individual Party as stated in Article 4.2(a) of the Climate Convention.

surface) temperature increase. Both conclusions demystify the debate about the year in which Annex I and non-Annex I emissions will be equal. However, in this hypothetical year a large share of responsibility for causing global warming will still be attributable to Annex I countries.

This context requires building an effective international climate change regime with a strong Kyoto Protocol, with ambitious targets for Annex I countries as the pillar for this effort, as well as a strong outcome of the international negotiation to enhance the full, effective and sustained implementation of the Convention. In order to achieve this aim, quantifying the relative responsibility of developed countries in relation to developing countries based on their contribution to the increase in global mean surface temperature must be part of the equation.

Equitable access to sustainable development: Carbon budget account proposal

CASS/DRC JOINT PROJECT TEAM[1]

1. Introduction

Carbon equity has been the key to addressing global climate change issues with respect to climate protection and sustainable development for the world as a whole. Without carbon equity, the comprehensive international climate change agreement cannot be reached. According to the United Nations Framework Convention on Climate Change (UNFCCC), 'Parties should act to protect the climate system "on the basis of equality and in accordance with their common but differentiated responsibilities and respective capabilities"'. Nonetheless, the developed countries call for 'common responsibility' on global emissions reduction, while the developing countries ask for 'differentiated responsibilities' and equitable access to global emission space to ensure sustainable development, since emission mitigation would be likely to affect their development. According to Garnaut (2008), global climate negotiation based on the arm-twisting of various countries, rather than on the principle of equity, may give rise to unfair results. However, the interpretations of carbon equity may vary according to different

1 The conceptual and methodological bases of this chapter draw heavily from Pan and Chen (2009) and DRC (2009). Additional work and updating are undertaken by PAN Jiahua, ZHANG Yongsheng, CHEN Ying and LIU Changyi. Communications can be sent to Pan Jiahua (jiahuapan@163.com) and ZHANG Yongsheng (zys@drc.gov.cn). Acknowledgements with thanks are due to DRC research team led by LIU Shijin who has been instrumental in the process of the work, to contributors in the CASS Team, and to participants at various workshops in China in the past two years. However, the views and errors are the responsibility of the authors. CASS is the abbreviation of Chinese Academy of Social Science. DRC is the abbreviation of Development Research Center of the State Council, P.R. China. This part is based on research work with support from Key National Basic Research Programme (973 Programme No. 2010CB955203 and No. 2010CB955700), and support under the 973 project, project number 2010CB955203.

perspectives, notably those of the developed and developing countries. Therefore, an objective principle of equity is needed.

In China, per capita accumulative emissions are used as a basis with respect to the principle of carbon equity in allocating a global carbon budget. Pan and Chen (2009), based on human development theory (Sen, 1997), and starting from the axiomatic truths of the limited nature of basic human needs and the carrying capacity of the global system, stress that an international climate regime should meet basic human needs, promote low-carbon development, curb extravagance and waste and at the same time fulfil the dual task of sharing emission reduction in an equitable way and safeguarding the world climate. The Development Research Centre (DRC, 2009) justifies the per capita accumulative approach as a means of preventing negative externalities of emissions, and proposes a global solution based on clearly-defined emissions entitlements for each country, similar to the framework conceputalized in Pan (2008a). The two studies are from different theoretical perspectives, but move towards the same conclusions.

A similar line of thinking in China is also found in Ding et al. (2009a; 2009b), Chen and He (2009),and Luo (2009), though their studies do not establish a systematic budget approach. Outside China, research and proposals following the budget approach are documented in the literature, for instance, WBGU (2009) and Kanitkar et al. (2010). At the first BASIC expert forum[2] in Rio de Janeiro in July 2010, the carbon budget approach was reviewed and agreed on as a framework for carbon equity, though agreement is yet to be reached on how to allocate the global budget.

The objective of this chapter is to synthesize the existing Chinese studies taking a carbon budget approach, as represented by CASS (Pan and Chen 2009) and DRC (2009). The rest of the chapter is arranged as follows. Section 2 introduces the principles and approach. In section 3, the methodology employed is presented. Section 4 reports the results with standardized parameters agreed upon among BASIC experts. Section 5 explores the implications for cooperation between developed and developing countries. Further discussions are made in Section 6 on some fundamental issues. Section 7 draws conclusions for the chapter. In addition, two appendices are attached, exploring alternative methods in measuring different countries' budget accounts. One is to use the current per capita GDP of each country as a substitutive proxy of real historic emissions, and the other is to depreciate the financial burden of Annex I by taking into account the emissions effects of technological progress.

2 The BASIC Ministerial Meeting in May 2010 mandated an expert forum on carbon equity in Rio, 25-26 July 2010.

2. Principles and approach

2.1 Principles

Both the proposals of CASS (Pan and Chen 2009) and DRC (2009) share the same per capita accumulative principle in allocating global budget, though based on different but complementary theoretical foundations.

Pan and Chen(2009) establish the theoretical foundations that support the equal per capita accumulative emissions principle, with three essential arguments:

- Equity is discussed in the context of resource allocation among individuals, instead of among nations. Therefore, the essence of equity must be interpersonal rather than international. In this regard, equal per capita is the right measurement.
- The key point in the promotion of interpersonal equity is to protect the rights of everyone on the planet and to ensure that *everyone has equal access to GHG (greenhouse gases) emission space, which is the accumulated amount of emissions during a specific period of time compatible with aclimate protection target.*
- As emissions can fluctuate over time resulting from natural and socio-economic changes, interpersonal equity is not an equal share of the flow of emissions (annual emissions) at a certain time now or in the future, but an *equal share in terms of the emission stock emitted in the past, at present and in the future at a given period of time*. Interpersonal equity is then measured as per capita equal cumulative emissions over a given period of time.

DRC (2009) justifies the per capita accumulative principle in an alternative way. It is argued that the problem of how to define (or allocate) each country's emissions entitlements can be treated as a problem of preventing a country from imposing extra external harm on others. If per capita emissions in country A exceed the world average, country A not only imposes a net negative externality on country B in which per capita emission is below world average, but also squeezes the emission or development space for country B, which should therefore be compensated. Since greenhouse gases emitted in the atmosphere are without boundaries and do not disappear in a short period of time, the per capita principle should be applied to emissions in both the past and future. Therefore, initial emissions entitlements of each country should be allocated based on per capita equal accumulative emissions. Once a global initial emissions entitlementis allocated, an efficient *ex post* global *real* emissions allocation will be achieved through the market or various international collaborative mechanisms. The emissions reduction will occur in the countries with the lowest opportunity costs.

2.2 Approach

The two independently-developed proposals move in the same direction and can be combined as one complete approach. The methodologies employed in this combined carbon budget account proposal are: (1) setting the global carbon budget that includes historic and future budget compatible with the temperature control target; (2) allocating the global budget among all countries according to per capita equal accumulative emissions; and (3) establishing an effective international collaborative mechanism based on the initial allocation. Specifically, the proposal consists of three steps.

The first step is to set the global carbon budget according to the long-term global temperature control goal. This global budget includes historical and future emissions. According to the Copenhagen Accord, the temperature increase should be kept below 2°C as compared to the level prior to the Industrial Revolution. This goal implies a carbon budget, a physical constraint. This means that there is a finite budget between now and a set future date, taking into account historical emissions.

The second step allocates emissions among countries.The basis for allocating the finite budget is per capita equal accumulative emissions. The size of population for such allocation uses the number of an agreed particular year, instead of dynamic numbers. Countries then have their respective initial national accounts corresponding to population sizes. Two or more countries can create budget bubbles as a joint account.

Step number 3 is to design and establish cooperation mechanisms among countries, in particular between countries with surpluses and those with deficits in their respective national accounts. All countries need to clear their accounts at the targeted time. The cooperation mechanism will be so designed as to allow transfers of budget among countries while keeping the global budget in balance. Budget transfers can be made through international emissions trading scheme (IETS), joint implementation (JI), the clean development mechanism (CDM), international climate change funds, etc. The change of national accounts should be reported, registered, and verified. Institutions must be set up for agreement compliance. Individual countries have the freedom to choose their own domestic mitigation approach, but need to make a credible mitigation roadmap subject to their budget. Countries with surplus in their budgets can sell their emissions entitlements to those with deficits, for financial and technological resources for their development.

2.3 Features

Three unique features in the budget account approach should be highlighted.

First, three distinct concepts are key elements in a budget account approach. A clear understanding of their definitions is essential to avoid confusions in applying such an approach.

1. *Emissions entitlements.* The global budget includes historic emissions and future emissions, and should be allocated according to a per capita principle. Each country's emissions entitlement is its allocated share in the global budget. If a country buys emission entitlements from another country, its entitlements will increase accordingly, while those of the selling country decrease.
2. *Real emissions.* Each country's real emission is the amount of greenhouse gases emitted within its boundary.
3. *Balance of budget account.* Each country's balance of budget account is the result of its emissions entitlement with deduction to its real emissions, taking into account budget transfers.

Secondly, each country needs to clear its balance of budget account by the target year (e.g. 2050). Countries with emission deficits can purchase entitlements from the countries with emission surpluses. The transaction should be reflected in changes to their respective account balances.

Thirdly, there is no need for the per capita cumulative real emissions to converge among countries at the target year. A country can choose its optimal real emissions as long as it can afford to buy emission entitlements from the countries with surpluses. In this case, there is no need to worry about above-budget emissions by some countries since the total real emissions by all countries is subject to the global budget set according to global temperature control target. This does not only provide emission space for the developed countries with emission deficits, but also provides sustainable development space and funding sources for the developing countries with emission surpluses.

2.4 Advantages

The carbon budget account approach has a number of advantages.

Firstly, it can guarantee the achievement of the global emission reduction goal as the goal is built into the proposal, since the global budget is scientifically determined and then allocated among all countries.

Secondly, it offers full coverage: all countries can be covered. To classify the countries into industrialised and developing countries is then no longer necessary in the proposal. The problem of carbon leakage does not exist once all countries are covered by the new protocol. In practice, it can cover the major emitters first, and then extend further to cover the minor emitters later.

Thirdly, the additionality problem of the CDM is effectively removed. A CDM project will increase the balance of the investing country and accordingly reduce the balance of the host country side-by-side. The budget account approach can therefore not only overcome the additionality problem, it can further extend the CDM to a two-way mechanism – that is, the firms in developing countries can also invest in emissions-reduction projects in industrialised countries.

Fourthly, the principle of ‘common but differentiated responsibilities’ is well reflected and greatly simplified in the proposal. The budget account is an effective tool by which to measure and manage global emissions reductions. Each country’s emissions balance exactly represents its current responsibility for emissions reduction.

Fifthly, once the budget account is established for individual countries, emissions reduction becomes a self-interest behaviour: the more a country reduces, the more quotas it can sell or the fewer quotas it needs to buy. A strong incentive mechanism for global emissions reduction is therefore established.

Sixthly, the budget account approach is compatible with various existing international collaborative mechanisms and domestic reduction approaches. For instance, all the Kyoto mechanisms can work under the budget account framework.

3. Methodology

3.1 The budget account for an individual country

Acountry's budget account can be established according to its (1) initial emissions entitlements e_i^r ; (2) real emissions e_i ; and (3) transfer of emissions through trading, e^t . The account balance for an individual country then exactly represents its 'differentiated responsibilities' in global emissions reduction(or their entitlements to emit). If a country's real emissions e_i is greater than its initial emissions entitlements e_i^r , then its account balance is in deficit, unless it purchases emissions entitlements from other countries with surplus budget.

For simplicity, we use Figure 1 to illustrate time horizon for the budget period. T_0 is the starting year for the accounting period; T_1 is the current year; and T_2 is the end year for the budget.

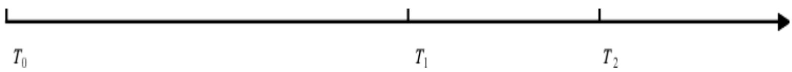

Figure 1: The timeline of the carbon budget

A country's emissions entitlements e_i^r during T_0-T_2 is:

$$e_i^r = E^r \cdot N_i \tag{1}$$

where E^r is global budget, including historic emissions and future emission space, N_i represents the share of a country's current population in the world population, in which $i = 1, 2...n$ stands for different countries.

Using e_i to represent a country's real emissions during T_0-T_1, its balance of budget account is

$$b_i = e_i^r - e_i \tag{2}$$

If international collaborations are introduced, say the IETS, then the cross-border emissions entitlements flow, represented by e_i^t , should be reflected in the budget account. A country's current budget balance then becomes

$$b_i = e_i^r - e_i + e_i^t \tag{3}$$

3.2 Parameters and data

Meinshausen et al. (2009) estimate that cumulative CO_2 emission over 2000–2050 reaching 1,000 $GtCO_2$ would yield a 25% probability of warming exceeding 2°C;[3] while

---

[3] In designing the future globalemission scenario, the long-term global objective may be expressed in different ways. For example, the emission objective in some analyses requires stabilization of greenhouse gas concentration in the atmosphere at the level of 450ppm, while the EU has proposed keeping the rise in global temperature within two degrees

a number at 1,440 $GtCO_2$ would give a 50% probability of warming exceeding 2°C. Evidently, there will be a very limited carbon emission space left for the next half 50 years. Based on the agreement reached at the BASIC expert forum in February 2011, key parameters used for analysis are given as follows:

1. **Starting and ending year**. Three starting years (T_0) are chosen for analysis, including 1850, 1900 and 1970. The ending year T_2 will be 2050 only. The results indicate that the difference between 1850 and 1900 as the starting year is rather small, while the gap between 1900 and 1970 is substantial. Therefore, the year 1900 is chosen as the starting point of time for accumulation.
2. **Reference year**. The choice of reference year is highly sensitive, as the size of population corresponding to the year determines the amount of carbon emission budget for a country. Year 2000 is chosen as the reference year T_1 in this paper. The UN population database is the basis of population for individual countries.[4] The world total population was recorded at 6.06 billion in 2000.
3. **Probability of exceeding 2°C**. In this paper, the probability of exceeding 2°C will be chosen between 37%–74% (with the medium as 50%). Following the analysis from Meinshausen et al. (2009), the total emission budget over 2000–2050 is given at 1,440 $GtCO_2$. If the target is to limit temperature rise below 2°C at a higher probability (e.g. from 50% to 75%) at 2050, the total global emission over the budget period would be much tighter.
4. **The scope and source of GHGs**. This paper only deals with carbon dioxide. CO_2 emission data are retrieved from the World Resource Institute CAIT database.[5] We choose 'national total' in the database as the source of CO_2 emission, coming from fossil fuel combustion associated with energy consumption, industrial processes, agriculture and waste emissions, but excluding sectors such as Land use, land use change and forestry (LULUCF) and international bunkers.

---

centigrade. There is a certain functional relationship between emissions, concentration, and temperature increase, but they do not correspond exactly and some uncertainties exist.

4 Retrieved from http://esa.un.org/unpp/index.asp. Accessed on April 20, 2011. Some countries' population data is missing, such as the South Korea, North Korea, Tanzania, Taiwan, Moldova, Congo and Macedonia. These countries' population data in 2000 are retrieved http://www.nationsencyclopedia.com.

5 Climate Analysis Indicators Tool (CAIT) Version 8.0. (Washington, DC: World Resources Institute, 2011). Retrieved from http://cait.wri.org. Accessed on April 20, 2011. Japan's emission data over 1850~1949 is missing, so these missing data are retrieved from ORNL CDIAC database from http://cdiac.ornl.gov/. According to the estimation of our work and DRC (2010. p.144), Japan's carbon dioxide emission is 3940 Mt over 1900~1949 and 4100 Mt over 1[8]68~1949.

