Climate Change in Brazil

economic, social and regulatory aspects

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Por um Brasil desenvolvido

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Federal Government

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FOREWORD

This book gives continuity to the commitment of the Institute of Applied Economic Research (Ipea) in developing studies and research in the area of climate change, which already rests on a long tradition of reflecting on topics such as: costs and benefits of mitigation and adaptation actions, environmental planning in urban and social environments, international politics, development of instruments for technological advancement and regulation of market instruments, as well as in contributing to the Brazilian delegation on the Climate Convention negotiations. This book is a joint effort of the Department of Sectorial Policies and Studies in Innovation, Regulation and Infrastructure (Diset) and the Department of Regional, Urban and Environmental Policies and Studies (Dirur).

Above all, this publication testifies to the importance of the climate change topic in for the process of formulating public policies and actions. The principal objective is to offer readers a Brazilian publication about policies that address global warming, through analytical texts produced by 40 specialists, many of which participated as Brazilian negotiators at the Conferences of the Parties of the Climate Convention and are members of the Intergovernmental Panel on Climate Change (IPCC). They represent 18 Brazilian institutions among which universities, research centers and ministries of the federal government.

The intention of this book is not to exhaust all topics nor to present academic texts. But rather to offer chapters with analytical rigor that discuss some aspects of the Brazilian and international regulatory frameworks from various perspectives. Thus, this book reaffirms the role of Ipea in the debate on climate change and related public policies, in the national and international arenas. This is yet another demonstration that Ipea is even more devoted to the Brazilian government's efforts of formulating public policies through its ability to coordinate research efforts and its disciplinary and institutional diversity.

Marcio Pochmann
Ipea's President

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We are thankful to the editorial service of Ipea for the efficient and agile work that helped us to compile this book and this edition in English especially.

This book is, however, the result of valuable collaboration of various specialists that generously accepted with great enthusiasm the invitation by Ipea to lend us their knowledge and understanding for the construction of this work. The editors are thankful for the privilege and gratification of working together with these renowned specialists. Without their dedication, this work would not be possible.

For the edition in English, we would like to offer a special thanks to the authors who did not spare any efforts in performing additional reviews of the texts.

We would also like to thank very much GIZ (*Gesellschaft für internationale Zusammenarbeit*) that provided financial resources that enabled the revision of this edition in English.

INTRODUCTION

Current levels of greenhouse gas (GHG) concentrations are already worrying, and scientists predict that the average temperature on the planet could rise between 1.8°C and 4°C by 2100, which would cause drastic alterations to the environment. This prediction was presented in the 4th Evaluation Report of the Intergovernmental Panel on Climate Change (IPCC, 2007), which congregates scientists from all over the world to evaluate climate change.

This scenario of temperature increase would bring elevated intensities of extreme weather events as well as alterations in patterns of rainfall, resulting in greater instances of droughts and flooding. Studies demonstrate that in addition to putting life of large urban populations at risk, climate change can unleash epidemics and plagues, threaten water and energy infrastructures, as well as transport systems. Agriculture would also be severely affected, especially in regions where water scarcity already persists such as the Brazilian Northeast. Many of these impacts may occur before 2050, with elevated economic effects.[1]

Understanding the nature and dimensions of these impacts is crucial to designing policies that address global warming. Furthermore, it is necessary to analyze the effects of these policies on economic growth in different countries and on income distribution at both domestic and international levels, especially between developed and developing countries.

Minimizing the impacts of climate change requires a global and coordinated effort of mitigation and adaptation actions that demands great commitment from present and future generations in each country. The scope and distrubution of this effort, however, are far from consensual among countries.

As such, it is essential to understand structures of costs and benefits and winners and losers, as well as governance structures that determine, regulate and monitor the implementation of actions to combat global warming.

1 GLOBAL AGREEMENTS

The United Nations Conference on Environment and Development, held in 1992 in Rio de Janeiro (UNCED, or Rio-92), adopted the United Nations Framework Convention on Climate Change (UNFCCC) , or simply 'the convention' as it

1. See for example Stern (2007), for a global analysis, and Margulis, Dubeux e Marcovitch (2010), for an evaluation of the Brazilian case.

will be referred to in this text.[2] This is an international agreement that is already signed by 192 countries, that establishes objectives and rules for combating global warming. The ultimate objective of the convention is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC 1992, Art. 2). On the other hand, the convention admits that negative effects may already be inevitable and predicts that:

> The developed country Parties and other developed Parties included in Annex II shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects (UNFCCC, 1992, Art. 4.4).

As current concentrations of GHG above natural levels are the result of past economic activities, the convention adopted the principle of common but differentiated responsibilities. This principle recognizes that the responsibility of each country is differentiated, in virtue of the contributions of its past emissions to temperature changes on the planet, and that countries have distinct capacities to contribute to the solution of the problem. Thus, the convention established that developed countries should lead the global effort and should therefore assume commitments to limit their emissions and assist more vulnerable countries in their adaptation and mitigation actions.[3] The necessity of guaranteeing economic growth in developing countries was also recognized.

These commitments were only put into practice in 1997, when the Kyoto Protocol (KP) was signed, in which 37 developed countries and countries in transition[4] committed to reduce their emissions by on average 5.2% in relation to 1990 levels. The targets of each country were differentiated, with greater reductions in the European countries, Japan, the United States and Canada.[5]

To increase flexibility of achieving the targets and at the same time minimizing costs and stimulating sustainable development in developing countries, market instruments were created to allow reductions to be realized in other countries, including in those without targets, through markets for emission credits and/or permits.[6]

2. Beyond UNFCCC the Convention to Combat Desertification and the Convention on Biological Diversity were adopted.

3. Vulnerability resulting from very low income levels and/or the magnitude and reach of climate change impacts. There is also an alliance, The Alliance of Small Island States (Aosis), recognized by the convention.

4. Almost all developed countries listed in Annex I of the convention also appear in Annex B of the KP and are thus denominated "Annex I countries".

5. The US did not ratify the Protocol years later.

6. Carbon markets for Annex I countries and the clean development mechanism (CDM) for transactions with countries outside Annex I with the supplementary objective of promoting sustainable development. See Seroa da Motta (2002) for a discussion on the trade offs between this doubble objective.

Though the KP was the beginning of global cooperation, the reduction targets to which rich countries committed are not only insufficient to revert the tendency of increasing concentrations of GHG in the atmosphere, but up to now they are not even being entirely followed.[7]

Furthermore, if countries such as China, India and Brazil continue its growth path and speed they will in the near future have important responsibilities for current global emissions and without their contributions, a rapid and efficient global action will be very difficult.

In December 2009, UNFCCC signatory countries gathered in Copenhagen, Denmark, at the Conference of Parties (COP 15), to implement the objectives approved in 2007 at COP 13 in Bali, the so called Bali Action Plan (BAP), that can be summarized as follows:

- more ambitious commitments and targets for developed countries, that could reach reductions of up to 40% in 2020 and 80% in 2050;
- voluntary contributions, in the form of actions aimed at reducing expected emissions increases in developing countries, that are monitorable, reportable and verifiable (MRV); and
- allocation of resources for developing countries to finance voluntary mitigation actions and assist in adaptation actions.

The results achieved fell short of the stated objectives. A new agreement binding all signatories was not achieved, and instead only the so called "Copenhagen Accord" was signed, in which the commitment to limit the temperature increase to 2°C was ratified and which required signatories to confirm their unilateral commitment proposals announced during the conference.[8] Some developed countries assumed more ambitious commitments and targets than those of the Kyoto Protocol, without however accepting its immediate renewal.

Developed countries partially followed the structure of the KP and adopted percentage reduction targets in relation to a base year, which tended to vary in ambition levels, but almost always with bolder objectives only in the case of a global agreement binding the participation of all the large emitters.

Developing countries, in contrast, adopted commitments in the form of deviations from emission trends. In an attempt to ensure flexible future emissions, China and India adopted reduction targets related to the carbon dioxide intensity (CO_2) of the gross domestic product (GDP).

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7. Considering that the first commitment period of KP expires in 2012, only European Union countries, as a whole, are fulfilling their targets.
8. This Accord was not legally binding within the UNFCCC, but rather a political commitment among signatory countries.

These countries presented their voluntary commitments in the form of nationally appropriate mitigation actions (NAMAS), with the objective of reducing emissions in 2020 in relation to a trend scenario up to this year. For the effective implementation of these commitments, developed countries should provide technological, financial and training support.

Brazil, for example, confirmed in the Copenhagen Accord and COP 16 in Cancun, its commitment to national voluntary actions to reduce GHG emissions, with reductions between 36.1% and 38.9% comparing to estimated emissions by 2020. This commitment was ratified in the National Policy on Climate Change (PNMC).[9]

At COP 15, there were also some advances related to directives on the mechanism for Reducing Emissions from Deforestation and Forest Degradation (REDD), with the conservation of carbon stocks as principal focus.

However, the lack of definition of sources and rules for financing, verification and registration of NAMAS and for technology transfer at Copenhagen, greatly frustrated those countries that believed that COP 15 would be the beginning of a new era in combatting global warming.

COP 16 in Cancun, yet again was unable to reach a new legally binding global accord, though it was possible to advance the content of the Copenhagen Accord by bringing its objectives and principles to the official convention text. In objective terms, some important decisions were reached, such as: overcoming certain barriers in the MRV directives; detail REDD concepts and strategies; advance in negotiations on financing with the creation of the Green Climate Fund, among others; establish continuity of the work to renew the Kyoto Protocol; and in terms of adaptation, to advance the Cancun Adaptation Framework, the Adaptation Committee and a working program on losses and damages.

2 THE TRAGEDY OF THE COMMONS[10]

Why such difficulty in constructing a multilateral agreement to combat global warming? If everyone loses, why does everyone not want to cooperate?

First, since the atmosphere is a common resource, user rights are open to everyone. This results in a common action demanding individual costs in exchange for common benefits. Thus, opportunities are created for “free-riding” on the actions of others, where users enjoy the benefits of climate maintenance at

9. Law nº 12.187, December, 2009. In addition to supporting Brazilian positions in multilateral and international discussions on addressing global warming, the PNMC is actually a legal mark for the regulation of mitigation and adaptation actions in the country.

10. The "tragedy of the commons" concept was developed by Hardin (1968), when referring to problems of managing goods with unclear ownership or common to a group of actors with difficulties to organize themselves to optimize the use and preserve continued supply of the resource.

stable levels without incurring any of the costs. If this “free-rider” effect cannot be detained, chances of cooperation are reduced.

Second, although common, the distribution of its benefits is unequal. Consequently, those that gain less expect those with greater benefits to do more. If the distribution of these benefits is uncertain and perceived differently by each actor, yet again chances of cooperation are reduced.

Third, equity problems could arise from the fact that the saturation of the atmosphere results from past individual actions caused by differentiated contributions across countries. If there is disagreement about these differentiated responsibilities, equitable division of efforts becomes difficult, thus also cooperation.

This situation of non-cooperation with disastrous social effects is called “the tragedy of the commons” when individual actions, although rational from the point of view of each one, negatively impact everyone. Refusing to cooperate may seem irrational considering the aggregate result, but if individuals doubt the possibility of cooperation, then the individual cost could be greater than the expected benefits, and hence the strategy with the greatest return for the individual would be to not cooperate. Incentives to escape from these situations include those that enable individuals to perceive a cost-benefit calculus that is more favorable to cooperation.

The UNFCCC deals with a typical “tragedy of the commons” situation. The most efficient solution would be to personalize access rights to environmental resources, to establish more evident and controllable costs and benefits, through for example the definition of national emission targets for each party.

However, the climate change problem is global and thus difficult to personalize. Furthermore, climate impacts will affect each part of the planet in a different and uncertain way. Controlling the sources of emissions on the planet is very costly and in some cases even impossible. Penalizing “free-riders” is even more difficult for reasons of national sovereignty.

Also, it is difficult to arrive at criteria for establishing emission targets acceptable to everyone. The various criteria possible – per country, per capita, considering history since a specific date etc – each results in very different targets.

It should be emphasized that GHG’s remain in the atmosphere for more than 100 years, and as such emissions from the beginning of the past century still affect climate. Furthermore, the countries that industrialized most during this time are those that most contributed to the problem, as recognized by the convention. And less developed countries that emitted with less intensity, are those with fewer resources to cope with climate impacts.

Currently industrialized countries, that are still the greatest contributors to GHG concentrations, tend to diminish their annual emissions and consequently also their future responsibilities. This countries have achieved a mature economy with reasonable well-being, while developing countries still need to considerably amplify the well-being of their still growing populations, which requires more energy consumption, infrastructure and more carbon emissions.

This reality is known to negotiating parties to the convention; nevertheless the incentives identified so far have not proven capable of inducing cooperation. There is consensus about the necessity to avoid a temperature increase above 2ºC, but the contribution of each country to the global effort remains to be determined.

3 THE POLITICAL ECONOMY OF CLIMATE CHANGE

The European Union, like Brazil, has, for historical reasons, constructed growth models based on expensive and renewable energy – in comparison to other countries – and has consequently already entered a low-carbon trajectory, thus demanding that other large polluters contribute equally. Negotiations await moves by the United States and China, the two locomotive nations in the global economy that are also the largest actual absolute emitters of GHG on the planet.

The American economy is intensive in cheap energy and carbon, and a bold limit on emissions could have short term impacts on economic growth; a topic that has divided the country and consequently also the Congress. Even more so currently, given difficulties faced in economic crisis.

In China, that still seeks to urbanize hundreds of million individuals, emissions accompany vertiginous economic growth. Thus, the country faces great difficulties in limiting its emissions in the short term. It is worth mentioning that China's emissions in per capita terms are still about four times less than those of the United States.

The collection among rich countries of approximately US$ 100 billion per year, the minimum required to finance NAMAS and adaptation in poor countries is another element that complicates negotiations. Since some rich countries compete with emerging countries in international trade, there could be a conflicting interest in financing competitors.

Thus, it is very difficult to design a global agreement of quantitative and binding commitments in the traditional sense of centralized governance. Nevertheless, due to pressure from public opinion, some cooperative platform will have to be constructed. This could be polycentric, and not centralized in a single globally binding agreement, offering a diversity of national, regional and local actions in different formats and partnerships – between public and private spheres, with local or regional scopes, or even among sub-sets of countries. These actions would be subject to periodic reevaluations, for continuous adjustments of trajectories (OSTROM, 2009), as is the case of agreements promoted at recent COPs.

4 CLIMATE COMPETITION

The polarization between the United States and China must be resolved in order to facilitate the possibility of any type of agreement with targets adjusted to the 2ºC trajectory. However, despite of the evolution of the convention agreements, these two countries have selected strategies delimited by competition necessities, wether in the creation of trade barriers or in technological competition.

Even though the creation of trade sanctions have not advanced at the recent COPs, some developed countries are already proposing national climate regulation that penalizes the import of products from countries without UNFCCC recognized emission reductions. The justification for these measures is that the penalization of emissions in one country encourages its dislocation to another, where the cost of polluting is smaller. This possibility is referred to as carbon leakage.[11]

Another possibility is for this confrontation to be driven to conquer international markets. The United States retains the greatest stock of human capital on the planet and is the incontestable leader in science and technology. Chins is still constructing its physical capital stock, therefore it has technologically advanced standards. Nevertheless, both have clear policies for energy security in place and the diversification of sources is crucial for that.

Recent studies imply that the United States leads the development of low-carbon technologies and that China presented the highest growth in patents of these technologies in the past decade. This knowledge is translated into leading projects in wind and solar energy, and in methane destruction.[12]

In other words, taking effective actions to avoid dangerous climate change is no longer a demand from public opinion only, but world leaders also seem to be engaging in a new competitive paradigm of clean growth. Although this technological competition may generate positive indirect effects for everyone, countries that do not follow may compromise their future economies.

In any case, there are no guarantees that this competition can create the necessary incentives for a rapid and sufficient transformation to a low-carbon economy immune to economic crises and necessary consumption. Even the

11. See for example, Tamiotti *et al*. (2009).
12. See for example, Dechezleprêtre *et al*. (2009).

voluntary commitments assumed at COP 15 and 16 fall short of the reductions necessary for a 2ºC trajectory. Thus, a global accord with targets and the reallocation of resources between countries remains necessary. The coming years will be decisive for international efforts to combat global warming.

5 THIS BOOK

As can be observed, even with modest advances towards a global agreement, recent years have transformed the debate on addressing global warming. The debate has attracted public opinion and is already part of political agendas in various countries and poses among the most important issues on the multilateral global agenda.[13] In the case of Brazil, this transformation resulted in a first regulatory accomplishment on the mitigation and adaptation of climate change and a differentiated Brazilian position in international negotiations. Brazilian scientific research, which helped to stake out this new regulatory framework, continues its advances in providing insights regarding the challenges of implementation.

The principal objective of this book is to provide a national publication on the policies to combat global warming with articles by specialists on pertinent topic with an analytical focus. This edition in English has the additional objective of offering the international community a comprehensive view of discussions on this topic in Brazil. As such, analytical texts by 40 specialists are presented, many of which have participated in the negotiations at some COPs and are members of the IPCC. They represent 18 Brazilian institutions such as universities, research centers, associations and ministries of the federal government.

The intent of this book is not to exhaust all topics, nor to present academic texts. But rather to offer analytically rigorous chapters that discuss certain national and international regulatory aspects outlined previously through diverse perspectives. As the reader will observe, the texts vary from economic, institutional, sectoral and social analyses. This discussion will be presented in two sections.

Part I, *Climate change in Brazil*, deals with these topics in relation to the Brazilian context at both national and subnational policy levels, the characteristics of our emissions and the impacts of climate change on the Brazilian economy and society, including aspects of efficiency, equity, income distribution, climate justice and international trade.

Part II, *Brazil and the international climate change regime,* discusses these aspects in the context of international negotiations, with a focus on COP 15 and COP 16 results, highlighting the most promising and controversial issues, such

13. COP 15 in Copenhagen gathered the greatest number of national government representatives in the history of UN meetings outside its headquarters in New York.

as the second commitment period of the Kyoto Protocol, reducing of emissions from deforestation and degradation (REDD), financing and technology transfer and the positions assumed by Brazil concerning them and our voluntary targets.

Chapter 1, *The national policy on climate change: regulatory and governance aspects*, that opens part I, presents the reader the regulatory framework for climate change in Brazil. The author, Ronaldo Seroa da Motta, discusses in detail the National Policy on Climate Change (PNMC), approved by the National Congress (Law nº 12.187, December 2009). In addition to confirming the Brazilian targets announced at COP 15, this policy also presents the economic instruments that will be applied to achieve these targets through credit and fiscal mechanisms as well as through a carbon market. The PNMC Regulatory Decree stipulates rules and standardization for measuring targets and formulating sectoral plans. The decree also achieved advances in the governance structure by allocating the coordination of the plans to the Inter-ministerial Committee on Climate Change (CIM). However, the author emphasizes that further institutional improvements are still necessary to bring about a bolder and more complex regulatory power. This improvement seeks to ensure links between sectoral plans and economic instruments, as well as the monitoring of efforts to achieve targets.

Furthermore, the regulatory framework of PNMC must recognize and accommodate subnational policies on climate change. Chapter 2, *Climate change regulation in Brazil and the role of subnational governments*, by Viviane Romeiro and Virginia Parente, analyzes these policies from the perspective of Brazilian subnational governments and their recognition of the climate change issue. The authors present a comparative analysis of the main characteristics of subnational laws related to targets, economic instruments and governance. Furthermore, they make recommendations for the creation of additional mechanisms to promote compatibility between subnational policies and the PNMC. Unilateral mitigation actions applied in isolation, whether national or local, may not be sufficient to revert climate change, but implementation may still bring local benefits. In addition to promoting technological development across regions, climate change actions almost always generate positive synergies with other actions aimed at controlling local atmospheric pollution and environmental preservation and even with social policies to improve life quality, such as related to sanitation and solid waste collection and disposal. These opportunities are more promising in urban areas where pollution and infrastructure conditions more directly and significantly affect poor populations.

Chapter 3, *Complementarity between greenhouse gas mitigation policies and urban life quality policies*, by Carolina Burle Schmidt Dubeux, addresses the main inter-relations between global, regional and local pollution and their respective emission sources. The author presents the principal options and actions for mitigating GHG emissions that can be adopted by municipalities and investigates the local benefits that result from their implementation.

To regulate emissions it is necessary to understand the evolution of Brazilian emissions. *Brazilian inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol* is the title of chapter 4, by Ana Carolina Avzaradel, that presents the entire process of compiling the Brazilian Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases, which is part of the Brazilian national submissions to UNFCCC.

The author analyzes the characteristics of Brazilian emissions, including in comparison with other countries. In addition to discussing the main advances achieved since the first inventory published in 2004, the author makes recommendations for the improvement and institutionalization of this inventory in the country.

Increases in aggregate national income coupled with improved distribution would enable a large portion of the Brazilian population to increase its consumption of goods. Such consumption tends to raise energy use in a way that could reduce the capacity of the State to diminish the carbon content of the energy matrix. This, however, does not necessarily imply that combatting poverty is incompatible with addressing global warming. Thiago Fonseca Morello, Vitor Schmid and Ricardo Abramovay, in chapter 5, *Breaking the trade-off between poverty alleviation and GHG mitigation: the case of household energy consumption in Brazil*, seek to demonstrate that the majority of consumption in Brazil could be carbon neutral. The authors estimate, by income level, GHG emissions from family consumption of energy and transport services. The results reveal that the elevated emissions from increased consumption of vehicle fuels induced by poverty reduction are more than compensated by the emission reductions generated by the eliminated consumption of firewood and charcoal.

Some of the previously presented chapters demonstrate that the Brazilian emissions profile is strongly characterized by emissions resulting from land use change and that, consequently, our 2020 mitigation targets are concentrated on controlling deforestation. Nevertheless, the authors imply that by 2020 and certainly after 2020, Brazil will need to implement mitigation efforts in other sources. The following three chapters thus address the possibilities of a low-carbon economy in the agriculture, road transport and energy sectors.[14]

14. A posição da indústria está apresentada no capítulo 16, na parte II.

In chapter 6, *Agriculture and cattle raising in the context of a low carbon economy*, Gustavo Barbosa Mozzer explains that the transition in this sector towards a new global economic model focused on productivity and sustainability is not an option, but rather a necessary prerequisite to secure investments, development and the diffusion of technologies that increase the systemic resilience of the sector against the increases in temperature and rainfall that will result from global warming. In addition to presenting a detailed analysis of sector emissions in Brazil, the author points out the technological opportunities associated with the transition process, and highlights the current promising evolution in the country from the adoption of these technologies.

Identifying these opportunities, that in addition to mitigating greenhouse gas emissions promise productive efficiency, is also addressed in chapter 7, *Road transport and climate change in Brazil*. The author Patrícia Helena Gambogi Boson argues that in order to conceive a Brazilian position that translates in to an effective contribution to reducing GHG emissions, it is necessary to also conceptualize a robust program for the transport sector. Thus, the author emphasizes the importance of economic and financial instruments to stimulate investments in research and innovation in large scale production and distribution of cleaner automotive fuels and to improve technologies and production of more environmentally efficient vehicles and engines. The author also proposes a program that implements a renewal of the Brazilian vehicle fleet and the consequent scrapping of the old fleet, restores road infrastructure, discourages the use of individual motorized transport, improves public transport and promotes investments in diversifying the transport matrix, most notably through the amplification and strengthening of railways and waterways.

The chapters on agriculture and transport highlight the importance of direct and indirect consumption of fossil fuels in sectoral emissions. In summary, the climate question is related to various aspects of the production and consumption of energy.

The following chapter discusses economic instruments that have already been adopted and are being developed under UNFCCC, and their implications for Brazilian development, namely: CDM and NAMAS. Maria Bernadete Sarmiento Gutierrez, in chapter 8, *From CDM to nationally appropriate mitigation actions: financing prospects for Brazilian sustainable development*, discusses how CDM from the Kyoto Protocol and NAMAS should express complementary characteristics, as opposed to substitutive, in the financing of sustainable development in developing countries, especially in the Brazilian case. The author stresses that despite the urgency of achieving GHG stabilization and imposing greater participation of developing countries through NAMAS, it is important to maintain as well as amplify CDM through a sectoral framework, as a way to guarantee financing of sustainable development. In Brazil, for example, it is worth highlighting the importance of this mechanism in supporting renewable energy projects.

Considering the current necessity to mitigate emissions from land use change, Brazilian growth will require a complete technological transformation of the productive sectors. In chapter 9, *Development, cooperation and transfer of low carbon energy technologies*, Gilberto de Martino Jannuzzi and Marcelo Khaled Poppe summarize the development stages of various environmentally beneficial energy technologies, as well as explore interests of cooperation and transfer of these technologies between Brazil and other countries, both industrialized and developing.

Another issue analyzed in this publication includes opportunities for discriminatory trade practices that could be implemented in unilateral mitigation actions. From this perspective, Ronaldo Seroa da Motta analyses, in chapter 10, *Trade Barriers and Climate Policies*, trade barriers related to climate change policies, including their effectiveness and compatibility in relation to international trade rules. The author summarizes studies that estimate economic, commercial and environmental effects from simulations of these barriers, giving emphasize to impacts in the Brazilian economy in relation to our main trading partners and competitors. The author concludes that Brazil would lose less than China, Russia and India in the case that sanctions were implemented. However, losses in Brazilian agricultural exports could be elevated and much greater than those of energy intensive industrial sectors.

Considering the inevitable global temperature increase and that certain areas and regions are more vulnerable to the resulting impacts, there is an urgency to define and implement actions to adapt to these impacts. In other words, in addition to mitigation efforts, climate change policies also have to address adaptation to climate change through analyzing the vulnerabilities and capacities to respond in various territories and productive sectors.

As mentioned at the beginning of this introduction, there is a consensus among studies of climate change impacts that urban settlements and agriculture, especially in arid regions, will be most affected by increased intensities and frequencies of extreme climate phenomena. The following three chapters address these issues in the Brazilian context.

Chapter 11, *Vulnerability of Brazilian megacities to climate change: the São Paulo Metropolitan Region (RMSP)*, by Carlos Afonso Nobre and collaborators: Andrea Ferraz Young, Paulo Hilário Nascimento Saldiva, José Antonio Marengo Orsini, Antonio Donato Nobre, Agostinho Tadashi Ogura, Osório Thomaz, Guillermo Oswaldo Obregón Párraga, Gustavo Costa Moreira da Silva, Maria Valverde, André Carvalho Silveira and Grasiela de Oliveira Rodrigues presents a study that outlines vulnerability scenarios in the São Paulo Metropolitan Region (RMSP), by demonstrating current impacts and projections for 2030. The authors identify the areas that will possibly be occupied in the future and the potential risks associated the unchecked expansion of current settlement patterns. The chapter also presents estimates of impacts to human health caused by climate effects. At the end, the authors make detailed recommendations applicable to any Brazilian mega-city, highlighting among other things, the amplification of modeling capacity and a network for monitoring climate and its impacts aimed at urban and regional planning and the promotion of research, energy efficiency and forest carbon sinks in public areas.

Chapter 12, *The climate justice discourse in Brazil: potential and perspectives*, by Bruno Milanez and Igor Ferraz da Fonseca, draws attention to the fact that the social actors most vulnerable to climate events are also those that contributed least to climate change. This observation raises the issue of climate justice, which is presented and discussed in this chapter. The authors demonstrate that despite climate injustice events that are already taking place in Brazil, the climate justice discourse is still not consistently considered in the country. Through documental research of the main newspapers in São Paulo and Rio de Janeiro, the authors suggest that media, society in general and the communities affected still do not clearly associate episodes of environmental injustice, extreme wheather events and climate change. Thus, public decisions end up utilizing palliative corrections instead of policies designed to reduce vulnerability and to ensure adaptation to climate change.

Chapter 13, *Climate change and vulnerability to drought in the Semiarid Region: the case of smallholder farmers in the Brazilian northeast*, written by Diego Pereira Lindoso and collaborators: Juliana Dalboni Rocha, Nathan Debortoli, Izabel Cavalcanti Ibiapina Parente, Flávio Eiró, Marcel Bursztyn and Saulo Rodrigues Filho, analyzes the elevated vulnerability of poor communities in the Brazilian semiarid region. In this context, the chapter presents a proposal for a system of indicators to evaluate the vulnerability of family agriculture to drought, using the example of seven municipalities in the semiarid state of Ceara based on three perspectives: sensitivity, adaptive capacity and exposure. The results make explicit the various dimensions of vulnerability that, according to the authors, confirm the necessity to link adaptation actions to other public policies. This chapter closes part I of the book.

Part II, that addresses international negotiations, begins with chapter 14, *Cost-benefit analyses of climate change*. This chapter reviews various studies that compare the costs of GHG mitigation to the benefits generated from reducing the onus of climate impacts. As the authors Jorge Hargrave, Ronaldo Seroa da Motta and Gustavo Luedemann demonstrate, there is significant divergence among studies. Though many prescribe forceful immediate action to reduce emissions, some imply that the costs of this immediate attitude may not compensate for avoided future impacts. Despite differences in valuation methodologies, aggregation of costs and benefits and databases utilized, divergences in results depend heavily on the way that future benefits of climate regulation are compared with costs incurred to implement this regulation in the present, that is, the results depend on the magnitude of the discount rate used. It is concluded that despite recent advances there are still many methodological challenges, both in measuring and valuing climate impacts in order to provide the insight necessary to guide decision makers.

Irregardless of the temporality of mitigation actions, global action will be required, and as such the distribution of costs among countries and economic actors must be determined. As discussed throughout this introduction, this is the main objective of the climate convention.

Chapter 15, *The targets of the Copenhagen Accord and the Cancun Agreements*, by Ronaldo Seroa da Motta, Jorge Hargrave and Gustavo Luedemann, initially summarizes the main results of the Copenhagen and Cancun COPs, which will be more in-depth analyzed by other chapters in part II. The authors then dedicate themselves to a detailed analysis of the Brazilian targets submitted in the Copenhagen Accord and confirmed in Cancun, discussing their implications for future negotiations and their contribution to the commitment of limiting global temperature increase to between 1.5°C and 2°C.

In chapter 16, *Climate change negotiations from an industry perspective*, the author Paula Bennati discusses how recent decisions at COP 15 and 16 directly interfere in the strategies being developed by Brazilian industry to address challenges related to managing their GHG emissions. As such, the author discusses how to construct technical and intellectual capacities throughout the business networks of companies, because all are indispensable in the transition to clean technologies and new ways of conducting business.

One of the most controversial topics in Cancun was the negotiating process for a second commitment period for the Kyoto Protocol. José Domingos Gonzalez Miguez, in chapter 17, *The Kyoto Protocol and the current negotiations of the international regime on climate change*, describes in detail these negotiations. According to the author, the process was unfortunately delayed because negotiators chose to advance in both tracks parallel and BAP negotiations, did not advance and consequently there were no significant advances in the KP negotiations. This is worrisome, according to the author, considering that the establishment of commitments for the second term of the protocol should occur through amendments. Furthermore, there is the necessity of ratifying amendments by all parties to the protocol, which demands time and with the conclusion of discussions delayed to COP 17 in Durban, South Africa, only one year remains for the protocol ratification process in order to avoid a gap between the end of the first commitment period (2008-2012) and the beginning of the second.

