DEVELOPING PERSPECTIVES ON CLIMATE CHANGE

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The Brazilian Proposal and its Scientific and Methodological Aspects

Working Draft

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Published by the International Institute for Sustainable Development

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This publication was made possible through support provided by the Bureau for Economic Growth, Agriculture and Trade, Office of Environment and Science Policy, Climate Change Team, U.S. Agency International Development, under the terms of Grant No. GEW-G-00-01-00013-00. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the U.S. Agency for International Development or IISD.

The Brazilian Proposal and its Scientific and Methodological Aspects

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Introduction

During the negotiations of the Kyoto Protocol in 1997, Brazil's delegation made a proposal for distributing the burden of emission reductions among Parties included in Annex I to the United Nations Framework Convention on Climate Change (UNFCCC). The proposal suggested that reductions towards an overall emissions ceiling for all Annex I Parties were to be shared among individual Annex I Parties proportional to their relative share of responsibility for climate change. The proposal suggested the use of an agreed upon simple climate model for estimating the temperature increase resulting from emissions of different countries. The scientific and methodological aspects of the proposal were questioned and the Kyoto Protocol was designed using the emissions of the year 1990 to share the responsibilities among the Annex I Parties to the Convention.

However, the Brazilian Proposal is a unique option for international burden-sharing being carried out by the UNFCCC officially.[1] At the moment, the international community is starting to discuss the next commitment period of the Kyoto Protocol and the proposal by Brazil can help the discussions on the share of responsibility.

The Brazilian Proposal (BP) presents a different option for sharing responsibilities among countries related to the climate change issue due to anthropogenic activities, shifting the focus of the debate from the emissions to the temperature increase.[2] The main aspects of the Brazilian Proposal (2000) are:

1. to consider the existent process between the emission of a greenhouse gas and the consequent effects in the climate change, such as the temperature increase in the earth's atmosphere. For that, it is necessary to measure the emissions, taking into account that greenhouse gases have different lifetimes.[3] Another important point foreseen by the BP is that emissions present different climate responses at different times. The responsibility related to a temperature elevation in the present needs to be associated to respective emissions in the past for each gas evaluated; and
2. to force the countries that do not accomplish their commitments to pay a tax for a Clean Development Fund. It was foreseen that the Fund could be used for projects in developing countries to promote greenhouse gas emissions reductions programs.

In this paper we highlight the newest methodological and scientific aspects of the proposal by Brazil that are being discussed in scientific and political spheres and should be agreed to by international adoption of the Brazilian Proposal.

The Brazilian Proposal (BP)

The contents of the Brazilian Proposal

In the Brazilian Proposal, the criterion for the burden-sharing among those Parties should be measured by the increase in the global mean surface temperature, since the emissions in a particular year, 1990 for example, do not reflect the true contribution of a country to global climate change, which is related to cumulative emissions of greenhouse gases. The proposal by Brazil aims at sharing equally the burden of mitigation, accounting for the past contribution for the global warming.

The proposal suggested that reductions towards an overall emissions ceiling for all Annex I Parties (30 per cent below 1990 levels by the year 2020) were to be shared among individual Annex I Parties proportional to their relative share of responsibility for climate change. "The principle of the common but differentiated responsibilities, between Annex I and non-Annex I Parties, arises from the acknowledgement by the Convention that the largest share of historical and current global emissions of greenhouse gas originated in the developed countries" (UNFCCC, 1997).

However, the Brazilian Proposal may also provide a framework for discussion between Annex I and non-Annex I countries on future participation of all countries in emission reductions.

Because of data availability, the original Brazilian Proposal presented an approach for distributing the burden of emission reductions among Annex I Parties based on the effect of cumulative historical CO_2 emissions from the energy sector and cement production from 1840 on the global average surface temperature.

The original proposal also contained a penalty mechanism called the "Clean Development Fund" which was to be sustained by requiring non-complying Annex I Parties to pay US$10 for every tonne of carbon above the target. The money was to be used to fund projects in non-Annex I countries. The distribution of funds was originally proposed to be proportional to the impact of the non-Annex I Party on the global-average surface temperature.

The Brazilian Proposal was not used in the Kyoto Protocol, but it has inspired new issues: the Clean Development Fund has motivated the Clean Development Mechanism and the focus on temperature increase (replacing the emissions focus) has influenced the development of new climate change models.