Table 1: Key parameters for analysis

Global budget	Historical 1850–1999 1970–1999	 965.26 Gt CO_2-eq 574.04 Gt CO_2-eq
	Future (2000-2049)	1440 Gt $CO_{2\text{-eq}}$ (29% to 70% probability of exceeding 2 ºC)
Historical starting point		1850, 1970, *1900*
Population		Static – population for 2000
LULUCF		not included[6]
Financial transfer		estimates made, assuming carbon price of $20/t $CO_{2\text{-eq}}$ and $50 (both reported)

4. Results

Different probabilities imply different future global budgets. The total global budget includes a historic budget and a future budget. Global historic budgets differ with different starting years, while global future budgets differ with different probabilities of temperatures exceeding 2°C. This global carbon budget is then divided on an equal per capita basis based on the global population in a given base year. Every nation's total entitlement for cumulative emissions is then determined by the relative share of the country's population in the global population in the given base year. Its balance of budget is then determined by subtracting its actual historical emissions from its total entitlements. The results, calculated according to Table 1, are given in Tables 2 and 3.

Table 2: Global carbon budgets with different starting years

	*Starting Year**	*Historical budget (*~1999, $GtCO_2$)*	*Future budget (2000~2049, $GtCO_2$)*	*Total carbon budget (*~2049, $GtCO_2$)*
1	1850	965.26	1440	2,405.26
2	1900	927.10	1440	2,367.10
3	1970	574.04	1440	2,014.15
*Note: * means different starting years.*				

6 In the WRI-CAIT database, the data for Land Use Change and Forest (LUCF) is only from 1990~2005. Houghton (2008) estimated LUCF emissions from 1850 to 2005, but did not give specific emissions for each country. Therefore, his numbers cannot be used for analysis here.

Table 3: Balances of carbon budgets accounts in 2000 with different starting years
Data source: WRI CAIT 8.0

	Starting years*	(1) Emissions entitlements (*-2049, $GtCO_2$)	(2) Actual emissions (*-1999, $GtCO_2$)	(3)=(1)-(2) Balance $GtCO_2$)
	1850	2405.26	970.07	1435.19^
World	1900	2367.10	930.91	1,436.19^
	1970	2014.15	574.04	1,440.11
	1850	490.73	755.64	-269.01
Annex 1	1900	483.25	721.91	-238.66
	1970	410.93	402.35	8.58
Non-Annex 1	1850	1,910.43	204.24	1,706.20
	1900	1,883.85	209.00	1,674.85
	1970	1,603.22	171.69	1,431.53
	1850	69.09	7.10	61.99
Brazil	1900	67.99	7.10	60.89
	1970	57.85	5.85	52.00
	1850	502.54	67.69	434.84
China	1900	494.56	67.69	426.87
	1970	420.82	58.27	362.55
	1850	413.54	19.44	394.11
India	1900	406.98	19.32	387.66
	1970	346.30	14.77	331.53
South Africa	1850	17.80	10.55	7.25
	1900	17.52	10.52	7.00
	1970	14.90	7.06	7.85
	1850	1,002.97	104.78	898.19
BASIC	1900	987.05	104.63	882.42
	1970	839.88	85.95	753.93

*Note: (1) * denotes different starting year; (2) Total surplus/deficit=Total budget-Historical emission; (3) Negative figures denote carbon budget deficit, while positive figures mean carbon budget surplus; (4) ^ are different from the original 1,440 GtCO2 is due to differences in data for some smaller countries and/or rounding errors.*

Using 1900 as the starting year, the total global carbon budget is calculated at 2,367.1 $GtCO_2$ over 1900–2049. Since the world had emitted 927.1 $GtCO_2$ over 1900–1999, the balance of budget for 2000–2049 amounts to 1440 $GtCO_2$. However, this number may not be ideal for use as the budget for the future. For example, the world emitted 29.53 $GtCO_2$ in 2007; assuming that the world emits CO_2 at this constant rate, the amount of carbon budget left for the future would be exhausted before the year of 2049. This means that business as usual way of emissions is unlikely to keep our carbon budget in balance.

From Table 3 and Figure 2, we can see that Annex I countries as a whole have a deficit at 238.66 $GtCO_2$ over 1900–1999, with the US and EU as the two biggest deficit countries. By contrast, non-Annex I countries as a whole have a surplus at 1,674.85 $GtCO_2$ over 1900–1999, with China and India as the biggest surplus countries. The BASIC countries together account for more than half of the surpluses, amounting to 882.42 $GtCO_2$. It is worth noting that South Africa turns out to be a surplus country over 1900–1999, but with only 7 $GtCO_2$ in total left for 2000–2050.

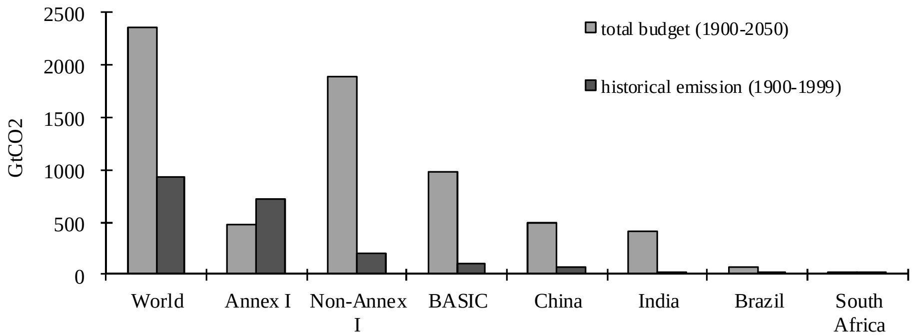

Figure 2: Carbon budgets for BASIC countries (starting year 1900, $GtCO_2$)

5. Implications for support by developed countries for their developing counterparts

At step three in this proposal, once each country's budget account is established, an open and compatible mechanism for international cooperation can be arranged using these accounts. The flows of carbon budgets between countries mean transfer of funds and technologies at any given price for carbon. Countries with emission surpluses can sell their unused emission entitlements to countries with an emission deficit in exchange for funds and technologies for their development.

5.1 Transfers and balance of carbon budget for Annex I

As shown above, budget transfers between countries are not only necessary but also feasible. Taking into account the fact that the negotiations on climate change and the sharing of international obligations are carried out through national political entities, this analysis does not look at internal budget transfers temporally. The focus here is on international transfer payments between countries or groups of countries, including two essential budget transfers: (1) for balance of historical budget deficit of Annex I over the period 1900–1999;[7] and (2) for meeting the extra emission needs beyond the allowable future carbon budget of Annex I countries over 2000–2050, where zero budget is left over.

As current per capita emissions in developed countries remain at a high level, the allocated per annum per capita emission rate is calculated at 2.59 tons of CO_2 using starting year 1900. Such a rate is not sufficient to maintain their present standard of living.[8] As some of the developed countries have used up all the emission budgets and nothing is left for the future, considerations will have to be made to ensure that basic necessity emissions for people in the rich countries should be guaranteed as well. These would mean that there is a need for a second transfer of carbon budgetfor meeting the basic needs of those who have no budget available for their future. Furthermore, if any country's emission exceeds their allocated budget after two transfers of carbon budget between countries or groups of countries (which probably will happen for the US, Canada, Australia, etc), there will be a third transfer of carbon budget to cover that extra part. Meanwhile, a punitive financial mechanism, such as the progressive levy can be adopted (Pan and Chen, 2009).

Under the national account of carbon budget, these transfers can be achieved in various ways, in return for financial transfers at either a negotiated or market price for carbon; for example, through transaction in the IETS, or by JI, and theCDM (DRC, 2010, p.135).

5.2 Financial transfers

In coping with the problem of global climate change, actions have to be taken for mitigation and adaptation. Mitigation of GHG emissions requires capital and technology, so does adaptation to climate change. The developing countries, in particular, are hugely short of capital and advanced technologies for climate change adaptation and low-carbon development. However, lack of funds has long been a big problem.

Where do the funds come from? The carbon budget proposal provides a fair and effective financial mechanism. First, there are transfers of carbon budget between countries or groups of countries. In a world where there is a shortage of carbon budget, competition for carbon assets would mean that the price of carbon must be larger than zero. Thus the flow of capital is indicated along with the transfer of carbon budgets.

Following the above analysis, the amount of financial flows can be roughly estimated from Annex I to non-Annex I. The numbers in Table 4 are derived using

---

7 Here we can reasonably assume that there is no internal cross-time transfer in the deficit countries. However, in the national account of each country, these operations will be common and practical.

8 The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) released in2007 clearly set out the target of cutting global greenhouse gas emissions by at least half by2050. The global emissions reduction target specified in the report of the G8 summit in July 2008 confirmed in clear terms the long-term target of emission reductions of 50% by 2050 and the converging target of average emissions of two metric tons per capita put forward in the Stern Review.

different rates of carbon prices and different starting years. The results using starting year 1850 and starting year 1900 are rather close. If year 1900 is used as the starting point, the financial flow from Annex I to Non-Annex I would reach 8.04 trillion dollars at a price level of 20\$/tCO_2 and 20.1 trillion dollars at a price level 50\$/tCO_2 respectively. However, if year 1970 is used at the starting point, the historical deficit of Annex I over 1970–1999 will be substantial reduced as compared to the numbers under the starting years 1850 and 1900. Consequently, the amount of financial flows would be much less as well.

Table 4: Financial flows from Annex I to non-Annex I (billion \$) against transfer of carbon budgets

Assumed carbon price	*Starting year*	*Historical emission deficit (–1999, GtCO_2)*	*Payment for deficits of carbon budget (total, bl \$)*	*Payment for deficits of carbon budget (Per year, 2011–2050, bl \$)*
20\$/ton CO_2	1850	384.52	7,690	192.26
	1900	401.88	8,039	200.94
	1970	250.15	5,003	125.08
50\$/ton CO_2	1850	384.52	19,226	480.65
	1900	401.88	20,098	502.35
	1970	250.15	12,508	312.69

*Note: * denotes the different starting years.*

6. Discussions

6.1 Mechanism design for international cooperation

The carbon budget proposal involves initial allocation, transfer of carbon budgets, market and financial mechanisms in addition to reporting, verification and compliance mechanisms. An overall international framework is required so as to encourage all countries to limit their emissions within their respective carbon budgets and contribute to the fulfilment of the long-term target for global climate protection. The scientific basis and methodologies provide a solid foundation for operational design of such a proposal, but many aspects of the carbon budget proposal as a master plan for global greenhouse gas emission reduction will be agreed upon through international political and diplomatic negotiations.

It is important to have an open and compatible international cooperation mechanism and a domestic mitigation mechanism established against individual national account of carbon budget. Each country balances its accounts of carbon budget through such mechanisms. These important international mechanisms include the account balance of carbon budget, financial flows, operational arrangements for measurement, reporting and verification (MRV)[9] and compliance (Pan and Chen, 2009). Flexible mechanisms can be made compatible under the overall framework, such as IETS, JI and CDM (DRC, 2009).

Under carbon budget constraint, once a country establishes its own national account of carbon budget, it can draw up its own mitigation roadmap, formulate its policies to meet the basic needs of its people and at the same time cut its emissions, and assess whether it will be able to keep its own carbon budget in balance. If not, it will either have to adjust its emissions reduction policy (Pan, 2008a), or acquire carbon emission quotas from developing countries through various ways, for example through international transfer of carbon budget, through bilateral or multilateral negotiations, or through various flexible international cooperation mechanisms (e.g. IETS, JI, CDM), in order to coverits deficits and future needs. Meanwhile, those countries with surplus carbon budget can trade their emission entitlements in exchange for capital and technologies to develop their economies and for their mitigation and adaptation activities. If one country can balance its own national account at the ending year of the budget period, it can choose its own mitigation pathways and policies.

6.2 The starting point of historical responsibilities

On this issue, a popular argument holds that the year of 1990 should be the starting point for measuring the historical responsibilities of all countries as the IPCC's assessment report was first published in 1990. However, such reasoning is insufficient for sound decision making. This is for two reasons.

First, the concept of 'common but differentiated responsibilities' was put forward as early as 1992, according to which 'differentiated responsibilities' reflect the historical responsibilities of each country based on the impact of accumulative emissions on the environment by countries from the Industrial Revolution through to 1992, not the carbon emissions of countries from 1990 to present. This point is reflected in the following two quotes:

> *Rio Declaration* (1992) (Principle 7): 'In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.'

> *UNFCCC:* 'Parties should act to protect the climate system "on the basis of equality and in accordance with their common but differentiated responsibilities and respective capabilities".'

Second, greenhouse gases discharged by developed countries since the Industrial Revolution still cause harm to developing countries today. Theoretically speaking, the historical responsibility of each country should therefore begin from the Industrial

---

[9] Another appropriate expression is International Consultation and Analysis (ICA).

Revolution. In practice, given the lack of available historical data, political negotiations between developed and developing countries might have to be resorted to agree the starting point that is acceptable to both parties.

6.3 Contraction and convergence

Since the concept of 'contraction and convergence' was first proposed by the Global Commons Institute in 2000, it has been widely embraced by some industrialised countries. Under contraction and convergence, each country will start out with emission entitlements equal to its current real emissions level, and then, over time, converge to equal its per capita entitlements, while the overall global budget contracts to accommodate the emissions reduction objective.

The problem of convergence is that per capita allocation as a fair principle should be applied from T_0, rather than as late as the 'converged point' in the future (T_2). 'Real emissions' is a different concept from 'emissions entitlement'. A country's high/low per capita real emissions cannot justify its high/low emission entitlements. In the process of convergence, the rights and interests of a country with low current real emissions are infringed by a country with high real emissions. In the budget account proposal, per capita emission entitlements of all countries are equal from the very start, and per capita real emissions of different countries do not have to converge in the future, as long as each country clears its budget accounts by the target year.

6.4 The issue of embedded emissions

The issue of embedded emissions has also been widely discussed. In the carbon budget account proposal, embedded emissions in different situations have different welfare effects. First, during the historical period of T_0–T_1, since emission entitlements were not clearly defined and emission costs were not reflected in the price of traded goods, the embedded emissions, in theory, should be treated as the real emissions of the importing country – though it is almost infeasible to be measured in practice. Second, since each country's emission entitlements during T_1–T_2 are clearly allocated and the emission costs will be reflected in the price of traded goods, it is not meaningful to take into account embedded emissions in the production-approach measurement. Third, if, however, some countries are not covered by the international emissions reduction protocol, countries not covered will impact on the export industries of the countries producing emissions-embedded goods. Carbon leakage to the countries not covered is inevitable. The solution to this problem is not to relax the emissions reduction targets of home countries, but to ensure all countries are covered by the international agreement.

6.5 What does the per capita principle mean to large developing countries?

Many people might think that the populous developing countries, such as China and India, will benefit greatly from the per capita principle. But this is not the case. The per capita principle merely allocates a low carbon growth model to China and India, since, according to the principle, their per capita accumulative emissions can reach only the world average level in the future – much lower than the current high level of real emissions in the industrialised countries. It is impossible for China and India to adopt a business-as-usual growth model in the future as the industrialised countries did in the past. They will be under huge pressure to lower their emissions in compatible with the per capita principle.

According to DRC (2010a), if China's GDP growth and emission intensity during 2008–2049 follow the same path as Japan's during 1967–2007, then China's GDP, emission intensity and real emissions in 2049 would be 467%, 58.23% and 272% of 2007, respectively. In this scenario, the real emissions during 2008–2049, if we take into account emissions from energy consumption only, emissions would amount to 489.9 Gt CO_2, a number obviously higher than the budget. This means that China has to go a low carbon road.

7. Conclusion

Based on the synthesis of the Chinese studies on carbon budget, this paper presents a comprehensive proposal on global GHG emissions reduction. The basic idea of the proposal is to first set the global carbon budget that includes a historic budget and a future budget according to the goal of long-term temperature control, and then equally allocates the global budget among all countries according to per capita accumulative emissions and establishes budget accounts for all countries. An open and compatible international collaborative mechanism can then be created against budget accounts so as to facilitate international collaborations on mitigation and adaptation.