The REDD mechanism was finally approved at COP 16. The author of chapter 18, *REDD and the challenge of protecting the global forest cover*, Thaís Linhares-Juvenal, depicts negotiations since COP 15 and discusses in detail the approved text. The text establishes that this mechanism requires technical and institutional preparation, a phase for consolidating preparations and initiating demonstration with quantification of results, and a phase dedicated to implementation, when countries have the capacities to present results that are fully measurable, reportable and quantifiable. According to the author, the importance of governance structures for REDD is clear. Such an understanding, however, to a certain extent, make financing possibilities for this mechanism less flexible and causes what the author explains as "the REDD paradox".

A rapid reduction of emissions and urgent necessity for adaptation to the adverse impacts of climate change, require large-scale diffusion and transfer, or access to, environmentally sound technologies. Chapter 19, *Transfer of technology under the climate change regime*, by Haroldo Machado-Filho and Marcelo Khaled Poppe, closes this publication. The authors initially discuss commitments related to technology transfer under the scope of the convention and the implementation difficulties of a technology mechanism linked to a financing mechanism. Next, they describe in detail negotiations during the two recent COPs and the prospects of success for the Cancun Agreement, including the decision to establish a Technology Executive Committee and the Climate Technology Center to facilitate the effective employment of the technology mechanism.

We hope that the chapters of this book offer the reader a comprehensive and in many cases detailed, view of the economic, social and regulatory aspects of climate change that in recent years have mobilized public opinion and the political agenda in Brazil and in the world.

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PART I

CLIMATE CHANGE IN BRAZIL

CHAPTER 1

THE NATIONAL POLICY ON CLIMATE CHANGE: REGULATORY AND GOVERNANCE ASPECTS

Ronaldo Seroa da Motta*

1 INTRODUCTION

Through the Copenhagen Accord and the Conference of the Parties (COP 16) in Cancun, Brazil has confirmed its national voluntary reduction targets for greenhouse gas (GHG) emissions, with reductions between 36.1% and 38.9% of projected emissions by 2020. These targets were defined in the National Climate Change Policy (PNMC, in Portuguese) approved by the National Congress (Law nº 12.187, dated December 29th, 2009). As will be discussed in other chapters of this book, the Brazilian position in the absence of a binding global agreement, requires that these targets proposed within the scope of the United Nations Framework Convention on Climate Change (UNFCCC)[1] be voluntary. However, the PNMC goes beyond formalizing the Brazilian position from an international perspective. In addition to supporting the Brazilian positions in the multilateral and international discussions that address global warming, the PNMC essentially offers a legal framework for the regulation of national actions aimed at mitigation and adaptation. This framework dictates principles, guidelines and instruments for attaining the national targets irregardless of the evolution of the global climate agreement.

As outlined in the legal document, a decree by the Executive Branch would establish, in agreement with the National Climate Change Policy, sectoral plans for climate change mitigation and adaptation aimed at the consolidation of a low-carbon economy. In December 2010, Decree nº 7.390 was implemented (dated December 9th, 2010) to regulate Articles 6, 11, and 12 of Law nº 12.187/2009, which establishes the PNMC and offers other provisions. This decree made it possible to clear up and define several regulatory aspects of the legal text related to the measurement of targets, formulation of the sectoral plans and the governance structure.[2] This chapter discusses those improvements and highlights other pending regulatory aspects that still need to be developed, in particular related to governance structure.

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1. United Nations Framework Convention on Climate Change (UNFCCC).

2. For a detailed analysis of the regulatory aspects of PNMC, see Seroa da Motta (2010a and 2010b).

After section 2, which discusses in detail the formulation of the sectoral plans and the setting of targets, sections 3 and 4 deal with the types of financing, particularly highlighting the roles of financial instruments and carbon markets. The link between instruments and sectoral plans, as outlined in the legal document, will essentially depend on the governance structure that is analyzed in section 5. The chapter is concluded with some final remarks.

2 BRAZILIAN TARGETS

The national targets were defined at the end of the legal document, in Article 12 of the PNMC (BRASIL, 2010c), namely:

> To reach the objectives of the PNMC as a voluntary national commitment, the country will adopt mitigation actions for greenhouse gas emissions that aim to reduce between 36.1% (thirty six point one percent) and 38.9% (thirty eight point nine percent) of estimated emissions by 2020.Decree nº 7.930/2010, which regulates the PNMC, estimates national GHG emissions for 2020 of 3,236 million tCO_2eq, and to reach the voluntary national commitment estimated emissions will be reduced by between 36.1% and 38.9%. In table 1, we can observe that the commitment would represent a reduction to between 6% and 10% of 2005 emission levels.

TABLE 1
Voluntary commitments of GHG reductions in Brazil

Mitigation targets for 2020 (%)	Total to be mitigated in 2020 (mi tCO_2eq)	Total emissions in 2020 after mitigation (mi tCO_2eq)	Mitigated in 2020 in relation to 2005 (%)
36.1	1168	2068	6
38.9	1259	1977	10

Sources: Brasil (2009a, 2010b).

Article 11 of the PNMC states that an Executive Decree will establish, in agreement with the National Climate Change Policy, sectoral climate change mitigation and adaptation plans aimed at the consolidation of a low-carbon economy in the following areas: generation and distribution of electric power, urban public transportation and the system standards for interstate transport of cargo and passengers, the manufacturing industry and the durable consumer goods industry, chemical industries, the pulp and paper industries, mining, the civil construction industry, health services, and agriculture and cattle farming, (BRASIL, 2010c). In order to meet incremental targets of quantifiable and verifiable anthropogenic emissions reductions, considering the specificities of each sector, this may also be achieved by means of Clean Development Mechanisms (CDM) and Nationally Appropriate Mitigation Actions (NAMA).

In the section that outlines targets for 2020, Decree nº 7.390/2010 (2010b) links the sectoral plans from Article 11 of the PNMC to mitigation actions related only to *land use, agriculture and cattle farming,* and *energy* sectors, aggregating industry and the generation of solid wastes in *others*.[3] It is presumed that the other sectors may be subject to inclusion, as the PNMC dictates, but for now they will not contribute to the efforts for 2020.

The regulating decree disaggregates the emissions projections for 2020 by sectors as follows: *i)* land use change: 1,404 million tCO_2eq (68% of which being in the Amazon Forest, 23% in the Cerrado (Brazilian Savanna) and the remaining 9% in the Atlantic Forest, the Caatinga and Pantanal); *ii*) electric power: 868 million tCO_2eq; *iii)* agriculture and cattle raising: 730 million tCO_2eq; and *iv*) industrial processes and waste treatment: 234 million tCO_2eq.

In order to achieve these targets, the decree establishes that the following actions will be considered initially:

1. An 80% reduction of the annual deforestation rates in the Legal Amazon in relation to the average verified between 1996 and 2005.
2. A 40% reduction of the annual deforestation rates in the Cerrado Biome in relation to the average verified between 1999 and 2008.
3. Expansion of the supply from hydroelectric power, alternative renewable sources, especially wind farms, small hydroelectric and bioelectric farms, biofuel, and increased energy efficiency.
4. Recovery of 15 million hectares (ha) of degraded pasture land. Extension of the integrated farming and cattle raising forest system by 4 million hectares.
5. Expansion of direct planting practices to 8 million ha.
6. Increasing biological nitrogen fixation in 5.5 million ha of cultivated areas, to replace the use of nitrogenous fertilizers.
7. A forest planting expansion covering 3 million ha.
8. Extended use of technologies for the treatment of 4.4 million m^3 of animal waste.
9. Increase the use of charcoal from planted forests and improvements in the carbonization process efficiency in the steel industry.

As observed, the decree does not indicate sectoral reduction targets, but rather emissions targets for 2020, which shall be executed based on the sectoral plans.

3. It is observed that the entire energy sector consumption is aggregated in the *electric power* bill.

The preparation of the sectoral plans will rely on a wide public consultation process for interested parties, represented especially by directly affected economic activities. As such, the decree stipulates the minimum content of those plans as follows:

- emissions reduction target in 2020, including incremental targets with a maximum three-year interval;
- actions to be implemented;
- definition of indicators for the monitoring and evaluation of their effectiveness;
- a proposal of regulatory and incentive instruments for the implementation of the respective plan; and
- sectoral competitiveness studies with estimates of costs and impacts.

Although neither the PNMC or its decree define sectoral mitigation percentages, these were estimated in the correspondence from Brazil to the UNFCCC for the Copenhagen Accord, where out of the 38.9% national target, deforestation would be reduced by 24.7%, and the remaining 15.2% would be divided between the energy (7.7%), agriculture and cattle raising (6.1%), and other sectors (0.4%). The same partition is valid for the 36.1% target.[4] From these figures, it is evident that the national effort will be concentrated on controlling deforestation.

The distribution of mitigation efforts by sector can also be deduced if we compare the projected emissions for 2020, as described in the decree, with the 2005 emissions, according to table 2.

TABLE 2
Variations in sectoral emissions – 2005/2020

Emissions (millions tCO_2eq)	Land Use	Agriculture and Cattle Raising	Energy	Others[1]	Total
Observed in 2005	1268	487	362	86	2203
Projection for 2020	1404	730	868	234	3236
Variation 2020-2005 (%)	11	50	140	172	47

Sources: Brasil (2009a, 2010b).
Note: [1] Other industrial processes and waste treatment

Table 2 indicates that total national emissions will increase by 47%. However, emissions from the industrial sectors and from solid wastes will increase by 172% and the energy sector by 140%. Greater efforts will be made in the high growth rate agriculture and cattle raising sector that will only be able to

4. The proposition of two targets depends on hypotheses for sectoral growth trends.

increase emissions by 50%. This effort will be doubled in the land-use case, where emissions will only be able to increase 11% by 2020.

3 FINANCING THE TARGETS

National targets concentrated on controlling deforestation can offer the country a significant comparative advantage, since deforestation reduction is undoubtedly less restrictive to economic growth than limits to energy consumption, including in industrial processes.[5] Emerging countries such as China and India are fearful of adopting emission trend estimates at this moment, and therefore opted to instead declare COP 15 targets in terms of CO_2 or energy intensities in relation to gross domestic product (GDP).

Furthermore, deforestation control can utilize mechanisms in which owners of forested areas receive payments in an amount greater than or equal to the current net revenue generated by an enterprise in return for forest maintenance, thereby avoiding emissions from deforestation. This mechanism is referred to as reducing emissions from deforestation and forest degradation (REDD), and was one of the items related to regulation that made significant advances at COP 15 and COP 16. This mechanism can also generate additional benefits beyond combatting global warming, similar to those resulting from biodiversity protection and poverty relief. Through REDD, payments equivalent to the earnings received from activities that require deforestation are transferred to land proprietors, so that they preserve the forest. Furthermore, low-productivity agriculture and cattle raising are practiced in several rural areas on lands without defined property rights, where deforestation is mainly motivated by land-titling opportunities. Payments should reflect the opportunity costs of deforestation which are mostly associated with large-scale cattle raising or low-productivity agriculture. Studies indicate that in many areas of the world, such as the Amazon areas currently outside the deforestation arch,[6] this opportunity cost tends to be much lower than options that reduce emissions from other sources, such as those related to energy consumption.

Therefore, a company or a government that seeks to reduce emissions would have an interest in paying for the conservation of these areas, in return for carbon emission credits equivalent to what the avoided deforestation would have generated, and thus using those credits to comply with its targets. As the cost differential between REDD and other forms of mitigation can be very high,

5. As the results of Tourinho, Seroa da Motta and Alves (2003) have already indicated through a computational general equilibrium model (CGE), the impacts of carbon rates in the Brazilian economy would not be expressive in the aggregate; however, as would be expected, rates would be greater in the energy-intensive sectors. Also see Seroa da Motta (2005) for an analysis of the economic cost of deforestation.

6. See, for instance, Ipam (2007) and Strassburg *et al.* (2009).

if managed appropriately, REDD payments can even result in revenue earnings greater than the income generated by deforestation activities. A mechanism like REDD would consequently be capable of generating three socially desirable dividends: climate control, biodiversity protection and income distribution.

Although no government decision has been made so far, the financing of deforestation NAMAs could be achieved through international resources, either from a climate convention mitigation fund, or through other multilateral and bilateral means.

Brazil, for instance, already relies on the Amazonian Fund, financed by donations from government, multilateral institutions, non-governmental organizations (NGOs) and businesses. Its purpose is to promote projects related to deforestation prevention and control, and conservation and sustainable forest use in the Amazon Biome. The management of the fund resides with the Brazilian Development Bank (Banco Nacional de Desenvolvimento Econômico e Social – BNDES) and resources are applied as non-refundable financing. These donations are adjusted according to the progression of average deforestation rates.[7]

In addition to the annual plan of resource application from the National Fund on Climate Change, Articles 5th, 6th and 7th of the NPCC go further by proposing financial instruments, such as tax and credit incentives, National Treasury concessions and national or international donations, to promote mitigation actions including technological development. Article 8, makes public financial institutions available for specific credit and financing lines for the development of mitigation actions.

4 THE CARBON MARKET

The carbon market offers another form of financing.[8] In Brazil, there are already carbon market mechanisms to foment greenhouse gas emission reduction projects, along the lines of the CDM, including a system for the negotiation of carbon credits in the Brazilian Mercantile & Futures Exchange (BM&F), called the Brazilian Market for Emissions Reduction (MBRE).

Although the MBRE has so far been restricted to credits from CDM projects aimed at achieving the goals of the Kyoto Protocol signatory countries, Article 11 of the PNMC predicts that the MBRE will be operated in commodities and futures markets, stock exchanges and private companies, authorized by the Securities and Exchange Commission of Brazil (CVM), where the negotiation of securities representing avoided and certified GHG emissions will take place.

7. See Amazonia Fund (2010).

8. See, for instance, na analysis in Smale *et al.* (2006).

In other words, the MBRE not only encompasses a wider scope than that of negotiating CDM credits, it also recognizes that the negotiated volumes are securities. This accounting recognition is an important factor in setting values for market transactions that prior to the PNMC did not have the legal support necessary for accounting them.

However, the PNMC is not very clear about how this market will develop to protect efforts to achieve national targets. Paragraph 3 in Article 4 of Decree nº 7.930/2010 nevertheless establishes that the targets of the sectoral plans can be used as parameters for the establishment of the MBRE, as dealt with in Article 9 of Law nº 12.187/2009.

The 4^{th} paragraph of Article 6 of the same decree also allows mitigation actions of the sectoral plans to be implemented through clean development mechanisms or other mechanisms under the scope of the United Nations Convention Framework on Climate Change. This possibility demonstrates that the domestic carbon market can be linked with other national markets that are regulated by the convention.

Outside the scope of the PNMC, but in agreement with its objectives, there is a working group from the Brazilian Association of Technical Standards (ABNT) that is developing standards for the creation of a voluntary carbon market and which has already attracted the interest of financial institutions and stocks exchanges.[9]

Although the decree expands and assures an important and promising role for the carbon market, it is important to discuss some relevant regulatory issues to be resolved prior to its implementation, such as the criteria and instruments for the allocation of licenses, in order to evaluate the magnitudes of sectoral costs of license purchase in the case of auctions and income transfers in the case of a free allocation of licenses. Furthermore, it is also necessary to evaluate how these magnitudes vary if markets in Brazil are linked to other markets abroad.

5 GOVERNANCE

The success of the PNMC will depend on the compatibility between public and private initiatives and the participation states and municipalities.

For such success, however, the PNMC will have to rely on an autonomous and transparent governance structure in order to avoid deviations resulting from both the influence and interests of regulated entities, as well as changes in government or political opportunism.

9. Commission of Special Study of the Voluntary Carbon Market (CEE)/ABNT-146. Project went to public consultation in February, 201.

Thus, governance within PNMC should differentiate the regulating power from the implementing power. The former should formulate the sector policy with a high degree of representativeness and the latter should implement the policy with a strong sense of autonomy and transparency.[10]

Representatives from all involved sectors of society should participate in the entity, or entities, responsible for guiding the development of the policy, that compose the regulating power. This power is thus responsible for deliberating on implementation issues as required by law, ensuring that it follows the principles, guidelines and actions that it promulgates. However, the PNMC was not accurate in Article 7 concerning the governance of its economic and financial instruments. The listed institutional levels include the existing Inter-ministerial Committees and civil society organizations, namely: the Inter-ministerial Committee on Climate Change (CIM, in Portuguese); the Inter-ministerial Commission for Global Climate Change; The Brazilian Forum on Climate Change (FNMC); the Brazilian Research Network on Global Climate Change (Rede Clima); and the Commission for Coordination of Meteorology, Climatology, and Hydrology.

Fortunately, Decree nº 7.390/2010 makes some progress on that matter. For instance, Article 7 defines the CIM (instituted by Decree nº 6.263, dated November 21st, 2007) as the general coordinator of the mitigation actions to be prepared in the sectoral plans, which seems to give the CIM a regulating power role. Article 8 establishes that the follow-up, which can be understood as a way of generating accountability, will be accomplished by the Brazilian Forum on Climate Change.

The other organizations mentioned in the PNMC, such as "Rede Clima" and the Commission for Coordination of the Meteorology, Climatology and Hydrology Activities, as it seems, will still have to be accommodated, but considering their technical character they may very well act in the form of assistance to the CIM.

Concerning the Inter-ministerial Commission for Global Climate Change, it seems that it will maintain its executive role in the approval of CDM projects, inventories, and other relations with the UNFCC.

However, the PNMC goes beyond Brazil's international commitments in the climate change arena, and its essence is in the achievement of national targets unrelated to the commitments that may arise from the convention or other forums. Hence, the main executive initiatives are of a domestic character, such as the rules and the standards that will be discussed and deliberated on within the CIM.

10. See Cruz (2009) and Seroa da Motta (2009).

Article 9 of Decree nº 7.390/2010 sets forth further progress by obligating the Multiannual Plans and annual budgetary laws to include the PNMC programs and actions. On the other hand, Article 10 obligates sectoral plans to formulate actions that include appropriate methodologies and mechanisms to assess compliance.

Finally, it is important to analyze the link between the PNMC and several other initiatives of subnational policies on climate change which are being approved in several states (for instance, São Paulo, Minas Gerais and Rio de Janeiro) and municipal districts (such as Rio de Janeiro and Curitiba).[11] Subparagraph V in Article 3 of the PNMC establishes:

> (...) national actions for addressing current, present and future climate change issues, shall consider and integrate the actions promoted at state and municipal levels by public and private organizations. (BRASIL, 2010c).

However, the integration between federal and subnational policies is always defined by the federal limits and, therefore, if there is not a guiding legal provision,[12] the institutional arrangement needs to seek consensus practices for a given articulation. It is important to emphasize that the decree does not mention anything about the need to integrate the standards formulated for the sectoral plans.

Ultimately, the new institutional arrangement of Decree nº 7.390/2010 broadly bestows the regulating power in the CIM. However, in order to apply its deliberations another governance entity with implementation power is needed (for instance, an agency under a special authority)[13] with instruments aimed at monitoring, inspection and accountability, but with an eminently technical and transparent capacity.

Such entity would be responsible for managing the rules and standards defined by the CIM and it would be the ultimate administrative stance to implement rules and norms with fully autonomy in the exercise of their functions.[14]

With potential gains from integration and coordination, its mandate could exert regulation in other areas, such as the creation of inventories, supervision of the carbon market and registration, monitoring and verification activities. In this sense, the implementation power could also be the management body of the National Fund on Climate Change (Law nº 12.014/2009).

11. See specific chapter under subnational policies in this publication.

12. For instance, the proposal of a Clean Energy Law in the United States (Waxman-Markey Bill) and its amendment (The American Power Act or The Kerry&Lieberman Bill) predicted the adequacy of the subnational laws to the national laws.

13. As well as the National Water Agency, the National Health Surveillance Agency, the National Civil Aviation Agency, the National Electric Energy Agency and other similar ones.

14. Being the last administrative stance means the finalist act in federal administration. However, this does not exclude the dispute of the contradictory in legal claims.

Additionally, this entity would enable compatability between federal policies and several other state initiatives as relates to registration and other conflicting actions.

Hence, the regulatory challenges of controlling GHG emissions reside in the choice of the most efficient economic and financial instruments, in shaping regulatory governance for these instruments and in the degree of autonomy that this body will exert within the existing regulation.

6 FINAL REMARKS

Brazil has greatly improved its regulation of actions that combat global warming, including the approval of the Brazilian targets for reducing greenhouse gas emissions as defined in the PNMC. These national targets are concentrated on deforestation control, which as mentioned represents a comparative advantage for Brazil. Reducing deforestation is certainly less restrictive to economic growth than mitigation actions related to energy consumption and industrial activities that other emerging economies would have to adopt.

The PNMC, besides confirming the national targets announced at COP 15, also recommends economic instruments that will promote the achievement of these targets through credit and fiscal mechanisms as well as the carbon market. As discussed, these mechanisms still require further analysis and the definition of some regulatory aspects related to the criteria and impacts in the allocation of incentives and emission rights. Equally important will be the definition of the regulatory governance of these instruments.

The regulating decree of the PNMC has improved rules and standardization, the measurement of targets and the elaboration of sectoral plans. The advances in governance structure, though significant by allocating the coordination of the plans to the CIM, still require a bolder and more complex institutional improvement in the regulatory power.

The development of sectoral plans, if coupled with appropriate economic instruments, will consequently offer opportunities for Brazil to increase the efficiency of its transition to a low-carbon economy. For this to take place, the PNMC may adopt a regulatory governance structure similar to that of other regulated sectors, in which an autonomous agency is responsible for the implementation of the objectives of the regulatory framework established by law. Such initiative will be the beginning of compatibility between the federal and state governments, the private sector and NGOs, and efforts along these lines should be on the agenda of the present discussions on sectoral plans.

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CHAPTER 2

CLIMATE CHANGE REGULATION IN BRAZIL AND THE ROLE OF SUBNATIONAL GOVERNMENTS

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1 INTRODUCTION

The international geopolitical climate scenario faces the challenge of designing agreements to combine the economic development targets of the various countries and the differences of their distinct sustainability strategies, even among nations that are imbued with the common purpose of preventing climate change. Progress in public policy and regulatory governance in the direction of a worldwide climate governance has become increasingly more complex due to the plurality of political positions and statutory schemes in various countries (OBSERVATÓRIO DO CLIMA, 2008).

In this context, the evolution of national policies on climate change can play a key role in advancing the international climate agenda, contributing to the construction of a more harmonic and therefore more effective strategy. Regarding the importance of national action to achieve a global objective, Giddens (2008) establishes that political leaders must be constantly attentive to the analysis of the political changes needed to mitigate climate change impacts, especially at the national level, where such actions must indeed take place.

Taking into account the global scenario, the aim of this chapter is to analyze the evolution of climate change regulation in Brazil with the creation of subnational policies and verify their impacts in the context of the National Policy on Climate Change (PNMC, in Portuguese), established in December 2009.

After this brief introduction, the next section of this chapter summarizes the recent literature that details some of the main national public policy guidelines for carbon emission reduction. Also, the state and local public policies on climate change in Brazil are discussed within the roles of subnational governments.

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In order to bring greater depth to the issues addressed, section 3 presents a summary of a series of interviews with researchers and experts on climate change issues in Brazil and abroad. Finally, section 4 offers the concluding remarks of this chapter. Among these, measures to be adopted in the implementation of local climate policies are highlighted. Also pointed out is the fact that regulatory issues related to the mechanisms to achieve these targets still must be clearly defined and analyzed, particularly concerning their criteria and impacts on the allocation of targets in the various economic sectors.

2 CLIMATE REGULATORY GOVERNANCE AND THE ROLE OF SUBNATIONAL GOVERNMENTS

The analysis developed in this research carries as assumption the relevance of subnational governments in furthering state and municipal policies, on the progress of climate change discussions at national and international levels. However, there is a lack of convergence on measures taken by policymakers, as shown below (table 2 of subsection 2.1). Consequently, transparency and regulatory mechanisms of such policies could contribute to better governance in the area, facilitating the balance between environmental, social and economic aspects, as well as to promote convergence between the various local interests.

The Stern Report (STERN, 2007) asserts that public policies to reduce emissions should be based on certain guidelines. Among these, the following stand out: *i*) definition of a carbon price, through the implementation of taxes; *ii*) regulatory or market presence; *iii*) development of low carbon technologies with a focus on energy efficiency; and *iv*) removal of behavioral barriers.

In relation to the suggestion of levying carbon taxes as highlighted by the Stern Report, Marcovitch (2010) adds that carbon pricing could achieve some important targets in the arduous task of combating climate change. The first of these targets refers to increasing consumer awareness about goods and services with high carbon contents that should consequently be avoided. The second relates to inducing input substitution of low carbon options in the industrial sector. The third seeks to foster the development of more efficient products. Finally, the fourth and last objective aims to implement the above items at the lowest possible information cost.

Another aspect of carbon taxation to be considered, however, is how such taxation affects different economic sectors. This burden could entail a reduction or loss of competitiveness and thereby stimulate the migration of businesses and industries to regions or countries with less stringent regulation, to the detriment of the climate.

With regard to creating markets and regulation, the enhancement of carbon markets as well as the possibility of exemptions and the establishment of compensation by means of specific incentives, are considered necessary mechanisms and should be part of the objectives of all climate change policies in Brazil.

Another prominent tool in climate governance refers to the creation and improvement of mechanisms that encourage energy efficiency in various sectors. In this context, high-efficiency and low-carbon technology transfer policies deserve attention.

In the case of Brazil, it is clear that the country has advanced significantly in the implementation of climate policies and plays an important role on the international arena. Indeed, several States of the Federation have adopted laws to: *i*) encourage the reduction of emissions; *ii*) stimulate the protection of forests; and *iii*) promote the development and adoption of less energy-intensive technologies (IPEA, 2010).

It should be pointed out that the National Policy on Climate Change (PNMC), approved by the federal government in December 2009, stipulates a reduction target of 36.1% to 38.9% of estimated emissions by 2020. The law also recommends mitigation actions that should be adopted, and orders the creation of a Brazilian market to reduce emissions. A separate analysis of the PNMC is presented in chapter 1 of this book.

Additionally, some states have created local policies, establishing regulation to encourage mitigation and adaptation. For instance, in November 2009 the state of São Paulo approved a 20% emissions reduction target by 2020, considering 2005 as the base year. It is worth mentioning that until the beginning of 2011, this was the only State that presented targets of a mandatory nature.

The cities of São Paulo and Rio de Janeiro have also assumed reduction targets. São Paulo has pledged a 30% reduction, based on emissions from 2005 to 2010 (SÃO PAULO, 2009a), and Rio de Janeiro has pledged 8% by 2012, 16% by 2016 and 20% by 2020 (RIO DE JANEIRO, 2010). These local policies that encourage reductions of regional and local emissions, as well as generate statewide discussion forums on the topic, represent relevant and comprehensive efforts to engage different sectors of the economy and society. The effectiveness of such policies in achieving the targets will depend on how governments will enable the implementation of the relevant activities, as outlined in their respective laws. Especially, how governments will measure emission reduction targets, verify compliance and implement appropriate sanctions.

In this context, the authors considered it appropriate to review the legal frameworks outlining the roles of subnational governments and their recognition of the climate change issue. Through a comparative analysis of the main features of the law, discussions were centered around the incentives implemented and the creation of additional mechanisms to contribute to the achievement of established targets.

2.1 Role of subnational government

In Brazil, the national and state climate change forums are intended to mobilize society and promote dialogue and integration between institutions of various sectors, with the objective of adopting policies and programs in accordance with the United Nations Framework Convention on Climate Change (UNFCCC). In this context, the Brazilian Forum on Climate Change was established in June 2000 and composed of 12 Ministers of State. By February 2011, 16 Brazilian states had established local forums as presented in Table 1, ordered by creation date.

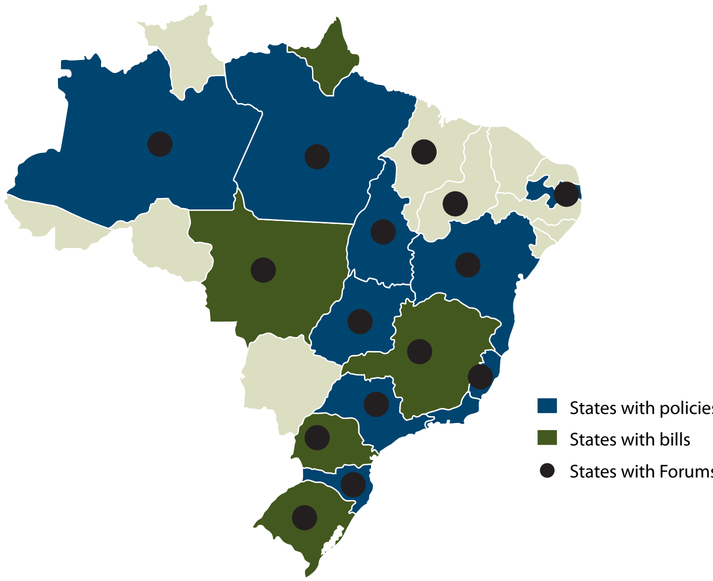
TABLE 1
Chronology of the implementation of the climate change state forums

State Climate Change Forum	
São Paulo	February, 2005
Minas Gerais	June, 2005
Bahia	August, 2005
Maranhão	November, 2006
Espírito Santo	April, 2007
Tocantins	April, 2007
Rio de Janeiro	May, 2007
Piauí	June, 2007
Rio Grande do Sul	June, 2007
Ceará	April, 2008
Paraná	February, 2008
Pernambuco	February, 2009
Amazonas	February, 2009
Santa Catarina	March, 2009
Mato Grosso	April, 2009
Pará	September, 2009

Sources: State laws related to the creation of climate change state forums.
Compiled by the authors.

In relation to public policies on climate change, out of the 27 units of the Brazilian Federation (UFs), ten have established policies and five have initiated draft legislation (PLs). As mentioned, only the State of São Paulo has mandatory targets (PROCLIMA, 2011). Map 1 highlights states that have policies, bills and climate change forums.

MAP 1
States with already established policies, bills and forums



Sources: State climate change laws.
Adapted by the authors.

Table 2 summarizes the contents of public policies in Brazil with regard to climate issues. Some items considered relevant in the context of a climate change policy are highlighted, such as: targets, creation of funds, inventory, clean development mechanism (CDM) and incentives for energy efficiency.

TABLE 2
Content of state public policies on climate change

State	Law	Decree	Targets	Inventory	MDL	Energy Efficiency
Amazonas	Jun./07	Yes	No	Yes	Yes	No
Tocantins	Apr./08	No	No	Yes	Yes	Yes
Goiás	Feb./09	No	No	Yes	Yes	Yes
Santa Catarina	Aug./09	No	No	Yes	No	Yes
Pará	Sept./09	No	Progressive	Yes	Yes	Yes
São Paulo	Nov./09	Jun./10	Yes	Yes	Yes	Yes
Rio de Janeiro	Apr./10	No	To define	Yes	No	Yes
Pernambuco	Jun./10	No	Progressive	Yes	Yes	Yes
Espírito Santo	Sept./10	No	To define	Yes	Yes	Yes
Bahia	Mar./10	No	No	Yes	Yes	Yes

(continues)

(continued)

State	Law	Decree	Targets	Inventory	MDL	Energy Efficiency
Amapá	Bill	No	Progressive	Yes	Yes	No
Mato Grosso	Bill	No	Progressive	Yes	Yes	No
Mina Gerais	Bill	No	No	Yes	Yes	No
Paraná	Bill	No	No	No	No	No
Rio Grande do Sul	Bill	No	No	Yes	Yes	Yes

Sources: Proclima – Laws and state data declared by April 2011.
Compiled by the authors.