Frequently, the SBSTA promotes workshops and reports about the methodological and scientific aspects of the Brazilian Proposal and evaluates the necessity of the continuity of its supervision under the SBSTA. Since 1997, the methodological and scientific aspects of the proposal by Brazil have been reviewed under the supervision of the (SBSTA). At present, the SBSTA is conducting a methodological and scientific assessment of contributions to climate

Figure 1. The synthesis of the Brazilian Proposal for sharing of the burden of mitigation among the Annex I Parties and the UNFCCC process.

Historical line summarizes the evolution of the proposal by Brazil in the period of 1995–2001.

1995

- The Berlin Mandate was written and it was established the Ad-hoc Working Group on the Berlin Mandate – AGBM.

1997

- Proposed elements of a protocol to the UNFCCC: presented by Brazil in response to the Berlin Mandate.
- The proposal by Brazil was referred to the Subsidiary Body for Scientific and Technological Advice (SBSTA) for its advice regarding the methodological and scientific aspects.

1998

- During COP-4, the first workshop was organized regarding the proposal.

1999

- The expert meeting held in Cachoeira Paulista concluded the existence of sufficient scientific and technical basis for operating the Brazilian Proposal.

2000

- In January 2000, the Brazil Delegation launched the review of his proposal. The secretariat distributed a letter to all Parties asking for further nomination to the roster of experts.
- The secretariat host the Web page http://unfccc.int/issues/ccc.html

2001

- The expert meeting in Bonn on the review of the scientific and methodological aspects of the proposal by Brazil (UNFCCC, 2001a).
- All Parties, especially those not included in Annex I to the Convention, are requested to nominate further experts to the UNFCCC roster of experts.

change, while the issue was in the past discussed under the heading "Scientific and methodological aspects of the Brazilian proposal."

In the next sub-chapter we will compose a historical view of the official documents of the UNFCCC related to the proposal by Brazil. There are many official documents in the UNFCCC Web site referring to the Brazilian proposal. There is also a dedicated site about the Brazilian Proposal in the UNFCCC's Web site (http://unfccc.int/issues/ccc.html).

In the workshop organized in 1998, during COP-4, it was suggested: (i) that the contribution of emissions to the rate of global mean surface temperature increase and global mean sea level rise be used as indicator of contribution; and (ii) to consider all anthropogenic sources of greenhouse gases, since the calculations presented in the Brazil Proposal were based on fossil CO_2 emissions using a linear model. It was acknowledged that the original methodology contained certain shortcomings and was not valid outside its time domain of 1990–2020.

The expert meeting of Cachoeira Paulista (1999) documented that temperature increase is not the only unique climate change indicator and acknowledged the existence of non-linearities involved in the translation from concentration to radiative forcing. During COP-5, the Brazil delegation was commended for its work on the subject regarding the workshop organized by Brazil and the revised version of the methodology proposed. It was noted that the IPCC Third Assessment Report (TAR-WGI, 2001) is likely to contain the best available information related to the values of the parameters and other material relevant to the assessment of the proposal and that the need for further scientific analyses could contribute to future discussions on global burden-sharing issues.

In 2002, the secretariat organized an expert meeting September 25–27, 2002, held at Bracknell, U.K. (UNFCCC, 2002a) to assess the preliminary results provided by the participating research institutions to encourage cooperation between developing and developed country scientists and to identify next steps, including future analysis. The results of this meeting are the newest consensus of the scientific community and will be discussed in this paper. The IVIG presented the results of the project Historical Contribution by Country of Three Greenhouse Gases (CO_2, CH_4, and N_2O) to climate change. It was very well received.

In the SBSTA 17, during the Eighth Conference of the Parties—COP-8 (New Deli, October–November 2002)—the Brazilian delegation negotiated with all delegations the maintenance of the methodological and scientific aspects of the proposal by Brazil under the supervision of the SBSTA (UNFCCC, 2002b). The IVIG/COPPE/UFRJ was supporting the Brazilian delegation on this issue. The Saudi Arabian delegation strongly opposed the issue because efforts to control the consumption of fossil fuel are not interesting to their economy. China and India opposed serenely, because they were reticent about its implications. The European Union, United States of America, Canada, Australia and New Zealand were favourable to the continuity of the Brazilian Proposal because their scientists are working on this issue.