International cooperation mechanisms include IETS, JI, CDM, international climate change funds, and the like. In addition, relevant mechanisms for reporting, registration, verification and agreement compliance should be established. All countries have the freedom to choose their own domestic mitigation approach, but they need to make a credible mitigation roadmap subject to their budget constraints. The results of the budget account show that Annex 1 countries have already come up budget deficits, while Non-Annex 1 countries have budget surpluses. The collaborations between Annex 1 and Non-Annex 1 are needed for a win-win solution under this proposal.

Appendix 1: Carbon budget account: An indirect measurement

Although the per capita accumulative principle is well established, there are still some practical difficulties in turning the principle into real measurement. First, all emission data available are estimated by academic institutions, not official, and cannot yet be directly used in negotiation. Secondly, although it can be theoretically justified that the starting year for measure historic responsibilities should from the Industrial Revolution, the arguments from the developed countries on starting year are not completely unconvincing. The debate on the starting year is a problem that needs attention. Thirdly, embedded emissions: the emission data we used are measured from a production approach, and cannot accurately reflect a country's real emissions. Nonetheless, to use a consumption approach would make things too complicated and difficult. Fourthly, the frequent changes of the borders of many countries in history make the emission data inaccurate. Fifthly, technological progress: it is a fact that the technologies the developed countries used were high-emission technologies, and the developing countries enjoyed the spill-over effect of technological progress.

Therefore, though it is the most feasible method to use the data of real historic emissions to directly measure a country's real emissions and accordingly establish budget account for it, it may also bring some equity problems. We need to continue the efforts to look for a method that is consistent with per capita accumulative principle and overcome the problems.

DRC (2010b) made efforts with this respect. In accordance with this approach, the DRC project team gauges out the 'differentiated responsibilities' of each country through both direct and indirect measurement. Direct measurement refers to the initial emission entitlements for each country based on a global carbon budget and per capita principle, while the real emissions be calculated directly in its historical accumulative real emissions. In light of the high lineal correlation between per capita GDP and per capita accumulative CO_2 emission (Figure AI-1), an 'indirect' measurement is also adopted to gauge the differentiated responsibilities using current per capita GDP (PPP) as a substitutive indicator of accumulative real emissions.

Both direct and indirect measurements have their own merits and demerits, but both show that developed countries register massive emission account deficits, while developing countries enjoy a great deal of account surplus. In this sense, the emission reduction commitment by developed countries lags far behind their responsibilities they should take. The key results of the above two measurements are presented as follows.

For the indirect measurement, we apply per capita GDP to the Annex 1 countries and Non-Annex 1 countries. In general, the balance of carbon budget accounts in most countries through indirect measurement is close to the results of direct measurement with discrepancies for just a few countries.

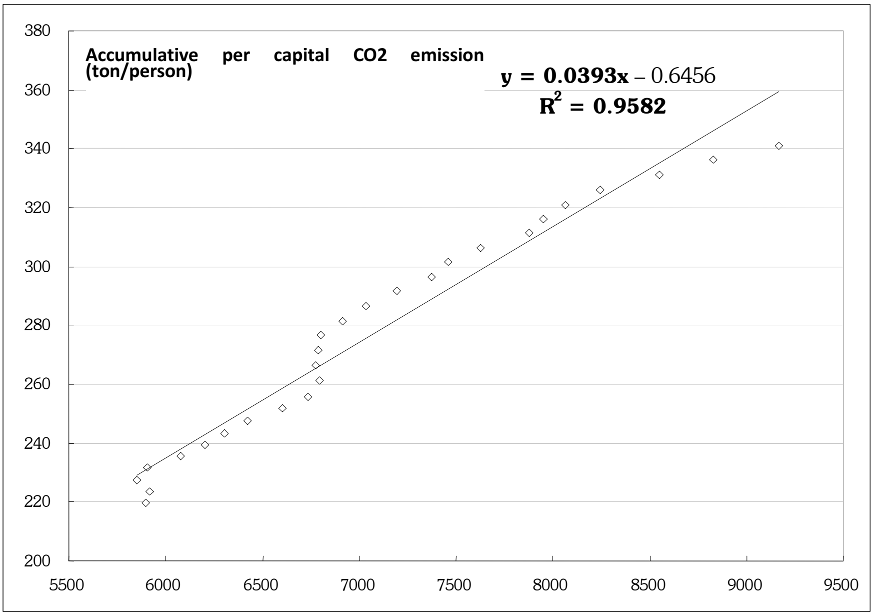

Figure A1-1: World average per capita GDP and per capita accumulative CO_2 emissions
Source: DRC (2010b)

Table A1-1: Balance of carbon budget account in 2006 with 50% probability exceeding 2°C ($MtCO_2$)

	Emission entitlements(1850-2050)	*Balance of carbon budget account (2006)*
World	2,477,032	1,218,420
Annex I	482,593	-314918
Non-Annex I	1,967,720	1,533,338
Note: The aggregate global carbon budget during 1850-2049 is calculated with 50% probability exceeding 2℃ with the figure standing at 2,477 $GtCO_2$. See Meinshausen et al (2009).		

Both the direct and indirect measurements indicate that developed countries experience large emission deficits while developing countries generally have large emission surpluses. Such results genuinely speak for the ‘differentiated responsibilities’ between developed and developing countries, which will not be changed by single-track or dual-track global climate change negotiations. With clearly defined ‘differentiated responsibilities’, developed countries should get emissions quotas from developing countries through various collaborations or international emission trading schemes to maintain their development, which will provide crucial financing for developing countries to gain access to new green technologies and to adapt to climate change.

Appendix 2: Carbon budget account with consideration of technological improvement and spill-over effects

There are some pros and cons with regard to the treatment of historical emissions. Legally, emissions before 1990 should not be liable as no official agreements were made. This is counter-argued by the fact that greenhouse gases emitted before 1990 are still around in the atmosphere and the current increase in temperature is attributable to emissions in the past. This counter-argument is supported from a social and economic perspective as well: physical carbon stock accumulated in the past is in existence and functioning and there is no need to re-accumulate such physical carbon stock in the developed countries. While in the developing world, the amount of physical carbon stock in terms of urban infrastructure, buildings and durables is limited or virtually not in existence. Therefore, historical emissions should be kept liable from an environmental and socio-economic perspective even if not from a legal perspective.

There is another counter-argument to diminish historical emissions from a technological point of view. For the same level of physical carbon stock such as steel and cement, per unit carbon in the past could produce much less than what we can today. For instance, thermal power generation 50 years earlier would require 500 grams of coal for one kWh of electricity while the latest super-super critical power generation unit requires less than 300 grams of coal. As a result of innovation and technological R&D, energy efficiency increases over time.

This argument is certainly valid. If this is the case, Since developing countries have a ‘latecomer’s advantage’, they can employ much more advanced technologies and emit less CO_2 for the same level of output as compared to the parameters decades earlier. Evidently, it is fair to take into technological improvement and spill-over impacts into account in the calculation of emissions. In this regard, AEEI (Autonomous Energy Efficiency Improvement) might be an appropriate indicator to reflect the differences of emission requirement over time.

In essence, physical amount of emissions do not disappear quickly in the atmosphere. For both the developed and developing countries, the concern over responsibility is with financial calculations. If the price of carbon is discounted using AEEI, the financial responsibility in the past by the developed countries would be progressively reduced along time farther in the past. According to this way of thinking, the financial burden for the historical emissions of Annex I is depreciated using AEEI. In accordance with statistical analysis, AEEI is estimated at a rate 1.5% per year.[10]

Basically there are two ways to depreciate the financial burden. The first is to depreciate the real CO_2 emissions in the past, while keeping the price of carbon constant. The other approach is to depreciate the price of carbon directly, while keeping the historical emissions as recorded. Here we report the results of both calculations.

---

[10] Essentially, this way is used to demonstrate that if employing the AEEI, at what extent will the Annex I will reduce their burden and which countries will reduce how much. Those results are more illustrative rather than practical.

(1) Discounting historical emissions in physical amount. In this way, emissions in the past are discounted using AEEI. The further back in the past, the more the physical amount is diminished. Firstly, for all the deficit Annex I countries, deduct the real emissions of a country in each year (e_t) by its average entitlement per year (e_0), and then get its annual surplus/deficit of each year (e_t-e_0). Secondly, multiply the depreciation coefficient (which was discounted at 1.5% per annum in the past exponentially) by these annual surplus/deficits, and get the depreciated annual surplus/deficit, and sum up all these depreciated annual surplus/deficits, then get the total deficit. Finally, we multiply this total deficit by the constant carbon price and get the total financial transfer.

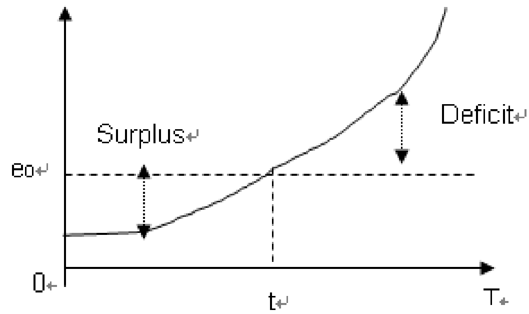

Figure A2-1: An illustration of depreciation of a deficit country's emissions

With historical emissions discounted, historical deficit of Annex I is reduced from 401.88 $GtCO_2$ to 298.5 $GtCO_2$ (Table A2-1).Using this amount of discounted carbon to calculate the financial liabilities for the Annex I countries, we can see that the amount of financial flows required from Annex I is decreased substantially, from originally 8.03 trillion dollars (at $20/$tCO_2$) and 20.1 trillion dollars (at $50/$tCO_2$), to 5.97 trillion dollars and 14.93 trillion dollars respectively, approximately74.3% of its original burden.

(2) Discounting the price of carbon. Firstly, for all the deficit Annex I countries, we find out which year it ran out of its historical entitlement and thus became deficit. We call this year the 'break-even year', so the emissions after this break-even year are simply all deficit emissions. Then we sum up these annual deficits of each deficit Annex I countries. Secondly, we depreciate the carbon price at 1.5% per annum in the past exponentially. Finally we multiply these depreciated prices by these annual deficit emissions, sum them up and then get the total financial transfer for the deficit emissions. The cumulative deficit of Annex I countries over 1900–1999 are illustrated in Figure A2-2.

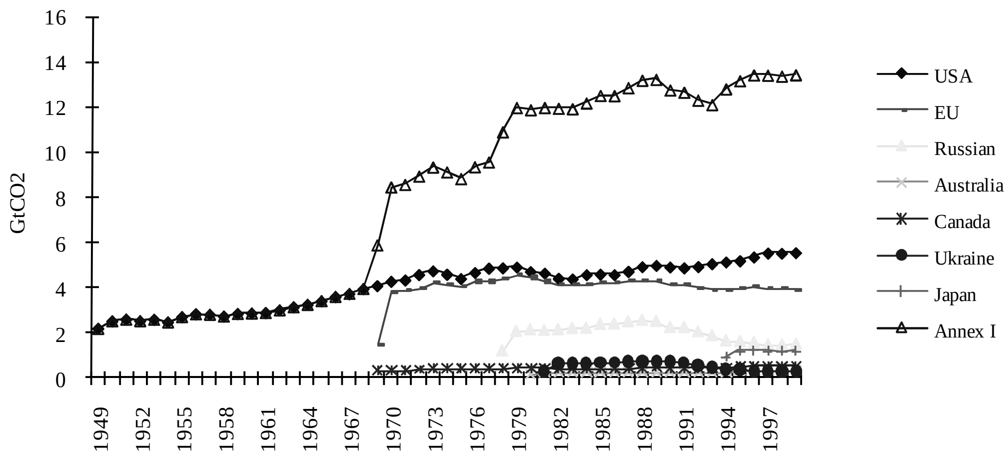

Figure A2-2: Annual deficits of Annex I countries (1900-1999)

From Table A2-1 we can see that after discounting either the emissions or the price of carbon, the liability of financial payment for budget deficits by Annex I would be reduced to about three quarters of its original liability. Total financial flows to cover the budget deficits in the past by Annex I are calculated at 6.18 trillion dollars (price level at \$20/tCO_2discounted at 1.5% per annum in the past exponentially) and 15.44 trillion dollars (price level at \$50/tCO_2 discounted at 1.5% per annum in the past exponentially), approximately 76.8% of the number without discounting the price of carbon.

Table A2-1: First financial transfer after depreciation (1900-1999, billion \$)

Annex I	*Historical deficit (GtCO₂)*	*Liabilities of payments at \$20/tCO₂*	*Liabilities of payments at \$50/tCO₂*	*Financial flows required from Annex I bl \$/a at \$20/tCO₂ (2011–2050)*	*Financial flows required from Annex I bl \$/a at \$50/tCO₂ (2011–2050)*
Without discounting	401.9	8,039	20,098	200.94	502.35
Discounting physical amount of emissions	298.50[11]	5,970	14,925	149.25	373.13
Discounting the price of carbon	417.3[12]	6,178	15,444	154.44	386.1

11 Under both of the discounting methods, we regards EU 27 as a whole while ignore the internal surplus/deficit of its member countries.

12 Total deficit of Annex I here is larger than the original 401.9 GtCO2, because under this methods a few Annex I countries with surplus budget are excluded, which is about 15.4 GtCO2 over 1900~1999.

As both the developed and developing countries are moving towards a lower carbon economy, low carbon technologies are expected to progress at a much faster rate than the past. This means that carbon productivity will be higher and higher further into the future. Developing countries will certainly employ the latest technologies with higher carbon productivity. As a result, for the same level of physical output such as steel and cement, emissions by the developing countries in the future will be much less. Assuming that technological levels among countries in the future will converge, the substantial differences of carbon productivity over time in the past must be reflected in the calculation of historical liabilities. From the preliminary results as give in this appendix, it is clear that the liability for historical emissions by the Annex I countries would be about three quarters of its original financial burden using AEEI at a rate of 1.5% per annum.

With such treatment, deficits and surpluses in the past would be adjusted to reflect technological improvement. As a result, the amount of financial burdens for the Annex I countries would be reduced and lower carbon technologies would be further developed and employed for economic development.

References

Baer, P., Athanasiou T., Kartha S., and Kemp-Benedict E. (2008). T*he greenhouse development rights framework: the right to development in a climate constrained world*. (revised second version). http://www.ecoequity.org/docs/TheGDRsFramework. pdf [Accessed on July 2, 2009].

Bodansky, D.,Chou S., and Jorge-Tresolini C. (2004). *International climate efforts beyond 2012*. PewCenter on Global ClimateChange. Dec. 2004. http://www.pewclimate. org/docUploads/2012%20new.pdf [Accessed on 2 July 2009].

CAIT (Climate Analysis Indicators Tool) Version 8.0. (Washington, DC: World Resources Institute, 2011). Retrieved from http://cait.wri.org. Accessed on April 20, 2011.

CDIAC (Carbon Dioxide Information Analysis Center). http://cdiac.ornl.gov/trends/emis/meth_reg.htm,Accessed onApril 15, 2011.

Chen,Y.,Pan J. H.,andXie L. H. (2008). The energy content of China's merchandise imports and exports and its policy implications.' (中国外贸进出口商品中的内涵能源及其政策含义). *Economic Research Journal* (经济研究), 7.

Ding Z. L., Duan X. N., Ge Q. S. and Zhang Z. Q. (2009a). Control of atmospheric CO2 concentration by 2050: An allocation on the emission rights of different countries. Sci China Ser D-Earth Sci, 2009, doi: 10.1007/s11430-009-0155-3 [丁仲礼，段晓男，葛全胜，张志强，2050 年大气 CO2 浓度控制：各国排放权计算.《中国科学 D 辑：地球科学》. 2009 年第 39 卷第 8 期：1009–1027.]