With regard to municipal climate change policies, two Brazilian cities have established mandatory targets: São Paulo and Rio de Janeiro. Table 3 summarizes the status of some items considered of greater relevance in the context of these two municipal policies, such as: targets, inventory, MDL and incentives for energy efficiency.

TABLE 3
Content of municipal public policies on climate change

Municipal District	Law	Decree	Targets	Inventory	MDL	Energy Efficiency
São Paulo	Jun./2009	No	Yes	Yes	Yes	Yes
Rio de Janeiro	Nov./2009	No	Yes	Yes	Yes	Yes

Sources: Municipal regulations, updated as of February 2011.
Compiled by the authors.

The main point of convergence in all analyzed state and municipal laws is the challenge to combine economic development with protection of the climate system, targeting specifically the reduction of greenhouse gas (GHG). In this sense, the analyzed Brazilian climate policies share the following basic features:

- Practical implementation of GHG mitigation through incentives to reduce emissions by the various productive sectors, either through the creation of a market for emissions, or through a carbon taxation mechanism.
- Implementation of actions to adapt to climate change effects according to the vulnerabilities of each region.
- Incentives for the development and transfer of low-carbon technologies.
- Dissemination of knowledge for human resource training.

Another relevant item discussed is the creation of additional mechanisms for the exchange of obtained rights. Such mechanisms are mentioned in four of the examined laws, as illustrated in table 4.

TABLE 4
Provisions in laws for the creation of additional mechanisms

	Mechanisms provided in the laws
Pernambuco	Market mechanisms for implementing the goals of UNFCCC
Rio de Janeiro	Additional mechanisms for the exchange of rights obtained
São Paulo	Additional mechanisms for the exchange of rights obtained
Tocantins	Other mechanisms and market schemes to reduce emissions

Sources: State regulations, updated as of February 2011.
Compiled by the authors.

São Paulo is, at the time of writing this chapter (March 2011), the only state with mandatory targets at state and municipal levels. Table 5 summarizes the targets established by federal laws and the state and municipal laws of São Paulo related to climate change.

TABLE 5
National, state and municipal climate change policies in the State of São Paulo and São Paulo city

Policies	National Policy on Climate Change	State Policy on Climate Change of São Paulo	Municipal Policy on Climate Change of São Paulo
Law	nº 12,187/2009	nº 13,798/2009	nº 14,933/2009
Targets	36.1% and 38.9%	20% by 2020	30% by 2012
Baseline	Emissions projected by 2020	Based on the inventory of 2005	Based on the inventory of 2005

Sources: Brasil (2009), São Paulo (2009a, 2009b).

We observe that the PNMC and the actions stemming from it, performed under the responsibility of political entities and government agencies, and following its principles: *i*) precaution; *ii*) prevention; *iii*) sustainable development; and *iv*) common but differentiated responsibilities, have been extensively discussed because of their current relevance to the division among the state signatories to the UNFCCC into developed countries (with mandatory targets) and developing countries (no targets) (MULLER, HOHN, ELLERMANN, 2007).

Using the state of São Paulo as a reference, for being the first to establish a State Policy on Climate Change, it appears that its policy complies with the following principles: *i*) prevention; *ii*) precaution; *iii*) polluter pays; *iv*) user pays; *v*) civil society participation; *vi*) sustainable development; *vii*) common but differentiated responsibilities; *viii*) governmental action; *ix*) cooperation, nationally and internationally; *x*) wide publicity; and *xi*) environmental education.

The Municipal Policy on Climate Change in São Paulo meets the following principles: *i*) prevention; *ii*) precaution; *iii*) polluter pays; *iv*) user pays; *v*) protective receiver; *vi*) common but differentiated responsibilities;

vii) holistic approach; *viii*) internalization of social and environmental costs; *and ix*) the right of access to information. Table 6 presents these principles within the three legal spheres.

TABLE 6
Comparative overview of the principles set out in federal (Brazil), state (São Paulo) and municipal (São Paulo) policies

Municipal	State	Federal
Prevention	Prevention	Prevention
Precaution	Precaution	Precaution
Polluter-pays	Polluter-pays	
User-pays		
Common but differentiated responsibilities Common but differentiated responsibilities Common but differentiated responsibilities		
Internalization of social and environmental costs		
Right of Access to information		
Sustainable development	Sustainable development	Sustainable development
	Governmental Action	
	National and International cooperation	
	Participation of civil society	Participation of civil society
	Environmental Education	

Sources: Brasil (2009), São Paulo (2009a) and São Paulo (2009b).

Based on the principles and targets established in the above laws, we find it appropriate to review the incentives and / or penalties (command and control policies) to economic sectors in order for the government to implement more effective actions related to climate change. As such, it is important to examine how to implement such mitigative and adaptive actions.

3 INTERVIEWS

In order to incorporate other views and perspectives in the analyses of this research, semi-structured interviews were conducted with certain researchers, scholars and journalists on climate change. The following questions were discussed:

- What are the major structural problems of the Brazilian national and state policies?
- How to combine the obligations and targets of state and local policies with the national policy?

- How should the private sector act in order to reduce potential risks and increase competitiveness?

The climate change experts interviewed belong to the Management Center for Strategic Studies (CGEE); Institute of Electrotechnics and Energy (IEE/USP), the Institute for Applied Economic Research (Ipea), Center for Economics and Finance in Energy (CEFEN/USP); Alberto Luiz Coimbra Institute for Engineering PostGraduate Studies and Research of the Federal University of Rio de Janeiro (COPPE/UFRJ, Polytechnic School of USP (Poli/USP); Estado de São Paulo Newspaper and the School of Economics, Business Administration and Accounting (FEA/USP).

According to the interviewees, the policies specify how items should be applied, however, with regards to the national policy the result is not very effective yet. Beyond the disability management structures and regulations there was little evidence of progress to implement the proposed actions established in these policies.

Although the science of climate change is already well established, comprehension and awareness of different scenarios require not only a scientific approach, but also political and economical viewpoints, which have entered the debate only recently. The various aspects of the climate issue have not yet been internalized as a requirement for adjustment and policy settings within all levels of government (federal, state and municipal). Thus, it is fair to say that the legal and regulatory framework is not yet properly implemented, especially in developing countries that lack targets for reducing greenhouse gas emissions under the UNFCCC.Some of the interviewees claimed that the Environment Ministry (MMA) had already anticipated the issue of forming a regulatory institution to deal with the instruments created by the national policy at the time when the National Plan on Climate Change was established, but ultimately no agreement was concluded. When considering the activities of each Ministry, climate change objectives are not always converging, which emphasizes the relevance of management that is independent of government objectives. But what kind of entity would be the most suitable to regulate the implementation of the PNMC? Considering that the task of the Executive Office is administrative management (and not political strategy, as has been observed in the legislation), some interviewees regard it necessary to establish a specific entity to be responsible for the implementation of the PNMC.

The interviewees point out that there have been advances in climate negotiations within the context of Brazil, which were materialized through the discussion and creation of a national climate policy. They also recognize that although there are still failures and barriers related to the effective management and governance of this policy, at least the issue of targets, even if voluntary, has entered into the discussion.

Finally, climate change legislation depends on a thorough process of discussions to be implemented. The Climate Change Policy of the State of São Paulo, for example, indicates that there are many elements to be further developed in other state policies, especially the issue of including mandatory or voluntary targets for reducing GHG emissions. This reinforces the importance of incentives, at least at this early stage of implementation of the climate framework. Considering that the incentives aspect should dominate this initial phase of regulation, it is worth citing some recommendations of practices aimed at reducing emissions that resulted from the conducted interviews:

- Investment in research and development (R&D) and in extension projects, in order to facilitate means to implement the adoption of low carbon practices.
- Fostering greater dialogue with the private sector regarding implementation of the PNMC and subnational policies, as well as in international negotiations on climate change in conjunction with the ministries involved in the issues.
- Involvement of the various economic sectors in discussions on the implementation of the climate change legislation.

Public policies generally sanction the creation of economic and financial mechanisms, as well as provide technology investments, in order to seek solutions to mitigate and adapt to the effects of climate change. Sanctions on the other hand are restricted to specific cases as mandated by laws and vary in accordance with regional and local contexts. Thus, the development of climate policy should be an ongoing effort to provide the conditions for Brazil to join the international effort and contribute to the necessary coordination of global climate issues. When setting targets it is important to determine the impacts of the actions proposed by policies on the competitiveness of states and the country itself. This is one reason why viable economic incentives are necessary. Consequently, a difficulty of dealing with the subject predominates in the business arena, especially considering the ignorance or the multiplicity of information that is not always convergent, as well as the very complexity of the issues. The private sector needs a clear idea of the obligations they will have to meet, so that the actions related to climate do not become merely new costs, but rather competitive advantages.

If a company decides to invest in a potentially polluting activity, the lack of clear rules could make the enterprise unviable in the medium and long term. Over a period of five or ten years such an activity may be blocked due to the creation of a more severe restriction on the type of enterprise, and the investor, without advance warning, could face serious losses in trying to adapt.

4 CONCLUDING REMARKS

This chapter discussed the evolution of policies to tackle climate change in Brazil as well as various aspects of the regulatory framework. The adoption of national targets through the National Policy on Climate Change (Federal Law nº 12.187/2009) can bring, if properly implemented, significant emission reductions that can be combined with regional and local actions.

The use of economic instruments such as fiscal incentives and fees can play a key role in the development and implementation of climate policies throughout the different states. These tools can accelerate the process of efficient energy use, while enabling the development and dissemination of advanced technologies to reduce GHG emissions.

Mechanisms to achieve the targets to avoid harmful climate impacts, however, still require a greater degree of definition regarding regulatory aspects. We observed that the guidelines currently in place are not clear enough and that the measures to be adopted still need definition, particularly with regards to criteria for allocating targets (emissions by sector or by units). The main obstacles observed include the lack of convergence of actions implemented in the various units of the Federation and the temporality of policy measures adopted at national, state and municipal levels. In São Paulo for example, the municipal policy was enacted in June 2009, while the state policy did not surface until November 2009, and finally the national policy was enacted in December 2009. Furthermore, the targets and strategies are also distinct in the three spheres of the country – federal, state and municipal – which makes the standardization of GHG reduction measures and its respective monitoring even more difficult and less effective. Regulations still do not indicate if concrete reduction targets will be established for each economic sector, which would be a great innovation since Brazil does not yet have binding reduction targets under the scope of the Climate Convention. Equally relevant would be the creation of a market for emission reductions, at the Federal Government level.

However, it should be stressed that environmental policy is still a relatively recent phenomenon not only in Brazil but in all countries, thus subject to failures, problems, trials and new initiatives, until satisfactory solutions and arrangements can be found. As such, the lack of appropriate governance mechanisms observed in this study should not discourage new initiatives in the environmental area.

The barriers within the current governance framework should not be cause for discouragement, but rather viewed and yet another element that must be part of future planning and analysis of any organization, institution or country that seeks to maintain future competitiveness. To maintain competition, initiatives such as increasing stakeholders awareness about the real impacts of reducing emissions and creating a business environment favorable to minimizing the future regulatory risk resulting from climate change policies, are necessary.

These policies are certainly important tools in Brazil's progression towards sustainable development and, consequently, of its productive sectors towards a low carbon economy. The fact that some of the analyzed policies already have voluntary targets for reducing emissions indicates advances toward a less intensive effect on climate. The creation of climate policies, coupled with proper regulation and necessary enhancements, represents an opportunity for developing countries to enhance their positions in the international context.

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CHAPTER 3

COMPLEMENTARITY BETWEEN GREENHOUSE GAS MITIGATION POLICIES AND URBAN LIFE QUALITY POLICIES*

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1 INTRODUCTION

Approximately two thirds of the world's energy is consumed in urban areas, contributing around 80% of global greenhouse gas (GHG) emissions (WORLD BANK, 2009). In 20 years, the International Energy Agency (IEA) foresees that cities will be responsible for 73% of global energy consumption (IEA, 2008).[1] Most of that consumption will be needed to fulfill demands from the transport sector, commercial and industrial activities and acclimatization. Therefore, efforts to mitigate global warming require extensive involvement of cities worldwide.

Main factors that contribute to increasing the greenhouse effect also cause local and regional pollution. As such, synergies can be obtained from policies that ultimately deal with global warming, local pollution, environmental conservation and those designed to expand urban infrastructure. This is the case, for instance, of policies that reduce fossil fuel consumption, which is also beneficial to the climate, air pollution and acid rain problems. Linkages occur because the same combustion process that causes emissions of the principal GHG's[2] also generates conventional pollutants[3] with adverse effects on human health, ecosystems, agricultural productivity and materials.

Appropriate land-use planning and efforts to increase urban vegetation are also local attributions that deserve special attention as mitigating activities that result in countless benefits to cities.

However, in some cases policies have negative side-effects. For instance, better landfill storage of solid waste results in higher production of biogas with

* Based on Dubeux (2007).

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1. Estimates for the reference scenario.

2. In combustion processes expected GHG are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Other Kyoto Protocol GHG are sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).[2]

3. In this chapter conventional pollutants are other substances than GHG.

high concentration of methane (CH_4), a GHG. The same occurs with domestic and industrial sewage under anaerobic treatment systems. To prevent that appropriate final waste disposal – a benefit to the local environment - increases the greenhouse effect, projects must be designed to cope with both issues, for example by using CH_4 from biogas as a renewable energy source.[4]

In summary, effects of actions in favor of the climate can contribute to increased life quality in cities, as is already happening in many places worldwide. Likewise, investments that increase life quality can result in mitigation of GHG emissions. Moreover, polices need to avoid trade-offs that could emerge when interactions are not taken into consideration.

This chapter discusses the main synergies between policies on climate change and those dealing with conventional pollutants and urban infrastructure, that can most easily be applied to Brazilian cities.

Section 2 addresses the main interrelations between global, regional and local pollution. Section 3 introduces the main local policy options and investigates key benefits to the climate and cities. Section 4 summarizes and concludes the work.

2 RELATIONS BETWEEN GLOBAL, REGIONAL AND LOCAL AIR POLLUTION

Brink *apud* AAE (2004a) summarizes the different aspects of the problem and subdivides interrelations between local and regional air pollution and climate change into four categories, namely:

1. Pollutant emissions that can aggravate pollution and contribute to reducing climate change: this is the case of for example sulfur dioxide (SO_2), which contributes to acidification, but that partially compensates the greenhouse effect by increasing sulfate aerosols in the atmosphere.
2. Climate change effects on air pollution and vice-versa and in the volume of emissions: in this case the relation between air pollution and climate change takes place when the latter alters the atmospheric transport patterns of air pollutants and ecosystem sensitivity to acid deposition. There is also the effect of the acidification and the deposition of nitrogen from CH_4 and nitrous oxide (N_2O) emissions in some ecosystems as well as the effects of increasing temperature on nitrate leaching, which results in groundwater contamination.
3. Measures to reduce GHG emissions that affect air pollutant emissions and vice-versa: this is the case when technical measures to reduce air pollutant emissions have an adverse effect on the reduction of GHG

4. Methane from biogas when burned do not impact climate unlike methane from natural gas.

emissions or vice-versa. For instance, scrubbers in coal power plants reduce SO_2 (a local pollutant) but cause an increase of carbon dioxide (CO_2) emissions due to increased coal consumption. This is also the case of three-way catalysts in vehicles to reduce local pollution of nitrogen oxides (NOx) and volatile organic compounds (VOC), which has the effect of increasing N_2O emissions.

4. Joint emissions of local pollutants and GHG by the same sources: this category contains an important connection between local air pollution and climate change, since the great majority of emissions that impact both phenomena come from the same sources and, thus, policies that focus on one of the problems can significantly influence the other. This is the case, for instance, of climate change policies for CO_2 reduction. As this GHG originates to a large extent from the use of fossil fuels, a reduction in this use, either by increasing equipment efficiency or by replacing them with alternative energy sources (renewable and nuclear), also reduces carbon monoxide (CO), SO_2, and VOC, among other pollutants.

As outlined, there are substantial correlations between global, regional and local pollution, whether from the perspective of the contribution of each gas to more than one type of problem, or simply by the fact that different gases have common emission sources. Policies designed to deal with problems related to the atmosphere in different dimensions can and should consider their multiple implications, in order to maximize the results that can be achieved in all areas. Policies need to consider the cost-effectiveness and the environmental effectiveness of the proposed solutions in an integrated way, taking into account the effects in different environmental sectors. Such integration prevents inefficient use of resources and the implementation of suboptimal solutions (AAE, 2004b, p. 9).

Thus, it is of fundamental importance to focus on measures that tackle all problems at the same time, bearing in mind that local pollution issues vary across different contexts and that sometimes it is challenging to find a solution that fulfills all requirements from social, economic, environment and financial perspectives.

3 MAIN OPTIONS FOR MITIGATION OF GHG EMISSIONS IN CITIES AND IMPROVEMENT OF LOCAL ENVIRONMENTAL QUALITY

Cities need policies (and projects) that bring improvement to all environmental issues. For this purpose, there are innumerable opportunities to reduce GHG emissions when implementing a series of actions towards local improvement and vice-versa. Some options for Brazilian cities are as follows.[5]

5. As local pollution problems vary according to air basin characteristics, atmospheric modeling exercises and air monitoring are powerful instruments for identifying the best options.

3.1 Energy

3.1.1 Biogas from wastes (WTP)

Wastes disposed of in open air or garbage dumps, rivers, ponds and any sort of unsuitable location constitute an environmental problem and a public health problem. According to Dubeux *et al.* (2005, p. 148), "landfills are still one of the most appropriate final disposal options for the great majority of Brazilian cities." This is due to low investment and operational costs, mainly in areas where the opportunity cost of land is low. Anaerobic biodigestors, for both solid wastes and sewage, are good options when high land costs require the use of smaller areas for sanitation projects. As biogas from solid wastes contains about 50% CH_4 and in the case of sewage about 75%, investments in sanitation can result in increased GHG emissions. To prevent this, high efficiency flares can be installed. However, instead of simply burning the biogas, it can be used instead of fossil fuel energy sources, and as such projects that produce biogas contribute to GHG mitigation in a more effective way.

Biogas can be used to generate electricity (see section 3.1.6) or directly as fuel for Otto cycle engines, boilers or injection into gas pipelines. In these cases, there are two options:

- Direct use of the medium Btu gas (simpler and usually of higher cost – effectiveness) in boilers and in industrial processes, for instance, drying operations, kiln operations, cement and asphalt production. The gas is injected in a small pipeline and delivered directly to a nearby consumer; and
- Biogas depuration for a high BTU product injected into a regular natural gas pipeline. Due to the higher capital cost, this option will only be cost-effective for large landfills with substantial amounts of gas recovery. There is still the option of using high BTU gas in Otto cycle vehicles, mainly in captive fleets that would not require the use of a pipeline.

Concerning the environmental impacts of waste biogas use according to Rosa *et al.* (2003):

> (...) waste biogas contains volatile organic compounds (VOC), the main contributors to the depletion of the ozone layer, and toxic pollutants, which are slowly and continuously released into the atmosphere as a product of waste decomposition. When collected and used appropriately, these compounds are destroyed, preventing consequent environmental damage.

3.1.2 Biodiesel from various origins

Biodiesel is a substitute for conventional diesel, obtained from new or used vegetable oils and animal fat. Byproducts in the process are biodiesel - an ester - and glycerol or water in the case of acid inputs from sewage.

From an environmental viewpoint, the use of biodiesel (100% biodiesel or B100) significantly reduces the emissions of pollutants, and is able to reach a 98% reduction of sulphur, 30% of aromatics and 50% of particulate matter (PM) and, at least a 78% reduction of greenhouse gases (ROSA *et al.*, 2003). However, biodiesel can be blended with diesel at any concentration leading to a proportional reduction of GHG emissions. An EPA's study (2002) indicates that the higher the level of biodiesel in the blend the higher the reduction of CO, HC (hydrocarbon) and PM emissions. Nevertheless, there is an inverse relation with regard to NOx, since the higher the share of biodiesel, the higher the emission of these pollutants, mainly due to use in older vehicles. Therefore, if photochemical smog (O_3) is a pressing problem for a city, given the relevance of NOx in its formation, the opportunity to have fleets running on biodiesel (or a blended proportion) must be assessed so that this phenomenon is not worsened.

It is worth mentioning that in Brazil biodiesel is already added to mineral diesel, as enacted by Federal law. Therefore, only an increase in the mixing ratio can be considered as a local mitigation measure of GHG emissions.

3.1.3 Ethanol from sugar cane

Ethanol is a nationally approved fuel, both the anhydrous form currently added to gasoline,[6] as well as the hydrated pure form. In 2003, flex fuel technology was deployed in the country and demand has been increasing since then.[7] As ethanol is a renewable fuel it mitigates GHG emissions when replacing fossil fuel use. Ethanol from sugar cane, as used in Brazil, is the most effective.

With regard to local environmental pollution, emissions of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and aldehyde depend on the age of the vehicle fleet and on technology. When comparing average emission factors for new 2010 vehicles, dedicated gasoline C cars emit less of the above mentioned pollutants than flex fuel cars running on gasoline C and even less than on ethanol.[8]

However, it is worth mentioning that fuel prices in Brazil are not a matter of local decision. Therefore, as in the case of biodiesel, only decisions on fuel for captive fleets can be influenced at the municipal level.

6. Gasoline C: a blend of gasoline (75%) with ethanol (25%), in volume. Percentages vary around this figure over time.
7. In Brazil, new dedicated ethanol vehicles are no longer for sale.
8. See CETESB, 2010 for details.

3.1.4 Solar panel (thermal)

The main advantage of solar panels is that their use is entirely clean, and that conventional pollution from manufacturing is controllable. Solar panels require very little maintenance and costs have been decreasing over time. Thermal panels prevent the need to transport fuel for heating. It is worth mentioning that there is high incidence of sun light in Brazil, making solar energy use viable in most parts of the country.

3.1.5 Electricity from conventional Sources

In Brazil, electricity supplied from the interconnected grid has a very small climate impact due to its low carbon content, since hydropower plants generate the majority of the energy. Thus, the replacement of transport modes running on fossil fuels with electric vehicles offers great potential for mitigation of GHG and local pollutants. In cities connected to the grid, the replacement of diesel bus fleets with a trolleybus or subway system offers significant positive environmental benefits.

According to La Rovere *et al.* (2006a, p. 32), ... data from the São Paulo Metro System indicate that in 2011, when the "Consolidated network" will be totally ready, the light duty fleet will avoid the consumption of 84,600 m^3 of gasoline C .... In 2025, when the "Essential network" is ready, avoided consumption will reach 208,500 m^3.

The trolleybus is, in spite of its limited use, according to Branco (2007, p. 7), ... the best option for bus transportation because its energy efficiency is above 80%, double that of any combustion engine, and its emission is null in the urban environment. This vehicle is appropriate and economically viable, especially in dedicated bus lanes where the demand is huge. Due to a series of bureaucratic reasons, overcharging of electricity at peak hours and misallocation of responsibilities for grid maintenance, trolleybuses have been eliminated and cities adversely affected due to replacement by polluting alternatives.

3.1.6 Electricity from renewable sources

Although electricity from the grid is very clean in Brazil, some carbon content is due from connected fossil fuel power plants, usually running on natural gas or coal. Even in isolated communities, electricity generation produces local and global pollutants when using small generators, usually diesel. Thus, projects that replace conventionally generated electricity with renewable sources reduce emissions with local and global benefits. Examples of such renewable sources include wind generators, photovoltaic energy convertors, small hydro power plants and biomass plants. The following alternative sources are some of the most suited for Brazilian cities:[9]

- *Windpower*: Recently the availability of this technology has grown rapidly in Brazil. The potential is mostly concentrated on the Northeastern coast and to a lesser extent on the coast of Southern and Southeastern regions. There are also some locations far from the coast especially in Bahia, Minas Gerais and Paraná with good wind speeds.
- *Photovoltaic energy*: With one of the highest global radiation averages (around 230 Wh/m^2), Brazil enjoys excellent conditions for solar energy use. The highest incidence is in the Northeast (260 Wh/m^2) according to Costa and La Rovere (2005).
- *Small hydropower plants*: small and micro hydropower plants are an option for conventional generation in isolated areas, avoiding generators that pollute locally and globally.
- *Biogas generation*: the most traditional use of biogas is as fuel for electricity generation. There are several power generation technologies: internal combustion engines, combustion turbines, steam turbines etc. Steam from cogeneration can be used locally for heating, cooling and other processes or even transported by pipeline to nearby consumers, thus obtaining additional sources of project income.
- *Waste incineration*: Incineration is not a technology that has been deployed in Brazil like in developed countries. It is mainly used to treat hospital waste and hazardous materials. However, this technology is best utilized when process exhaust gases which normally reach over 1.000^{o}C are recovered and routed to a heat recovery boiler, which produces steam to move a turbine and generate electricity. Concerning local impacts of combustion, gases and substances are formed and need to be purified before being discharged into the atmosphere. Nitrogenous oxides (NOx) and carbon monoxide (CO) are produced in any combustion, which through controlled burning and gas treatment systems coming out of combustion chambers, can be reduced to tolerable levels (ROSA *et al.*, 2003 *apud* OLIVEIRA, 2004, p. 78). Process controls are required to avoid the formation of dioxins and furans, which are highly toxic compounds.

9. Not all renewable sources are appropriated to any city. It depends on many factors such as city size, distance from the grid, technology costs and requirement for complementarity between sources besides other parameters that need to be taken into consideration in the decision making process.

3.1.7 Energy Efficiency

Energy efficiency is a suitable strategy designed to reduce emissions of most pollutants. Energy efficiency gains are the objective of many interventions in the transport system aimed at increasing mobility, reducing energy consumption, among other measures. The main ones are:

- *Improvement of traffic management and control systems:* implementation of computerized control of traffic signals to reduce congestion; adoption of parking management policies that introduce parking fees to inhibit the use of private cars; and use of speed control devices and traffic calming measures.
- *Vehicle inspection and maintenance (I/M) programs*: There are several modalities of implementation of an I/M program. In broad terms, the general condition and emission levels of vehicles are tested.[10] The performed test is mainly on the exhaust system, but I/M programs can also check evaporative emission and adulteration of the emission control system. Vehicles that fail the test must undergo repairs or maintenance to bring the emission performance up to acceptable levels, or they must cease operating. Many times, engine regulation is required what increases energy efficiency by reducing fuel consumption per km travelled.
- Such a program is particularly relevant for bus fleets that usually run on diesel and are responsible for a big share of CO, HC, NOx and SO_2 emissions in cities.
- Pollution control and I/M programs offer many co-benefits. General benefits are summarized as follows (LA ROVERE *et al.,* 2006b):
  - Benefits for the community: fewer traffic accidents; reduction of traffic congestion; less atmospheric contamination; lower hospital and emergency assistance costs; new direct and indirect jobs;
  - Benefits for the state: increase in road safety and environmental quality; collection of indirect and direct taxes; collection of concession taxes (when I/M is performed by a third party); creation of a fleet database; and reduction of vehicle tax evasion;
  - Benefits for owners: personal and family safety; savings on fuel consumption due to engine optimization; increased resale value due to better conservation of vehicle; increased safety for used car buyers; decreased maintenance expenses due to better conservation; elimination of unnecessary repairs; and lower insurance costs.

10. Noise can also be tested.

- Benefits for the automotive sector: absorption and development of new technologies; production of new components; demand for new inspection centers and specialized repair stations etc.

- Benefits for the environment: reduced pollution emissions; data collection and identification of polluting vehicles, adulteration effects, average conditions, ages, accurate mileage values, types, technologies and socioeconomic conditions of car owners associated with the models in circulation etc.
- *Rationalization of itineraries*: the rationalization of traffic itineraries in general and in particular the optimization of bus itineraries aimed at reducing distances and traffic congestion, are measures of great importance. Separation of traffic, including bus priority systems (such as dedicated bus lanes) and improved interchange between transport modalities to facilitate the interconnection of transport networks, are also very important measures.
- *Bicycle lanes and pedestrian zones:* complete or partial closure of streets to motorized traffic through the creation of pedestrian zones and bicycle lanes is extremely important for increasing the share of non-motorized transport modes. Adequate sidewalks, pedestrian crossings, and bicycle lanes are the only basic provisions required.
- *Road user charge or road pricing: the* congestion tax is a demand-side management scheme that aims to reduce private car use or at least to increase the number of passenger per vehicle per trip in urban areas. When used as a traffic congestion reduction instrument, the tax charges the actual costs of using the roads, meaning that costs will be greater when roads are congested and smaller when traffic is light, thus reducing the demand for roads during rush hours and lowering emissions from queuing cars (RIBEIRO *et al.*, in the press).
- *Less carbon intensive building materials:* building impacts the environment in many different ways. Emissions from this sector greatly result from the use of materials produced in several polluting industrial sectors. Wood or concrete houses, for example, are options that based on several factors affect the environment at different levels and magnitudes. Thus, regulation can induce the use of building materials with relatively fewer impacts.
- *Use of less energy- intensive equipment*: there are countless mitigation options related to more efficient equipment. Replacement of conventional light-bulbs with energy-efficient bulbs and using natural cooling systems instead of electrical equipment are measures to be promoted by municipal governments.

- *Land-use planning*: there is a close interaction between urban transport and land use. The more sprawled the city, the greater the demand for transport systems. Therefore coordination of land use and transport planning can be key to increase mobility without elevating demands for energy consumption. Good planning should favor non-motorized transport, especially cycling.
- *Recycling*: use of recyclables as inputs in the economy is, in a great number of cases, an energy conservation measure that can be promoted by cities mainly through public procurement processes by favoring products with some degree of recycled material in the production process. Recycling of building materials is a measure of great relevance that requires special efforts to become a common practice. Encouraging recycling can result in considerable gains in energy savings and therefore also reduce emissions. (OLIVEIRA; ROSA, 2003).

3.2 Carbon sequestration

Reforestation programs implemented in cities can recover degraded areas and help to rebuild original ecosystems. These programs can be designed to improve socioeconomic conditions in low-income settlements, resulting in both carbon sequestration and the creation of jobs in developing countries.

Broadly speaking, increasing vegetation stocks in cities brings great improvements to life quality in urban centers. Due to their multiple functions, parks produce a more pleasant climate, improve air quality, reduce noise levels, provide an attractive landscape and an indispensable refuge to remaining fauna. Through a reduction in direct incidence of solar energy and an increase of air humidity, parks contribute to lowering temperatures in heat islands (built areas where average air temperature is higher than in nearby rural areas) and thus reducing demand for cooling.

4 FINAL REMARKS

Local policies should explore synergies to maximize the benefits that can result from coordinated actions conceived to reduce pollutants with distinct scales of reach, as well as to avoid the trade-offs that can emerge when interactions are disregarded.

As such, there are innumerable opportunities to be explored by cities that simultaneously contribute to mitigate climate change and increase citizen well-being. The emission of various gases and particles of local, regional and global importance are usually correlated in their generation process, main sources being the burning of fossil fuels and biomass. Furthermore, investments in sanitation, forestation and land-use planning can simultaneously contribute to the climate and to life quality in cities.