The main conclusions of SBSTA 17 are that the scientific and methodological aspects of the proposal by Brazil should be improved in the robustness of the preliminary results and it should be explored in terms of uncertainty and sensitivity of the results to different assumptions. It was noted that, for the purpose of validating the models against observed climate, the analysis should also include factors influencing global climate other than the greenhouse gases covered by the convention and the Kyoto Protocol (UNFCCC, 2002b).

The methodological and scientific aspects

There are two main issues related to the Brazilian Proposal (BP): the scientific and the methodological issues. The scientific issues are related to aspects like robust tools, data and models, and the methodological issues are related to indicators for contributions to global warming, non-linearities and feedbacks, and attribution dates, among others. In the expert meeting held in Cachoeira Paulista in 1999, it was concluded that there was sufficient scientific and technical basis for operating the Brazilian Proposal.

Some authors (Elzen *et al.* 1999) have made a critical analysis of the two versions of the Brazilian Proposal from scientific and methodological points of view. Related to the first version (UNFCCC, 1997) of BP, there are three very important observations about Brazilian Proposal:

1. the study claims for the inclusion of other two greenhouse gases, N_2O and CH_4, as BP calculates only the CO_2 emissions due to the energy sector;

2. the study also claims for the inclusion of land use change and forestry sectors and its contribution to global warming, as BP calculates only emissions from fossil fuel; and

3. the study considers it an error to suggest that there is a long time delay between the contribution to CO_2 concentrations and temperature increase, showing that other models disagree with it.

The BP authors' arguments to the first two points can be clarified by the following affirmation: "Different greenhouse gases can be included, with their respective constants of proportionality between temperature (or sea level rise) and the accumulation of concentrations, and their individual effects added in terms of the resulting change in temperature or sea level rise over the period considered" (UNFCCC, 1997).

Related to this question, there is a study by Rosa *et al*. (see http://unfccc.int/issues/ccc.html) with the objective of showing the robustness of the BP in this respect. It is an exercise using different parameters in a same climate response model to compare the results in terms of time delay.

Other themes discussed by the authors are the transfer of "energy-efficient" technology from developed to developing countries; the starting year for calculating emissions; and the technical uncertainties related to estimating land use changes, carbon content of biomass and terrestrial dynamics. Nevertheless, it seems that in fact, the three first issues represent, even after the second version of BP with revision (2000), the most important ones in respect to decision-making implications.

The expert meeting held in Bracknell, U.K., September 25–27, 2002, had some important results in terms of scientific and methodological issues. Besides, new suggestions for different targets arose to be implemented in the next steps of the research. The main issues discussed and organized in a document (UNFCCC, 2002a) are listed below: "Indicators," "Non-linearities and feedbacks," "Databases," "Methods of attribution," "Variation of attribution start and end dates," "Evaluation data," "Other forcing: aerosols and ozone precursors," "Different scenarios" and "Display of results." The most important issues for the scope of the present work involve the inclusion of aerosols and some GEE precursor emissions in the climate response effects, the creation of strong historical data surveys in terms of gas emissions and the importance of making efforts to make climate change indicators easier to be dealt with by policy-makers and non-specialists. We will comment on the indicators, non-linearities and the databases in the following sections due to their fundamental importance.

Indicators

Indicators are used in the contribution to climate change to measure the impact of each nation on global warming. An ideal indicator should be close to impacts, understandable and certain. The Brazilian Proposal defends "temperature increase" as the best indicator to understand climate change because "the obvious choice of a variable to measure climate change is the change in global mean surface temperature," since other global variables such as the time rate of change of the global mean surface temperature and the rise in mean sea level are derived from the change in global mean surface temperature (UNFCCC, 1997). The nature of such changes and the implications and usefulness as criteria for burden-sharing need to (i) closely resemble the impacts of climate change; (ii) be understandable to scientists as well as the public; (iii) have certainty and robustness in the calculation of the indicator[4]; and (iv) be discounted retroactively to not give less "weight" to emissions that occurred a long time ago.[5]

Some important climate change indicators identified by the experts in the Bracknell meeting were analyzed in terms of usefulness for policy-makers: emissions, concentration, radiative forcing, temperature increase and sea level rise. Nevertheless, different indicators will result in different attributions (UNFCCC, 2001a), as the adoption of annual emissions of the Kyoto Protocol.[6] Sea level rise, an indicator of climate change of considerable interest to many coastal countries, is closely related to change in average global temperatures, but not all countries are impacted by the sea level rise, while the temperature increase affects all. The most important indicators are listed below (UNFCCC, 2002a):

Cumulative emissions: The sum of annual emissions from a source between a start and an end date. This indicator can only be applied for one greenhouse gas at a time. Effects of several gases cannot be compared.