Ding Z. L., Duan X. N., Ge Q. S. and Zhang Z. Q. (2009b). On the major proposals for carbon emission reduction and some related issues. Sci China Earth Sci, 2010, doi: 10.1007/s11430-010-0012-4. [丁仲礼，段晓男，葛全胜，张志强，国际温室气体减排方案评估及中国长期排放权讨论. 《中国科学 D 辑：地球科学》. 2009 年第 39 卷第 12 期：1659–1671.]

DRC (Project Team of the Development Research Center of the State Council, China 2009,): 'Greenhouse Gas Emissions Reduction: A Theoretical Framework and Global Solution', Chapter 17, in Ross Garnaut, Ligang Song and Wing Thye Woo (eds) 2009: *China's New Place in a World in Crisis: Economic, Geopolitical and environmental dimensions*, The Australian National University E-Press, and Brookings Institution Press, pp.389-408. (http://epress.anu.edu.au/china_new_place/pdf/ch17.pdf).

DRC (Project Team of the Development Research Center of the State Council, China, 2010a). 'Carbon Budget Account Proposal: A Measurement and its implications' (in Chinese), A report of the project 'Fighting Climate Change' Project.

DRC(Project Team of the Development Research Centre of the State Council, China, 2010b): 'Carbon Budget Account Proposal: A New Measurement' (in Chinese), A report of the project 'Fighting Climate Change' Project.

Fan G, Su M. and Cao J. (2010). An Economic Analysis of Consumption and Carbon Emission Responsibility. *Economic Research Journal*. 2010(1): 4-14. [樊纲，苏铭，曹静，最终消费与碳减排责任的经济学分析. 经济研究，2010 年第 1 期, pp.4-14].

Houghton, R.A. (2008). Carbon Flux to the Atmosphere from Land-Use Changes: 1850–2005. In *TRENDS: A Compendium of Data on Global Change*. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. Retrieved from http://cdiac.ornl.gov/trends/ landuse/houghton/houghton.html

IEA. (2008). *CO_2 emissions from fuel combustion*. Paris: OECD Publishing, 2008.

IPCC. (2007a).*Climate change 2007 synthesis report.* (CoreWritingTeam,Pachauri R.K. and Reisinger A.eds.). Valencia, Spain, 17 November 2007. http://www.ipcc.ch/ ipccreports/ar4-syr.htm [Accessed on July 2, 2009].

IPCC. (2007b). Climate change 2007 – mitigation of climate change: contribution of Working Group III to the fourth assessment report of the Intergovernmental Panel on Climate Change, 2007.

Jiang,L. W.andHardee K. (2009).How do recent population trends matter to climate change? *Population Action International,* April, 2009. http://www. populationaction.org/Publications/Working_Papers/April_2009/population_trends _climate_change_FINAL.pdf [Accessed on July 2, 2009].

Kanitkar T., Jayaraman T., D'Souza M., Sanwan M., Purkayaths P. and Talwar R. (2010). *Global Carbon Budgets, Emission Trajectories and Burden Sharing in Mitigation Actions*, Presented at the CASS Forum (2010 Economics) on Climate Justice and the Carbon Budget Approach, April 15–16, 2010, Beijing, China.

Meinshausen M., Meinshausen N., Hare W., Raper S. C. B., Frieler K., Knutti, R., Frame D. J. and Allen M. R. (2009). Greenhouse gas emission targets for limiting global warming to 2°C. *Nature,* 458, 1158–1162.

Meyer,A. (2004). GCI briefing: contraction & convergence. *Engineering Sustainability*, 01/12/2004.

Pan J. H. and Chen Y. (2009). The Carbon Budget Scheme: An Institutional Framework for a Fair and Sustainable World Climate Regime. *Social Science in China*. 2009(5):83-99. [潘家华、陈迎（2009）.碳预算方案：一个公平、可持续的国际气候制度框架.中国社会科学. 2009(5):83-99]

Pan, J. H. (2005). Fulfilling basic development needs with low emissions: China's challenges and opportunities for building a post-2012 climate regime. In *Governing climate: the struggle for a global framework beyond Kyoto*, Sugiyama T. (ed.). International Institute for Sustainable Development (IISD), 2005.

Pan,J. H. (2008a).A carbon budget that meets basic needs and its implications for international equity and sustainability (满足基本需求的碳预算及其国际公平与可持续含义). *World Economy and Politics* (世界经济与政治), no. 1.

Pan, J. H. (2008b). Welfare dimensions of climate change mitigation. *Global Environmental Change*, vol. 18, no. 1.

Rawls, J. (1971). *A theory of justice*. Harvard University Press.

Rosa, L. Pinguelli, and S. K. Ribeiro. (1997). The present, past, and future contributions to global warming of CO_2 emissions from fuels: a key for negotiation in the climate convention. *Climatic Change*, vol. 48.

Sen, A. (1997). *Development as freedom*. Oxford: Oxford University Press.

State Family Planning Commission of China. (2007). *Research report on the national population development strategy* (国家人口发展战略研究报告). Beijing: China Population Publishing House.

Stern, N. (2008). *Key elements ofa global deal on climate change*. London School of Economics and Political Science, April 30, 2008. http://www.lse.ac.uk/collections/granthamInstitute/publications/KeyElementsOfAGlobalDeal_30Apr08.pdf [Accessed on July, 2009].

UNFCCC. (1997). *Proposed elements of a protocol to the UNFCCC* (FCCC/AGBM/1997/ MISC.1/Add.3). Bonn: UNFCCC. http://unfccc.int/cop4/resource/docs/1997/agbm/ misc01a3.htm [AccessedonJuly 2, 2009].

UNFCCC. (2002). Scientific and methodological assessment of contributions to climate change, Report of the expert meeting, Document number FCCC/SBSTA/2002/ INF.14,2002.

UNFCCC. (2007). *Bali Action Plan*. http://unfccc.int/.

WBGU (German Advisory Council on Global Change). (2009). *Solving the climate dilemma: The budget approach*. Berlin.

Zhu,X. L. (2006). Carbon emissions that can meet basic needs of human development (人文发展基本需要的碳排放). Ph.D. thesis, the Graduate School of the Chinese Academy of Social Sciences.

Equitable access to sustainable development: An Indian approach

T. JAYARAMAN, TEJAL KANITKAR and MARIO DSOUZA

1. Introduction

Scholars, civil society and policy makers from India, along with their colleagues from developing countries, have had a long-standing engagement with the question of equity in climate change. This engagement has not only been reflected in India's climate policy in the run-up to and the signature of the United Nations Framework Convention on Climate Change at Rio de Janeiro in 1992 but also in further contributions to the climate debate, both in the negotiations and outside, over the years.

The range of views and opinions from India on this issue has also undergone further evolution since the signing and ratification of the UNFCCC. Several academic papers[1] and other writing have discussed the issue of equity and equitable access to global atmospheric space or global carbon space with different specific proposals. We will not review these papers in detail but we note the indebtedness of the view presented here to these earlier proposals.

2. Basic features of equitable access to sustainable development

2.1 The equity dimension

Equity must be a fundamental aspect of any global response to the challenge of global warming and climate change. Article 3.1 of the UNFCCC is unambiguous in calling on Parties to protect the climate system 'on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities.' It is important to emphasise that the term 'on the basis of equity' cannot be equated with the term 'common but differentiated responsibilities', as has been the tendency in part of the academic literature. From the language of Article 3.1 it is evident that there must be three elements that characterise any global effort to protect the climate system. The first

1 See for instance Agarwal (1999), Ghosh (2009), Gupta and Bhandari(1999), Shukla (1997), for a representative sample.

is that equity must be the basis for action. Second such efforts at protecting the climate system must be in accordance with common but differentiated responsibilities. And thirdly the efforts of individual Parties will also depend on their respective capabilities.

Equity clearly refers to the nature of the goal that is to be achieved in terms of the stabilization of greenhouse gases in the atmosphere, not just as a global goal but including the disaggregation of that goal into separate goals for individual countries. The concept of common but differentiated responsibilities recognizes further that any such equitable arrangement for protecting the climate system must also be co-operative in character, acknowledging the need for all countries to contribute but at the same time recognizing that different countries have contributed differentially to the problem of global warming. Hence their respective responsibilities to protect the climate system are not the same but are varying. Finally, countries that have greater capabilities are urged to act towards the common good by making a greater contribution to the effort.

If we deem continued greenhouse gas emissions to be a harm that afflicts all humanity, both now and in the future, such a determination also recognizes that the atmosphere is a global atmospheric commons that belongs to all humanity, now and in the future. Global warming imposes a sink constraint; since the capacity of the atmosphere to absorb greenhouse gases is limited, such gases cannot be put in the atmosphere beyond a specified limit. We may also equivalently consider global warming as imposing a resource constraint, as it constrains the carbon space (meaning thereby the space for emissions) available for humanity as a whole. As a consequence of the carbon cycle, this limitation extends to the entire atmosphere-oceans-land system. Thus the foremost issue in effort-sharing in solving the problem of global warming is the question of how the rights of access to the global atmospheric commons are to be assigned.

It is these rights of access to the global atmospheric commons that need to be determined on the basis of equity and suitably operationalised.

In the Indian approach, the basic principle of equitable access to the global sink is that of apportioning the entire available sink capacity equally across all individuals on the globe. Rights to equitable access are then assigned to nations based on their population.The question of deciding the year for determining the population or whether a varying population figure should be used is a technical matter and not one of principle. We note that using national population as the basis for defining the access for individual nations can also be regarded as a measure of the relative size of nations, which is clearly necessary in order to distinguish the access of a wide variety of nations.

Often referred to as the per capita approach, this principle of equitable access has attracted considerable academic attention, and there is a strong scholarly literature in support of this principle.[2]

It is important to emphasize here that the thrust of this paper is on the question of international equity (or equity between nations) and not merely global equity without any reference to nations. While the equal right of access of all individuals to the global

---

2 For a representative sample of such literature, see for instance, Sinden (2010) and Singer (2010).

atmospheric commons (or equivalently the equal right of access to sink capacity) is the foundation of our considerations, this leads to considerations of both equity between nations and equity within nations. In this paper we focus on the former. While equity within nations is significant and is an integral part of dealing with the climate issue, it does not in any way trump the significance of the question of international equity.

The second point in the Indian approach to equity is noting that the emissions of greenhouse gases in the atmosphere in an earlier era, from nations that have industrialised earlier, has reduced the sink capacity available to nations that are industrialising in a later era. Thus past historical emissions are relevant in assigning access rights to the global sink capacity in the future. Consideration of access rights to global sinks in the future without reference to the past would be inequitable if some nations had overused the global atmospheric commons in the past beyond their equitable share.

Both the points taken together imply that equitable access to the global atmospheric commons must be based essentially on stocks and not on flows of emissions. It is the relative contribution to greenhouse gas emissions stocks that determine how much of the atmospheric commons various nations have used and how much of the global atmospheric commons remains for use by all nations in the future. Indeed, to focus solely on current and future emission flows rather than emissions stocks would be to sanction inequality since it essentially allows the current state of unequal access to the global atmospheric commons to continue unchecked.

Prior to the Bali Action Plan and its emphasis on a shared vision for long-term cooperation, it may have been possible (even if somewhat incorrectly) to consider the assignment of common but differentiated responsibilities solely on the basis of emission flows. From the perspective of emissions flows it would also appear that equity is also more or less identical to the principle of common but differentiated responsibilities. However it is the focus on stocks rather than emissions that separates the notion of equity clearly from that of common but different responsibilities. In terms of laying out a shared vision for long-term co-operation as required by the Bali Action Plan, it is consideration of stocks that must take precedence over flows.

We emphasize that this discussion does not exhaust all aspects of equity in the climate change issue. But equity in the shared vision for long-term co-operation is the starting point for the consideration of equity in other dimensions of the climate change issue. Other aspects of equity such as equity in adaptation, it can be argued, are not separate from the basic thrust of equity in the shared vision for long-term cooperation though obviously there are different operational conclusions relevant to the various aspects.

2.2 The sustainability dimension

Alongside equity, the sustainability dimension of the climate change issue is of equal importance. While all nations seek economic growth and development, it is clear that the world cannot admit such growth based on the hitherto known relationship between growth, the use of fossil fuels and corresponding GHG emissions. The need for limiting emissions to sustainable levels by all nations is a necessity.

In this respect, Article 2 broadly provides the objective of sustainability in the context of the problem of global warming, enjoining on Parties to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. At the same time, apart from reference to ecosystems and food-production systems, Article 2 is explicit in requiring that such stabilization take place within a time-frame that enables 'economic development to proceed in a sustainable manner.'

It is clear that the sustainability dimension is intimately connected to the question of equity and cannot be treated as independent. Sustainability, as defined by the Brundtland Commission, has a clear emphasis on inter-generational equity. At the same time, while clarifying the definition, the commission itself made it evident that inter-generational equity is inseparable from intra-generational equity.

Operationally, sustainable development cannot be reduced solely to the duty of developing nations to proceed along a low-carbon pathway of development. Developing nations still have substantial development deficits and need to develop their infrastructure and industrial capabilities. Such infrastructural and industrial development is also an inseparable part of building the adaptive capacity of developing nations and reducing their vulnerability, especially as they are likely to suffer greater damage due to climate change impacts in the absence of development. The development of a green or low-carbon economy is the responsibility, in the first instance, of those nations that have contributed the most to pushing the climate system towards unsustainability.

Article 3.1 recognizes the special role of developed countries, emphasizing that they would have to take the lead in combating climate change and the adverse effects thereof. However, developing nations too will need to do their part, to preserve sustainability, even as they proceed with poverty eradication and erasing their development deficit. The extent of what they need to do will depend on the exact details of the availability of global carbon space. It is also a scientific fact that developing countries will not have the same access to global atmospheric resources as the developed countries, though this cannot become a rationale to freeze their historic lack of access into the future.

Similar to the error in the case of equity, again it is a common error in considering sustainability to focus solely on the current flows of GHG emissions. Even from a purely scientific viewpoint, recent scientific work makes it evident that cumulative emissions, or a global carbon budget as it is referred to, is really the most robust indicator of the sustainability limit for GHG emissions. Thus the cumulative emissions from the entire globe have to be kept within specified limits if global temperature increase is to be kept below a specified maximum. So, if global temperature rise has to be kept below 2°C (with a mean probability of 50%. then the cumulative emissions from 2000 to 2049 cannot exceed 1440 Gt (Gigatonnes) of carbon dioxide. In general, with 1440 Gt of

CO_2, the probability of a 2°C rise in temperature ranges from 29% to 70%.[3] Similarly for 1000 Gt of carbon dioxide we get a mean probability of 25% of keeping global temperature increase below 2°C.

3. Operationalising equitable access to sustainable development

3.1 The main proposal

3.1.1 Entitlements

It follows from these considerations that equitable access to sustainable development must in the first instance be based on equitable access to global atmospheric space or equivalently equitable access to global carbon sinks. The total available carbon space for the world can be computed, based on purely scientific considerations, from some suitable initial date (fixed sufficiently early to account for historical emissions) till some specified target date in the future. The total carbon space available to the world will depend on the maximum global temperature increase that is considered acceptable. The total carbon space available to the world will form the global carbon budget which will have to be apportioned equitably. Every nation will have to limit their emissions, between now and the specified target date in the future, to what is left over of their share of the global carbon budget after having subtracted what they have already emitted before now. The share of each nation is, essentially, based on its population share in some specified year. (It is possible in variations of this calculation to take into account changes in the carbon budget share of every nation as its population share in the world population changes)

It is clear that the essence of this proposal is the sharing of global atmospheric resources based on a equal per capita distribution of cumulative emissions, inclusive of emissions in the past (from some specified initial year) and possible emissions in the future (up to some specified target date). However this is not a claim of a right to pollute since the potential global emissions are limited and no nation is permitted to exceed its share.