From a different perspective, negotiations taking place under the United Nations Framework Convention on Climate Change (UNFCCC) can lead to a future commitment that requires cities to play a role in reducing their GHG emissions. Thus, we can conclude that mitigation actions may not be imposed on citizens as a cost, because if well-conceived, these actions may represent an opportunity for life quality improvements in developing countries. Moreover, carbon markets may bring financial resources from GHG mitigation that can ultimately benefit cities.

Likewise, investments pursuing local benefits become an opportunity for cities to collaborate with the global effort to address the climate problem.

As a result of the correlation between local, regional and global pollution, many policies in the most developed countries worldwide have been designed and implemented to cope with all these issues using an integrated approach. In Brazil, there is still room for a great amount of coordinated actions, and some possibilities concerning cities were explored in this text.

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CHAPTER 4

BRAZILIAN INVENTORY OF ANTHROPOGENIC EMISSIONS BY SOURCES AND REMOVALS BY SINKS OF GREENHOUSE GASES NOT CONTROLLED BY THE MONTREAL PROTOCOL

Ana Carolina Avzaradel*

1 INTRODUCTION

Brazil was the first country to sign the United Nations Framework Convention on Climate Change (UNFCCC). As a Party to the Convention, one of the country's main commitments undertaken is the development and periodic update of national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHG) not controlled by the Montreal Protocol, using comparable methodologies agreed upon by the Conference of the Parties. Developing country Parties inventory submissions must be accompanied by another set of information related to national circumstances and a general description of the steps taken or envisaged by the country to implement the Convention, producing a document called *National Communication* (BRASIL, 2010).

The Brazilian Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the *Montreal Protocol* is an integral part of Brazil's Second National Communication to the United Nations Framework Convention on Climate Change. The Ministry of Science and Technology (MCT) is responsible for elaborating national communications, according to the government division of tasks established in 1992. However, the work is conducted in a decentralized manner, involving a large number of institutions of excellence in the country.

The inventory presents emissions estimates of greenhouse gases, covering the entire country and all sectors of the economy over the period from 1990 to 2005. The structure of the work, as well as the methodologies adopted[1] for the calculations, follows the guidelines of the Intergovernmental Panel on Climate Change (IPCC), and therefore is classified according to the following sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Land-Use Change and Forestry (LUCF), and Waste.

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1. The following documents were adopted: *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 1997) and *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC, 2000), whose adoption is encouraged, but not mandatory, as in the case of the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC, 2003). In some cases, it was deemed necessary to resort to *Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006), whose use must be justified, given that it has not been formally adopted even for developed countries – the so-called Annex I countries, in the jargon of the Convention.

Section 2 presents the development process of the inventory and significant improvements achieved since the first *Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases not Controlled by the Montreal Protocol*, published in 2004. Section 3 presents the main inventory results and analyzes Brazilian anthropogenic emissions. In section 4, the Brazilian anthropogenic emissions profile is compared to those presented by developed countries. Section 5 concludes the chapter with a discussion of the prospects for the next national inventory.

2 BRAZILIAN INVENTORY

The national inventory is the result of an effort led by MCT, whose execution relies on the participation of institutions with recognized competence in several areas. For each sector of the inventory, a contract or partnership has been established with institutions.[2] As a consequence, the work is developed in a decentralized manner, which brought great benefits to data collection and compilation.

The first national inventory was delivered in December 2004 and covered the period from 1990 to 1994. The second national inventory presents emissions estimates for the period 1990 to 2005, recalculating estimated emissions from 1990 to 1994, in order to maintain time series consistency. Thus, the inventory goes beyond the reference year 2000, as established by the UNFCCC guidelines for the Second National Communication of developing countries. The first inventory experience served as a starting point for the second one and since then much progress has been made. The set of information and the number of institutions, as well as authors, contributors and reviewers greatly expanded since the first inventory. The database has been amplified and its quality improved.

The National Network of GHG Inventory of the Waste Sector was established, together with CETESB, with the aim of creating awareness about Waste sector inventories, involving a greater number of experts in the work and improving the information and data quality used in the inventory. This was a pilot initiative that can be extended to other sectors of the inventory, such as Industrial Processes and Agriculture. The network has been successful in establishing a discussion forum and promoting the release of state inventories for the Waste sector in several states of the country.

2. In the case of the Energy sector, which is divided into emissions due to combustion and fugitive emissions from oil, gas and mining, the civil society organization of public interest (OSCIP) e & e was contracted for the first case, with support from the Ministry of Mines and Energy (MME). A partnership was established with Petróleo Brasileiro S/A (Petrobras) and a contract was signed with the Brazilian Association of Coal (ABCM) for fugitive emission estimates. For the Waste sector, a contract was established with the Society of Environmental Sanitation Technology (CETESB), responsible for the estimates for solid waste, effluents and incineration. The Agriculture sector had support from the Brazilian Agricultural Research Corporation (Embrapa) and Industrial Processes cooperated with several institutions: Brazilian Chemical Industry Association (Abiquim), the Brazilian Aluminum Association (Abal), National Union of the Cement Industry (SNIC), the Brazil Steel Institute (IABr) and the National Electric Energy Agency (Aneel). The Foundation for Science, Applications and Space Technologies (Funcate) and the National Institute for Space Research (INPE) contributed to the Land-Use Change and Forestry sector.

Project activities of the Clean Development Mechanism (CDM) were also used as a data source for the inventory. For the Waste sector, information contained in the monitoring reports of CDM landfill project activities, which had already received certified emission reductions (CERs) was used, allowing for methane recovery deduction in the calculations from 2003 on. In 2005, when CDM projects were still incipient in Brazil, a reduction of 62.5 Gg in CH_4 emissions was accounted for (BRASIL, 2011a). Impacts from emissions reductions due to CDM project activities in this and other sectors of the inventory will certainly be much greater in the next inventory.

The Land-Use Change and Forestry sector is the major net emitter of carbon dioxide (CO_2) in the country and, therefore, commanded much of the inventory efforts. 2003 *Good Practice Guidance* guidelines were adopted even though it was not mandatory and a more complex and detailed approach was used. As a result, the scope of CO_2 emissions and removals was expanded, which in the first inventory were calculated only for land-use changes related to Forest Conversion to Other Uses and Abandonment of Managed Lands. Estimates of anthropogenic emissions by sources and removals by sinks for this sector were made for 1994 and 2002 and extrapolated to cover the entire period of the inventory. The study utilized 429 satellite images covering the whole country, of which 198 were of the Amazon and 118 of the Cerrado, which represent another important advance from the first inventory. In total, 7,581,333 polygons were identified, over 50% in the Amazon biome. Each polygon represents information about the biome, municipal boundaries, vegetation type, soil type and land use for 1994 and 2002. An effort was undertaken to improve the information for the used parameters, such as the values of carbon stock in the vegetation types, for instance. Carbon stock in roots was included in the estimates, leading to higher results in comparison with the first inventory (BRASIL, 2011b).

For the Industrial Processes sector, a larger share of industries participated in the development of the second national inventory. Emissions from the use of lime were included in the iron and steel industry and in the glass and magnesium production estimates (BRASIL, 2011c). In the first inventory, emissions from the iron and steel industry were fully reported in the Energy sector, according to IPCC (1997) guidelines and due to the lack of data that would allow for the dissociation of fossil fuel combustion emissions from those originated in industrial processes. Data obtained for the second national inventory from industries allowed CO_2 emissions from iron and steel industrial processes to be correctly allocated to the Industrial Processes sector, consequently reducing the emissions of the iron and steel Energy sub-sector.

A reassessment of the organic land area used in agriculture, nitrous oxide estimates from agricultural soils and waste management of the Agriculture sector, has resulted in significant reductions compared with the first inventory. Another important improvement concerns the data used in the estimates. Awareness on manure management systems has improved, as well as the emission factor related to direct emissions from synthetic and animal fertilizers and from crop residues. In addition, new data on animal ages and its impact on nitrogen concentrations in animal excrement were used in the estimates (BRASIL, 2011d).

More detailed estimates for some sub-sectors in the Energy sector were conducted, such as civil aviation, for which a specific background report was produced for the first time. Estimates were based on more detailed data on fuel consumption and aircraft movements, allowing for a more accurate disaggregation between civil aviation and international bunkers. Since more detailed data were only available for more recent years, methodologies with different complexity levels were applied. In this case, time series consistency was ensured by applying the superposition method. Calculations were carried out in full transparency and data, hypotheses and methodologies were published and made available for consultation (BRASIL, 2011e).

One of the primary results achieved in the compilation of the inventory was the guarantee of compliance with the principles that guide the preparation of national inventories, in accordance with Decision 17 of the 8th Conference of the Parties to the Convention on Climate Change:[3] transparency, accuracy, consistency, comparability and completeness (TACCC[4]).

18 background reports were prepared and publicly disclosed on the MCT website from April to September 2010 to complement the inventory. The reports can be accessed by specialists who may be interested in estimate details for certain sectors. Specific aspects of calculation procedures, data used and hypotheses assumed are presented, reproducing the principles of the inventory, as already mentioned. The public consultation process conducted by MCT already sets an important quality assurance procedure, providing experts who did not directly participate in the construction of the inventory with the opportunity to review it.

As previously presented, estimates of greenhouse gas emissions are made available in the inventory up to 2005, although the reference year is 2000 according to Decision 17/CP.8. In this chapter, the most current results available in the inventory will be analyzed. For some sectors and sub-sectors more current estimates can be obtained, as reported in the background reports. For example, the Energy sector emissions can be updated since the main database is public, easily

3. Document FCCC/CP/2002/7/Add.2 dated March 28th, 2003.

4. The acronym TACCC summarizes the principles that should be adopted when preparing national inventories, namely: *transparency* concerning methods, data and hypotheses; *accuracy*, with low uncertainty levels; *comparability* between calculation methods, *completeness*, thoroughly covering all gases and sectors and *consistency* throughout the time series (IPCC, 2000).

accessible, and published on an annual basis.[5] For the Agriculture sector, data were obtained from the agriculture and cattle farming census. The most recent publication refers to 2006, creating a ten year gap after the previous publication, and was only released at the end of 2009, thereby affecting the preparation of the inventory. As per the Land-Use Change and Forestry sector the difficulty is of another kind, considering that the resources necessary for its updates are much more robust than for any other sector. The year 2005 is, thus, the most recent year for which it was possible to obtain estimates for all sectors.

3 BRAZILIAN EMISSIONS

The results presented in the inventory reveal a 65.2% increase in net anthropogenic emissions of carbon dioxide over the period from 1990 to 2005. In 2005, 76.8% of total CO_2 emissions (1,637,905 Gg) came from the Land-Use Change and Forestry sector, which was also responsible for 100% of CO_2 removals. The Amazon Biome is the main segment of this sector, contributing with 51.5% of total net CO_2 emissions in the country. Net CO_2 emissions from the Amazon Biome grew 83% between 1990 and 2005. The energy sector presents a 74.3% increase of CO_2 emissions, driven by the industry and transport sub-sectors. In particular, CO_2 emissions from road transport grew 72.1% between 1990 and 2005, representing almost 40% of sector emissions in 2005. Fugitive emissions contributed with only 0.8% of total CO_2 emissions in 2005. Emissions from coal mining and handling decreased by approximately 30% since 1990. The key driver of CO_2 emissions in the Industrial Processes sector is the iron and steel sub-sector, where emissions increased by 54.6% between 1990 and 2005. As mentioned in section 2, part of this observed increase is due to the reallocation of iron and steel emissions estimates that were previously reported in the Energy sector. The contribution of the Waste sector to total net CO_2 emissions is minimal (BRASIL, 2010).

The sector chiefly responsible for methane (CH_4) emissions is Agriculture, with 70.5% of CH_4 emissions in 2005. It is estimated that 53.9% of the country's CH_4 emissions resulted from enteric fermentation of Brazilian cattle. Animal manure management is dominated by pigs and cattle and contributes with a small proportion of CH_4 emissions. Land-Use Change and Forestry released 16.8% of CH_4 emissions in 2005, and Waste was responsible for 9.6% of total CH_4 emissions. In this case, the key drivers are solid waste disposal and wastewater

5. Data used in the calculations of the Energy sector mostly comes from the National Energy Balance (NEB) and may be obtained on the website of the MME and the Energy Research Company (EPE). In some cases, however, other data sources were used to improve estimates. For civil aviation and aviation bunker fuels, data from the National Civil Aviation Agency (ANAC) and the National Agency of Petroleum, Natural Gas and Biofuels (ANP) were used for the adoption of a more detailed methodology for the years from 2005 to 2007, allowing for a more accurate estimate for the entire period from 1990 to 2005. For oil and natural gas fugitive emissions estimates, data were directly obtained from Petrobras.

handling. The energy sector is responsible for only 3% of CH_4 emissions. Emissions from the energy sub-sectors predominate, in particular from charcoal plants, whose participation in total emissions are almost equivalent to that of fugitive emissions from oil extraction and production. Methane emissions from the Industrial Processes sector derive from the chemical industry and are not relevant to total emissions in the country (BRASIL, 2010).

The Agriculture sector also accounts for the largest share of nitrous oxide (N_2O) emissions. Direct emissions, especially those resulting from pasture animal waste, and indirect emissions from agricultural soils together represent approximately 85% of total emissions. The second sector that contributes the most to N_2O emissions in Brazil represents only 4.2 % of total emissions, namely the production of nitric acid and adipic acid which, along with other productions of the chemical industry, is responsible for the emissions from the Industrial Processes sector. The remainder is attributed to Land-Use Change and Forestry, with 3.8% of total N_2O emissions, Waste (2.6%) due to domestic effluents, and the Energy (2.2%) from the industry and transport sub-sectors (BRASIL, 2010).

Greenhouse gas emissions referred to as partially fluorinated hydrocarbons or hydrofluorocarbons (HFCs), as well as perfluorinated hydrocarbons or perfluorocarbons (PFCs) are associated with the Industrial Processes sector. The only one of these gases produced in Brazil was HFC-23, a by-product of HCFC-22 production, which was ended in 1999 when emissions amounted to 0.09716 Gg. At that time, HFCs and PFCs were adopted in the production of refrigeration and air-conditioning, aerosols and fire extinguishers and protection against explosions, replacing substances with ozone layer destruction potential (BRASIL, 2011f). Sulfur hexafluoride (SF_6) emissions derive from magnesium production as well as from the use of HFCs, PFCs and SF_6. Perfluormethane (CF_4) and perfluorethane (C_2F_6) are gases originating in aluminum production as a result of the anode effect. For other gases, potential emissions associated to its use are considered.

Precursor, or the so-called indirect, greenhouse gases such as carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOC) are also accounted for in the inventory. Total CO emissions grew 17.1% between 1990 and 2005. 64.4% of emissions in that year resulted from the Land-Use Change and Forestry sector and 27.3%, from the Energy sector, especially from the residential and transport sub-sectors. The key driver in Agriculture sector emissions, which contributed with 6.8% of total emissions, was the burning of agricultural waste, in particular sugar cane. In the Industrial Processes sector, aluminum production and the manufacture of other products participated with 1.5% of total CO emissions (BRASIL, 2010).

NOx emissions are 70.2% concentrated in the Energy sector, with almost 40% coming from the transport sub-sector specifically from road transport.

22.3% of the remaining emissions are due to the Land-Use Change and Forestry sector, 7% to the Agriculture sector, mainly because of the burning of sugar cane waste, and 0.5% to the Industrial Processes sector.

NMVOC emissions grew 27.1% since 1990. The main sectors that contributed most to the emissions increase include the Industrial Processes sector, which represented more than 85% of the growth between 1990 and 2005 and culminated at 27.8% of total emissions, followed by the Solvents and Other Products Use sector. Emissions from this sector have grown 70.2% between 1990 and 2005. The Energy sector contributed with 44.5% of total emissions in 2005, despite a 6.2% emissions decrease since 1990 (BRASIL, 2010).

In order to sum[6] up emissions from different gases and report them in aggregate terms, it is necessary to convert them to a common unit, which was arbitrarily defined as carbon dioxide equivalent (CO_2 equivalent). However, there is still no consensus on the most appropriate metric to be used for this conversion. The discussion about the suitability of the metrics adopted for emissions aggregation is treated in a box in the inventory and is addressed in multilateral negotiations on climate change. The Brazilian government objects to the use of the *Global Warming Potential* (GWP) of a period of 100 years for the comparison of greenhouse gases, since it does not properly represent the relative contributions of different gases to climate change, overestimating impacts of gases with short lifetimes in the atmosphere, such as methane, and underestimating the contribution of gases which remain for a longer period of time in the atmosphere, such as the PFCs. Therefore, Brazil decided to transparently report emissions by gas in the inventory, in units of mass. The *Global Temperature Potential* (GTP) is a possible alternative to the use of GWP to measure emissions impacts of different gases on the average temperature of the Earth surface. For methane, whose GWP is 21,[7] the GTP is only 5 (SHINE *et al.*, 2005 *apud* BRASIL, 2010). Consequently, the use of GWP allows CDM projects that reduce methane emissions to receive carbon credits per unit of methane reduced in a much higher volume than what it is necessary to mitigate the average temperature increase, i.e. a greater reduction than what actually occurs is attributed to these projects. The consequence is that developed countries that buy these credits for the purpose of achieving quantified emission limitation and reduction commitments are actually acquiring a permission to emit that surpasses the reduction that took place in the developing country. The overall result is an increase in emissions. The difference between using the two measurements can be observed in Graph 1. The Brazilian emissions trend over the period from 1990 to 2005 is presented in Graph 2.

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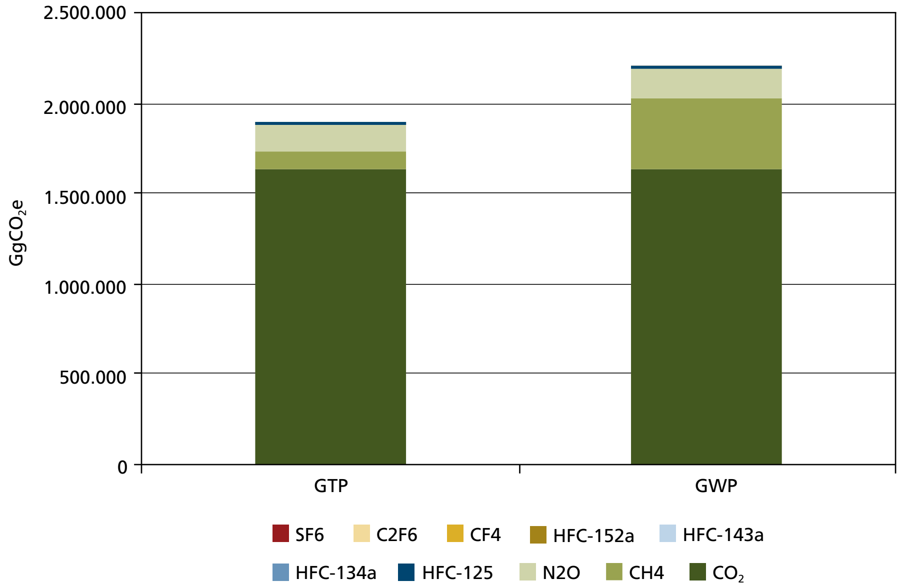
6. Emissions resulting from fuel combustion activities in international aviation and maritime transport, denominated as bunker fuels should be reported in the inventory only for information purposes and are not counted in the country's total emissions and, therefore, will not be treated in detail in this work.

7. According to the IPCC Second Assessment Report and recommended in Decision 17/CP.8.

GRAPH 1

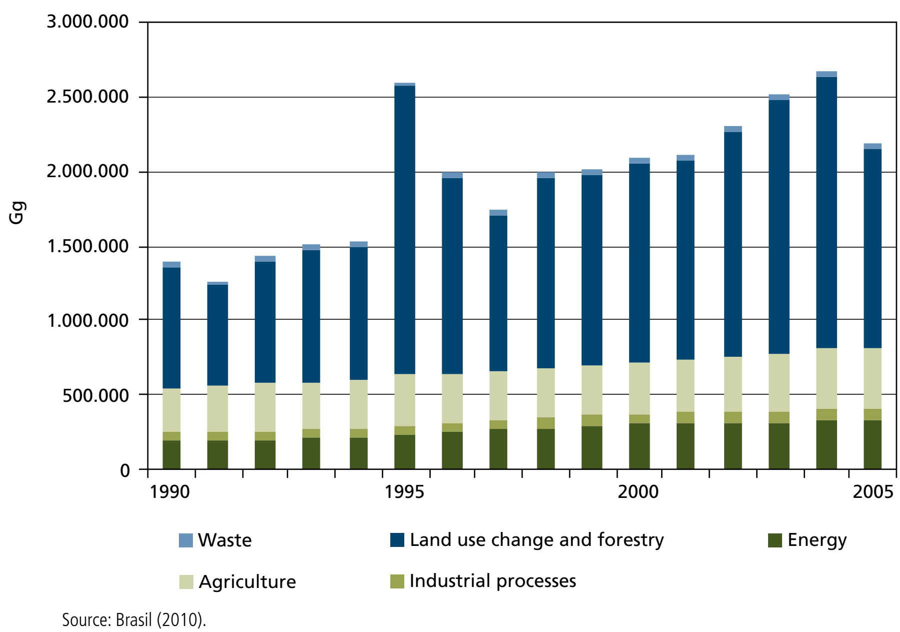
Brazilian greenhouse gas emissions, in CO_2 equivalent – 2005



Source: Brasil (2010).

GRAPH 2

Brazilian emissions trend converted to CO_2eq, through the use of GWP



Source: Brasil (2010).
Compiled by the author.

4 INTERNATIONAL CONTEXT

An analysis of developed countries emissions, denominated as Annex I countries in the jargon of the UNFCCC, evidence that emissions that result from fossil fuels combustion represent the largest share of total emissions of these countries. Annex I countries, as a total, accounted for a total of 14.68 Tg CO_2eq[8] emissions coming from the Energy sector in 2008;[9] 1.23 Tg CO_2eq, from the Industrial Processes sector; 1.35 Tg CO_2eq, from the Agriculture sector; 0.48 Tg CO_2eq, from the Waste sector; and -2.07 Tg CO_2eq, from the Land-Use Change and Forestry sector. Between 1990 and 2008, the key driver to the energy sub-sector emissions growth was transport, contributing with 13.9% (UNFCCC, 2010). Aggregated data of the European Union for 2008 show that over 85% of their emissions result from the Energy sector. In the case of the United States, this percentage rises to almost 100%, considering net emissions of Land-Use Change and Forestry in the total sum, or of approximately 87% when net emissions from LUCF are not considered.[10]

Brazilian emissions profile is quite different from that which is presented by developed countries. In the case of Brazil, most emissions are due to deforestation, which means that the main driver of emissions is not tied to socio-economic growth of the country and does not contribute to its development.

5 FINAL CONSIDERATIONS

The previous sections briefly presented the inventory process of compilation and organization, the principles that guide it, advances already achieved relative to the first version, main results obtained and the Brazilian emissions profile contrasted to emissions of developed countries.

As indicated in section 2, a very expressive improvement was observed between the first and the second Brazilian inventories. However, there is still room for improvements. Although the results clearly indicate the areas where the highest percentages of anthropogenic emissions of greenhouse gases are concentrated, it is important that the preparation process of the next inventory involves the sector and key category analyses. In addition to indicating areas that should still be developed, this analysis is useful to indicate segments of the inventory that should be given priority in terms of resources, time and level of

8. By the beginning of 2011, all Annex I countries has already submitted to the Framework Convention tables with anthropogenic emissions by sources and removals by sinks data using the Common Reporting Format (CRF) for 2010 together with the National Inventory Report (NIR). However, 2009 data had not yet been reviewed when this chapter was written, thus, 2008 data was the most recent available at that time.

9. In this case, the aggregation of the gases is done by conversion to a common unit – CO_2e – through the use of GWP.

10. In 2008, net CO_2 emissions from the LUCF sector in the United States were reported as -908.148 Gg CO_2eq, which means that total removals outweighed total emissions in that year.

methodological complexity. Sectors and categories that are classified as key should have their emissions estimated with higher tiers and, if possible, with country specific emission factors.

This obviously does not mean that the inventory sectors and sub-sectors with smaller contributions to national total net emissions should not be further investigated. It is the case of navigation, for instance, estimates require detailed treatment of data to disaggregate fuel consumption between navigation and marine bunkers, as occurs with civil aviation and international air transport. Results obtained in this inventory with respect to details of the calculating methodology of emissions from air transport were fairly satisfactory and can serve as a basis to compile similar work for marine bunkers.

Another area that should be improved and can be the focus of new studies regards the development of more adequate emission factors for national circumstances. Some attempts have already been made in this inventory, as in the case of the nitrous oxide emissions estimates from agricultural lands and from the coal mining and handling sub-sector, among others. In the latter case, the developed surveys indicated factors well below the minimum value recommended in the IPCC (1997) guidelines, but without enough robustness to justify the adoption of such factors. Therefore, the results of these studies could only be used in the inventory in a qualitative manner, justifying the option for the lowest factor, among those suggested in the guidelines. It is necessary to give continuity to studies like this, and working with Academia in order to promote awareness of topics that are in the national interest to develop.

It is clear that the effort to obtain data for constructing the inventory is huge. Several strategies have been implemented to try to overcome the problem, such as the establishment of the Inventory Network for the Waste sector and the decentralization of the work, which has expanded the efforts to improve the quality of available information by involving a large number of stakeholders and institutions.

Even so, inventory execution highly depends on the capacities of other institution to generate high-quality data continuously. Therefore, it is essential to establish legislation that is capable of regulating data supply so that works of great relevance to the country, such as the inventory, are not compromised.

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CHAPTER 5

BREAKING THE TRADE-OFF BETWEEN POVERTY ALLEVIATION AND GHG MITIGATION: THE CASE OF HOUSEHOLD ENERGY CONSUMPTION IN BRAZIL

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1 INTRODUCTION

Improving the standard of living of the poor would almost unavoidably result in the increase of greenhouse gases (GHG) emissions. It is true that the generalization of developed countries' consumption patterns is incompatible with the maintenance of the basic services they ecosystems render to human societies (BEHRENS *et al.*, 2007; FRIENDS OF THE EARTH; SERI, 2009). However, even if the technological innovations directed to the decarbonization of economies advance faster than they do nowadays, nevertheless, to satisfy the basic needs of the global population in terms of feeding, clothing and access to information, culture, education, dwelling and mobility – only to mention some issues – will not be performed without increasing emissions.

But the association between quality of life improvement and emissions is not necessarily valid for all the constitutive items of which quality of life quality is made of.

Firewood is currently the most important biofuel used by the world's poorest as household energy source and it is harmful for three reasons: In the first place, a significant part of the household firewood results from the cut of virgin forests, which compromises biodiversity (UHLIG, 2008). Secondly, the wood stoves are frequently precarious, causing serious damages to families who depend on them in several parts of the world, mainly in India and Africa (*op. cit.*).Finally, the use of firewood as household fuel is responsible for a significant part of the

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world's GHG emissions. The "black carbon" is responsible for 18% of the global warming, just behind the carbon dioxide (CO_2) that provokes 40% of emissions (ROSENTHAL, 2009).

This means that the improvement in the quality of wood stoves and above all, the substitution of firewood for other fuels – even if they are from fossil origin, as liquefied petroleum gas (LPG) – would reduce GHG emissions, improve living conditions of firewood-dependent households and reduce pressure on biodiversity (UHLIG, 2008).

The chapter shows that in Brazil, firewood consumption is inversely proportional to family income – what is also true for charcoal. Then, in theory, more income and broader access to fuels such as LPG can lead poor families to reduce their emissions. The opposite is true for fuels associated with transport services, especially for gasoline employed in family-owned private automobiles. It increases with household income in a ratio sufficient to compensate for the regressive effect of "traditional biomass" – term used by Uhlig (2008).

These are the two evidences presented in section 3 of this chapter. By aggregating the CO_2 content of the energy bundles consumed by families, which is done in section 4, their distribution throughout social classes, can be observed. In section 5, social ascensions among contiguous income levels are related to their carbon cost. A short conclusion follows.

2 LITERATURE REVIEW: THE INTERNATIONAL DEBATE

In the international debate on "climate justice", the imposition of a unique target of CO_2 emissions proportional reduction for all the nations of the world is rejected. This is materialized in the idea of the Kyoto Protocol of common, but differentiated responsibilities (CHAKRAVARTY *et al.*, 2009). The differentiation refers to emissions levels accomplished in the past. With regards to that, it is worth mentioning the qualification of Pan and Chen (2010, p. 28) that "the emissions of the past were not considered wrong due to the limited knowledge on global warming" (PAN; CHEN, 2010, p. 28). The fact is that those gases were released through the construction and consolidation process of the material and institutional basis of developed countries, which in several aspects, is still not paralleled in the underdeveloped world – examples are urban infrastructure, industrial services of public utilities, power generation plants and respective transmission grids, as well as industries, schools, universities and other public institutions.

Of course, besides the differences among countries, the contribution of any given nation is also heterogeneously distributed among its citizens.

Chakravarty *et al.* (2009) estimates the individual emissions of a country's inhabitants from data on income distribution and national CO_2 emissions. Once a limit is established for future emissions, it is possible to identify where the main responsible people for global warming live. It can also be imposed a limit for individual CO_2 emissions that complies with the basic energy needs of the poorest.

It is demonstrated that just a small portion of the world population is the main responsible for future emissions, being it almost equally distributed in the following areas: United States, countries of the Organization for Economic Cooperation and Development – OECD except the United States, China and countries which are not members of the OECD, except China,. When considering poverty eradication, it results that the emissions growth coming from the third world are counterbalanced by the reduction in 16% of the emissions by the richest countries.

Ananthapadmanabhan, Srinivas and Gopal (2007) take the international debate on "climate justice" to India and show the urgent need to apply the principle of the "common, but differentiated, responsibilities".

Starting from the analysis of primary data on electricity consumption and transport of different socioeconomic classes in India, and its conversion into CO_2, the authors demonstrate that although the *per capita* average level of the countries' emissions is below the world average - the reason why the Indian government demands its right to carbon-intensive economic development - this only happens because the enormous level of emissions of the small richer portion of its population (less than 1%) is "camouflaged"[1] by a legion of poor people (more than 70% of the population) whose emissions are almost negligible.

Groot (2010) elaborates Lorenz curves for GHG worldwide emissions, where the inequality of the population distribution of these gases is notorious.

This is the context of Pan and Chen's (2010) carbon budget proposal. The foundation is the concept of basic needs inspired by Amartya Sen's works, which prioritizes the allocation of emissions derived from the consumption of necessary human needs, such as clothing, feeding, dwelling and mobility. Since the basic needs are finite under a biological perspective but they undergo environmental and physical restrictions – due to the finitude of the planet – and considering that the consumption drive is unlimited, it is necessary to evaluate the contribution of countries in terms of future emissions of CO_2, distinguishing the portion that concerns meeting the basic needs of the poorest.

1. In other words, the discrepancy between the rich and the poor becomes imperceptible when emissions are divided by the population as a whole.

From that "functional accounting" of carbon comes a measure for the international unevenness of emission distribution: the authors prove that there are both deficient and surplus nations, with regards to what they need to emit in order to provide minimum living conditions for their populations.

This criterion (emissions coming from basic needs) can be applied for the intranational scope, aiming to obtain an individual GHG distribution.

Seroa da Motta (2002, 2004) measured the contribution of Brazilian households for the spread of pollutants in the atmosphere, in the water and in the soil, as well as the degradation of watercourses. He concluded that however the poor tend increase their environmental impact in a higher level than the rich, the income concentration in the latter acts in a compensatory way, keeping them responsible for the major part of the total impact.