Concentrations: The effect of all emissions between a start and an end date on concentrations of the greenhouse gases in the atmosphere at the end date. This

indicator can only be applied for one greenhouse gas at a time. Effects of several gases cannot be compared.

Integrated past concentrations with climate response: Integrating the increased concentrations due to emissions from a start date to an end date. This indicator was used in the calculations that accompanied the original Brazilian proposal. (The revised proposal by Brazilian calculates temperature increase, rate of temperature increase and sea level rise.) It is the first proxy for the temperature increase. This indicator can also only be applied for one greenhouse gas at a time. Effects of several gases cannot be compared.

Radiative forcing (due to increased concentrations): The radiative forcing due to the increased concentrations at the end date. The effects of different gases can be combined with this indicator.

Integrated past radiative forcing: Integrating the radiative forcing due to increased concentrations from a start date to an end date. This indicator is very similar to integrated past concentrations with climate response. It can be used to combine the effects of all gases.

Integrated future radiative forcing: The radiative forcing due to the concentrations integrated from when emissions end to a future date. It applies the concept of global warming potentials (GWPs) to concentrations (instead of applying it to pulse emissions), taking explicitly into account the unrealized effects that will occur in the future after the gases have been emitted.

Temperature increase: The increase in global-average surface temperature due to emissions. The calculation takes into account the effect of emissions between a start and an end date on concentrations and on radiative forcing.

Rate of temperature change: The rate of temperature change calculated as the derivative of the temperature increase.

Sea level rise: The processes of thermal expansion of water and melting of ice. Because sea levels increase very slowly (in the order of thousands of years), the effects seen today may be small compared to those that will occur in the future, even if emissions stop.

There is a "trade-off" among indicators. On the one hand, the indicator should be as close as possible to the actual impacts of climate change as possible, i.e., damages. It should, therefore, be further down the cause-effect chain. On the other hand, it should be calculated with certainty and, therefore, be at the beginning of the cause-effect chain. Table 1 lists the indicators and their characteristics as assessed by Bracknell expert meeting.

The main conclusions about indicators of the expert meeting of Bracknell are that (i) the indicators from concentrations onwards do not include the effects of the emissions that will occur after the emission, since greenhouse gases stay in the atmosphere after they have been emitted for a period of time, the gases contribute to increased concentrations, radiative forcing,

Table 1. Indicators for attribution to climate change and their characteristics.

Indicator	Close to impacts	Understandable	Certain	Backward discounting
Cumulative emissions	-	4	3[7]	-
Concentrations	1	4	2.5	3
Integrated concentrations with climate response	1.5	-	2.5	2
Radiative forcing (due to increased concentrations)	2	2	2	3
Integrated past radiative forcing	3	-	2	2
Integrated future radiative forcing	3.5	-	2	3
Temperature increase	4	4	1.5	2
Rate of temperature change	4	2[8]	1	?
Sea level rise	4	4	0.5	1

Source: UNFCCC, 2002a.

increased temperatures and sea level rise depending on their particular removal processes; (ii) it is possible to combine various indicators into composite indicators in order to resemble more closely actual damages, but no one was suggested; (iii) the experts only considered indicators evaluated at the global scale, regional indicators also could be defined, but such calculation would be extremely complex and more uncertain (UNFCCC, 2002a).

Non-linearities and feedbacks

Several processes in the climate system are non-linear and include feedbacks. Consequently, the sum of the effects of emissions from individual regions is not equal to the effect of all emissions together. Some non-linearities occur, for example, in the carbon cycle, the atmospheric chemistry, the relationship between concentration of CO_2 and radiative forcing, the relationship between radiative forcing and temperature increase and the relation between temperature increase and sea level rise.

Feedback processes will lead to non-linearities when the feedback is strong. Even when the feedbacks behave linearly, they introduce the same methodological challenge as non-linearities. The experts felt that at this stage it is difficult to determine the relative significance of the non-linearities and feedbacks for the attribution calculation.