3.1.2 The gap between entitlements and physically accessible carbon space

However, it will be clear from the data (as we shall shortly demonstrate) that most developing countries cannot attain their carbon space entitlement, meaning their due share of the global carbon budget by a target date such as 2050 or even 2100. This is because of the gross over-occupation of global atmospheric carbon space by the developed nations that have, as a group, occupied well beyond their due share. How much each nation will obtain in terms of actual, physical carbon space cannot obviously be predicted exactly since what it can physically obtain (as opposed to its entitlement) is limited by what other nations do. This is especially true of developing nations vis-a-vis the developed nations. As a result of their over-occupation of carbon

3 See Meinshausen et al (2009).

space, whereby they have emitted well over the share of the global carbon budget that is available to them (even up to 2050), the developed nations are in fact allowed only negative emissions between now and 2050.

We can estimate, using an emissions model based on optimization techniques,[4] the physical distribution of the remaining carbon space among nations based on various scenarios of emissions reduction by developed countries. Of course to ensure that the global carbon budget is adhered to, developing nations also have to reduce emissions subsequently.This model also enables us to provide a different account of the relative extent of burden-sharing between different nations. In this view, burden-sharing is the difference between what would have been available to nations in a equitable scenario without the sustainability criterion and what is in fact available within a scenario of equitable access circumscribed by the criteria of sustainability.

It is clear, though, that the critical issue for developing nations is the gap between their equitable share of the global carbon space and the physical share of carbon space that will be accessible to them. This gap clearly has to be bridged by appropriate financial and technology transfer. The delimitation of this gap in physical terms will enable the correct determination of the scale of financial and technology transfer. The gap may be measured either (a) with respect to what would have been obtained with equity without enforcing sustainability, or (b) with respect to the equitable share within a sustainable budget. We shall estimate in a subsequent section the scale of financial transfer implied in bridging the gap, measured in terms of option (b) above.

Clearly any agreement on a shared vision for long-term co-operation needs to have as an essential ingredient a scheme for equitable access within the goal of sustainability. It is clear that co-operative behaviour is essential when dealing with a global atmospheric commons resource that is limited. If one nation takes away more than its equitable share, this inevitably reduces the share of the others. Any unilateral declaration of a share, without a scheme of equitable access, as is practised currently by Annex-I countries (whereby they declare a global goal and also unilaterally announce their share in this goal), amounts to unilateral occupation of carbon space.

3.1.3 Marginal cases

A minority of cases exist among developing countries where their current cumulative emissions have left them with less carbon space than their requirement for their development needs in the future. However we will suggest a strategy by which these marginal cases can be accommodated in a general scheme of equitable access.

---

4 This emissions model, developed in collaboration between the Tata Institute of Social Sciences and the Delhi Science Forum, is described in detail, Kanitkar, Jayaraman (2010) in the proceedings of the conference on Global Carbon Budgets and Equity in Climate Change, available on the website of the Ministry of Environment and Forests, Govt. of India, at http://moef.nic.in/downloads/public-information/tiss-conference-cc-2010.pdf.

3.2 Some technical details of the proposal

3.2.1 Calculation of the entitlements

Below we present two tables on the national carbon budgets for select regions and countries. In Table 1 the cumulative emissions of each region/country are accounted for from 1850 and in Table 2 are accounted for from 1970. While 1850 as a base year for historical responsibility is well known, 1970 is more uncommon. However 1970 is around the period when the first intimations of global warming were being discussed globally and countries such as the United States had already begun investigating its strategic implications for their future. We have not chosen 1990 or subsequent years as they then eliminate any reference to historical responsibility. We also assume that the world has a carbon budget of 1440 Gt of CO2 for the period 2001-2050, which is equivalent to 393 Gt of C. We do not consider here the role of other greenhouse gases.

In Table 1 and Table 2 we have only taken into account gross carbon emissions based on the CAIT database. These emissions data do not take into account emissions due to land-use change, deforestation, etc. The use of 16 regions is for illustrative purposes and the number of regions/countries may be suitably modified (in the tables below Other EE refers to Other Emerging Economies and the RotW refers to Rest of the World, namely all other countries not previously referred to).

Table 1

1850 basis non-LUCF	*Population (millions) – 2000*	*Entitle-ments (%)*	*Entitlements – (1850–2050) [GtC]*	*Current contribution (1850–2000) [GtC]*	*Future entitlements (2000–2050) [GtC]*
USA	287.84	5	30.95	81.57	-50.62
EU	481.18	8	51.74	76.7	-24.96
Russian Fed.	146.67	2	15.77	22.84	-7.07
Japan	126.71	2	13.63	10.1	3.53
Australia	19.17	0	2.06	2.85	-0.79
Canada	30.69	1	3.30	5.95	-2.65
Other Annex I	145.77	2	15.68	10.02	5.66
China	1,266.95	21	136.24	19.37	116.87
India	1,042.59	17	112.12	5.58	106.54
Brazil	174.17	3	18.73	2.02	16.71
South Africa	44.87	1	4.83	2.96	1.87
Indonesia	205.28	3	22.07	1.24	20.83
Mexico	99.35	2	10.68	2.55	8.13
South Korea	46.43	1	4.99	1.89	3.10
Other EE	355.15	6	38.19	10.2	27.99
Rot W	1,643.54	27	176.74	9.63	167.11
Total	**6116**	**100**	**658**	**265**	**392**

Table 2

1970 – non-LUCF	*Population (millions) – 2000*	*Entitle-ments (%)*	*Entitlements – (1970–2050) [GtC]*	*Current contribution (1970–2000) [GtC]*	*Future entitlements (2000–2050) [GtC]*
USA	287.84	5	26.01	41.1	-15.09
EU	481.18	8	43.48	35.03	8.45
Russian Fed.	146.67	2	13.25	16.33	-3.08
Japan	126.71	2	11.45	8.5	2.95
Australia	19.17	0	1.73	1.97	-0.24
Canada	30.69	1	2.77	3.63	-0.86
Other Annex I	145.77	2	13.17	7.11	6.06
China	1,266.95	21	114.49	16.8	97.69
India	1,042.59	17	94.22	4.31	89.91
Brazil	174.17	3	15.74	1.68	14.06
South Africa	44.87	1	4.06	2.01	2.05
Indonesia	205.28	3	18.55	1.04	17.51
Mexico	99.35	2	8.98	2.12	6.86
South Korea	46.43	1	4.20	1.77	2.43
Other EE	355.15	6	32.09	8.57	23.52
Rot W	1,643.54	27	148.53	8.04	140.49
Total	**6,116**	**100**	**553**	**160.01**	**393**

From the data it is clear that the Annex-I countries have contributed the most to the exhaustion of the planet's carbon sinks, illustrated by the following tables, Table 3 and Table 4, that show the results for the world divided into just two regions, namely Annex-I and non-Annex-I. In the last column we show what each region will actually get (using the emissions model referred to earlier) based on the assumption that the Annex-I countries will cut their annual emissions to 40% below their 1990 levels by 2020 and to 95% below 1990 levels by the year 2050.

Table 3

1850 Basis, Non-LUCF	*Entitle-ments – 1850–2050 (%)*	*Entitle-ments – 1850–2050 (GtC)*	*Contri-bution to stock – 1850–2000 (GtC)*	*Future entitle-ments – 2001–2050 (GtC)*	*Contri-bution to stock – 2001–2009 (GtC)*	*Future entitle-ments – 2010-2050 (GtC)*	*Potential actual share – 2010-2050 (TISS–DSF model)*
Annex-I	20	133.13	210.03	-76.90	35.12	-112.02	50.18
Non-Annex-I	80	524.60	55.44	469.16	30.88	438.27	271.13
Total	**100**	**658**	**265**	**392**	**66**	**326**	**321**

Table 4

1970 Basis, Non-LUCF	*Entitle-ments – 1970-2050 (%)*	*Entitle-ments – 1970-2050 (GtC)*	*Current contri-bution to stock – 1970-2000 (GtC)*	*Future entitle-ments – 2001-2050 (GtC)*	*Current contribution to stock – 2001-2009 (GtC)*	*Future entitle-ments – 2010-2050 (GtC)*	*Potential actual share-2010-2050 (TISS-DSF Model)*
Annex-I	20	111.88	113.67	-1.79	35.12	-36.91	50.18
Non-Annex-I	80	440.86	46.34	394.52	30.88	363.63	265.00
Total	**100**	**553**	**160**	**393**	**66**	**327**	**315**

It is a striking fact that even with 1970 as the year from which to count historical emissions, the Annex-I countries have occupied to date 66% of the total carbon space. Thus the over-occupation of the global atmospheric commons by the Annex-I countries is not just a remote historical fact, but very much part of the contemporary present. As we can see, even in the decade just gone by, 2001–2009, the Annex-I nations have contributed more than 50% of the total CO_2 put into the atmosphere in this period.

From the above figures, for the given budget of 393 Gt of C (equivalent to 1440 Gt of CO_2) for the period 2001–2050, it is evident that even if the Annex-I countries were to reduce their emissions to zero instantaneously, it would nevertheless be impossible for developing countries to collectively attain their fair share in the 1850 basis. Even on the 1970 basis (which amounts to writing off part of the Annex-I negative emissions or equivalently carbon debt) the Annex-I countries have to cease emissions in 2010 if developing countries are to obtain their full entitlement. Of course individual developing countries, including BASIC countries, will fall short of their entitlement by varying amounts. We turn to this issue in the next subsection.

However, we emphasize that the crux of the issue, in the first instance, is sharp and immediate reductions by the Annex-I countries. Without such reductions the non-Annex-I countries are going to be even more severely disadvantaged than they are currently. These figures also make it evident that sustainable development, or more precisely low-carbon development, is a necessity for developing countries and not a matter of choice. It is forced on them since the bulk of the developing countries will not obtain their fair share of carbon space at all.

3.2.2 Calculation of the physically accessible space for regions/countries:

The major problem for developing countries is that they are unable to achieve their entitlements under any constraint of global sustainability. However, estimating the extent to which individual countries or groupings are able to physically access carbon space is a more complicated calculation. Such a calculation is complicated precisely because no individual nation's behaviour is at issue; the final distribution of physically accessed carbon space for every individual nation depends on the behaviour of all other nations.

The further complication in assessing the physical carbon space that can be accessed is, of course, that there could be competing behaviour by various regions or nations; for instance, developing countries have a clear need for more carbon space, whereas countries like the US continue to insist that they will reduce their emissions slowly.[5] Such a calculation, therefore, is doable only for a broad set of scenarios, under some specific assumptions and not for all possible cases. However even such considerations are very useful in understanding the overall situation.

An optimization model (that we briefly alluded to earlier) that can calculate the physical availability of carbon space for various nations/regions based on some general rules of equitable access has been developed for the purposes of such calculations. The details of this model have been published elsewhere. Here, however, we will very briefly present some details about this optimization model and how it functions.

The model is based on a code written in the software language of GAMS where the main objective is to find how much physical carbon space each nation/region can access based on three general rules. The first rule is that global sustainability goal must be obeyed, that is, the total emissions for the given period, 2001 to 2050, must not exceed the global carbon budget for this period. The second rule is that those nations/regions who have emitted more than their fair share of global cumulative emissions up to the current date have to start reducing emissions immediately. Those countries that have emitted less than their allowed share to date are permitted to increase emissions subject to the first rule. The third rule is that even countries that have used less than their entitlements have nevertheless to slow down their rate of emissions increase if it is above a specified level. With regard to the second rule, we can construct various scenarios depending on how rapidly the developed countries have to cut and with regard to the third rule, the choice of scenarios depends on how rapidly the rate of emissions growth is slowed down.

Two important characteristics of these rules may be noted. The first is that the rules apply across all nations/regions. Second, the rules do not allow any country to pursue emissions growth without respecting the global constraint.

In Table 5 below, we compare the physically accessible carbon space for all nations/regions based on these rules to the entitlements of these nations/regions. In computing this we have assumed that the Annex-I countries would cut annual emissions 40% below 1990 levels by 2020 and by 95% below 1990 levels by 2050. The details of this model and such computations have been discussed in Kanitkar, Jayaraman (2010).

---

5 However, it is interesting to note that the U.S. Academies have recommended a carbon budget for the US in their report to the US Congress, titled ‘‘America’s Climate Choices’. In this report they declare a unilateral budget requirement for the US ranging between 170-200 Gt of CO2, for the period 2012-2050. This is of course well over their due share of global carbon space, even with the exclusion of historical responsibility.

Table 5: 1850 basis

1850 basis, non-LUCF	*Entitle-ments – 1850-2050 (GtC)*	*Contribution to stock – 1850-2000 (GtC)*	*Future entitle-ments – 2001-2050 (GtC)*	*Contrib-ution to stock – 2001-2009 (GtC)*	*Future entitle-ments – 2010-2050 (GtC)*	*Potential actual share (2010-2050) [GtC] – TISS-DSF model*
USA	30.95	81.57	-50.62	14.18	-64.80	18.41
EU	51.74	76.7	-24.96	10.09	-35.05	14.38
Russian Fed.	15.77	22.84	-7.07	3.89	-10.96	6.08
Japan	13.63	10.1	3.53	3.07	0.46	4.42
Australia	2.06	2.85	-0.79	0.95	-1.74	1.61
Canada	3.30	5.95	-2.65	1.07	-3.72	2.14
Other Annex I	15.68	10.02	5.66	1.87	3.79	3.14
China	136.24	19.37	116.87	13.73	103.14	87.38
India	112.12	5.58	106.54	3.09	103.45	68.08
Brazil	18.73	2.02	16.71	0.50	16.21	6.95
South Africa	4.83	2.96	1.87	0.83	1.04	1.53
Indonesia	22.07	1.24	20.83	0.86	19.97	10.45
Mexico	10.68	2.55	8.13	1.04	7.09	2.08
South Korea	4.99	1.89	3.10	1.23	1.87	1.87
Other EE	38.19	10.2	27.99	5.35	22.64	18.42
Rot W	176.74	9.63	167.11	4.25	162.86	74.53
Total	**658**	**265**	**392**	**66**	**326**	**321**

Table 6: 1970 basis

*1970 Basis, non-LUCF**	*Entitle-ments – 1970-2050 (GtC)*	*Current contribution to stock – 1970-2000 (GtC)*	*Future entitle-ments – 2001-2050 (GtC)*	*Current contribution to stock – 2001-2009 (GtC)*	*Future entitle-ments – 2010-2050 (GtC)*	*Potential actual share (2010-2050) [GtC] – TISS-DSF model*
USA	26.01	41.1	-15.09	14.18	-29.27	18.41
EU	43.48	35.03	8.45	10.09	-1.64	14.38
Russian Fed.	13.25	16.33	-3.08	3.89	-6.97	6.08
Japan	11.45	8.5	2.95	3.07	-0.12	4.42
Australia	1.73	1.97	-0.24	0.95	-1.19	1.61
Canada	2.77	3.63	-0.86	1.07	-1.93	2.14
Other Annex I	13.17	7.11	6.06	1.87	4.19	3.14
China	114.49	16.8	97.69	13.73	83.96	74.18
India	94.22	4.31	89.91	3.09	86.82	67.58

*1970 Basis, non-LUCF**	*Entitle-ments – 1970-2050 (GtC)*	*Current contribution to stock – 1970-2000 (GtC)*	*Future entitle-ments – 2001-2050 (GtC)*	*Current contribution to stock – 2001-2009 (GtC)*	*Future entitle-ments – 2010-2050 (GtC)*	*Potential actual share (2010-2050) [GtC] – TISS-DSF model*
Brazil	15.74	1.68	14.06	0.50	13.56	9.22
South Africa	4.06	2.01	2.05	0.83	1.22	1.53
Indonesia	18.55	1.04	17.51	0.86	16.65	10.45
Mexico	8.98	2.12	6.86	1.04	5.82	3.47
South Korea	4.20	1.77	2.43	1.23	1.20	1.87
Other EE	32.09	8.57	23.52	5.35	18.17	13.35
Rot W	148.53	8.04	140.49	4.25	136.24	83.21
Total	**553**	**160.01**	**393**	**66**	**327**	**315**

From this data it is evident that the bulk of developing countries will not physically access their equitable share of carbon space.