The environmental Kusnetz curve, according to which the degradation potential of nature increases with income and after a certain threshold begins to fall with income, is refuted by the notable growing trend found in the Seroa da Motta results (2002, 2004). The rich unequivocally degrade more.

The goal of the chapter is to advance in the direction of a precise evaluation of current consumption standards and their constitutive item levels and the relation between income and personal contribution for national GHG content. For the sake of precision, the scope of analysis is restricted to the fuels consumed in households (cooking and heating) and land transport services used by the population.

The reduction of the analytical prism allows to see that in the Brazilian case, the progression to higher income levels engenders two diametrically opposite phenomena: *i*) the abandonment of firewood and charcoal, a change that reduces GHG emissions; and *ii*) the increase in vehicle fuel consumption, which increases household carbon content.

3 THE CO2 CONTENT OF HOUSEHOLD ENERGY CONSUMPTION

3.1 From the Consumer Expenditure Survey (POF) to the National Energy Balance (BEN)

The work of Bôa Nova (1985) pioneered the use of household budget surveys to understand the unevenness in the access to energy in Brazil. Based on the National Survey of Household Expenditures (ENDEF) 1974-1975, Bôa Nova shows that households used 24% of the energy consumed in the country. From this total, 61% comes from intra-household fuel usage and 39%, from transports. Considering this last modality, the richest 10% consumed no less than 400 times more energy than the poorest 10%. But in the first case (cooking, heating), the poorest had the biggest share due to the extensive use of wood stoves, which have an energy efficiency three to seven times lower than gas equipment. Result: although the 10% richest Brazilians consumed a third of the whole electric power and almost half of the petroleum, no less than 43% of the biomass (firewood and charcoal) was used by the poorest 20%.

The Consumer Expenditure Survey (POF in Portuguese), carried out by the Brazilian Institute of Geography and Statistics (IBGE, 2004) dated 2002-2003, corroborates the results of Bôa Nova, obtained with data collected 25 years after. The POF has information that allows the identification of consumption standards of the different groups in which the Brazilian population is subdivided according to family income levels. Differently from the cited author, the concern is not with the energy general use, but rather, with GHG emissions that result from it. POF data allows detecting income-classes specific emission standards and specific fuel types.

3.2 The firewood case

The adopted methodology – which is formally presented in Morello (2010) – consists of starting up from the POF information concerning expenditures on energy of the different income classes to then convert into CO_2 the energy items purchased (or self-produced, as it is the case of a relevant portion of the firewood and charcoal reported). Therefore, it is important to signalize the similarity with the aforementioned work by Seroa da Motta (2002, 2004). For two aspects to which the analysis is restricted (household fuels and land transport), the CO_2 content is obtained from the application of a procedure recommended by the Intergovernmental Panel on Climate Change (IPCC). For the consumption of energy sources reported in the National Energy Balance (BEN, in Portuguese) – the standard in the reference reports of the *National Inventory of Anthropogenic Emissions of Greenhouse Gases* – specifically for the case of Brazil (2006, 2010) apply.

It is from the connection between those two databases (POF and BEN) that the results of table 1 come up. Results are from 2003.

TABLE 1
Household fuel consumption emissions per family – income classes as from 2002-2003 POF - Brazil, 2003 (tCO_2)
(In US$)

Item / Income class	≤US$222	US$222-US$333	US$333-US$556	US$556-US$667	US$667-US$889	US$889-US$1,111	US$1,111-US$1,667	US$1,667-US$2,222	US$2,222-US$3,333	≥US$3,333
Natural gas [1]	3,95E-04	5,35E-04	1,38E-03	3,57E-03	2,21E-03	6,86E-03	9,82E-03	1,48E-02	4,28E-02	8,38E-02
LPG [2]	0,23	0,28	0,32	0,33	0,34	0,34	0,34	0,32	0,31	0,33
Firewood	1,23	0,95	0,83	0,64	0,57	0,36	0,38	0,36	0,21	0,12
Kerosene[1]	2,14E-03	1,46E-03	7,82E-04	5,81E-04	4,07E-04	4,58E-04	1,40E-04	1,21E-04	5,76E-05	7,61E-05
Charcoal	0,10	0,07	0,04	0,03	0,02	0,02	0,02	0,02	0,01	0,01
Total per household	1,56	1,31	1,2	1	0,94	0,72	0,74	0,72	0,57	0,54

Sources: IBGE (2004), BRASIL (2003) and Brasil (2010).
Elaborated by the authors
Notes: [1] Due to their low magnitude, values are exhibited in scientific notation, E-03 = 1/1.000 or 10^{-3} and E-04 =1/10.000 or 10^{-4} etc.
[2] Liquefied petroleum gas.

Table 1 is in opposite direction to what the main works show about the social distribution of GHG emissions (section 2). Different from what happens when general consumption is at stake, in household fuel consumption, higher poverty is associated to higher emission. The group with incomes lower than US$ 222.22/family/month emits approximately three times more CO_2, when producing energy at home than the highest income groups. The residential energy consumption of the richest people is less carbon-intensive, which is explained by the insignificant importance of firewood.

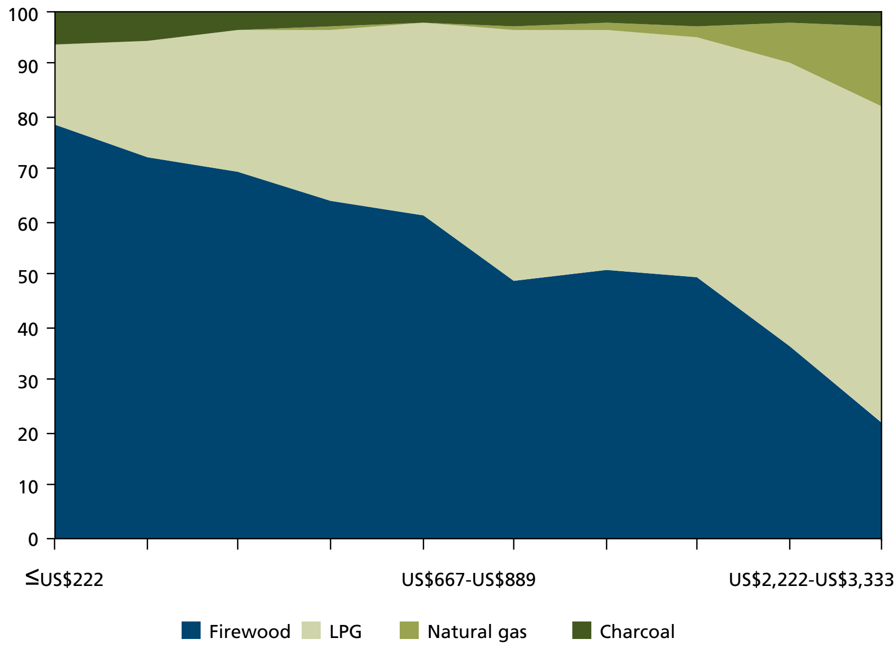
Graph 1 shows that about 80% of the poorest people's emissions have firewood burning as determinant. Such situation is progressively modified as we move towards higher family income: The LPG begins to respond for 46% of the emissions, starting from a monthly family income not lower than US$ 1,111.11.

But the importance of firewood in emission standards for the lower income classes does not stem only from its importance in the energy household consumption standard.[2] It cannot be ignored that the generation of a certain amount of energy through firewood causes the emission of a carbon mass 1.65 times higher than it would be needed to produce the same amount of energy through LPG burning (or natural gas).[3] It means that the lower the income, the higher in carbon the main source of energy used for family supply tends to be.

2. The relationship between exposure to poverty and the consumption of firewood is in agreement with some of the evidence pointed by Uhlig (2008), a study that re-estimates the energy consumption of firewood and charcoal following a methodology alternative to BEN. It is worth mentioning the following passage: "Because it is a source of low cost energy, not requiring processing before use and being a significant part of the energy base **o**f the developing countries, it has received the title of "energy of the poor", coming to represent at least 95% of the energy source in several countries (*op. cit.*) ".

3. The conversion coefficients of a firewood terajoule (TJ) into carbon and the proportion of carbon actually oxidized through burning, as presented in section 2.2 by Morello (2010), when multiplied, gives the carbon content by firewood terajoule, which is 28.033 tC/TJ. For LPG and natural gas, results in a value of 17.028 tC/TJ

GRAPH 1
Emissions distribution regarding household fuel consumption, 2002-2003 POF income classes – Brazil, 2003
(In %)



Sources: POF 2002-2003, BEN 2003 and Brasil (2010).
Elaborated by the authors.
Obs.: Illuminating kerosene was suppressed, because its market share is minimal.

3.3 The transports case

TABLE 2

Household emissions from land transport services -2002-2003 POF income classes, Brazil, 2003 (tCO_2)

Item / Income class	≤US$222	US$222-US$333	US$333-US$556	US$556-US$667	US$667-US$889	US$889-US$1,111	US$1,111-US$1,667	US$1,667-US$2,222	US$2,222-US$3,333	≥US$3,333
Gasoline[1]	0,05	0,08	0,2	0,27	0,48	0,69	0,99	1,54	1,98	3,32
Bus diesel[2]	0,06	0,11	0,19	0,26	0,29	0,33	0,35	0,29	0,31	0,25
Total per household	**0,11**	**0,19**	**0,39**	**0,53**	**0,77**	**1,03**	**1,34**	**1,84**	**2,29**	**3,57**

Sources: Brazil (2003), Brazil (2006, 2010), São Paulo (2007), IBGE (2004) and National Agency of Petroleum, Natural Gas and Biofuel (ANP, 2004).
Elaborated by the authors.
Notes: [1] Used in private automobiles – exclusively automobiles belonging to companies.
[2] Urban public transportation + interstate road + inter-municipal road. Based on the emissions regarding the 1997 fleet according to Brazil (2006) (reported in section 4 by Morello (2010) as a lower level).

Table 2 presents the CO_2 emissions that result from gasoline burning by automobiles owned and used by families and from diesel burned by buses. In this last case it is necessary to adopt two levels, since updated data related to the participation of the "bus" category in the Brazilian diesel oil fleet could not be obtained - see section by Morello (2010). However, to simplify the presentation, only the higher level was used. (what corresponds to the 1997 fleet (BRAZIL, 2006).

The diesel consumption is attributed in a proportion equivalent to the family participation in the total number of kilometers travelled by bus by all individuals in the country. Therefore we take into account both the family participation in the number of contracted travels and the average travelled distance. The considered transport modalities are urban public transportation, interstate and inter-municipal transport – section 4 by Morello (2010) details the procedure.

The gasoline consumed by family-owned automobiles is a source of emissions that are easier to evaluate, as POF directly collects the information concerning fuel expenditure. The emissions generated by that factor present a monotonic growth from the lowest to the highest income class, the same not being observed in the case of diesel. Between the first income class (income ≤ US$222.22/family/month) and the seventh one (income between US$ 1,111.11/family/month and US$ 1,666.67/family/month), the bus factor reveals a growing tendency, which reaches its peak in this last class, to then begin to fall again.

The path of emissions per family throughout social groups is equivalent to the path of expenditures per family, which means that up to a certain level of purchasing power (family income of US$ 1,666.67 thousand Reais/family/month) the bus expense increases with income. It is, thus, a normal good, in the microeconomic definition, what is reverted from this point on, then becoming an inferior good. Probably, the transport modality tends to lose importance in comparison to the private automobile, since emissions generated by gasoline burning increase monotonically with income.

In addition, it is necessary to emphasize that while the CO_2 mass distributed among families includes all bus transport modalities, the distribution procedure is based only on the public transportation modality, a limitation imposed by the data that could be gathered – as explained by Morello (2010) in section 4.

TABLE 3

Distribution of CO_2 emissions regarding household fuel consumption and land transport - 2002-2003 POF income classes, Brazil, 2003 (tCO_2) (In US$)

Item / Income class	≤US$222	US$222-US$333	US$333-US$556	US$556-US$667	US$667-US$889	US$889-US$1,111	US$1,111-US$1,667	US$1,667-US$2,222	US$2,222-US$3,333	≥US$3,333	Brazil (Gg CO2)
Natural gas	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,04	0,08	450,8748709
LPG	0,23	0,28	0,32	0,33	0,34	0,34	0,34	0,32	0,31	0,33	14.925,81
Firewood	1,23	0,95	0,83	0,64	0,57	0,36	0,38	0,36	0,21	0,12	34.274,09
Kerosene	2,14E-03	1,46E-03	7,82E-04	5,81E-04	4,07E-04	4,58E-04	1,40E-04	1,21E-04	5,76E-05	7,61E-05	41,62609306
Charcoal	0,10	0,07	0,04	0,03	0,02	0,02	0,02	0,02	0,01	0,01	2.157,33
Gasoline	0,05	0,08	0,20	0,27	0,48	0,69	0,99	1,54	1,98	3,32	29.604,75
Bus diesel	0,06	0,11	0,19	0,26	0,29	0,33	0,35	0,29	0,31	0,25	10.214,97
Total per household	1,66	1,49	1,59	1,53	1,71	1,75	2,08	2,55	2,86	4,11	91.669,44
Households (#)	7.928.656	6.744.349	10.188.564	3.543.521	5.091.324	3.340.910	4.568.525	2.424.975	2.236.551	2.467.262	48.534.637
Total per class (GgCO2)	**13.185,35**	**10.082,28**	**16.210,91**	**5.424,72**	**8.695,39**	**5.850,83**	**9.497,54**	**6.184,85**	**6.386,97**	**10.150,60**	**91.669,44**

Sources: Data of the Brazil (2003), Brazil (2006, 2010), São Paulo (2007), IBGE (2004) and ANP (2004).
Elaborated by the authors.

4 LOOKING THROUGH THE INCOME PYRAMID

The energy considered in section 3 constitutes a sample of CO_2 generating factors which are not due to technological decisions made by firms. On the contrary, the qualitative (goods and services) and quantitative composition (How much of each goods or service) of the fuel consumption bundle is a decision of the families. An example shows why such formulation is useful. It is up to the families to decide between the use of firewood or LPG for cooking. But it is not up to them to decide if the cooked meat shall be produced by means of the suppression of the Amazonian forest or in deforested areas that are inappropriate for agriculture – at least while there is not a certification that allows the consumer to distinguish between both origins.[4]

Invoking the Amartya Sen's capabilities approach (COMIN; QIZILBASH; ALKIRE, 2008), the "household fuel bundle" is a first approximation to the problem of understanding how the vector of capabilities hold by a family (set of actions that the family is able to accomplish) can be translated into a contribution to the greenhouse effect.

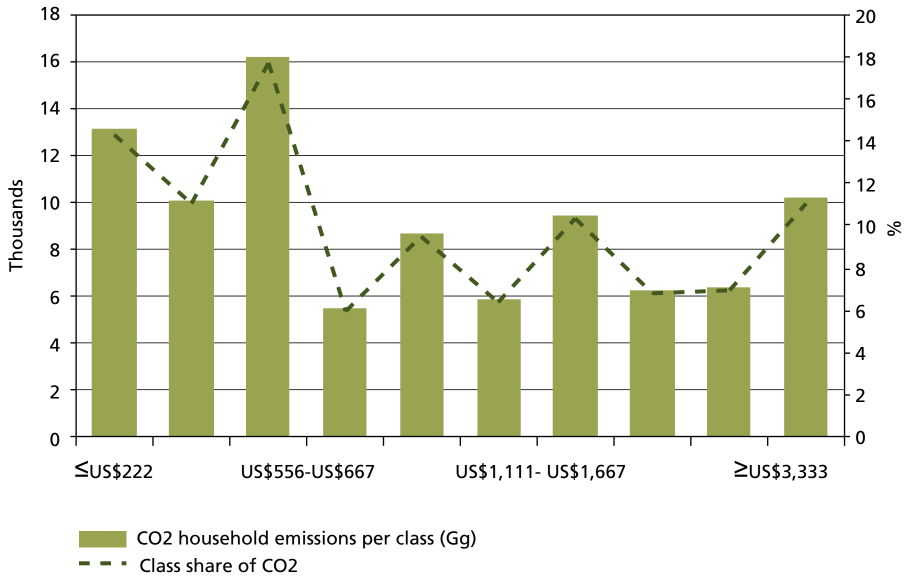
As discussed, the POF shows that the quantitative composition of the energy bundle presents non-negligible differences between the income classes in which the Brazilian population can be subdivided. However, for an analysis of the climatic impact of families, the relevant issue is not the composition of the bundle – in quality and/or quantity –, but, instead, its content measured in CO_2. This is the indicator to be evaluated, which is in the last line of table 3, including all the families of any given class.

As graph 2 shows, the families included in the first three classes of monthly household income are responsible for a higher GHG contribution. This apparent negative correlation between monthly household income and CO_2 content of the consumption standard can be verified more precisely if emissions per income class are decomposed into i) emissions per family; and ii) number of families per income class. Graph 3 below presents this division.

4. This microeconomic representation of the problem should not be taken to the limit, because as we can read in Uhlig (2008), the use of firewood and charcoal for cooking is far from being a rational decision: it is a direct implication of the inexistence of alternatives.

GRAPH 2

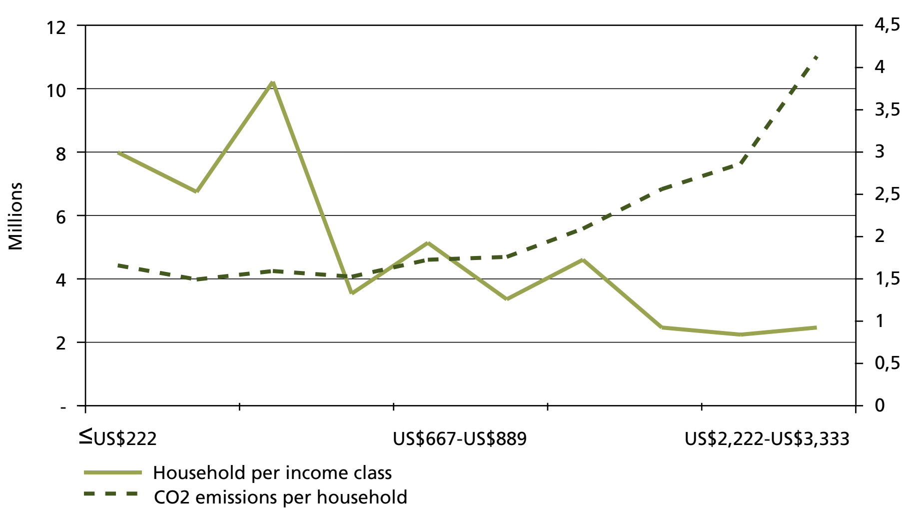
Distribution of the CO_2 emissions linked to household fuel bundle– 2002-2003 POF income classes – Brazil, 2003 ($GgCO_2$)



Sources: BEN 2003, Brasil (2006, 2010), São Paulo (2007), POF 2002-2003 and ANP (2004).
Elaborated by the authors.

GRAPH 3

Distribution of CO_2 emissions linked to household fuel bundle – 2002-2003 POF income classes– Brazil, 2003 ($GgCO_2$)



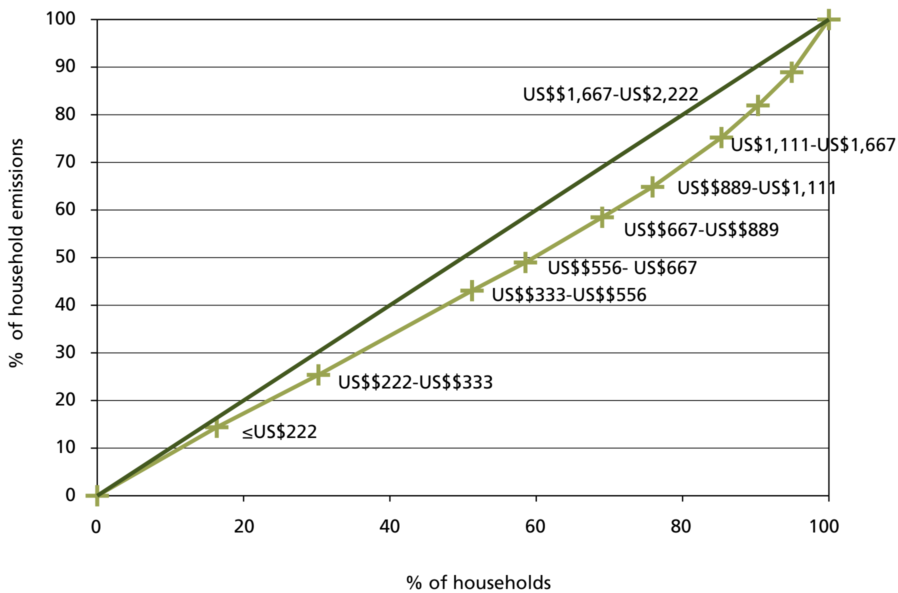
Sources: BEN 2003, Brasil (2006, 2010), São Paulo (2007), POF 2002-2003 and ANP (2004).
Elaborated by the authors.

It becomes evident then that the decreasing trend in the distribution of families per income class, alongside progressively higher levels of monthly household income, compensates for the growing trend that the emissions per family present throughout these levels. In other words, families are distributed into income classes in the opposite way CO_2 content is distributed by such classes.[5] The conclusion is simple: in Brazil, many people emit very little and few people emit a lot. This result is clearly limited to household energy consumption and land transport.

Graph 4 just makes the point more explicit. In this graph there is an adaptation of a Lorenz Curve (a diagram typically used to study income distributions) for CO_2 emissions associated with household consumption of fuels and land transport services.

GRAPH 4

Accumulated percentage of households versus accumulated percentage of CO_2 emissions, household fuel bundle, Brazil, 2003 ($GgCO_2$)



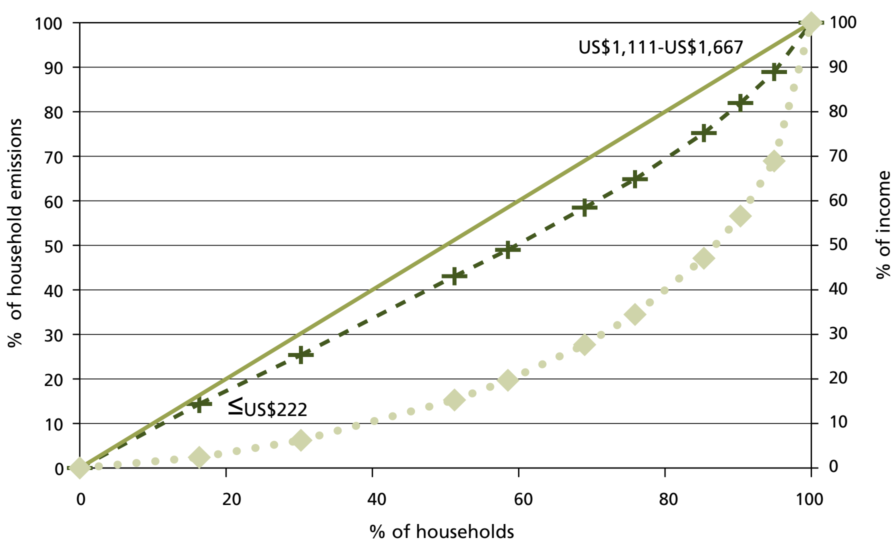
Sources: BEN 2003, Brazil (2006, 2010), São Paulo (2007), POF 2002-2003 and ANP (2004).
Elaborated by the authors

5. A standard that goes in the same direction of what was found by Seroa da Motta (2002, 2004) for the emission of pollutants.

If the Brazilian population was distributed per CO_2 ranges on an equitable basis, the Lorenz Curve should be superimposed to the line of 45° starting from the origin, this last one being the equality line for emissions. However, what effectively prevails is the dotted curve. Because of that, it can be stated that the inverse relation between GHG emissions per family and the number of families per income class means an unequal distribution of the national emissions of this gas by the Brazilian population. The inequality is given by the distance between each of the curve points labeled with their corresponding income classes and the equality line.

Just to have a parameter, it is interesting to compare the inequality in terms of CO_2 emissions with the one in terms of income – or revenue, in the POF terminology. Graph 5 below superimposes the Lorenz Curve in CO_2 with the income one, the latter being calculated by the intraclass sum for the monthly household income, as reported by this research (the variable *income* of the POF database 2002-2003).

GRAPH 5
Accumulated percentage of households, accumulated percentage of income and accumulated percentage of CO2 emissions, household fuel bundle, Brazil, 2003 ($GgCO^2$)



Upper curve (dotted in straight lines) => Lorenz CO2; lower curve (dotted in points) => Lorenz income.

Sources: BEN 2003, Brazil (2006, 2010), São Paulo (2007), POF 2002-2003 and ANP (2004).
Elaborated by the authors.

Two sources of information summarize the graph: *i*) families with income lower than US$ 222/family/month corresponded to 16% of the Brazilian households in 2003, concentrating 2% of income and 14% of estimated emissions (household fuels and land transport); and *ii*) families with income higher than US$ 1,111.11 thousand Reais /family/month corresponded to 15% of the population concentrating 53% of the income and 25% of estimated emissions.

It is clear that the income distribution is considerably more unequal than that of CO_2. A situation of full distributive equality may be represented by the superimposition of the Lorenz Curve on the 45°straight line considering the distance of each component point of this curve in relation to the point in this straight line which has the same horizontal coordinate – i.e., equal value for the abscissa – which gives us an inequality measure. It is trivial to demonstrate that measure can be computed by the sum of all of the points of this curve (ten, in this case) and the absolute value of the differences between the accumulated population proportion and the emissions or the accumulated income.[6] This results in an inequality in the income distribution 4.16 times higher than the inequality in the CO_2 distribution.

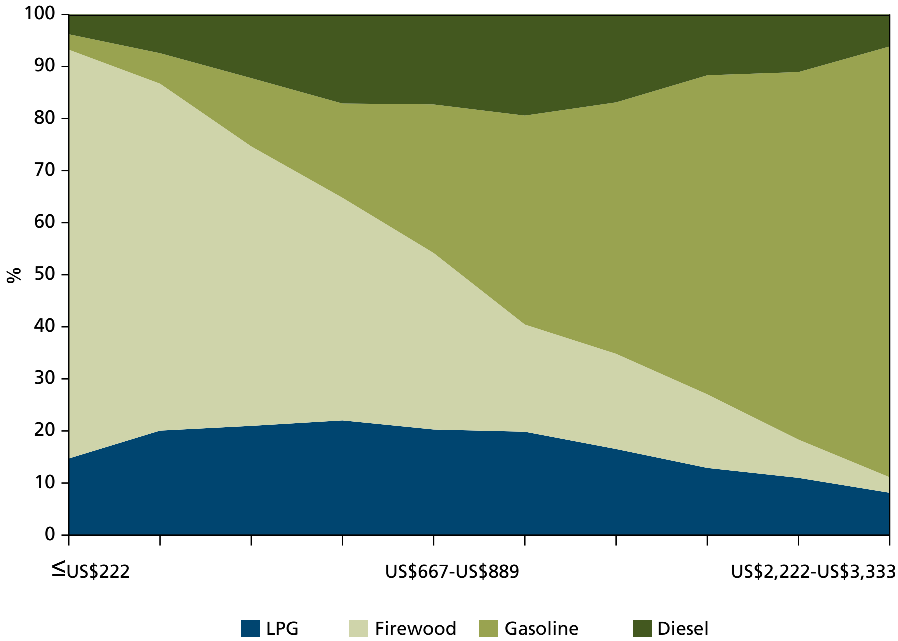
5 THE TRADE-OFF BETWEEN POVERTY ALLEVIATION AND GHG MITIGATION

The last line of table 3 reveals that the importance of firewood as CO_2 generating factor is such that compensates for the effect of monotonic increase in gasoline consumption over the total carbon content of household fuel bundle up to the fourth income class. It is only above an income level higher than US$888.89/family/month that the CO_2 level associated to families with income lower than US$222.22/family/month is overcome, starting the *gasoline effect* to dominate the *firewood effect,* as graph 6 shows – a direct consequence of the fact that it is in the first income class that the household firewood consumption reaches the peak.

6. Formally, the formula for the proposed inequality measure is $D = \sum_i |f(x_i) - x_i|$, where *i* is the i-th income class and $f(x_i)$, the proportion of income or emissions accumulated up to the i-th class of income.

GRAPH 6

Percentage distribution of emissions inherent to the household fuel bundle – 2002-2003 POF income classes – Brazil, 2003



Sources: BEN 2003, Brazil (2006, 2010), São Paulo (2007), POF 2002-2003 and ANP (2004).
Elaborated by the authors.

TABLE 4

Differentials of CO_2 emissions between contiguous income classes, household fuel bundle, Brazil, 2003 (tCO_2)[1]

Income class (US$100)	≤2 → 2-3	2-3→ 3-5	3-5→ 5-6	5-6→ 6-8	6-8→ 8-11	8-11→ 11-17	11-17→ 17-22	17-22→ 22-33	22-33→ >33
Differential (tCO2)	-0.25	0.12	-0.02	0.21	0.04	0.27	0.58	0.26	1.35

Elaborated by the authors.

Note: [1] Since the average size of the family varies among income classes, it is necessary to adjust family average emissions before calculating the differentials. For this purpose, it is enough to introduce an adjustment factor based on the average number of people per family, so that the interclass differentials are given by $[x_i + x_i/n_i*(n_{i-1} - n_i)] - x_{i-1}$, in which x_i is the average emission per family of class i and n_i is the average number of people per family for class i.

Table 4 presents the differences in CO_2 emission levels between two subsequent classes (exclusively household consumption of fuels and land transport) per family. This represents the cost in CO_2 of the ascension of a family to the immediately superior class. As it can be observed, for families with income not higher than US$ 222.22, the ascension to the subsequent class has a negative carbon cost, in other words, it is a non-carbon-intensifying change.

This information is relevant because it is possible to classify the families of the first range as poor.[7] Therefore, it results that by focusing on the emissions coming from the household consumption of fuels and land transport, a basic income policy that manages to take families with the lowest incomes out of the poverty line, such as the one considered by Suplicy (2005), would not have any impact in terms of CO_2 emissions.

As shown in the beginning of this section, this conclusion crucially depends on the dominance that the firewood effect exerts on the gasoline effect, which extends up to the fifth class of household income – it applies to all families with income not higher than US$888.89/family/month.

The obtained result shall be qualified based on the study of Uhlig (2008), in which an alternative methodology to the official one (BEN) is proposed to estimate the energy consumption of firewood and charcoal. Comparing his estimates with BEN's, the author concluded that the publication overestimates firewood consumption in 48.9% and charcoal in 62.9%. If the emissions herein estimated and associated to these two fuels are reduced in 50% and 63% respectively, the interclass differentials of emissions match values of table 5.

Even reducing the amount of firewood and charcoal consumed, the rank of the interclass differentials is maintained. It is interesting to compare the several possibilities of social ascension. A transition from the first to the third class – passing through the second one - has a total carbon cost of 0.19 tCO_2 /family, while the ascension to the next class costs 0.24 tCO_2.

By only considering the last three classes, the minimum carbon cost of ascension is 0.33 tCO_2, which is twice higher than the maximum cost of transition among income classes lower than US$ 1,666.67 thousand/family/month.