Due to the non-linearities and the feedbacks, it can be observed the following aspects (UNFCCC, 2002a):

- Emissions at different points in time will have different effects. For example, because of the non-linearity in the calculation of radiative forcing from concentrations, the additional radiative forcing due to additional CO_2 concentration is a quarter lower today (due to higher CO_2 concentrations) than it was at the beginning of industrialization (when the CO_2 concentration was lower).
- The effect of emissions of individual sources may depend on emissions of other sources. For example, the effect of CO_2 emissions from land-use change by fires is different from combustion of fossil fuel, due to the cooling effect of particulate matter.

These issues were also discussed in the expert meeting held in Cachoeira Paulista, Brazil, 1999 (den Elzen, 1999a). The original Brazilian proposal and some participating experts used simplified linear models. The representation of the climate system is less realistic, yet the attribution is simple, because emissions at each point in time are considered as having the same effect. After that meeting, there was a revision of the BP in which the period taken into account was reduced to solve this problem. In general, on short time scales, linear models are more reliable than on longer time scales.[9]

All models confront the same difficult of the uncertainties and non-linearities. It should be commended here the CICERO – Norway; CSIRO – Australia; DEA-CCAT – Denmark; ECOFYS – Germany; Hadley Center – United Kingdom; GRAPE and RITE – Japan; LBNL, UIUC and ISAM – United States of America, RIVM – the Netherlands and NIWA – New Zealand. There are two models in Brazil, the first one is the Brazilian Proposal itself and the other is the integrated past emission with climate response being conducted by the IVIG/COPPE/UFRJ.

Databases

According to the expert meeting held in Cachoeira Paulista, it is acknowledged that there are problems with the quantity and quality of data for global and particularly country level emissions (den Elzen, 1999a). Not all emissions data are on a country or regional basis and a scaling procedure is required to scale these emissions data towards emissions on the required aggregation level for the final analysis. Special attention is needed for possible inconsistencies between the historical data, and the present Intergovernmental Panel on Climate Change—IPCC emission estimate and emissions scenarios. The IVIG/COPPE/UFRJ is developing a research on this subject.

Besides, some experts emphasize the importance of making aerosols and ozone precursors database surveys. Aerosols (such as sulphates and carbonaceous material) and ozone precursors (CO, NO_x, non-methane volatile organic compounds—NMVOCs) have certain characteristics that are different from those of the greenhouse gases included in the Kyoto Protocol. Some aerosols can have a cooling effect (such as sulphate), others (such as black carbon) and ozone precursors contribute to a warming effect. Ozone precursors also have an effect on the lifetime of the greenhouse gas methane. Aerosols are not covered under the Convention or the Kyoto Protocol.

However, aerosols can be included in simple climate models to verify the historical record, as the last SBSTA decision established (UNFCCC, 2002b). Aerosols influence the attribution calculation. In some test cases, when the cooling effects are considered, the results changed significantly. Cooling effects introduce methodological challenges in comparing positive and negative contributions to radiative forcing and temperature change.

Related to historical CO_2 anthropogenic emissions for the energy sector (fossil fuels and cement production) there are the following databases sources: CDIAC-ORNL, RIVM and IISA. For the land-use sources there are: RIVM, IVIG, CDIAC-ORNL, IISA, Woodshole Research Center and EPA. For the historical anthropogenic CH_4 and N_2O emissions, the existent databases are: RIVM, IVIG and IIASA, and for the halocarbon emissions there are the following databases: RIVM and AFEAS.

Conclusions and suggestions

The annual emissions are not a measure of climate change and this explains the international attention about the scientific and methodological aspects of the proposal by Brazil to distribute the burden of the emission reductions.

Since the parties are presumed to have control over their annual emissions and one of the Convention requirement is that Parties report their annual emissions, given to a natural tendency to compare the annual emissions of Parties and thus implicitly to associate the emissions to the relative responsibilities in inducing the climate change (UNFCCC, 1997), we suggest that the Convention induces the Parties to report their historical emissions and the IPCC to develop methodologies to guide it. It will be necessary to evaluate the capacity of the countries to inventory their emissions related to the past as much as to foresee future emissions. Although such a proposition involves targets not easily achieved, mainly for the developing countries. The RIVM, CDIAC-ORNL, IISA, Woodshole Research Center and AFEAS are good example of the possibility of it. The IPCC Guidelines for National Greenhouse Gas Inventories is also the first step in this way.