In this context it is important to note that Annex-I countries have routinely echoed proposals that prescribe both a global goal by 2050 and a unilateral goal on behalf of the Annex-I countries, typically 50% below 1990 for the former and 80% below 1990 for the latter. It is clear from our analysis above that this does not do enough for the developing countries. First, since it is a unilateral declaration of the Annex-I carbon budget, it violates the principle of equity, both of process and of outcome. Secondly this statement is nearly not enough for the developing countries, as they require a guarantee that their loss of equitable share would be duly substituted in terms of financial and technological transfer. We emphasise that the developing countries are asserting the right to substitute ‘a loss of equitable share’ of carbon space that arises from the need to preserve global sustainability by adhering to the global carbon budget. They are not asserting a claim or a right to pollute.

In fact, differences in the ambition of even short term pledges by Annex-I parties can make a difference in terms of the carbon space available to developing countries. In the figure below we compare the carbon space that the Annex-I countries get under two scenarios. The first scenario is the sharp reductions (along the lines proposed by the IPCC in its Fourth Assessment Report[6]) that we used in Table 5 and Table 6. This is compared to a second scenario which is the aggregate of the so-called Copenhagen pledges till 2020 supplemented by a 80% reduction below 1990 levels by 2050. The figure below graphically illustrates the difference between the two scenarios. We assume here that it is left to the non-Annex-I countries to shoulder the burden of sustainability, namely that they will need to ‘pick up the remainder’ in terms of extra effort in mitigation to ensure that the world stays below the global carbon budget.

6 IPCC(2008).

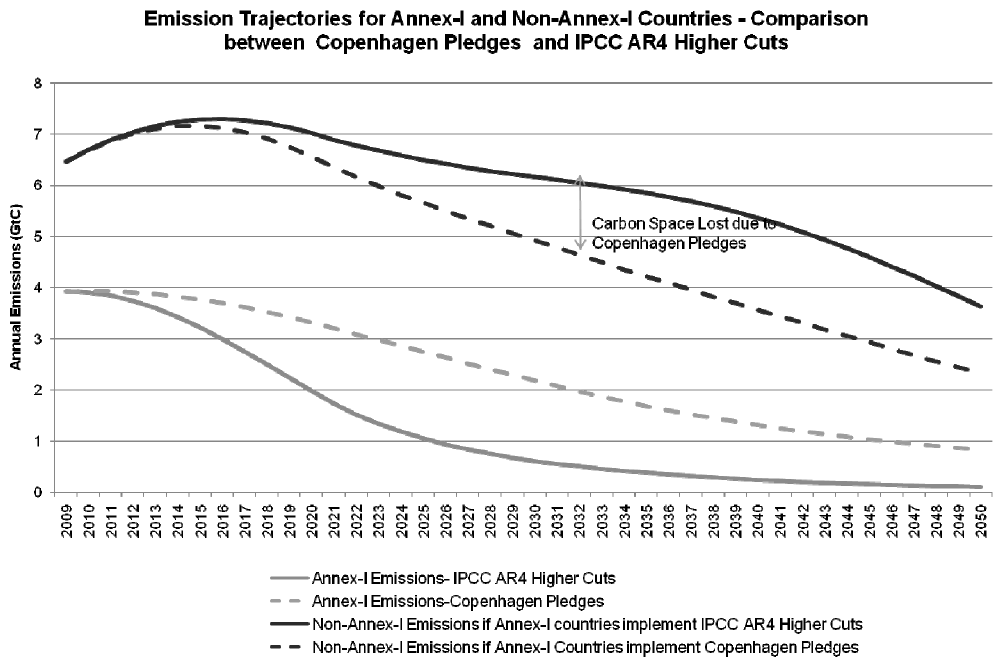

Figure 1

3.2.3 South-South co-operation in determining national carbon budgets

The tables above already demonstrate that there are a few countries in the global South whose cumulative emissions today have already reached 50% or more of their entitlements for the entire period 1850-2050. These countries are in this special situation for particular historical reasons. Equity cannot here be obviously driven solely by a formulaic perception. However, a natural solution to this important issue is revealed by the actual data. It turns out that the extent of overuse of carbon space by a small group of developing countries is actually numerically small in absolute terms. Hence their requirements for carbon space may be met by mutual adjustment and cooperation among developing countries without, however, sacrificing the overall principle that is true for a significant majority of developing countries.

These conclusions are clear from the entitlements and the actual use of carbon space by this group of nations.

Table 7

EE countries with more than 50% fair share exhausted	*Current contribution to historical stock (GtC) (1850–2009)*	*Entitlement for the future (GtC 2010–2050)*	*Fair share (as percentage of world total)*
Israel	0.46	0.225	0.11%
Korea South	3.12	1.480	0.73%
Kuwait	0.50	-0.246	0.04%
Qatar	0.21	-0.130	0.01%
Saudi Arabia	2.10	0.624	0.43%
Singapore	0.31	0.134	0.07%
South Africa	3.79	0.856	0.74%
Taiwan	1.66	0.516	0.34%
UAE	0.64	-0.184	0.07%
Uzbekistan	1.70	0.919	0.41%
Venezuela	1.39	1.150	0.40%
Total	15.88	5.344	3.36%

Table 8

Other countries with more than 50% fair share exhausted	*Current contribution to historical stock (GtC 1850–2009)*	*Entitlement for the future (GtC 2010–2050)*	*Fair share (as percentage of world total)*
Antigua & Barbados	0.00	0.00	0.001%
Azerbaijan	0.64	0.14	0.124%
Bahamas	0.04	-0.01	0.005%
Bahrain	0.14	-0.07	0.011%
Brunei	0.05	-0.01	0.006%
Cyprus	0.06	0.05	0.016%
Kazakhstan	3.00	-1.54	0.231%
Korea North	1.15	1.00	0.340%
Libya	0.34	0.26	0.095%
Macedonia FYR	0.12	0.08	0.031%
Malta	0.02	0.02	0.006%
Moldova	0.25	0.16	0.065%
Nauru	0.00	0.00	0.000%
Oman	0.14	0.13	0.044%
Serbia & Montenegro	0.66	0.28	0.148%
Suriname	0.03	0.02	0.007%
Trinidad & Tobago	0.23	-0.11	0.018%
Turkmenistan	0.53	-0.07	0.073%
Total	**7.40**	**0.32**	**1.221%**

4. Equitable access and financial and technological transfers

4.1 Entitlement shortfall and financial transfers

As we have already noted, the gap between the entitlement to carbon space (based on the equal per capita cumulative emissions paradigm of equitable access) and the actual physical carbon space available provides a basis for estimating the financial transfer required by developing countries. We can estimate based on the financial transfers by multiplying the gap between entitlements and physically available carbon space by the cost of carbon in $/ton. We present the results in the following table.

Table 9

1850 basis, non-LUCF	*Future entitlements – 2010-2050 (GtC)*	*Potential actual share (2010-2050) (GtC) – TISS-DSF model*	*Financial transfers at $20/tonne of carbon (billion $)*	*Financial transfers at $50/tonne of carbon (billion $)*
China	103.14	87.38	315.2	788
India	103.45	68.08	707.4	1,768.5
Brazil	16.21	6.95	185.2	463
Indonesia	19.97	10.45	190.4	476
Mexico	7.09	2.08	100.2	250.5
S. Korea	1.87	1.87	0	0
Other EE	22.64	18.42	84.4	211
Rot W	162.86	74.53	1,766.6	4416.5
Total	**437.23**	**269.76**	**3,349.4**	**8,373.5**

Table 10

*1970 basis, non-LUCF**	*Future entitlements – 2010-2050 (GtC)*	*Potential actual share (2010-2050) (GtC) – TISS-DSF model*	*Financial transfers at $20/tonne of carbon (billion $)*	*Financial transfers at $50/tonne of carbon (billion $)*
China	83.96	74.18	195.6	489
India	86.82	67.58	384.8	962
Brazil	13.56	9.22	86.8	217
Indonesia	16.65	10.45	124	310
Mexico	5.82	3.47	47	117.5
S. Korea	1.2	1.87	-13.4	-33.5
Other EE	18.17	13.35	96.4	241
Rot W	136.24	83.21	1,060.6	2,651.5
Total	**327**	**315**	**240**	**600**

It is evident from the table that financial transfers on the 1970 basis are extremely low as a result of the neglect of historical responsibility. It is evident that financial transfers cannot be computed on the gap between entitlements and actual attainable physical carbon space in the 1970 basis.

4.2 Cost of avoided carbon compared to fixed carbon prices

However, we also report here another method of calculation that keeps in view the actual difference in costs involved in producing equivalent amounts of energy by a low-carbon route as opposed to a high-carbon route. To keep the actual calculation tractable we will focus on the difference in costs in producing electricity by the two routes instead of attempting to do such a calculation for all forms of energy use. We refer to this difference in the cost of energy between these two routes as the cost of avoided carbon.[7]

Computing the avoided cost of carbon involves detailed estimates of producing the equivalent amount of electricity using different non-fossil fuel technologies. These estimates will vary across different countries since the preferred non-fossil fuel routes to energy production for each country will be different. Hence we will present in this chapter estimates only for India.

In the medium or long term, a low carbon path can be achieved through either the nuclear or solar route, or a combination of the two. While short term gains can be made by shifting a part of future growth to gas, this can at best be for a limited amount and a limited period. For India, wind and biomass are not major sources. India has limited wind resources. Biomass has competing uses – both as fuel and as cattle feed. It has also the problem of being seasonal and most biomass-based plants have encountered problems in procuring biomass.

Carbon sequestration as an alternative could allow continued coal use, but at a higher cost. The cost of carbon sequestration is not easily estimated at the moment – either as capital per KW or as variable cost per unit of electricity. However, we need to be cautious regarding the stability of the geological formations into which the CO_2 is pumped. Without an equitable agreement on technological transfer the possibility exists that a few large global firms controlling the technology may impose monopoly rent on the developing countries, making the cost of carbon sequestration prohibitive.

For India, nuclear power could become a major component in the future – 40,000 MW by 2020 is one estimate that has been much discussed. The other route is solar – 20,000 MW of solar thermal plants by 2022 as proposed in the National Solar Mission would be the first steps in this direction.

A detailed calculation provides the following comparative estimates of cost of electricity production by different technologies.

7 The discussion here on the avoided cost of carbon closely follows Purkayastha (2010) and we refer to this paper for more detailed discussions of the estimates.

Table 11: Comparative costs for coal, nuclear and solar plants

	Cost/MW ($ million)	*Plant load factor*	*Cost/KWhr (cents)*
Coal fired plant	1.2	80%	6.4
Nuclear plant (imported)	7.5	80%	25.3
Solar	4.5	25%	54.2

We note that the cost of power generated by nuclear power plants of Indian design and construction would be cheaper, but ambitious targets for nuclear power would involve large-scale imports.

In the case of solar power, since the Plant Load Factor (PLF) is about 25% for solar plants as against 80% PLF for coal-fired ones, we will have to install about 3 times as many solar plants – the capital cost for producing the same amount of electricity from solar plants is about 15 times that using the coal route or a high carbon route! So choosing a low carbon path has huge costs. Such high capital costs imply that, for producing the same amount of electricity, developing countries such as India will have to find large amounts of additional capital. For the kind of electricity generation that India needs over the next 20 years, this would imply astronomical sums of capital and would deny other sectors of the economy access to capital.

This is not the only problem of solar or nuclear power. If capital has a cost – cost of borrowings being obviously one of them – then this cost of capital would reflect also on the cost of electricity. Even assuming that operating costs for nuclear or solar plants are low, it would still involve the cost of electricity to be 4 times for nuclear energy and 9 times that for solar energy than electricity from coal-fired plants.

The avoided carbon per unit of electricity produced, if we switched from coal-based power to solar power, would be approximately 0.4 kg. We show in the table below the difference between the cost of avoided carbon and the cost of carbon proposed for financial transfers at the higher value of $50/ton.

Table 12

	Value of carbon at $50/tonne) (cents)	*Cost per unit using high carbon path (cents)*	*Cost per unit using solar low carbon path (cents)*	*Difference (cents)*
1 unit of avoided carbon per Kwh	1.95	6.4	54.2	47.8

Thus the differences in estimating the cost of a low-carbon route can be clearly very large, and estimates based on the cost of electricity actually generated by low-carbon technologies rather than coal suggest that the real costs of a low-carbon pathway are very high.

Of course, we have used here the estimates based on the current price of solar technology. And the full economy-wide cost of avoided carbon over the next 50 years would also depend on the fuel mix for electricity production over this period. However, these estimates suggest that unless there is drastic reduction in the cost of technologies such as solar power, developing countries are faced with a very high-cost energy future. It is evident that a strong case can be made that indeed the cost of avoided carbon should in fact be the basis of computing financial transfers from the Annex-I to non-Annex-I parties. We may add that by this technique of calculation, much higher levels of financial transfer would be suggested even in the 1970 basis.

5. Conclusion

We believe that this paper has made a significant and strong case for the need to consider both equity and sustainability in resolving the climate issue at the global level and has indicated in clear terms a viable scheme to operationalise these concepts in the climate context. We note that there is a specific technical content and meaning that sustainability carries in the climate context. The global carbon budget is this specific form of sustainability and it is notable that the full realization of equity in the physical sense of access to carbon space is trumped by both these criteria. Keeping global temperature rise below 2°C requires that sustainability be respected. But no global deal on climate can be acceptable to the developing world without ensuring that (a) whatever remains of equitable access to carbon space is realized and (b) and that equity, to the extent that it cannot be realized in physical terms, is also duly realized in the form of financial transfers and access to technology.

References

Agarwal, A., Narain S. and Sharma A. (1999), 'Global Environmental Negotiations 1: Green Politics'', Centre for Science and Environment, New Delhi.

Ghosh P. (2009), 'Quantifying Historic Differentiated Responsibility – Concept and Empirical Results', Presentation at the sixth session of the Ad-hoc Working Group for Long Term Cooperation of the UNFCCC, Bonn, June 4: available on the web at http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/7_indial. pdf

Gupta S., Bhandari P.M., (1999), 'An effective allocation criterion for CO_2 emissions', *Energy Policy* 27, pp 727-736.

IPCC (2008), Fourth Assessment Report, available on the web at http://www.ipcc.ch.

Kanitkar, Tejal, Jayaraman, T., DSouza, Mario, Sanwal, Mukul, Purkayastha, Prabir, Talwar, Rajbans and Raghunandan, D. (2010), Global Carbon Budgets and Burden Sharing in Mitigation Actions – Complete Report, in 'Global Carbon Budgets and Equity in Climate Change,' Tata Institute of Social Sciences and Ministry of Environmemnt and Forests, available on the web at http://moef.nic.in/downloads/public-information/tiss-conference-cc-2010.pdf

Meinshausen, M., Meinshausen, N., Hare, W., Raper, S.C.B., Frieler, K., Knutti, R., Frame, D.J. and Allen, M.R. (2009) 'Greenhouse-gas emission targets for limiting global warming to 2 deg C', *Nature* 458, pp1158-1163.