The conclusion is clear: with regards to comparable social ascensions, a combat policy against poverty does not seem to be carbon-intensifier. Such statement is limited to the fuels chosen by Brazilian families (household fuels plus land transport).

7. The government Family Grant Program (*Programa Bolsa Família*, in Portuguese), destined to the protection of families, has as target-population of families with average *per capita* income lower than US$ 83.33 (R$ 150). Since the average family size of the first income class (bellow US$222.22) , is 3.34 people, and the monthly average household income is US$ 147.49, the members of such class belong to the program's target population. Helfand, Rocha and Vinhais (2009) adopt half of the minimum wage as poverty line for the per capita income. This value corresponded to US$ 66.67 (R$ 120.00) at the end of 2003 (BCB, 2010), a value 1.51 times higher than the *per capita* monthly household income of the first income class – according to the numbers that have just been mentioned.

TABLE 5
Differentials of CO2 emissions between contiguous income classes, household fuel bundle, Brazil, 2003 (tCO2)

Income class (US$100)	≤2 → 2-3	2-3→ 3-5	3-5→ 5-6	5-6→ 6-8	6-8→ 8-11	8-11→ 11-17	11-17→ 17-22	17-22→ 22-33	22-33→ >33
Differential (tCO2)	-0.06	0.18	0.07	0.24	0.16	0.26	0.58	0.33	1.4

Source and elaboration of the authors.

6 FINAL CONSIDERATIONS

A Goldman Sachs Study (2008) estimates that between 60 and 80 million people are introduced to the consumer market of durable goods annually, forming a kind of new worldwide middle class. The environmental impacts of these new consumers are not negligible and this is a topic that motivates important international negotiations regarding limits to GHG emissions. The Chinese researchers' proposal led by Jiahua Pan (PAN; CHEN, 2010) tries to separate goods necessary to meeting basic needs from "luxury goods".

The chapter showed that the carbon content of individuals' basic needs can be very diverse. In the case of household fuels, the transition from firewood to other forms of fuels such as LPG results in an improvement of life quality and a reduction of both the emissions and the pollution caused by rudimentary wood stoves. In the case of transportation, the transition to individual transport powered by gasoline leads to a drastic emissions increase.

This is the factor that determines the positive relation between income and CO_2 content of the household fuel bundle. Even with the high weight of "traditional" fuels and also considering public transportation, overcoming the poverty line with regards to carbon consumption has a lower cost than other advances in the income pyramid - a result circumscribed to the fuels considered.

This is a necessary consequence of the fact that the gasoline effect – measured in CO_2 – even being (income) progressive, is not dominant, *vis-à-vis* the firewood effect, unless starting from an income higher than US$ 888,89/family/month.

The differentiation of the household income groups regarding consumption habits is therefore relevant and decisive in the CO_2 load share that the country throws into the atmosphere. This is a dimension to be eventually considered in the fine tuning of pro-climate policies, given the relevance of equity considerations and the climate justice debate (MILANEZ; FONSECA, 2010), which echoes the Seroa da Motta study. (2002, 2004).

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CHAPTER 6

AGRICULTURE AND CATTLE RAISING IN THE CONTEXT OF A LOW CARBON ECONOMY

Gustavo Barbosa Mozzer*

1 INTRODUCTION

Apart from other sectors, the agriculture sector faces specific challenges with regards to climate change. For this sector, food security is a key issue both from a physiological or nutritional aspect and from a strategic or political perspective.

Climate Change negotiations have indicated the need for increased mitigation efforts in absolutely all sectors of the world economy. The Cancun meeting (Conference of Parties – COP 16/Meeting of Parties – MOP 6) stressed the urgency of strong action to mitigate emissions of greenhouse gases (GHGs) in the magnitude of 24% to 40% below 1990 levels by 2020 in order to secure climate stability as pursued by the Working Group (WG 3) in the 4th Assessment Report on Climate Change from the Intergovernmental Panel on Climate Change (IPCC).

In 2012, the Earth Summit will celebrate its 20th anniversary by coordinating a new meeting in the city of Rio de Janeiro (Rio +20), where the main purpose will be to discuss the steps needed to achieve a new global economic paradigm. The incorporation of sustainability in economic processes will enable the progression of a new step of consolidating and disseminating concepts of the new green economy model.

For various sectors the green economy will entail implementing processes aimed at productivity and energy efficiency at every step of the production chain, including the use of raw materials, product half-lives and processes for disposal and recycling. In general, the adoption of sustainable standards involves an extensive process of inventory of GHG emissions followed by the definition of a systematic monitoring plan and the implementation of solutions, often already available on the market.

For almost all economic sectors, the main component in terms of GHG emissions is direct and indirect consumption of fossil fuels in either electricity generation, heat, or transport. In this scenario, making the transition to a green

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economy will involve changing the standards of consumption of fossil fuels, adopting new energy sources and improving consumption efficiency.

The agricultural sector, however, faces a different challenge. The significance of its contributions in terms of emissions of greenhouse gases is undeniable, not only arising from the consumption of fossil fuels and biogenic emissions such as those associated with cattle and sheep, but also the anaerobic decomposition processes associated with flooded production systems and the treatment and disposal of animal waste. Agriculture also contributes to soil degradation and deforestation of natural ecosystems when poorly managed. As such, GHG emissions from this sector are associated with the energy-intensive consumption of fossil fuels, but are also intrinsically related to the nature of practices and products in the agricultural sector.

Attention must be paid to the fact that the cost of mitigation for different sectors does not follow a symmetrical logic. The costs relate to socio-environmental variables that are directly influenced by complex inter-relationships between activity types of both the environment in which they are inserted and the abilities of actors to absorb information and modify behaviors.

Section 2 of this book discusses the strategic asymmetries in practices and the priorities of international policy on climate change. Section 3 analyzes the profile of emissions from agriculture and cattle raising activities and section 4 highlights the relevance of the sector in the low carbon trajectory, in particular related to Brazil's economy. Finally, Section 5 discusses the recent Brazilian strategy for low carbon agriculture.

2 INTERNATIONAL REGULATION

The relevance of the productive sectors has not been symmetrically or proportionally represented in the strategies, practices and priorities of international policy on climate change. The reason for this asymmetry results from the strategy adopted during the implementation of the Kyoto Protocol, during COP 3 in 1997. At that time, the priority was to demonstrate the feasibility of a multilateral instrument that would contribute to the adoption of decisive actions against climate change. Kyoto has shown that this task is extremely complex, which is further aggravated by the fact that countries, even developed ones, face different conditions related to popular interests and political will to solve the problem.

In that context, the rules adopted for the first commitment period of the Kyoto Protocol were developed focusing the industrial sector, since it represented and still represents the most relevant sector in terms of global GHG emissions. Furthermore, the monitoring of industrial activities would be simpler compared to other sectors. The forestry sector also achieved some success in starting a specific sectoral discussion process. Other sectors, such as agriculture remained semi-excluded from the process until very recently.

Over the past years, Kyoto proved to be a versatile and effective instrument for promoting cooperation among developed and developing countries aiming to intensify activities and actions that could maximize the use of capital to reduce greenhouse gas emissions, promoting technology transfer and enhancing sub-regional sustainable development.

It was found that achieving the purpose of the United Nations Framework Convention on Climate Change (UNFCCC), "the stabilization of greenhouse gas concentrations at such a level that would prevent dangerous anthropogenic interference with the climate system", would not be easily achieved. Such a challenge would require an effort far greater than the one committed to by the signatories to the Kyoto Protocol in 1992.

As such, seeking to improve the efficiency of the Kyoto Protocol as a multilateral instrument, a mandate was given by COP 13, in Bali, Indonesia, to start the negotiation for the second commitment period (Ad Hoc Working Group onfurther commitments for Annex I Parties under the Kyoto Protocol – AWG-KP). In parallel, negotiations began in hopes of achieving a systemic agreement capable of co-opting the United States of America to assume commitments equivalent to the ones agreed by other Annex I countries, in particular the European Community, Japan and Canada.

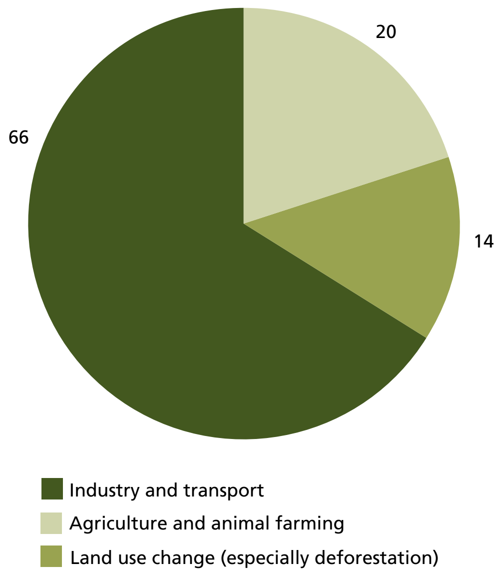
The negotiations structure of the Bali Agreement allowed the discussions on climate change to advance in parallel, considering not only Kyoto rules, but also new paradigms and concepts that could be developed under the UNFCCC.

In the face of this new paradigm, the role of the agricultural sector in the context of addressing global climate change has gained significant relevance. It is worth emphasizing that the Convention declares in its 2nd Article that stabilization of greenhouse gas concentrations should be achieved as described below:

> (…) within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Accounting for nearly 20% of global GHG emissions, the agricultural sector adds another additional 14% of anthropogenic emissions associated with land-use, land-use change and forestry, totaling 34% of global GHG emissions, as noted in graph 1.

GRAPH 1
Global liquid anthropogenic emissions of greenhouse gases
(In %)



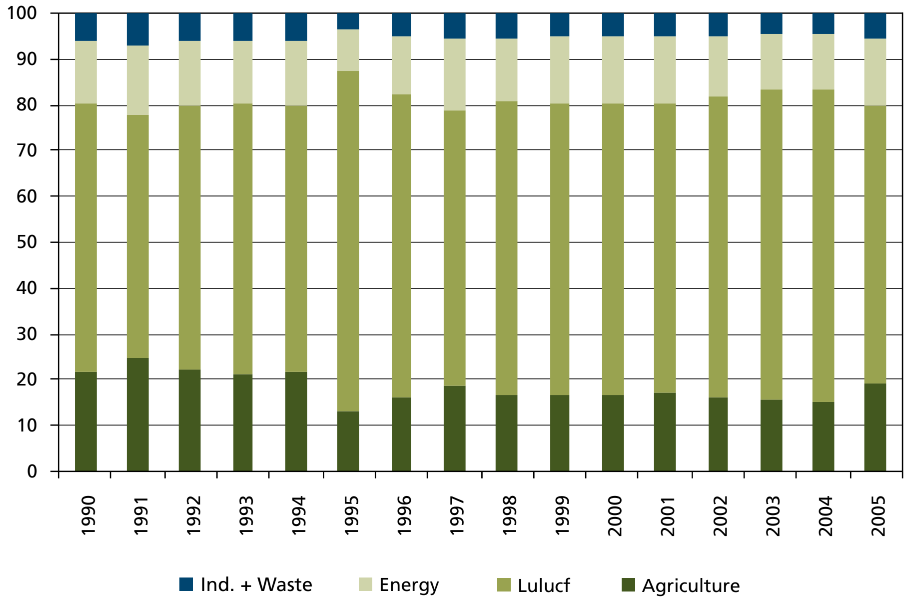
Source: IPCC (2007).

A recent report (FORESIGHT, 2011) published by the British government highlights the great vulnerability of the agricultural sector in facing the challenge to increase food production by about 40% by the year of 2050, and in that same period minimize the consumption of water resources by 30% and energy by 50%.

3 PROFILE OF EMISSIONS FROM THE NATIONAL AGRICULTURAL SECTOR

The 2nd Brazilian Inventory of Greenhouse Gases, published in 2010 with data up to 2005, the agricultural sector is shown for over 16 years as the second most relevant sector in terms of GHG emissions in Brazil. During this period, agricultural sector emissions reached the maximum relative emissions importance in the year 1991 representing 24.75%, in the following five years the relative importance of emissions from the agricultural sector decreased its importance and reached its lowest relative importance in 1995 (12.90%), coinciding with peak emissions from deforestation of nearly two million metric tons (t) of carbon equivalent (graph 2).

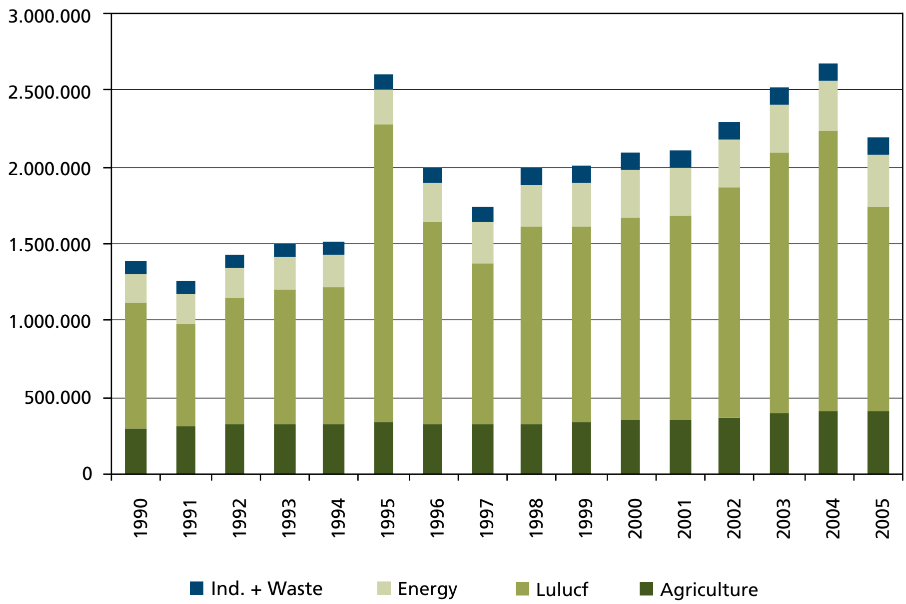
GRAPH 2
Relative importance of GHG emissions in sectors of the Brazilian economy
(In %)



Source: 2nd Brazilian Inventory of Greenhouse Gases/MCT (2010).
Note: Land use and land use change.

Over the subsequent five years, the agricultural sector has regularly raised its emissions in absolute numbers (graph 3), however, in relative terms, it has preserved a certain stability of the recent trend (2005) of increasing relative importance (18.96%), possibly due to the mild reduction of emissions from deforestation accomplished in Brazil.

GRAPH 3
Brazilian liquid emissions in CO_2eq – 1990-2005



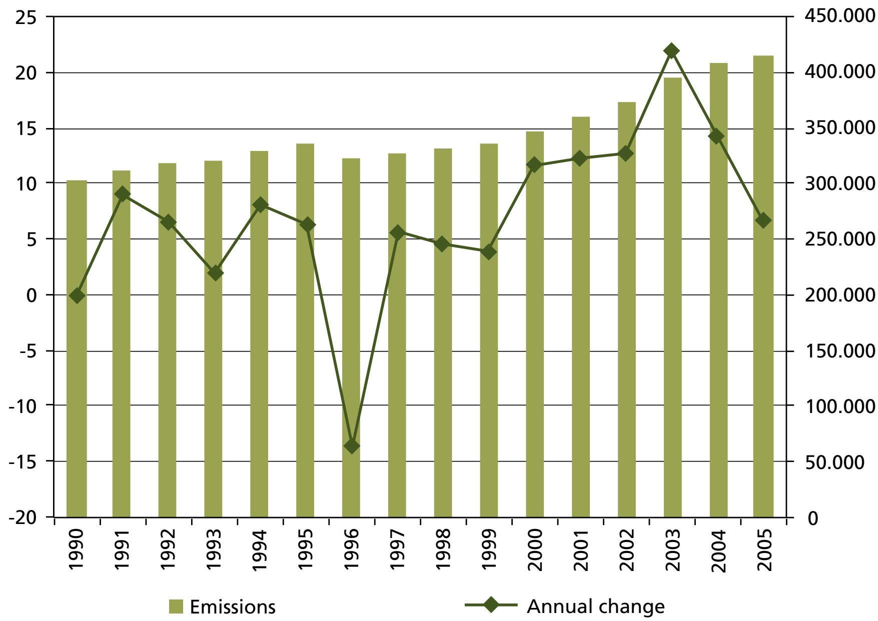
Source: 2nd Brazilian Inventory of Greenhouse Gas/MCT (2010).

From the perspective of liquid emissions, the agricultural sector has systematically increased its GHG emissions over the past few years (graph 3). Considering the strong trend of emission reductions in the forestry sector, it is natural that the relative importance of every other sector, including the agricultural sector, may increase over the next few years.

Over the last decade, the increase in emissions from the agricultural sector was not constant (graph 4), with observed annual rates below 10 thousand tons of CO_2eq between 1990 and 1999. Between the years 2000 and 2003 there was a significant increase in rates of GHG emission, reaching the peak of 21.994 tons of CO_2eq in 2003. Between 2003 and 2005, a reversal was observed in the pressure to increase emission in the agricultural sector, reducing emission by 2005 (6.559 tons of CO_2eq) to a level observed during the 1990s.

GRAPH 4

Liquid emissions from the Brazilian agricultural sector (histogram) and fluctuation of the annual growth rate of emissions in the sector in tons of CO_2eq – 1990-2005



Source: 2nd Brazilian Inventory of Greenhouse Gases/MCT (2010).

4 THE AGRICULTURAL SECTOR ON THE LOW-CARBON TRAJECTORY

The strategic relevance of the agricultural sector for climate change lies in the fact that there is an unquestionable need for expanded production to meet the current and future demands in food supply. It is also understood that this expansion should not contribute negatively by increasing current levels of emissions, and nor should it be achieved through processes that result in the loss of native vegetation or compromise environmental sustainability.

Thus, there is no simple solution and a joint effort on several fronts is required, combining the increase in sustainable production of food and energy with concerns about climate changes. For the solution to the agricultural challenge, the British Foresight (2011) report points to the pre-eminent need to consider all relevant technological alternatives, including the use of genetic modification, cloning and nanotechnology.

For the agricultural sector, getting involved in the transition process to a new global economic model focused on productivity and sustainability is not optional, but rather a necessary condition. Investments must be secured and technologies that contribute to systemically increasing the resilience of the sector, improving crop resistance to temperature and hydric stress must be developed and disseminated.

New opportunities will arise in the transition process from an energy-intensive economy to an environmentally aware economy, focused on efficiency solutions.

The perception that there is great potential in the adoption of a new agricultural model, capable of inducing increased productivity and efficiency due to better soil management, and contributing to the decrease of historical GHG emissions rates, has motivated several actors, including some developed countries with relevant agricultural sectors, to discuss the specific sectorial approach for agriculture in the context of the UNFCCC.

It is feasible that the quantification of the environmental liability resulting from agricultural practices will, in a few years, be consolidated to international trade through the concept of "carbon footprint" meaning the impact that a particular activity generates in terms of contributions to global warming. Thus, the higher the carbon footprint of a particular activity, the greater the generated the climate liability.

The international negotiation process under the agriculture topic has been developed at both the conventional multilateral scope, and in plurilateral actions, for example through the Global Alliance for Research on Greenhouse Gases in Agriculture and Cattle-Raising, whose purpose is to foster interaction between researchers and promote the development of metrics to compare GHG emissions between agriculture and cattle-raising processes in different countries.

Under the UNFCCC, attempts are made to recognize the potential of emission mitigation via adoption of good agricultural practices. In this sense, a text discussing specific guidelines for the agricultural sector was proposed during the negotiation process in Copenhagen (COP 15), Denmark.

The strategy widely supported by the developed countries began with a submission from Uruguay. The purpose was to discuss agriculture under item 1b4 (sectoral approach for mitigation), whose initial scope was exclusively (fuels for the maritime and air transportation sectors). From the perspective of developed countries there is clearly the perception that including agriculture in 1b4 could be strategically interesting, as it would allow the opening of specific discussions for the agricultural sector under the UNFCCC. This could potentially enable a differentiated treatment for sensitive issues, such as a market or trading scheme for emission reductions in the agricultural sector, the persistence of carbon in the soil and the environmental integrity of the climate system.

Developed countries try to emphasize the relevance of mitigation for the agricultural sector, despite the fact that the convention language has historically favored references emphasizing the importance of maintaining production levels (UNFCCC 1998, Art 2º), consequently encouraging adaptation actions to the detriment of mitigation.

Engagement in this discussion took place in a very polarized manner between developed and developing countries. To Brazil, the importance of discussing agriculture under the convention was evident, however, the main position defended by the national delegation was that the discussion on the agricultural sector should be balanced between adaptation, mitigation and efficiency. Argentina showed clear and emphatic concern that the text protect the guarantees that mitigation actions in agriculture would not generate future obligations or harmful consequences for international trade, such as the establishment of comparison standards. The United States and New Zealand ostensibly defended the introduction of mitigation concepts in agriculture, trying to connect them to the idea of soil carbon sequestration.

It is speculated that the United States could adopt policies to transfer costs associated with the adoption of any practices that focuses the reduction of GHG emission intensity to foreign markets, though non-tariff policies. Among these sectors, agriculture is pointed out as a strategic component of the North American emission reduction policy, through the promotion of practices and processes that strengthen soil carbon sequestration.

An understanding on the agriculture text could not be reached during the Cancun meeting (COP 16 COP/MOP 6), basically due to strong disagreements over the treatment of international trade in the agriculture sector.

In parallel with the negotiation conducted under the UNFCCC, the U.S. presented in partnership with New Zealand the idea of a plurilateral arrangement called the Global Research Alliance on Agricultural Greenhouse Gases, with the purpose of promoting the exchange of scientific knowledge and strengthened mitigation actions in the agricultural sector. However, it is speculated that this Alliance could also serve as an instrument to promote methodological standardization and the development of comparison models between products emission rates in the agricultural sector.

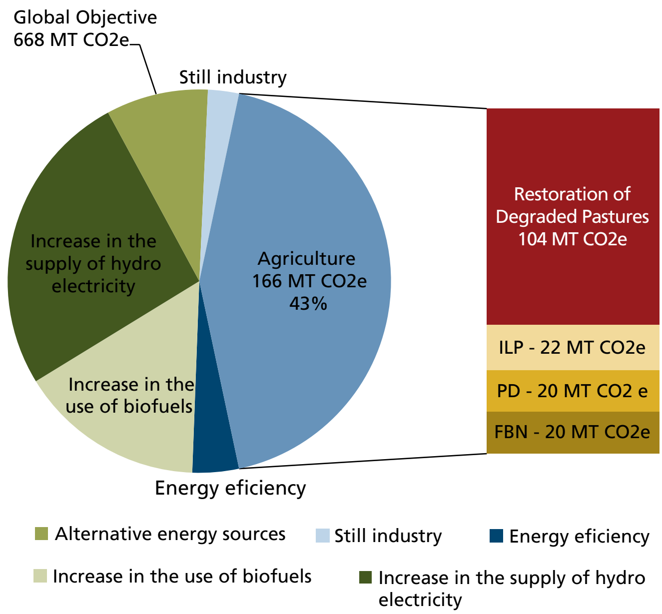
Brazil has adopted an emphatic attitude in defense of a balanced treatment of adaptation and mitigation in the Alliance negotiations. In the event of a balanced outcome, Brazil formally associated itself to the Alliance during a Ministerial meeting held in Rome in mid 2011.

5 THE BRAZILIAN STRATEGY

Internally, Brazil develops a specific policy to promote the transition from the traditional, extensive, inefficient and unproductive model of cattle raising, to a more efficient model, with better land use rates and capacity to promote increased productivity with lower rates of GHG emissions. Therefore, the agricultural sector has become a fundamental and inherent part of the implementation of the

Brazilian mitigation strategy for GHG emissions, submitted in December 2009 during COP 15 in Copenhagen, Denmark, as illustrated in graph 5.

GRAPH 5
Nationally appropriate actions for the reduction of GHG emissions proposed by Brazil in Copenhagen during COP 15, with emphasis on the agricultural sector



Source: Press release nº 31, January 29th, 2010/Ministry of Foreign Affairs (MFA).
Note: MT = megaton, ILP = crop livestock integration, PD = No-till, FBN = nitrogen biological fixation.

The agricultural sector is expected to reduce 166 million tons of CO_2eq over the next ten years, which represents 43% of national mitigation efforts (graph 5), excluding emission reductions associated with the direct reduction of deforestation as specified in the Brazilian emission reductions targets of 80% emission reduction of the deforestation rate for the Amazon Biome and 40% emission reductions for the Cerrado Biome, which alone represents 669 million tons of CO_2eq.

The proposed mitigation strategies for the agricultural sector are as follows:

- Recovery of degraded pastures: recover an area of 15 million hectares (ha) of degraded pastures through proper management and fertilization, which corresponds to a reduction from 83 to 104 million tCO_2eq.
- Agriculture – cattle-raising – forest integration (iLPF, in Portuguese): to increase the area of the iLPF system to 4 million ha, reducing emission from 18 to 22 million tCO_2eq.

- No-Till System (SPD, in Portuguese): expand the use of straw SPD to 8 million ha, corresponding to a reduction from 16 to 20 million tCO_2eq.
- FBN: expand the use of biological fixation to 5.5 million ha, corresponding to a reduction of 10 million tCO_2eq.

Additionally, the following strategies were proposed:

- Promote reforestation actions, expanding the area of planted forests, which is currently intended for the production of fibers, wood and cellulose by 3 million ha, thus growing from 6 million to 9 million ha.
- Expand the use of technologies for treatment of 4.4 million m^3 of animal waste for energy generation and production of organic compound.

The national GHG mitigation strategies were ratified in December, 2009, in Article 12 of the law which establishes the National Policy on Climate Change (PNMC), Law nº 12,187, thus defining that:

> (...) Executive Power, in accordance with the National Policy on Climate Change, will establish sectoral Plans of mitigation and adaptation to climate change aimed at consolidation of low carbon consumption, in the generation and distribution of electrical power, in urban public transport and modal systems of interstate transportation of cargo and passengers, in the processing industry and durable consumer goods industry, fine and based chemical industries, paper and cellulose industry, in mining, civil construction industry, health services and in agriculture and cattle-raising, in order to meet gradual targets of reduction of quantifiable and verifiable anthropogenic emissions, considering the specificities of each sector, including through the Clean Development Mechanism - CDM and Nationally Appropriate Mitigation Actions - NAMAs.

The Sectoral Plan of Mitigation and Adaptation to Climate Change Aiming at the Consolidation of a Low Carbon Emission Economy in Agriculture is at an advanced stage of drafting and will enter the phase of public consultation during 2011 or early 2012.

The process of drafting of the agricultural sectorial work plan took place in an open-ended manner with the creation of a working group (GT), under the coordination of the Ministry of Agriculture, Livestock and Food Supply (MAPA, in Portuguese) and the Presidency of the Republic and other federal government representatives such as Embrapa, the Agrarian Development Ministry (MDA, in Portuguese), the Ministry of Finance (MF), Ministry of Science and Technology (MCT, in Portuguese) and the Ministry of the Environment (MMA, in Portuguese).

Later, the working group was expanded to incorporate civil society representatives formally nominated by the Brazilian Forum on Climate Change

(BFCM) and the Climate Observatory. Representatives from the following organizations joined the group: Agriculture and Livestock Confederation of Brazil (CNA), National Confederation of Workers in Agriculture (CONTAG), Organization of Cooperatives of Brazil (OCB), Unique Workers' Center (CUT), The Institute for Socioeconomic Studies (INESC), Conservation International (CI) and the World Wide Fund for Nature (WWF) – Brazil.

Among the main actions proposed in the sectoral plan for agriculture, are environmental regularization of rural properties and intensified actions of the program 'Terra Legal' aiming to carry out the regularization of land ownership in the Legal Amazon.

Related to technical assistance, training and information, the following strategies stand out:

- Technology transfer, including teacher qualification, qualification of technicians and producers, incentives for the formation of technicians' networks, preparation of technical plans and technical assistance for producers, in addition to field days, lectures, seminars, and the implementation of Technological Reference Units (URTs, in Portuguese).
- Production of promotional materials and campaigns, including television (TV Banco do Brasil) to show the economic and environmental benefits of the actions predicted in subprograms.
- Conducting public announcements for the hiring of technical assistance and rural extension (Ater) for the preparation and implementation of projects for small family farmers and agrarian reform settlers.
- Realization of directed campaigns aiming at stimulating the implementation of iLPFs and Agroforestry Systems (AFS) in ecological corridors and restoration of areas of permanent protection (APP) and legal reserves on small farms.

With the purpose of offering economic incentives and financing to producers to implement the activities of the plan, the MAPA has developed a program whose specific purpose is to promote the implementation of good agricultural practices. Called "Low-Carbon Emission Agriculture" (ABC), this program aims to establish a broad process of dialogue between the actors involved in the national production system, and conduct a process of training and technology transfer of national, regional and sub-regional scope.

The 2010-2011 Agricultural and Livestock Plan incorporates the propositions defined in the ABC program, emphasizing the intention of MAPA in promoting a specific credit line to finance rural production committed to the reduction of greenhouse gases.

In practical terms, the actions proposed in the 2010-2011 Agricultural and Livestock Plan earmark, through the ABC program, the allocation of R$ 2 billion to finance adequate practices, adapted technologies and efficient production systems that contribute to greenhouse gas mitigation.

In addition, the 2010-2011 Agricultural and Livestock Plan allocates R$ 1 billion to the Incentive Program for Sustainable Agribusiness Production (Produsa) to stimulate the recovery of areas destined for agricultural production which, though still productive, offer below-average performance due to physical deterioration or low soil fertility. There are also further rural credit lines available to finance the activities established in the sectoral plan for agriculture (Commercial Planting Program and Recovery of Forests – PROPFLORA, National Program for the Strengthening of Family Farming – Forest PRONAF, Line of Credit for Investment in Renewable Energy and Environmental Sustainability PRONAF Eco).

In terms of research and technological development, it appears that in spite of the availability of technologies for the determined actions, continuous financing along the plan period will be required for actions related to research, development and innovation aiming to technologically improve primary areas defined in the agricultural sectorial plan. Among these actions, it is worth highlighting:

- Research and development of inoculants for BNF in new cultures, genetics of forest species, adequacy of machines and implements, alternatives to use of herbicides and quality indicators of SPD.
- Preparation of regional studies on environmental sustainability and economic and financial profitability of technologies, especially iLPF and SPD.
- Preparation of zoning of pastures, aiming to identify priority areas for the implementation of the activities of the plan.
- Mapping of regional abilities for implantation and adequacy of iLPF, with identification and creation of database on regional experiences.
- Strengthening and/or expansion of networks of long-term monitoring.
- Need of improvement and/or development of emission factors and technical/scientific indicators for climate contribution.

The actions described in the sectoral plan for agriculture include the following topics:

- Incentive to certification mechanisms, especially in sustainable cattle raising.
- Identification of barriers and market opportunities for the commercialization of products coming from iLPF based on new actions

aiming at the improvement of and access to markets, disposal cost reduction and added value to products.

- Preparation of micro-regional technical studies to identify alternative access to inputs, considering the final balance of GHG emissions.
- Availability of basic inputs and inoculants for family farmers and agrarian reform settlers.
- Promotion of forest-tree nurseries and network of seed collections of native species, implantation of forest-tree nurseries in agrarian reform settlements and establishment of program of acquisition and distribution of seedlings of forest species under the More Environment Program.

Monitoring of the application of these investments and their effectiveness in terms of mitigating GHG emissions will be maintained by the MF, which has been working closely together with Embrapa.