It is important to note that the Brazilian Proposal doesn't necessarily deal with the past in the theoretical point of view. The word "historical" can be applied to a certain period of time. The choice of the starting date implies in different share of responsibilities between Annex I and non-Annex I Parties to the Convention.

It is important to evaluate whether the approach of the Brazilian Proposal is compatible with the Kyoto Protocol, what shifts would be required compared to the current Protocol rules and the international negotiation process. On other hand the proposal by Brazil could be shifted to incorporate the efforts done in the Kyoto Protocol, such as the Clean Development Mechanism.

Frequently the SBSTA ask for nominations to the roster of experts for the review of the scientific and methodological aspects of the proposal by Brazil, especially those not included in Annex I to the Climate Convention. Efforts to exchange information between developed and developing countries can be a first step of international acknowledgment.

It was noted by the SBSTA 17 that for validating the models against observed climate, the analysis should also include factors influencing global climate other than the greenhouse gases covered by the Convention and the Kyoto Protocol (UNFCCC, 2002b). The inclusion of other gases not controlled by the UNFCCC involves a complex arrangement. It is necessary to show which ones are really important.

About the differences among the indicators for contribution to climate change, an ideal indicator should be close to impacts, understandable and certain. As exposed in the Table 1, the most adequate indicators are the temperature increase, the rate of temperature change and sea rise level. The Brazilian Proposal deals with the temperature increase and the sea level rise indicators.

To note the consistence of the proposal by Brazil approach facing the Climate Convention principles, the Brazilian Proposal is probably the best one to deal with the "common but differentiated responsibilities and respective capabilities and their social and economic conditions." The Brazilian Proposal contributes to the ultimate objective of the UN Framework Convention on Climate Change, once it involves a long-term approach. The security of future generations in a sustainable development focus can be linked to the proposal by Brazil.

Endnotes

1 Others approaches can be find in the literature, like the "Grandfathered Proposal" based on a hybrid per capita accountability; the "WRI's carbon-intensity related proposal"; the "Argentine proposal for index-linking targets to GDP"; the "Triptych Proposal" of University of Utrecht; the "Contraction and Convergence Proposal" of GCI – Global Commons Institute; the "Increasing participation/Multi-stage approach Proposal"; and others.

2 This implied the estimative of greenhouse gases historical emissions prior to 1990. Consequently this information goes beyond the National Communications being carried out at the moment.

3 This is illustrated by the sentences: "In a first approximation, the dependence of the atmospheric concentrations upon the emissions over a given period of time is proportional to the accumulation of the emissions up to the year in question, taking into account that the older the emission the smaller its effect on the concentration, due to the exponential natural decay of the greenhouse gases in the atmosphere with a different lifetime for each gas" (UNFCCC, 1997).

4 Each step further down the cause-effect chain (i.e., from emissions to concentrations or to radiative forcing and so on) introduces additional uncertainty, due to an additional step and non-linearities in the calculation.

5 For example, the concentration of methane today is not influenced by emissions of methane 100 years ago. Because of the short lifetime of methane in the atmosphere, these emissions have decayed almost completely by now. The experts noted that it is uncertain whether such 'backward discounting' reflects the influence of emissions with respect to damages. In addition, "backward discounting" also affects the certainty of the indicator, since information that dates further back is usually more uncertain.

6 It is important to highlight that the parties are presumed to have control over their future annual emissions and the Convention requirement is that Parties report annual emissions, given to a natural tendency to compare the annual emissions of Parties and thus implicitly to associate the emissions to the relative responsibilities in inducing the climate change (UNFCCC, 1997). This is the present approach of the Kyoto Protocol inducing the experts, policy makers and mainly the non-experts a misinterpretation of climate change.

7 The certainty depends on the certainty of the emissions.

8 While the indicator "rate of temperature change" is well understandable, the attribution of positive and negative contributions to the rate of temperature change is more abstract.

9 According to Pinguelli *et al*. (unfccc.int/issues/ccc.html) the variation of the parameters used to simulate the climate response do not change the main conclusion of the Brazilian Proposal, the non-Annex I countries will have the equivalent contribution of Annex I to the global warming after 2070.

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