Purkayastha, Prabir and Mandal, Tirthankar (2010), A Note on Carbon Space as Development Space, in Global Carbon Budgets and Burden Sharing in Mitigation Actions – Complete Report, in 'Global Carbon Budgets and Equity in Climate Change,' Tata Institute of Social Sciences and Ministry of Environmemnt and Forests, available on the web at http://moef.nic.in/downloads/public-information/tiss-conference-cc-2010.pdf

Shukla P.R. (1997), 'Socio-Economic Dynamics of Developing Countries: Some Ignored Dimensions in Integrated Assessment', Proceedings of IPCC Asia-Pacific Workshop on Integrated Assessment Models, March 10-12, Tokyo, Japan.

Sinden A., (2010), 'Allocating the Costs of the Climate Crisis: Efficiency Versus Justice', Washington Law Review, Vol. 85, pp 293-353

Singer P. (2010), 'One Atmosphere' in *Climate Ethics: Essential Readings*, Stephen Gardiner et al (eds), Oxford University Press

A South African approach – responsibility, capability and sustainable development

HARALD WINKLER, THAPELO LETETE and ANDREW MARQUARD[1]

1. Introduction

The pace of climate negotiations needs to step up significantly to deal with the urgency of the challenge posed by the science and economics of climate change. This poses challenges for developed and developing countries, in different ways. Equity must be central to the way in which the global community addresses the challenge of climate change.

This chapter presents analysis from South African experts on equitable access to sustainable development. The analysis builds on previous work on the issue of equity as it applies to climate change and development.[1] [2] [3] [4] [5] [6] [7] [8] [9] [10]

The chapter uses a principle-based set of criteria to operationalise equity in various dimensions. The aim is to allocate both provide sufficient time for low-carbon development (in the context of sustainable development) and the remaining physical carbon space available globally to 2049, consistent with the principles outlined in the UNFCCC. To ensure equity, fair shares of both effort required and the resource remaining need to be defined.

2. Approach and principles

The principle of equity suggests that to be viable, any proposal or package must also be fair.[10] Achieving such fairness is not a simple matter, given that we live in a world with high levels of inequality.[11] And not only is the world an unequal place, but the problem of climate change itself has an unequal structural characteristic, in the sense that those

1 All of the Energy Research Centre, University of Cape Town. The views expressed are those of the authors, based on the analysis presented and do not claim to represent the views of any organisation. Any correspondence may be addressed to Harald.Winkler@uct.ac.za

least responsible for the problem (the poor) are also the most vulnerable to the impacts of climate change. The challenge is to operationalise the principle of equity.

The approach starts from Convention principles, as stated in Article 3.[12] The UNFCCC's first principle refers directly to equity and common but differentiated responsibilities and respective capabilities. Hence responsibility and capability are key criteria in defining efforts to protect the climate system. The principle that Parties should promote sustainable development is equally relevant to equity. Hence, the core criteria used are based on the following three principles of the Convention:

- Responsibility, in particular historical responsibility for the cumulative emissions since the industrial revolution, which have caused the problem in the first place
- Capability, which should be assessed in broader terms of human development, not only income
- Development, which is based on the right to promote sustainable development

This paper takes a burden-sharing approach. In this approach, action to protect the climate system is framed in terms of sharing the global mitigation burden. The global mitigation burden is defined by the difference between one of the IPCC scenarios and a required global pathway. The area under the global pathway represents the remaining carbon budget. The global burden is allocated among countries according to historical responsibility for emissions, and capability to mitigate, which is quantified not only in terms of GDP, but also broader aspect of development. Both in the development-oriented approach to climate change and in the definitions of some of the indicators, we draw on the Greenhouse Development Rights (GDR) framework,[13] with some adjustments. Before outlining the methodology used to derive results for individual countries, we outline how each of these principle-based criteria is represented analytically.

2.1 Responsibility

Responsibility is calculated for each country based on cumulative emissions. The emissions can be summed starting from either 1850, 1900, 1950, 1970 or 1990 ending in 1999. For the purposes of this chapter, we report results for two starting years, 1850 and 1970. Thus for every country, *c*, the cumulative emissions, E_c, summed up from year y_1 to 1999 can be represented as:

$$E_c = \sum_{y}^{Y} e_{c_y}$$

Where: e_{c_y} = annual GHG emissions of country *c* for the year *y*

$y \in Y = [y_1, y_1+1, y_1+2, \ldots, 1999]$.

The cumulative total for each country is then divided by that country's population for 2000, P_c^{2005}, to arrive at a cumulative per capita emissions indicator $€_C$, which we use as the Final Responsibility indicator or FRI_c:

$$€_c = E_c/P_c^{2000} = FRI_c$$

2.2 Capability

Capability is measured in GDP-ppp in 2000, which is taken as a measure of mitigation capability. If g_c^{2005} denotes the 2000 GDP-ppp of country *c*, then per-capita 2000 GDP-ppp, G_c^{2005}, can be expressed as:

$$G_c^{2000} = g_c^{2000}/P_c^{2000}$$

2.3 Sustainable development

The objective of the Framework Convention as spelled out in Article 2 is not only about stabilization of concentrations of greenhouse gases, but significantly this objective must be achieved in a way that does not prejudice sustainable development. From the perspective of developing countries, ensuring that economic development can proceed in a sustainable manner remains as relevant as ever, as do social considerations and quality of life issues such as food security.[12]

We have assumed that in addition to wealth, broader human development is also an indicator of mitigation capability. We have used the UNDP's Human Development Index as an indicator of development on account of its wide acceptance, and applied this as a corrective factor to the GDP-based capacity indicator.

Given that different components of the HDI are on logarithmic and linear scales respectively, the technique that has been used to link the HDI to a capability measure first involves the exclusion of the GDP indicator, since this is already expressed in the capability indicator; in addition, the logarithmic basis for the GDP component of the HDI would dramatically underplay income differences between countries at the higher end of the global income spectrum. The other two components of the HDI are included using the following technique:

First the average of the two remaining indicators is calculated; if LEI_c^{2000} and EDI_c^{2000} are the 2000 Life Expectancy Indicator and the 2000 Education Indicator of country *c* respectively, then the combined Education & Health Indicator, ICI_C^{2000}, for country *c* can be expressed as:

$$EHI_c^{2000} = \frac{(LEI_c^{2000} + EDI_c^{2000})}{2}$$

The average, EHI_{ave}^{2000}, upper bound, EHI_{max}^{2000}, and lower bound, EHI_{min}^{2000}, of the index are then determined as the average, the smallest and the largest of the combined Education &Health Indices for all countries respectively.

Lastly the GDP-derived Interim capacity indicator is adjusted by a defined percentage in proportion to the deviation from the average within the boundaries set by the upper and lower limits. This is done by determining the *+Coeff* and the *–Coeff* defined as:

$$+Coeff = EHI_{max}^{2000} - EHI_{ave}^{2000}$$

$$-Coeff = EHI_{ave}^{2000} - EHI_{min}^{2000}$$

Then the percentage change of the Interim capacity indicator for each country *c* is calculated as follows:

If the Interim capacity indicator is adjusted by *X*% such that $0 \leq X \leq 100$, then if $EHI_c^{2005} > 0$, then the percentage change, $\%\Delta_c$, is

$$\%\Delta_c = 1 + \frac{(EHI_c^{2000} - EHI_{ave}^{2000})}{+coeff} * \frac{X}{100}$$

Otherwise the percentage change, %Δ, becomes

$$\%\Delta_c = 1 + \frac{(EHI_c^{2000} - EHI_{ave}^{2000})}{-coeff} * \frac{X}{100}$$

That is: if the average is 0.85, and the lower limit is 0.75, and a specific country's indicator is 0.8, (halfway or 50% between the average and the lower limit), and the Interim capacity indicator is adjusted by 66.7 %, then the capability factor is reduced by 50% x 66.7% = 33.35%. This means that the country's capability factor is adjusted by -33.35% to reflect the lower level of development of the country concerned. Thus the Final Capability Index, FCI_c, can then be expressed as

$$FCI_C = G_c^{2000} * \%\Delta_c$$

2.4 Combining the indicators

The two final indicators are then combined using a technique adapted from the GDR method as follows:

$$RCI_C = FRI_C^i x FCI_C^j$$

Where RCI_C is the combined responsibility-capability indicator for country *c*, with capability adjusted to reflect considerations of sustainable development outlined in section 2.3, and the power indices *i* and *j* are positive fractions such that:

$$i + j = 1$$

For purposes of this analysis, we assume i is 0.6 and j is 0.4, i.e. responsibility is given a weight of 60%.

3. Methodology

3.1 Model description

The methodology is implemented through a spreadsheet model. Assuming that global emissions follow a defined reduction pathway, the model calculates the implied pathway for all countries and the deviation from baseline of this pathway using the principle-based criteria described in section 2 above. The model combines the following essential elements:

- projections of future emissions trends or baselines, based on the IPCC SRES AIB scenarios;
- a global carbon budget which determines the desired future trajectory;
- the global mitigation effort as the difference between the two, allocated amongst countries on the basis of three indicators – responsibility, capability and sustainable development (as specified in section 2 above).

If b_{c_y} depicts the baseline emissions of country *c* in year *y*, then the global emissions for that year, B_y, can be represented by:

$$B_y = \sum_{c}^{C} b_{c_y}$$

Where c $\in C = \{all\ countries\}$ and y $\in \{1990, 1991, 1992, \ldots, 2050\}$.

The global emissions baseline is therefore described by the set $\{B_{1990}, B_{1991}, B_{1992}, \ldots, B_{2049}\}$.

If P_y denotes the total global emissions for year *y*, as required by the emissions pathway, such that:

$$P_y \in \{P_{1990}, P_{1991}, P_{1992}, \ldots, P_{2049}\}$$

then the global mitigation burden, M_y, for the year *y* can be represented as:

$$M_y = B_y - P_y$$

3.2 Data sources

The model starts with several types of data. All GHG emissions data is in units of Mt CO_2-eq. Emissions from international bunker fuels (maritime/airline) are not included. The data is sourced as follows:

1. Historical emissions, GDP and population data for all countries is obtained from CAIT.[14] Data for CO_2 emissions from 'energy' (combustion of fossil fuels) and cement production is available for all the years, while data for CH_4, N_2O, HFCs, PFCs and SF_6 s only available for 1990, 1995 and 2000. Data for these latter gases for other years is interpolated. Emissions from land use, land use change and forestry (LULUCF) is available only for 1990-2000; for 2001-2005 LULUCF emission values are kept constant. The error between this and global estimates is small.
2. All baseline projections are from the EVOC model, based on the IPCC SRES AIB scenario,[15] except LULUCF baseline projections for Brazil which are obtained from the Brazilian National Plan on Climate Change.[16]
3. Assumed emissions pathways: For the purposes of this chapter, we choose a emissions pathway consistent with a remaining global carbon budget of 1440 Gt CO_2-eq for the first half of the 21st century, which has a 29% to 70% probability of exceeding 2°C above pre-industrial levels.[17] The model is also capable of assuming other global emission pathways, which would imply different carbon budgets and probabilities of temperature increase.

3.3 Baseline emission projections

Baseline emission projections were sourced from the implementation of IPCC SRES AIB scenario in the EVOC model.[18] While the IPCC did not define a central scenario,[15] SRES AIB scenario is often used as a 'business as usual' scenario. The A1B projections are higher than the 'sustainable development' scenario (B1), and lower than the fossil fuel-intensive scenario (A1FI).

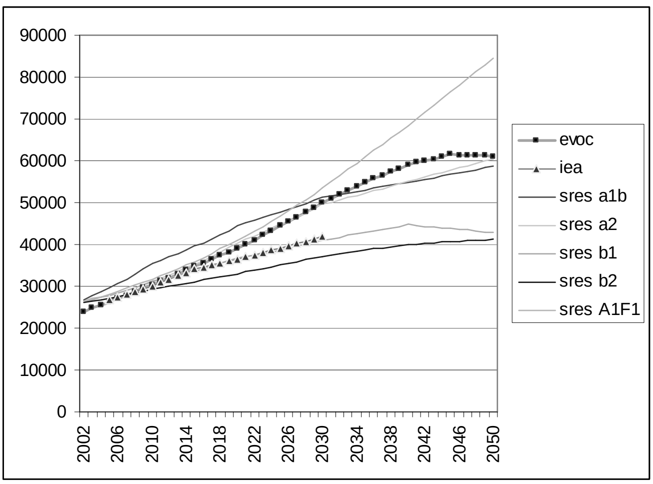

Figure 1: Baseline emission projections based on IPCC SRES, IEA and EVOC Source: Own analysis, based on data from IPCC SRES,[15] IEA and EVOC[18, 19] [CO_2 from energy only]

The baseline disaggregates across Annex I, Least Developed Countries and other non-Annex I countries, as shown in Figure 2.

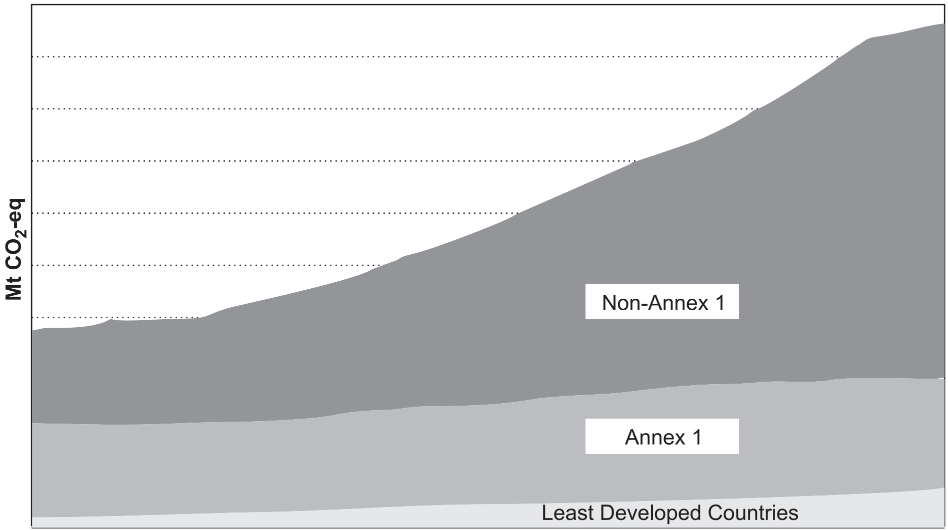

Figure 2: Baseline emissions disaggregated by regions
Source: Own analysis of data as described in text, see data sources of Figure 1

Annex I countries' emissions do not grow significantly. Although emissions from Least Developed Countries (LDCs) do grow, these remain insignificant, and the majority of emissions growth comes from other developing countries.

The model uses LULUCF projections by Houghton, which are higher than alternatives, and approximates historical emissions fairly well globally, although it underestimates non-Annex I emissions slightly, and overestimates Annex I emissions slightly, in the historical period. Global EVOC baseline projections are compared with other projects in Figure 1 below (CO_2 from energy only).

LULUCF baseline projections for Brazil from the EVOC model, however, were very unsatisfactory. They start off at about 2048 MtCO2 in 1990, decrease steeply to about -2300 MtCO2 in 2035 before rising steeply to 4667 in 2050. Emission estimates and baselines obtained from the Brazilian National plan on Climate Change[20] were therefore used in this model instead.

3.4 Carbon budget and required global emission pathway

To enable comparison with chapters written by experts from other countries, we have customised our analysis to a set of standardised parameters, as reflected in Table 2. The global carbon budget mainly enters our modeling framework as the required emission pathway, as outlined in section 3.1.

Table 2: Standardised parameters for analysis by BASIC experts
Source: Parameters agreed at BASIC Expert Forum
Delhi, February 2011 and updated in Zimbali, May 2011

Global budget	Historical 1850 – 1999 1970 – 1999	 965.26 Gt CO_2-eq 574.04 Gt CO_2-eq
	Future (2000-2049)	1440 Gt $CO_{2\text{-eq}}$ (29% to 70% probability of exceeding 2℃)
	Historical starting point	1850, 1970
	Population	Static – population for 2000
	LULUCF	not included[2]
	Financial transfer	estimates made, assuming carbon price of $20/t $CO_{2\text{-eq}}$ and $50 (both reported)

The main additional parameters which are assumed and particular to this chapter are the three indicators and their specification (see section 2 above).