The monitoring strategy of actions listed in the agricultural sectoral plan will be coordinated by Embrapa, which will centralize the collection and processing of information. The coordination of this work will be done through a new Multi-Institutional Laboratory Unit, involving public research and education institutions, who will be responsible for analyzing satellite images and documents related to monitoring the actions of the agriculture sectoral plan.

Along the same lines, Embrapa is developing specific research projects focusing on key topics related to climate change, such as: cattle-raising, grain and forest. The projects are being designed in a coordinated manner in order to allow the discussion of cross-cutting issues, such as: carbon sequestration in soil, standardization and methodological comparability.

In short, Brazil is acting in an integrated manner, combining its international position and at the same time, developing policies, local programs and practices, aiming to adapt to a new world economic paradigm which incorporates a green economy. Such actions aim to ensure the maintained competitiveness of national agricultural and efficiency to face the challenges posed by global climate change.

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CHAPTER 7

ROAD TRANSPORT AND CLIMATE CHANGE IN BRAZIL*

Patrícia Helena Gambogi Boson**

1 INTRODUCTION

The climate change topic still sparks a lot of controversy, especially regarding the degree of responsibility of anthropogenic actions in accelerating changes in climate parameters on a global scale. The subject brings the advantage of promoting thematic convergences on the necessity of improving the man – nature relationship. This involves the awakening of a collective interest in search of life quality, translated into technological conquests and the acquisition of assets, which through the application of appropriate and just socio-economic models provide a longer and more enjoyable life for everyone, without causing social exclusion and environmentally degrading externalities, and without jeopardizing the quality of life of future generations.

A discussion of road transportation in Brazil is of significant relevance. This is due to both its status as the second largest contributor to greenhouse gas emissions (GHG), about 7% to 9% of the national total (BRASIL, 2010), and its responsibility for 90% of the diesel oil consumed in the transport sector, or 80% of total domestic consumption. Vehicle emissions cause a loss of air quality and, consequently even loss of life in the form of health risks to populations, especially those concentrated in the great urban centers.

The relevance of this sector from an environmental perspective is further revealed by the fact that transport deals with a basic human need that is intrinsic to the development process, and consequently it is a service in constant expansion, especially its urban form. According to Branco *et al.* (2009), the demand for passenger and freight transport grows by 1.5 to 2 times faster than the gross domestic product (GDP) in developing countries, with the highest growth taking place in the road transport. According to data from the United Nations (UN), more than half of the world's population lives in cities, which will increase to almost 90% or six billion people inhabiting the urban space by 2050, with clear effects on the demand for transport.

* Thanks to the National Transport Confederation (CNT, in Portuguese), especially its board of directors and technical team in the environmental area, for the opportunity of sharing knowledge about this rich universe that is the transport sector and for the precious and essential information used in the construction of this chapter.

** Representative of CNT in the National Environmental Council (Conama, in Portuguese).

Characteristics of the Brazilian transport matrix further emphasize the relevance of the road transport sector in environmental discussions, and its implications on climate change issues. According to data presented by CNT, 62% of our freight transport matrix is attributed to the road modality. In parallel, Brazil has a road network of 1.6 million km, of which only 211 thousand km are paved and above 53% of the truck fleet is characterized by environmentally inferior technology. The negative environmental impacts are evident.

Therefore, irregardless of the level of concern of the public and business leaders in general, and environmental managers in particular, for the global effort to minimize GHG emissions and its negative impacts; the truth is that appropriate transport policies, especially for the road modality, are essential in the search for quality of life improvements. If Brazil intends to engage responsibly in leadership that is not skeptical of the impacts of human action on climate change, the road transport issue will follow that of deforestation, which leads the construction process of the program proposals and emission mitigation projects needed to solidify real and effective contribution.

Several segments of civil society that believe in this premise, especially the CNT, academia, study and research centers and nongovernmental organizations (NGOs) have over the past two years been eagerly discussing the participation of the transport sector in the climate change policy process. In this text, we present a review of those studies, especially the study entitled *Generation and Mitigation of greenhouse gases by transport in Brazil*) (FGV; EPC, 2010) and the results of the *Workshop on National Transportation and Climate Change*, promoted by CNT in partnership with the *Center for Sustainable Transport in Brazil* (CNT; CTS – BRASIL, 2009) and supported by the UK Embassy.

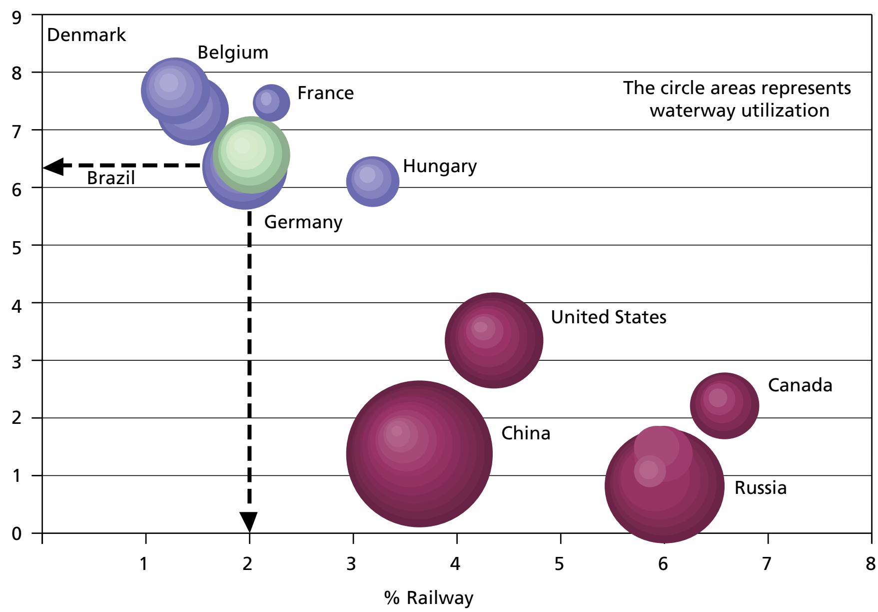
2 NATIONAL ROAD TRANSPORT SCENARIO

Data on the characteristics of road transport in in Brazil are important so that the real contribution of this activity to GHG emissions can be measured, and to evaluate the actions that Brazil needs to present and implement for the mitigation of those emissions in its territory. Mitigation can be based either on targets established in the National Policy on Climate Change (PNMC, in Portuguese), or on executing internationally assumed commitments. Next, we present some of the relevant road transport characteristics in Brazil.

2.1 Road freight transport

In spite of its continental size, Brazil rides on wheels due to historical contingencies and continuous and systemic mistakes in the application of public policies. Different from countries with similar characteristics (graph 1), the road modality is responsible for 62% of freight transport, compared to only 20% of rail transport, and no more than 18% of waterway transport. According to data presented in Carvalho (2010), a document issued by the São Paulo State government regarding CO_2 emissions reveals that waterway transport emits 20 kg/1000 KTU, railway transport 34 and road transport 116. These figures reveal a disadvantageous situation for Brazil.

GRAPH 1
Transport matrix in KTU

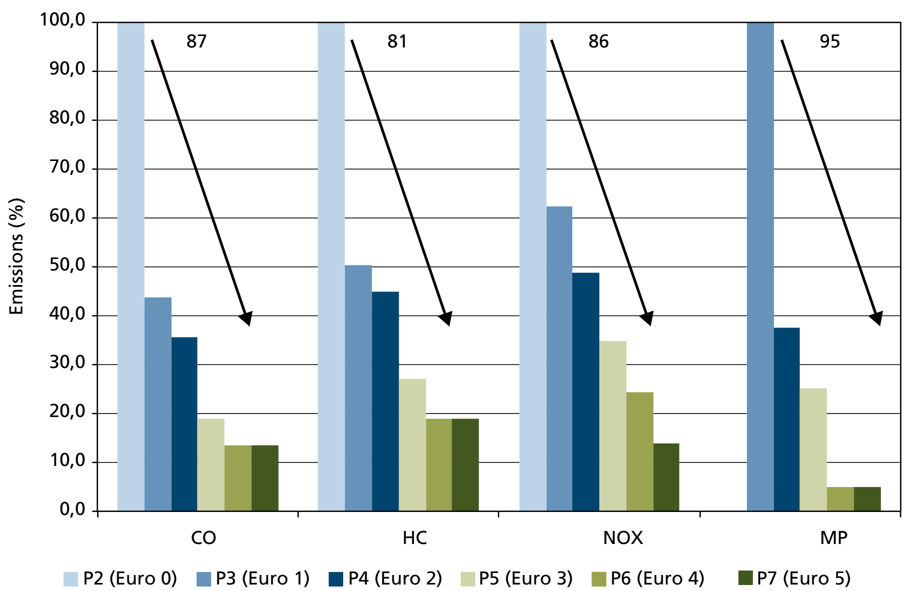


Source: Statistical Yearbook 2001 of the Executive Group of Transport Policy Integration (GEIPOT, in Portuguese).
Obs.: The circle area represents the use of the waterway modal.

The characteristics of the truck fleet further worsen the situation. In fact, according to data presented by CNT and CTS – Brasil (2009), around 1.3 million trucks traverse the country, out of which 45% are over 20 years old about 20% (260 thousand) have over 30 years of use.

Discussions have recently flaunted the immediate implementation of environmental regulation to impose the production of 'Euro 5 motors' with lower emissions to be fueled by a higher quality diesel called 'S10' by the year 2012. However, as observed, the reality in Brazil is that more than 50% of the truck fleet runs on engines that predate the 'Euro 0[1] phase. Graph 2 shows what that means in terms of annual atmospheric emissions. It is important to emphasize that a great part of the fleet is concentrated in the most populous areas of the Southern and the Southeastern regions of the country, as is illustrated in graph 3, compiled by the CNT team using data from the National Registration of Road Freight Transporters (RNTRC, in Portuguese) and the National Land Transport Agency (ANTT, in Portuguese).

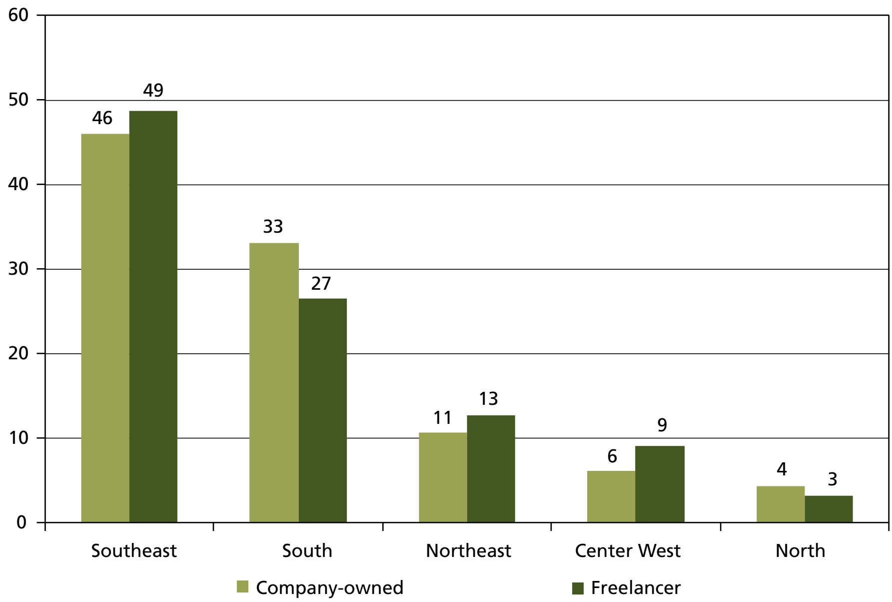
GRAPH 2
Emissions reductions during the phases of the Air Quality Program for Automotive Vehicles (Proconve, in Portuguese)
(In %)



Source: CNT (2010).

1. The European control of pollutant emissions exists since 1993, it began with the normative Euro 0 and now it is in its versions Euro 5 and 6.

GRAPH 3
Distribution of the Brazilian truck fleet per area
(In %)



Source: CNT (2010).

Graph 3 reveals another important fact, namely that the majority of trucks belong to self-employed, or independent owners. The average age of this fleet is 23 years, compared to 11 years for vehicles operated by freight companies. On the one hand, this could indicate a positive enterprising capacity within the freight sector, but on the other hand, it reflects the great complexity in the implementation of public policies aimed at mitigating emissions. Complexities that demand consideration include reviewing the need for a fleet renewal program *vis-à-vis* the implementation of improvement and control actions for vehicle technologies.

The quality of the road network in Brazil is another characteristic of road freight transport with environmental repercussions, especially with regards to climate change. Research on road paving carried out by CNT in 2010 evaluated more than 80 thousand km of highways, and revealed that 58.8% are in regular, bad or terrible condition. Considering the low overall investment levels, despite a significant increase in 2010[2] compared with previous years, the deficiencies in the examined networks are worrying. Poor road quality not only increases the operating costs in the freight transport sector by 30%, it also implies increases fuel consumption, atmospheric emissions and environmental impacts.

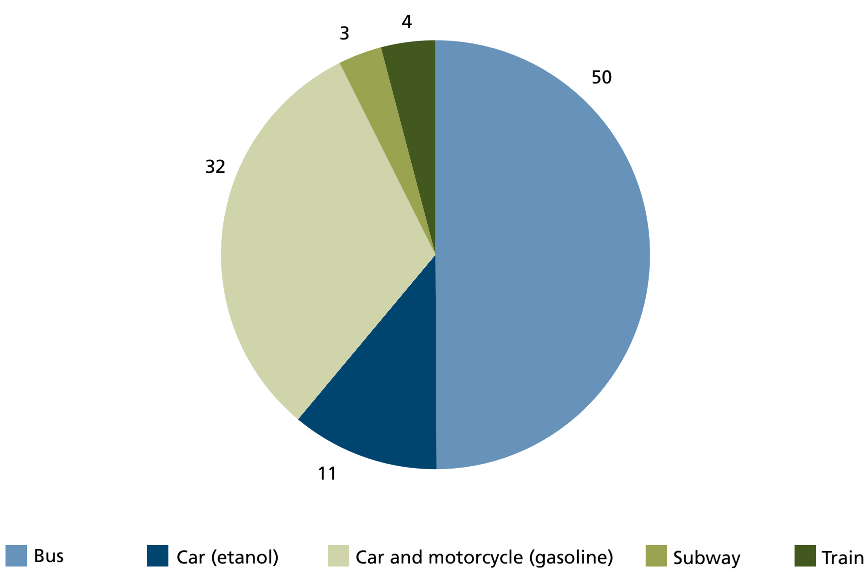
2. From 2007 to August 2010, R$ 27.71 billion were invested in infrastructure of transports.

Also important to this topic is the issue of fuel. The Brazilian road transport matrix mainly relies on diesel oil, a fossil fuel with greater environmental impact. The fleet of heavy, medium and light trucks accounts for 48% of the total diesel fleet in Brazil, according to data from the *1st National Inventory of Atmospheric Emissions by Road Automotive Vehicles* (BRASIL, 2010). Furthermore, the Workshop on National Transportation and Climate Change identified the low quality of the diesel used, which consequently raises the demand for investments into the adaptation and expansion of the refining capacity of a cleaner diesel supply.

2.2 Urban passengers transport

According to Gouvello (2010), as mentioned in the study of Fundação Getulio Vargas and Companies for the Climate (FGV; EPC, 2010), urban passenger transport in Brazil is concentrated around the use of automobiles (43%) and buses (50%), as measured in the number of passengers per kilometers travelled. Railway transport represents only 7% of the total. The distribution per modality of urban transport use in Brazil can be seen in graph 4.

GRAPH 4
Use of urban passenger transport – 2007
(In % of passenger-kilometer transported)

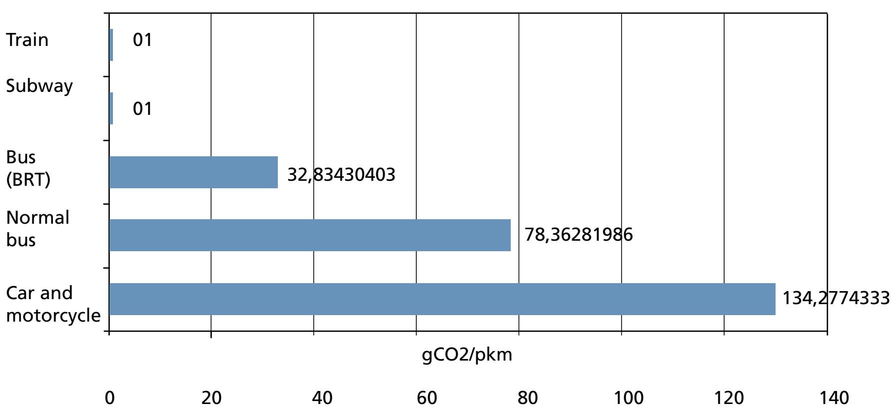


Source: FGV (2010) and EPC (2010).
Compiled by the author.

The characteristics of this matrix, as relates to controlling the emissions of pollutants and GHG, especially in big cities, are a source of great concern to the entire Brazilian society. Furthermore, around 48% of total emissions for the transport sector comes from urban passenger transport. The excessive number of automobiles result in measurable economic losses by causing inevitable traffic jams, which escalates the problems of atmospheric pollution and fuel consumption, with clear negative impacts on the health of the population. Contributing to this unfavorable scenario, motorcycles are increasingly becoming the best transport choice for the population, due to deficiencies in public transportation and uneven income distributions.

Analyzing vehicular emissions coming from buses, automobiles and motorcycles, we reveal the following relation: a passenger transported[3] by automobile emits 7.7 times more pollution[4] than one transported by bus and a motorcycle passenger emits 16.1 times more.[5] Graph 5 from the FGV and the EPC studies (2010), illustrates the impact in terms of CO_2 emissions caused by the preferential use of individual motorized transport.

GRAPH 5
Relative emissions of urban transport means
(CO_2 grams/passenger-kilometer transported)



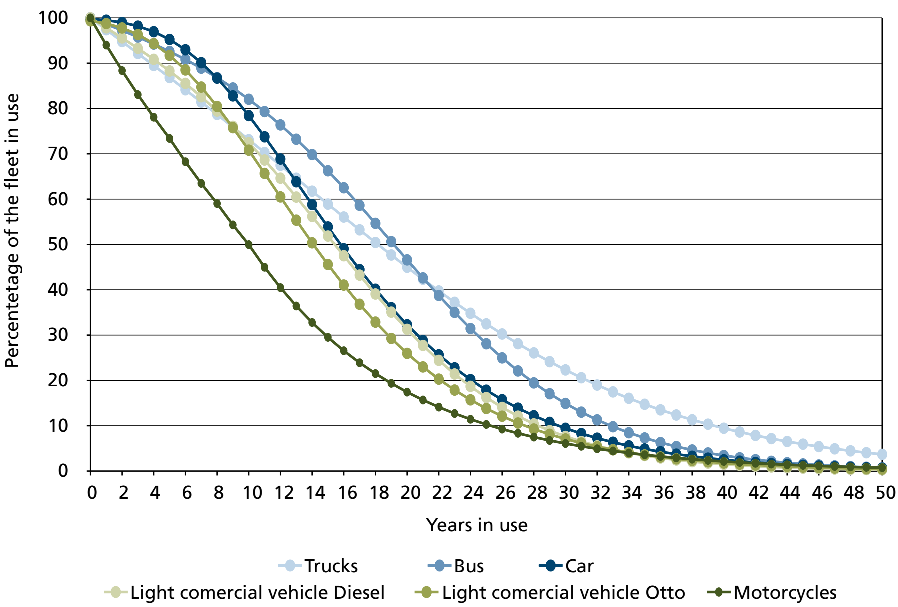
Source: FGV (2010) and EPC (2010).

The need to migrate from individual motorized transport to public transportation is evident, through the development and implementation of policies to discourage use of the former. Such an attitude offers an effective action to mitigate emissions from transport, while also reducing environmental and social impacts, and contributing significant economical gains and energy efficiency savings within the sector.

3. Occupation of the vehicles: 25 passengers by bus, 1.5 by automobile and one by motorcycle.
4. Carbon monoxide, oxygen nitrate, sulfates, hydrocarbons and particulate material.
5. State of São Paulo Environmental Company (CETESB, 2003), cited by Vasconcelos (2006).

A very important aspect, as stated by Branco *et al.* (2009), is that public transport requires systemic and regulated administration, as well as preventive and centralized maintenance control which, if well applied, offers it organization and reliability, unlike individual motorized transport. However, the Brazilian fleet of urban buses which consists of approximately 105 thousand vehicles reveals a worrying fact related to the average vehicle age, as demonstrated by the scrapping curve (graph 6) compiled for the *1st National Inventory of Atmospheric Emissions by Automotive Vehicles* (BRASIL, 2010).

GRAPH 6
Scrapping curve of the Brazilian automotive fleet



Source: Brasil (2010).
Obs.: For trucks, buses, automobiles and light commercial vehicles: scrapping curves adopted by the Ministry of Science and Technology (MCT) in the 1st National Communication (BRASIL, 2006). For automobiles and light commercial vehicles Otto: scrapping curves used by the Planning Service of the Brazilian Petroleum S/A (Petrobras), calibrating by the data of the National Household Sample Survey (PNAD, in Portuguese) of 1988. For motorcycles: curves adopted by Sindepeças for motorcycles of up to 200 cylinder capacities (SINDIPEÇAS, 2008).

In fact, considering the technological advances and environmental demands, with vehicles adopting electric engines compatible with the new phase of Proconve, P-7, predicted for 2012, it will be necessary to make an effort for a continuous renewal of the fleet of around 15 thousand buses every year.

3 POSSIBLE PUBLIC POLICIES AND BUSINESS INITIATIVES

Before the main characteristics presented for road freight transport and urban passenger transport, it`s possible to verify the large extension the problems that need to be solved, so that the sector could be a collaborator for the GHG emission mitigation process. Transport has, like every activity that involves an extensive and diversified social, political and economic chain, a complex group of links of solutions for each one of its diagnosed problems. Considering the purpose of this publication and the space allotted to the theme, it would be impossible to describe such solutions and to consider all the relationships, actors, causes and consequences, as well as investment quantities, or to do a discerning evaluation of the effectiveness and feasibility of executing each one. So, we opted to present, in an indicative and descriptive way, only the most evident solutions.

Given its nature as a basic and essential public service for all of society, most of the necessary solutions require public responsibility and a large investment. According to the 2011 CNT Logistics Plan at least R$ 405 billion is necessary for the accomplishment of 748 projects considered as essential. Among these, there are ones that result in the development and implementation of multimodal transport solutions that encourage the use of modalities with lower environmental impact, such as railroads and waterways. Considering that the social demands of a developing country go beyond the transport topic, it is necessary to develop mechanisms, instruments and economic and financial institutional arrangements that promote virtuous public-private partnerships with higher capabilities of attracting investments. This would enable Brazil to offer responsible solutions to control its emissions, conforming with the commitments to control and mitigate GHG emissions in its territory that the country has pledged in international agreements.

In an evaluation of opportunities to construct propositional investments scenarios, the negotiations for the drafting of multilateral agreements as applied during the environmental conferences of the United Nations (UN) shall be considered, especially the Climate Change Conference, where hundreds of nations including Brazil aim to converge their interests to obstruct global warming.

In this context, an opportunity can be found in the improvement of the clean development mechanism (CDM), built in to the scope of the Kyoto Protocol to facilitate the engagement of the transport sector. Appropriately designed nationally appropriate mitigation actions (Namas), which are aimed to strengthen and formalize national voluntarily assumed commitments, represent another opportunity. Namas, still in the structuring process, allow a programmatic and/or sectoral approach in which the transport case fits. Therefore, they can act as instruments to construct an attractive model for the consolidation of virtuous partnerships between developed and developing countries, in the global GHG emission mitigation effort. In that process, mechanisms can be predicted to enable developed countries to commit themselves to offering additional financing related to mitigation actions of carbon emissions, measurably, traceably and verifiably. Among the several appropriate national actions for the transport sector, considering the previous items discussed, there are:

- Development and implementation of a renewal program for the Brazilian
- fleet, with the scrapping of the old fleet and the forecast of an appropriate structure of incentives and taxation.
- Development and implementation of a program for improving the road
- infrastructure, as well as investments in the diversification of the transport matrix, especially through the expansion and invigoration of railroads and waterways.
- Invigoration and formalization of voluntarily assumed commitments, especially those aimed at the implementation of discouragement policies for the use of individual motorized transport, public transportation improvement and the integrated planning of transport and land use, in the growing urbanization process of the country.
- Development of mechanisms aiming to stimulate the investment in research, development and innovation, especially activities aimed at large scale production and distribution, cleaner automotive fuels and improvement of technologies and production of more environmentally efficient vehicles and engines.

With the scrapping of old vehicles, fleet renewal may be one of the most appropriate and urgent national mitigation actions. In agreement with the data on the average age of the freight transport fleet, Brazil would need to withdraw 30 thousand vehicles per year over ten years in order to stabilize the problem. It would be necessary to withdraw 50 thousand units annually over the next 13 years in order to eliminate from the fleet vehicles with more than 30 years of use.

Results from the International Seminar on Recycling of Vehicles and Fleet Renewal (CNT, 2010), in which technicians, researchers, managers and businessmen from the transport area participated actively, indicate an urgent need for the effective installation of a model for fleet renewal associated with the installation of recycling centers. All statements, especially those from countries such as Mexico, Argentina and Spain, converged to affirm that such a model would bring not only environmental advantages, but also widespread economic and social benefits. In the case of Mexico, the following information was presented: scrapping 15,100 vehicles would result in the reduction of 1.1 million tons of CO_2 a year, equivalent to planting 33 million trees.

The international meeting also revealed that the challenges are great and that the complexity of the solutions call for the involvement of several sectors, and above all governments. However, these implications did not discourage São Paulo State, which through its Green Economy program established (in the *Sustainable Transport* chapter) a renewal program for truck fleets with scrapping warranties for old trucks, as one of its recommendations.

Specifically related to environmental public policies, there are several important actions in course. It is indispensable to recognize the effort of the responsible government agencies, especially those responsible for air quality improvement, starting with controlling emissions from motor vehicles. Public policies fomented by MMA, within the scope of the National Air Quality Control and Air Control Program for Motor Vehicles (Pronar) and Proconve, and formulated by Conama, offer important contributions to the topic. Conama Resolution nº 403 (dated November 11th, 2008) advances demands to improve engines and fuels, and outlines the P-7 phase for 2012. Pronar and Proconve have solidified consistent and effective technical standards, to become configured in the agendas of higher success within environmental management. The gains from fuel improvement and environmentally friendly engine technologies are evident, without any doubts. In the Proconve context, there is also the recent Conama Resolution nº 418 (dated November 25th, 2009) which reinforces and foments the implementation of the Control Plans of Vehicular Pollution (PCPV) and where possible the Inspection and Maintenance Programs of Vehicles in Use (I/M) in all states. These are measures that unavoidably will promote for example fleet renewal, because the established emission standards often request not only the systematic maintenance of vehicles, but also upgrades to more modern and well-adjusted models.

In 2005, biodiesel was inserted into the Brazilian energy matrix, with the publication of law nº 11.097, which initially defines the addition of 2% biodiesel to diesel oil, with an increase to 5% by 2013. The federal government advanced the compulsory addition of 5% to 2010, implying a current increase of more than 60% in the participation of biodiesel in the Brazilian transport fuel matrix.

The use of ethanol is also being stimulated, with a predicted average increase of 11% over the next few years. The use of ethanol as a substitute to gasoline will be responsible for avoiding the release of about 508 million tons of CO_2 over the period 2008-2017, as cited by the FGV study of the EPC (2010).

The National Plan on Climate Change, in spite of lacking dedication from the transport sector, and the promulgation of law nº 12,187 (dated December 29th, 2009), which institutes the National Policy on Climate Change, are also important steps. Article 11 of the PNMC defines the need for establishing sectoral plans as means to execute other determinations and achieve the established voluntary reduction targets. In the design of mitigation and adaptation actions related to transport, the sectoral plan will include the following topics: urban public transportation and freight and passenger interstate transport system plans.

Despite the technological advances made in fuels and vehicles, especially the Brazilian *flex fuel* vehicles that are considered world references, public policies aimed at technological progress are still elementary. The extensive penetration of ethanol in the fuel market, for instance, which contributes to mitigation of GHG emissions, collides with the need to develop even more efficient engines, in order to prevent increased fuel use. It is necessary to develop mechanisms to encourage the use of more efficient vehicles and engines, including hybrids and electric vehicles, especially for urban passenger transport.

A larger deficiency, however, is identified by the absence of more robust public policies for urban passenger transport, especially in metropolitan areas, such as the urgent need to improve public transportation and discourage the use of individual automotive transport. It is necessary, for instance, to construct a regulatory standard to break the sectorial definition of cities and stipulate public transportation density in the directive plans of urban development, among other measures that promote the integrated planning of transport and land use.

Although the mitigation actions of this sector are predominantly public initiatives, the transport business segment does not shy away from discussing the topic and to give its contributions. A concrete example is in the 2007 implementation of the transport environmental program, under CNT, called *Despoluir*,[6] with the objective to promote commitment among businessmen, autonomous truck drivers, taxi drivers, transport workers and society in general to the concept of a truly sustainable development. One of its leading initiatives is the Reduction of Pollutant Emission by Vehicles project, which aims to promote the reduction of pollutant emission through vehicular measurement, ultimately seeking to improve air quality and encourage rational fuel use. Twenty-one (21) federations of freight transport, passengers and self-employed workers participated in the initiative under the national coordination of CNT. CNT, the Social Service of Transport and the National Service of Transport Learning (SEST/SENAT) equipped mobile units and installed fixed stations of vehicular measurement with opacimeters and equipment necessary to analyze the critical points that influence the emission of pollutants and in the rational use of fuel in vehicles run on diesel. The Incentive to the Use of Clean Energy project by the Transport Sector also contributes to this topic, as do two other auxiliary projects: Improvement of Environmental Management in Companies, Garages and Transport Terminals and Friends of the Environment.

6. <http://www.cntdespoluir.org.br>.

Numerous other initiatives by federations, associations and companies can be mentioned. Currently, 7.3% of the 547 firms with an ISO 14.001[7] certification are in the transport sector.

The Workshop on National Transport and Climate Changes (CNT; CTS-BRAZIL, 2009) gathered more than 50 organizations, with prominence for including the Center of Sustainable Transport of Brazil, to positively discuss the challenges faced by national transport to reduce global and local emissions. The output resulting from this event included a set of concrete performance recommendations and an evaluation of the effectiveness and feasibility for each one, organized in the following sub-topics: passenger transport, freight transport and technologies and fuels. Specifically, measures and actions for the following performances were defined:

- discouragement of the use of individual motorized transport;
- improvement of public transportation;
- Incentives to non-motorized transport (bicycles and pedestrians);
- integrated planning of transport and land use;
- modality transfer for the transport of freight;
- improvement of road transport;
- cleaner fuels;
- efficient vehicles and engines; and
- Vehicular inspection and maintenance.

4 FINAL REMARKS

According to the national inventory of emissions, the bulk of national GHG emissions result from land use, or more specifically deforestation, which represents about 70% of emissions, followed by the transport sector at between 7% and 9%. While the former tends to decrease due to territorial limitations and public policies of capacitation and control, emissions resulting from transport are increasing.