3.5 Allocating a fair share of mitigation effort for each country

To determine each country's fair share of effort, the combined responsibility-capability indicator (still expressed in per capita terms) is first multiplied by the country's population, and divided by the global population to calculate the share of the total mitigation burden for that country.

The share of mitigation burden for country *c*, m_{c_y}, for the year *y* can thus be represented as follows:

$$m_{c_y} = \frac{\left(\frac{P_c^{2000}}{\sum_c^C P_c^{2000}} * RCI_c\right)}{\sum_c^C \left(\frac{P_c^{2000}}{\sum_c^C P_c^{2000}} * RCI_c\right)} * M_y$$

3.6 Calculating the remaining emission space for the country

In this approach, the sharing of the resource (the remaining emission budget) is derived from the share of effort (in the previous section, 3.5). The remaining emission space for that country is calculated by deducting the mitigation burden for each country from the

2 In the WRI-CAIT database, the data for Land Use Change and Forest (LUCF) is only from 1990~2005. Houghton (2008) estimated LUCF emissions from 1850 to 2005, but he did not give specific emission for each country. Therefore, his numbers cannot be used for analysis here.

country's baseline, the remainder for the period. The 'burden' can be thought of as effort required.

The carbon space, s_{c_y}, for that year is just the difference between the baseline emissions of that country and its mitigation burden:

$$s_{c_y} = b_{c_y} - m_{c_y}$$

The country's total emission space until 2049 is simply the sum over the period 2000-2049.

4. Results

The first result from the model is the mitigation effort or burden required of each country, applying the principles, criteria and approach described in this chapter.

Table 3 shows the results for the BASIC countries individually and as a group, and the totals non-Annex I and Annex I countries.

Table 3: Mitigation burden according to South African approach (Gt CO_2-eq over period 2000-2049)

	Starting year: 1850		*Starting year: 1970*	
	with LULUCF	*without LULUCF*	*with LULUCF*	*without LULUCF*
Brazil	78	25	86	31
China	162	137	179	172
India	40	42	47	49
South Africa	13	15	14	17
∑BASIC	293	220	326	270
Non-Annex I	650	446	746	545
Annex I	1267	1470	1169	1370

Table 3 illustrates what equity means in the aspect that developed countries 'should take the lead' (Article 3.1)[12] – based on the approach and analysis in this chapter, Annex I must continue to make the greater effort for the first half of the 21st century. Regardless of the starting year or source, the mitigation burden calculated by our model – taking into account responsibility, capability and sustainable development – is significantly greater for Annex I than non-Annex I countries.

In that context, sharing the effort among developing countries is a secondary question. Figure 3 illustrates implications for the BASIC countries – clearly the choice of starting year and source matters for the countries concerned.

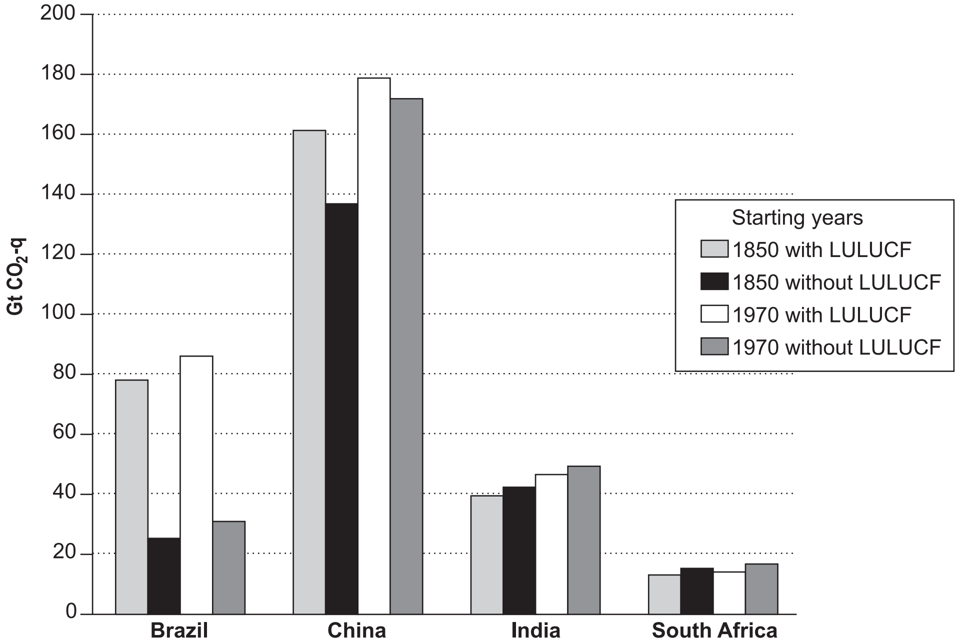

Figure 3: Mitigation effort for BASIC countries over first half of 21st century

The remaining carbon budget for each of the BASIC countries (and the same groups as in Table 3) can be derived by deducting the mitigation burden from the baseline missions for the country. This is reported in Table 4.

Table 4: Resulting carbon budgets in South African approach (Gt CO_2-eq)

	Starting year: 1850		*Starting year: 1970*	
	with LULUCF	*without LULUCF*	*with LULUCF*	*without LULUCF*
Brazil	60	113	52	107
China	374	399	357	364
India	238	236	231	229
South Africa	32	29	31	28
∑BASIC	704	777	671	727
Non-Annex I	1,713	1,917	1,616	1,817
Annex I	-270	-474	-173	-374

The results shown in Table 4 are shown, for the BASIC countries only, in Figure 4. The graph makes clearer the implication of including emissions from different sources. For Brazil, the inclusion of LULUCF means a significantly smaller remaining budget. This is a result that would have been expected; that additional space for China is perhaps not as obvious. In terms of the different starting years assumed, the remaining budgets are larger for all BASIC countries for the earlier year.

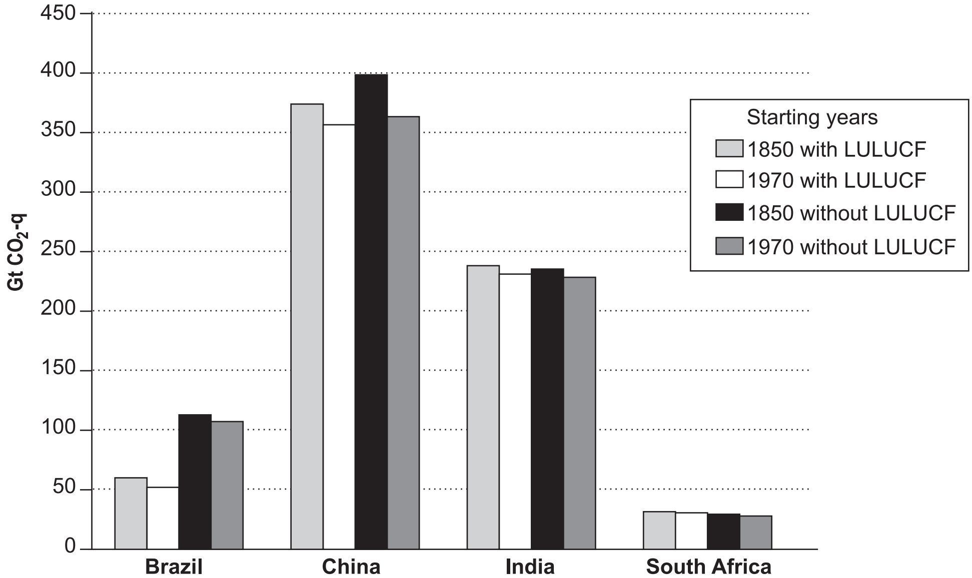

Figure 4: Remaining emission budgets for different starting years and sources

5. Implications for support by developed countries for developing countries

Equity is a matter not only of physical emissions space, but also of time for developing countries to make a transition to more sustainable development paths. The operational implication of 'time for development' is the provision of means of implementation by developed countries to developing countries. An initial analysis of support in the form of finance is derived as follows.

Annex I countries as a group have an emissions budget that is requires more than 100% of their emissions to be reduced. This is the 'required mitigation' line in Figure 5 below, which is the mitigation burden from our model for Annex I as a group. In physical terms, this is not possible; but considering finance, this can be achieved.[13] Any portion of the emissions budget that is negative would *have* to be purchased by paying for mitigation in other countries – in this analysis of Annex I countries, the other group are non-Annex I countries.

In addition, we assume that rates of emission reduction beyond 6% *per annum* are very costly to achieve, and that Annex I countries will prefer to purchase credits for this area as well – the entire reddish area in Figure 5. The area of domestic reduction is shown by the green area, illustrating the very large gap between what 6% rates of reduction and what is required of Annex I countries as a fair share. This physical approach can be translated into finance required by assuming carbon prices.

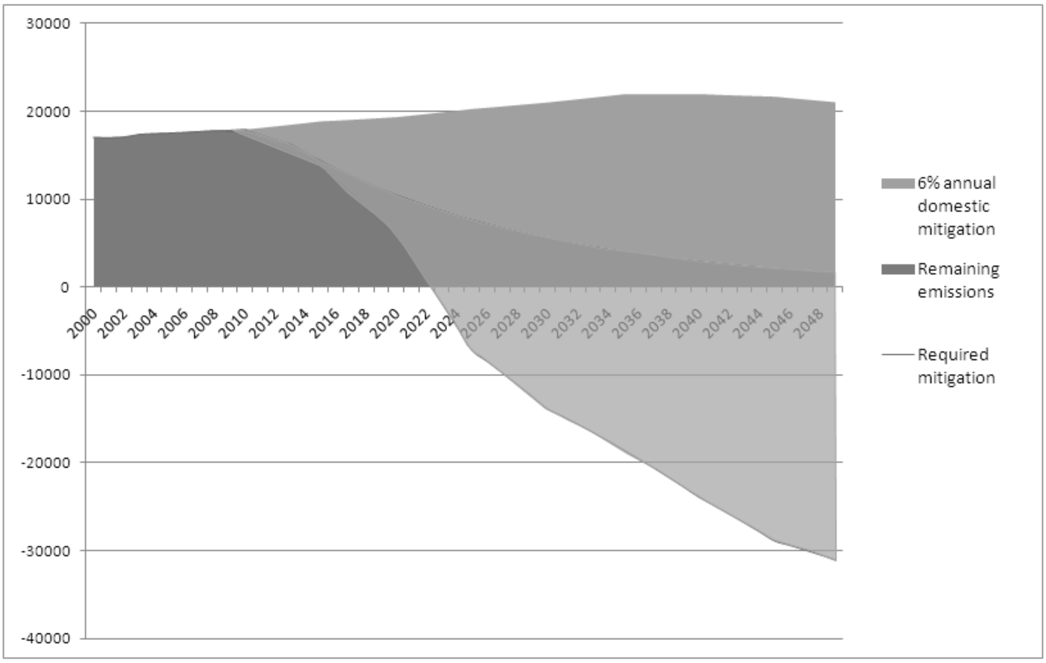

Figure 5: Gap between Annex I mitigation burden and assumed maximum annual reductions

Table 5: Annex I financial transfers (billion US$)

Assumed carbon price	*Starting year and sources*	*Average*	*Max*
20$/ton	1850 with LULUCF	268	656
	1850 no LULUCF	345	823
	1970 with LULUCF	231	576
	1970 no LULUCF	307	741
50$/ton	1850 with LULUCF	669	1,639
	1850 no LULUCF	861	2,058
	1970 with LULUCF	578	1,440
	1970 no LULUCF	767	1,852

Table 5 includes results for $ 20 and $50 per ton of CO_2-eq. The results scale linearly with the assumed carbon price. A higher finance requirement for Annex I results from an earlier starting year and from the exclusion of LULUCF. The average finance requirement ranges from a minimum of $ 231 billion per year (average at $20 / t CO_2-eq, starting year 1970 and including LULUCF), and a maximum of $ 2 058 billion per year (maximum at $50 / t CO_2-eq, 1850 and no LULUCF). The maximum required in any given year significantly exceed the average.

References

1. H. Winkler, R. Spalding-Fecher, L. Tyani (2001). What could potential carbon emissions allocation schemes and targets mean for South Africa? Energy & Development Research Centre, University of Cape Town, 2001.
2. H. Winkler, R. Spalding-Fecher, L. Tyani (2002). Comparing developing countries under potential carbon allocation schemes. *Climate Policy* 2, 303-318.
3. H. Winkler, R. Spalding-Fecher, S. Mwakasonda, O. Davidson (2002). Sustainable development policies and measures: starting from development to tackle climate change Energy & Development Research Centre, University of Cape Town, 2002.
4. H. E. Ott et al. (2004). South-North dialogue on equity in the greenhouse. A proposal for an adequate and equitable global climate agreement. Gesellschaft für Technische Zusammenarbeit, 2004.
5. H. Winkler, B. Brouns, S. Kartha (2006). Future mitigation commitments: Differentiating among non-Annex I countries. *Climate Policy* 5, 469-486.
6. M. Den Elzen, N. Höhne, B. Brouns, H. Winkler, H. E. Ott (2007). Differentiation of countries' future commitments in the global climate regime. An assessment of the 'South–North Dialogue' Proposal. *Environmental Science and Policy* 10, 185 – 203.
7. H. Winkler, S. Vorster, A. Marquard (2009). Who picks up the remainder? Mitigation in developed and developing countries. *Climate Policy* 9, 634–651.
8. H. Winkler, A. Marquard (2009). Changing development paths: From an energy-intensive to low-carbon economy in South Africa. *Climate and Development* 1, 47-65.
9. H. Winkler, A. Marquard, T. Letete (2009). Analysis of possible quantified emission reduction commitments by individual Annex I Parties. Energy Research Centre, University of Cape Town, 2009.
10. H. Winkler, 2010 An architecture for long-term climate change: North-South cooperation based on equity and common but differentiated responsibilities. In F. Biermann, P. Pattberg, F. Zelli, (eds) *Global climate governance beyond 2012: Architecture, agency and adaptation*. pp. 97-115. Cambridge University Press.
11. A. Agarwal, S. Narain (1991). Global warming in an unequal world: A case of environmental colonialism. Center for Science and Environment, 1991.
12. UNFCCC (1992) United Nations Framework Convention on Climate Change. United Nations, New York.
13. P. Baer, T. Athanasiou, S. Kartha (2007). The greenhouse development rights framework: Rationales, mechanisms, and initial calculations. EcoEquity & Christian Aid, 2007.
14. WRI (2003) Climate Analysis Indicators Tool (CAIT). Washington DC; WRI (2005) Climate Analysis Indicators Tool (CAIT), version 3.0. Washington DC.
15. IPCC (2000) *Special Report on Emissions Scenarios*. A special report of Working Group III of the IPCC. Cambridge University Press.

16. Government of Brazil (2008) National Plan on Climate Change in Development of Scenarios for the evolution of emissions of Greenhouse effect gases in Brazil. E. La Rovere, Ed. Centro Clima, UFRJ, Rio de Janeiro.
17. M. Meinshausen et al. (2009). Greenhouse gas emission targets for limiting global warming to 2°C *Nature Letters* 265-279.
18. N. Höhne, D. Phylipsen, S. Moltmann (2006). Factors underpinning future action Ecofys, 2006.
19. N. Höhne, C. Galleguillos, K. Blok, J. Harnisch, D. Phylipsen (2003). Evolution of commitments under the UNFCCC: Involving newly industrialized economies and developing countries Federal Environmental Agency (Umweltbundesamt), 2003.
20. Brazil (2008). National Plan on Climate Change: Executive Summary. Decree No. 6263 of November 21, 2007 Government of Brazil, Interministerial Committee on Climate Change, 2008.