According to the presented data, the national transport matrix is dominated by the road modality. More than 60% of freight transport is conducted via highways. The situation is worsened by the fact that about 45% of the fleet of transporting vehicles is older than 20 years, and 20% are more than 30 years old. These older vehicles have a high index of emissions, due to the inherent

7. ISO 14.000 is a series of international standards of voluntary character on environmental management. The set of standards of this one supplies a structure so that the organizations manage the environmental impacts.

maintenance difficulties associated with a fleet with outdated technology. To think that the solution would be in the simple withdrawal of those vehicles, through command and control policies, would be ignoring the Brazilian reality. More than 80% of old vehicles belong to self-employed workers with insufficient purchasing power to acquire new vehicles. Therefore, impeding the circulation of this fleet would cause enormous social and economic distress. To further complicate the scenario, firstly, despite Brazil's advances in renewable energy production such as ethanol and biodiesel, our vehicles are overwhelmingly powered by fossil fuel; and secondly, the precarious condition of more than 50% of the Brazilian road network inevitably reinforces the polluting effects of vehicles.

In order to strengthen the Brazilian position of effective contribution in the reductions of GHG emissions, it is also necessary to conceive a robust program for the transport area. This would include Brazilian fleet renewal and the consequent scrapping of the old fleet, supported by an appropriate structure of incentives and taxation. The program should anticipate restoration of the road infrastructure and promote investments to diversify the matrix, especially through the expansion and invigoration of railroads and waterways. It should also strengthen efforts to implement discouragement policies against the use of individual motorized transport, improvements to public transportation, and develop mechanisms to stimulate investment in research and innovation.

Investment should be encouraged in the wide scale production and distribution of cleaner automotive fuels and for the improvement of technologies and production of more environmentally efficient vehicles and engines.

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CHAPTER 8

FROM CDM TO NATIONALLY APPROPRIATE MITIGATION ACTIONS: FINANCING PROSPECTS FOR THE BRAZILIAN SUSTAINABLE DEVELOPMENT

Maria Bernadete Sarmiento Gutierrez*

1 INTRODUCTION

The two ways in which the international regime on climate change has been negotiated, created at the Conference of the Parties (COP 13), in 2007, and framed in the so called Bali Road Map, resulted in two task forces: the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol – AWG-KP and the Ad Hoc Working Group on Long Term Cooperative Action – AWG-LCA. While the former is in charge, among others, of the issues involving the Clean Development Mechanism (CDM) in all its aspects, the latter has as focus long term cooperative actions to be followed by the different countries, in particular what is called the *Nationally Appropriate Mitigation Actions* – (NAMAS), by which the developing countries would present mitigation actions in the context of their sustainable development on a voluntary basis.

As in the chapter of Miguez[1] in this publication, the interrelation between these two working groups can be summarized in the following way: AWG-KP constitutes the building block for negotiations concerning future periods of commitment of the countries belonging to the Annex I, under the Kyoto Protocol, while AWG-LCA was established as the way for further implementation of the United Nations Framework Convention on Climate Change (UNFCCC).[2] However, as it is well emphasized by Americano (2010), for many countries, the creation of these two groups could mean the creation of an additional protocol or a substitute to the Kyoto Protocol, which would be an enormous regression in the perspective of the developing countries that have been beneficiary of projects potentially financeable by the generation of carbon credits through CDM. Although the Cancun Conference (2010) has restated the importance of the continuation of this mechanism after 2012, it is right event the loss of its

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1. See Chapter 17 of this publication.

2. United Nations Framework Convention on Climate Change (UNFCCC).

relative importance in the case that the negotiations move towards a substitutive agreement of Kyoto Protocol.

CDM has had an important role in the financing of projects that contribute to the sustainable development of developing countries. However, the use of this mechanism has been limited by high transaction costs, which is reflected at a market of carbon credits generated by CDM projects below their potential. This recognition has been originating international negotiations among countries under AWG-KP to reform CDM, turning it more effective and efficient in the target of its main objective of promoting the sustainable development of its beneficiary countries.

In the previously outlined context, the CDM concept developed for Program of Activities (PoA), aiming at enhancing the CDM contribution for the global climate change mitigation and for the sustainable development of the developing countries, as it is stated in § 20 of the Decision 7/CMP 1.[3] Besides the scale factor, clearly PoA reduces the transaction costs. Going beyond, the sectoral CDM concept – more encompassing than PoA, but not approved yet – try to widen the possibilities to finance project and policies capable of promoting the sustainable development, and at the same time reducing the emission of greenhouse gases effect (GHG) to increase the commitment of the developing countries in the mitigation effort.

The Copenhagen Accord established in the Conference of the Parties (COP 15) in Copenhagen, in December, 2009, recognizes NAMAS as a means of increasing the participation of developing countries in the GHG emissions reduction effort. In COP 16, this agreement acquired juridical effectiveness, through the approval of the Cancun Agreements, approved in a consensual way, but not unanimous, since Bolivia rejected its endorsement. However, it remains as a pending activity for the future negotiations the issue of NAMAS' financing mechanisms for their implementation, as well as the negotiations for the second period of the Kyoto Protocol and, in particular, the CDM renewal after 2012.

In the context outlined before, this chapter has as main focus to emphasize that, in spite of the urgency of reaching the GHG stabilization to impose larger participation of the developing countries such as Brazil through NAMAS, it is important that CDM is maintained, as well as its enlargement through a sectoral approach, so that to ensure the financing of the Brazilian sustainable development and of other countries with similar development levels. It is argued that CDM and NAMAS should have a complementary role, and not a substitutive one, since they meet the different needs of the developing countries. In Brazil, for instance,

3. Conference of the Parties, in the quality of meeting of the parties of the protocol (CMP 1), held in Montreal, Canada.

it is worth highlighting the CDM importance in the support to the projects of renewable energy, as it will become clearer along the text.

The Cancun Conference (2010), however, has signaled that the favorable scenario in which CDM and NAMAS have a complementary role, and not a substitutive one, is surrounded by uncertainties that can jeopardize the financing of the sustainable development of the Non-Annex I countries, in particular Brazil. In that way, this chapter tries to emphasize the need to enlarge CDM through the reduction of the transaction costs, as well as it is assured the conditions by which financing mechanisms are created for the financing of NAMAS. The principle of common responsibilities, however differentiated, has been a fundamental factor to make possible the negotiations among developed and developing countries: CDM is the concrete expression of this recognition. It is reiterated the enormous regression is would mean its ceasing for the sustainable development of developing countries.

2 THE KYOTO PROTOCOL AND THE CDM

The entry into force of the Kyoto Protocol in 2005 created the basis for a global carbon market, constituted by different regional or national markets, as well as mechanisms of CDM emission reducing projects, or joint implementation (JI). The different markets diverge in several aspects, standing out size, conception characteristics, sectoral and geographical scopes, and nature, being voluntary or not. Some of these markets were created with the objective of complying with emission reduction commitments negotiated in the Kyoto Protocol, in which the CDM is inserted, while others are voluntary in nature, like Chicago Climate Exchange (CCX). The recent proliferation of national or regional initiatives for the creation of carbon markets attests the high political priority given to this instrument, as recognition of its advantages of economic efficiency and as an instrument to induce technological innovation.

On the one hand, carbon market negotiates two types of assets: *i*) emission licenses allocated in a regime of targets and negotiation (*cap and trade*) of the Kyoto Protocol; and *ii*) emission reductions based on projects that include CDM and JI. On the other hand, in a summarized manner, it can be said that the carbon market is divided in two segments: *i*) Kyoto, led by the European Union (EU); and ii) non Kyoto, with the leadership of the United States.

In spite of some already existing initiatives, like CCX, it can be said that carbon market was established in a consolidated manner with the appearance of the flexibilization mechanisms of the Kyoto Protocol. Two segments appear at carbon market: the trade of emission licenses and the trade of reduction credits, generated by reducing projects. The former, as we have seen, takes place when Annex I countries overcome their target and commercialize this excess as emission licenses for other Annex I countries. The "currency" used for such is the *assigned amount unit* (AAU). The second segment originates from the CDM and JI. The respective currencies are the certified emission reduction (CER)[4] and the emission reduction unit (EUR).[5] It is noticed that, in this last case, while it doesn't happen the final certification of the reduction generated by projects by United Nations (UN), the relevant concept is ERU.

3 CDM AND INSTITUTIONAL ASPECTS: HIGH TRANSACTION COSTS

The transaction costs in the context of the Kyoto Protocol are defined as all those incurred to complete the emission of RCEs. Basically, three are the generating sources of the transaction costs: *i*) preparation of documents; *ii*) validation and certification by the designated operational entities (DOE), including monitoring costs; and *iii*) costs charged by Executive Council of CDM and the host country.

At that stage, the specific transaction costs to CDM for projects that do not fit in the small scale category are already high, in both the initial phases and in the one of implementation. Estimates of World Bank (CEPAL, 2004) indicate average value of US$ 270 thousand regarding the costs of a project to only accomplish the technical-bureaucratic requirements of the CDM, being a true financial barrier for many projects, mainly in a context of inexistence of specific sources of capital financing or that are not being supported by a carbon fund. For the small scale projects, subject to a simplified analysis, similar estimates of World Bank point out a value of US$ 110 thousand, contributing to reduce the economical/financing profitability of the CDM projects[6] (OECD, 2004), also constituting in an important barrier.

From Gouvello and Coto (2003) it was evaluated the effects of the transaction costs in the small scale projects and that are subject to the simplified relevant rules. Its main conclusion is that these costs can vary from US$ 23 thousand to US$ 78 thousand, being a true barrier for the implementation of some projects in developing countries.

Another study estimates average value of US$ 200 thousand for the transaction costs for sample of 30 CDM projects, being World Bank as manager of the carbon fund – Prototype Carbon Fund (PCF) (CEPAL, 2004). These costs also include some items that are specific to World Bank operations, such as: *i*) Concept Note of the Project, document of PCF, which is a more detailed and documented

4. Certified emission reduction (CER).

5. Emission reduction unit (ERU).

6. COP 8 defined simplified modalities and procedures for CDM projects classified as small scale: *i*) renewable energy with maximum capacity of 15 MW; *ii*) energy efficiency up to the equivalent to 15 GWh; and *iii*) other reducing projects of GHG emissions up to 15 $KtCO_2eq$.

Project Information Note (PIN); *ii*) compliance to legal aspects related to the bank; and *iii*) verifications of the environmental impacts, financial and technical studies compatible with the strict criteria adopted by World Bank. Table 1 displays the detailed transaction costs of the CDM projects included in this sample.

TABLE 1
The cycle of CDM projects financed by PCF and the transaction costs
(In US$)

Steps of the CDM cycle	Costs
Preparation and review of the project	27,216
Study of base line and monitoring/verification	61,412
Validation Process	33,415
Negotiation of purchase agreements	89,990
Total of the transaction costs	212,033

Source: PCF/World Bank (CEPAL, 2004).

Other further costs include the value of 2% on the RCEs destined to an adaptation fund managed by the UN, the registration of the project at Executive Council of CDM (US$ 10 thousand), the commissions and the fees of consultant and intermediary companies destined to the commercialization of RCEs (5% to 20% of RCEs) and still the costs of periodic verification by an operative entity before the emission of RCEs (US$ 3 thousand the US$ 15 thousand for each verification period).

The carbon funds and other intermediaries assume the transaction costs so as to recover them later with the sale of RCEs. The initial expectation that the transaction costs would reduce with larger number of CDM projects was not partially concretized, due to the high rejection by Executive Council of CDM several methodologies of baselines and monitoring processes, which had already been approved by designated operational entities. The effect of the transaction costs is to significantly increase the costs of a potential CDM project, as well as reducing the offer, considering that many projects do not leave the paper because of transaction costs.

The most negative effect of the presence of transaction costs is the one of privileging large projects capable of potentially generating high volume of RCEs, which are capable of maintaining net economical-financial profitability of these costs. Particularly, projects related to electric generation and methane capture, HFC destruction, among others, are types of projects that tend to maintain economic profitability in the context of the CDM rules. The most penalized projects by the transaction costs are, no doubt, the ones of small scale, which cannot often generate enough RCEs to cover them.

It should be added that the transaction costs are summed up to the degree of risk that the emission reductions are not certified. The commercialization of great part of the reductions, that is, ERUs, occurs in an uncertainty context as for the final certification of those emission reductions; therefore, directly affecting the side of the expected income of the projects, on both the volume side and the one of the price of the carbon credits. Other risks no less important include the traditional ones associates to the implementation of the project and its technological, economical and political success. Besides the previously mentioned transaction costs, the risk presence in all these levels tends to be source of further costs, reducing the potential profitability of CDM (JANSSEN, 2001). It is a possible result that the project is not carried out, which, however, would not eliminate these mentioned costs.

4 CDM PANORAMA IN BRAZIL

The original expectation, expressed in a document of the Economic Commission for Latin America and Caribbean (CEPAL) (2004), was that Latin America would have a leadership role in the CDM market, due to a group of factors, including appropriate institutions for the approval of projects and the government support, besides quite a varied potential offer of projects, with highlight for hydroelectric projects, wind farm, energy efficiency, waste management, among others. In agreement with information of PCF and Certified Emission Reduction Unit Procurement Tender (CERUPT), the most accurate public information about this market at that time, the Latin American projects represented 31% and 48%, respectively, of the global amounts of their worldwide portfolios; therefore, by potentially configuring Latin America as the most promising area in terms of CDM projects in 2003.[7]

That expectation quickly turned as not being true. While in 2002-2003 Latin America presented participation of 40% in the total carbon offer generated by projects, and Asia 21%, in the following period, 2003-2004, this leadership position had already been inverted. In this last period, Asia responded for 51% of the total carbon offer through projects, overcoming Latin America with 27% of this offer (WORLD BANK, 2005).

That leadership loss is explained partially by the project type. Differently from the period 2002-2003, when the more negotiated projects were the ones of landfill methane capture and destruction, in the period 2003-2004, the largest negotiated volume refers to the projects of HFC-23 destruction, frequent in China, and which respond for 35% of the offered total volume.[8]

7. Seroa da Motta *et al.* (2000) rightly they did not share this expectation and predicted a small participation for Brazil due to its minor number of options for low cost reduction.

8. Projects of landfills, when leaving of emitting methane, whose power of global warming is 21 times higher than CO_2, and energy generation starting from the biogas has high potential of generation of RCEs.

Such Asian leadership position ever since consolidated, in which China and India appear as the countries responsible for more than 50% of CDM projects. In 2006, 61% of the volumes of negotiated credit came from Chinese market, a little below the same participation of 73% in 2005. India follows in second place, with participations of 3% and 12% in 2005 and 2006, respectively. Latin America presented participation of 10% in the CDM market in 2006, corresponding to Brazil 4% (WORLD BANK, 2010).

The most recent statistics (BRASIL, 2011) show that, in the case of Brazil, the largest number of projects concentrates on the area of electric generation and pig raising, which respond for 67% of the total of projects. The scopes that will reduce more GHG emissions are the ones of renewable energy, landfill and N_2O reduction, activities which are responsible for 70% of the reduction of the emissions in the first period for obtaining credits. Table 2 displays the distribution of the project activities in Brazil by project type.

TABLE 2
Distribution of the project activities in Brazil by project type

Projects in validation/ approval	Number of projects	Number of projects (%)	Annual emission reduction (%)	Emission reduction in the first period of obtainment of credit (%)
Renewal energy	245	51.4	39.8	37.6
Landfill	36	7.5	22.7	21.3
N_2O reduction	5	1.0	12.6	11.2
Pig raising	76	15.9	8.4	9.8
Change of fóssil fuel	46	9.6	6.6	7.0
Energy efficiency	30	6.3	4.3	5.2
Afforestation	2	0.4	0.9	3.3
Industrial processes	14	2.9	2.0	1.9
Waste	19	4.0	1.4	1.4
Fugitive emissions	4	0.8	1.4	1.4

Source: Brasil (2011).

Another important piece of information concerns the size of the project. The CDM project activities can be of small or big scale and this division is made through the verification of some factors, as defined by Marrakesh Accords. For effects of the necessary procedures for the approval of the projects, there are simplified rules for the ones of small scale, such and which defined by Marrakesh Accords. In Brazil, approximately 57% are considered of large scale. This result seems to suggest that, in spite of the simplified rules, the transaction costs can be impeding larger use of this mechanism in the projects of small scale (BRASIL, 2011).

Brazil, according to the most recent statistics, continues to occupy the third place in number of projects registered in Executive Council of CDM (183), with China in first place (1,167), followed by India (605) (BRASIL, 2011).

5 A SECTORAL VIEW OF CDM: FROM THE INDIVIDUAL TO THE COLLECTIVE

There is wide consensus about the need of turning CDM into a more effective mechanism in the reach of its original objectives: to reduce the greenhouse gases effect emission and promote the sustainable development in the Non Annex I countries. With this objective, in COP/CMP 1, in December of 2005, in Montreal, the decision was made of establishing further guidelines related to CDM to improve the effectiveness of this instrument in the reach of its original objectives, turning it more agile and reducing the associated transaction costs. As we have seen, the high existent transaction costs in CDM act to significantly limit the sides of the offer and demand market for carbon credits generated from CDM. Enlarged mechanisms of carbon credits in sectoral level base on the same idea of CDM, extended to a sector. The baselines would be sectoral. The government's role would be fundamental to provide a regulatory framework capable of inducing the agents to implement actions that aim at GHG mitigation.

In COP/CMP 1,[9] the programmatic CDM was approved, allowing that programs or projects belonging to national or regional policies can be aggregated to generate carbon credits. In that way, national policies that generate development, at the same time they reduce emissions, can be enlarged credit receivers, with smaller transaction costs. This includes a set of projects of small scale in a program, for instance, small companies, residential sector in a location, programs of rural electrification, transport, among others. The treatment of these sectors in an individual base would be made unfeasible by the high CDM transaction costs, which does not occur in a collective way. In a way still more promising, the inclusion of sectoral policies in CDM will open new financing perspectives for the sustainable development, which will be treated further on. As the programmatic CDM illustration, it stands out the project of Sadia S/A for methane gas capture and combustion, in its Sustainable Pig Raising Program, created in 2005.

Another promising enlargement of CDM for the developing countries refers to the possibility of implementing promoting policies of sustainable development while at the same time reducing emissions. In COP/MOP1, this proposal was not approved in the extent of UNFCCC. This has been gaining momentum and, very probably, the future negotiations will be based on a sectoral basis including policies. In that sense, some initiatives were already launched and the country

9. It is about the first conference in the extent of CQNUMC, after the Kyoto Protocol approval.

that waits the formal approval will be losing opportunities of partially financing its sustainable development with carbon credits.

As expression of effort for adapting to the changes for a wider sectoral CDM, China, for instance, launched a program to reduce the energy use by 100 larger companies to increase the energy efficiency in the industry sector, with a reduction target of 20% in the energy consumption by unit of the product in the period 2006-2010.[10] Other initiatives include the joint work between the International Energy Agency (IEA)[11] and the World Bank, with the objective of establishing indicators of the *benchmark* type for the energy efficiency for Brazil, China, India, Mexico and South Africa (WORLD BANK, 2006).These initiatives consist of initial step for the implementation of a wide sectoral CDM. It must be highlighted that a sectoral mark is not incompatible with a CDM based on projects as analysis unit or a group of similar projects. For CDM it becomes an instrument of larger relevance for both developing countries and also the proper effective combat to greenhouse effect, this enlargement becomes necessary.

This perspective of a sectoral CDM is compatible with multiple objectives with the final purpose of turning the combat actions against greenhouse effect more effective and efficient. In a second instance, it becomes crucial to create the basis for a more encompassing CDM that can meet the objectives of sustainable development of developing countries, also promoting effective technology transfer. A sectoral framework would allow identifying reduction targets in the GHG emission compatible with objectives of sustainable development in developing countries. The adoption of development policies with environmental objectives could also be important instrument to engage the developing countries in the emission mitigation effort, at the same time contributing with their sustainable development financed by potential carbon credits. It should be emphasized that, in the climate negotiations after 2012, the pressures will be high for countries such as Brazil, China and India to participate in the emission reduction effort. A wide sectoral CDM could be an important instrument in connection with the objectives of sustainable development, reaching the simultaneous reduction in GHG emission.

A sectoral CDM extended to the inclusion of sectoral policies would hugely enlarge the possibility to generate sectoral carbon credits, which would benefit developing countries, particularly Brazil. This means that the mechanism of generating carbon credits would happen for several emission sources belonging to an economic sector. All the statistics relevant for the generation of carbon

10. This proactive role of the Chinese government, being early to the facts, without a doubt, it is a factor to explain the position of leadership of China in CDM.

11. International Energy Agency (IEA).

credits would need to have sectoral aggregation. In a second step, the issue of how to distribute the generated credits in a sectoral manner for individual sources would be presented. The carbon credits could be generated starting from policies, changes in environmental indicators or market system of the *cap and trade* type (OECD, 2006). These three options are hereinafter presented:

1. Credits generated starting from policies: the credits to be obtained would be measured based on the emission reductions resulting from certain policies. It is requested, in this case, careful evaluation of the policy contribution in question to the effective emission reduction. An enormous advantage in this option is to allow that projects and sectors that would not have access to the carbon financing for several reasons, for instance, high transaction costs, can have this access.
2. Credits generated starting from indicators: the baseline indicator would be defined as emissions divided by an established metric unit, reflecting in level of activity of the sector (e.g. tons of steel or aluminum, energy consumption etc.). A sector would have carbon credits if and when it lowered emissions to below the baseline.
3. Credits generated starting from fixed reduction target – or *cap and trade*: a sector would become potential receiver of credits if its emissions reached a volume lower than the established target.

Those three previous options share common aspects. The first important aspect concerns the establishment of a baseline, reference on which the reductions will be measured. Another important issue refers to the sector definition itself. Equally relevant is the aspects regarding the monitoring and verification mechanisms. It can be stated that these aspects common to the three options of sectoral credits shall receive the appropriate treatment. We have seen the high transaction costs in the case of the CDM projects; the international community should work so that the lessons learned with the CDM operation are reflected in the creation of an effective and efficient sectoral credit system.

According to the Brazilian perspective that – for matters of equity Brazil shall not have GHG reduction targets that can compromise its development process – the generation of sectoral carbon credits shall occur since there is compatibility between its growth/development and the sectoral GHG reduction target.

The CDM expansion from project to a sector can occur by the implementation of one or more Policies and Measures of Sustainable Development (PMDS, in Portuguese), economic sectors in national level or certain areas (SARAMIEGO; FIGUERES, 2002; SCHMIDT *et al.*, 2004). This way, a strong incentive is created to implement changes for policies that promote sustainable development with clear environmental benefits. On the other hand, it would happen the reduction of the transaction costs, which at the moment acts as impeding factor for many projects and/or companies.

In a joint effort of World Bank, BM&F Bovespa and Financier of Studies and Projects (FINEP) (2010), were mapped the opportunities of increasing the CDM use in Brazil. This work shows that, in spite of the Brazilian participation in the CDM world market is quite expressive, occupying as said the third place in number of projects, there is still a high potential for the development of other project activities, which could be included in an individual or programmatic mark. This study contemplated inventory of the opportunities of mitigating projects of GHG reductions in the following sectors:

- electricity – generation, distribution and consumption;
- fossil fuel for the industry – production, distribution and consumption;
- other inputs for the industry – production and by-product treatment;
- transports/fuels for vehicles – production, distribution and consumption; and
- management of solid waste and liquid effluents – generation, treatment and disposal.

This study points that in Brazil the possibilities of the CDM enlargement are very high, once the favorable conditions for these projects are created. This high potential in the use of CDM by the Brazilian companies should direct the Brazilian position in its negotiations. Shortly, a study with the quantification of this potential will be published.

6 FROM THE SECTORAL CDM TO NAMAS

The Bali Action Plan launched in the COP 2007 established the concept of *NAMAS,* as already mentioned, which means the mitigation actions of the developing countries that would happen as Measurable, reportable, verifiable (MRV)[12] and which could, but not necessarily, be financed by Annex I countries. The conception of NAMAS has as one of its origins the recognition that developing countries should participate in the reduction effort in the GHG emissions, which, not happening, could endanger any emission reduction agreement.

NAMAS should have the following characteristics:

12. *Measurable*, *reportable*, *verifiable* (MRV).

1. The reduction in the emissions of a country in medium and long terms additional to the situation of which would have happened through the carbon market.
2. To be consistent with the priorities and the objectives of sustainable

development of a country.

Ideally, therefore, NAMAS are identified with the national strategies conceived with the main purpose of reaching high reductions in the emissions of greenhouse gases and would have as consequence the carbon intensity reduction of the economy in THE medium to long terms. It is important to emphasize that NAMAS definition is wide enough for also embracing actions that would happen for motivations of another nature, but that result in reductions of emissions significantly. Finally, NAMAS should include policies and measures in all sectors with high potential of mitigation. They can also happen in different action levels and scales: project level, sector or also programmatic or national one, constituting a mark to integrate actions aiming at the reduction of the carbon in an economy.

Although there is a high degree of agreement on NAMAS concept, the stage of its precise definition has not been reached yet.[13] There is reasonable consensus on some of its characteristics. Being voluntary and chosen by the developing country, for instance, is a consensus point. As Americano (2010) points out, the points that originate higher controversy are those regarding the nature of the household actions, the financial support, technology and the capacity to MRV procedures. Regarding Namas that do not search for external support, there are important uncertainties not only about its own definition, as well as on which would be the appropriate specific procedures.

In January 2010, Brazil directed its NAMAS to the UNFCC, besides formally associating itself to the Copenhagen Accord (AMERICANO, 2010). The following mitigation actions were proposed, totaling growth reduction of the Brazilian emissions estimated until 2020 between 36.1% and 38.9% regarding a *business the usual* scenario (BAU):

- reduction of 80% in the deforestation of the Amazonian forest – an estimate reduction of 564 million tons of CO_2 until 2020;
- reduction of 40% in the deforestation of Savanna – an estimate reduction of 104 million tons of CO_2 until 2020;
- recovery of pastures – estimate reduction increase from 83 million tons to 104 million tons of CO_2 until 2020;

13. It is important to emphasize, in the case of Namas that receive external financing, the generated carbon credit is going to enter the reduction accountancy of the financing country, and not of the country that is going to implement it.

- agriculture/cattle-raising integration – estimate reduction increase from 18 million tons to 22 million tons of CO_2 until 2020;
- No-till – estimate reduction increase from 16 million tons to 20 million tons of CO_2 until 2020;
- energy efficiency – estimate reduction increase from 12 million tons to 15 million tons of CO_2 until 2020;
- expansion of the energy offer by hydroelectric power stations – estimate increase reduction from 79 million tons to 99 million tons of CO_2 until 2020;
- alternative sources: small hydroelectric power stations, bioelectricity, wind farms – estimate increase reduction from 26 million tons to 33 million tons of CO_2 until 2020; and
- Siderurgy: substitution of the deforestation coal for coal from planted forest – estimate increase reduction from 8 million tons to 10 million tons of CO_2 until 2020.

The previously described targets acquired legal status, through Law nº 12.187/2009, which institutes the National Policy on Climate Change (PNMC). The study by Seroa da Motta[14] discusses the regulatory and governance aspects necessary for the PNMC implementation. It must be emphasized that the financing possibility through the CDM is described in the referred law, which shows unequivocally the importance of this mechanism for the financing of the Brazilian sustainable development.

7 NAMAS AND ISSUES RELATED TO THEIR FINANCING

A successful agreement after 2012 implies the appropriate financing framework of NAMAS that leads to their effective implementation. Central in this discussion is the matter of how to promote the balance between the financing needs of NAMA and the availability of funds. It is worth reminding that, according to § 1st, line ii, subparagraph b, of the Bali Action Plan, we have:

> The nationally appropriate mitigation actions by the developing countries parties in the context of sustainable development supported and enabled by technology, financing and capacity building, in a measurable, reportable and verifiable manner.[15]

14. See chapter 1 of this publication.

15. *Nationally appropriate mitigation actions by developing country parties in the context of sustainable development supported and enabled by technology, financing and capacity building, in a measurable, reportable and verifiable manner*.

The Cancun Agreements, according to the chapter by Wehbe[16] in this publication, meant some important conquests for the developing countries regarding financing. It is remarkable the establishment of the Green Fund for the Climate, a permanent committee to comply with the financial mechanism and the allocation of resources, besides the recognition of the collective commitments of short and long term financing. The scale of resources to be made available is of US$ 30 billion in the short term until 2012 and US$ 100 billion annually until 2020. However, although these values seem expressive in absolute terms, they are insufficient due to estimates of financing necessary for the mitigation effort in the developing countries.

Some studies have analyzed the investment levels necessary for the implementation of mitigation actions in the developing countries. For instance, the UNFCC report (2007) shows that the hypothesis of 25% reduction in the emission levels from 2000 to 2030 implies a cost from US$ 200 to 210 billion annually (UNFCC, 2009), from which US$ 130 billion will be necessary in the developing countries. Considering that the CDM mobilized US$ 3 billion in 2009, the following observations are relevant:

- The current financing levels for mitigation plans will have to be significantly increased in a regime after 2012.
- The mobilization of resources of the private sector will be crucial to provide the necessary resources for Namas financing.
- The demand for financing will far probably exceed the offer of resources.

The CDM experience is quite illustrative concerning this matter. The CDM has been an important catalyst of low carbon investments, facilitating and leveraging resources of values which are much higher than the ones of its own market. According to World Bank (2010), in the period of 2002-2008, the CDM generated US$ 23 billion in carbon credits, whose generating projects of these involved resources totaling US$ 106 billion, mainly in renewable energy. For comparison effects, the investment in renewable energy in developing countries totaled between US$ 80 and 90 billion in the same period. These results indicate the CDM potential as mechanism to increase the mobilization of resources. One of the reasons would be, with no doubt, the higher efficiency necessary in the administration and in the operation of the CDM projects, since these ones are conditions necessary for obtaining the carbon credits themselves. In this context so outlined, the efficiency in a resource allocation mechanism also capable of mobilizing the private sector resources acquires crucial importance, so that the financing gaps are minimized.

16. See chapter 22 of this publication.

That mechanism of balancing the financing demands with the offer of funds should have some characteristics. The first aspect that emerges in this context is that the external financing of NAMAS should be supplementary to the government financing, and it should not substitute already existent financings. Another important aspect concerns the criterion of privileging mitigation actions that would not be easily financed by the carbon market or by other private investment channels.

Another important element in the referred mechanism would be to direct the financing to NAMAS in the sectors in which the CDM has not been operating. To illustrate the argument, it could be the case of sectors in which technology has been demonstrating high potential, but that did not reach the commercialization stage yet, as the carbon capture and storage sector (*carbon capture and storage*). It could also be the case for sectors where there are market barriers to the implementation of projects, such as increase of energy efficiency by the demand, as well as sectors not included in the CDM, as nuclear energy, if these sectors are not included in the regime after 2012. Anyway, a lack of consensus can be expected among the countries as for the inclusion of these activities as susceptible to financing.

Also considering that NAMAS concept itself needs more definitions, an appropriate financing mechanism should prioritize the actions for which there is shortage of resources for their implementation. A first important step is with no doubt the preparation of NAMAS by the countries which are not included in Annex I, which is already made by some countries, including Brazil, as mentioned, followed by clear indication of which actions will be implemented with domestic resources and those searching for external financing.

8 FINAL CONSIDERATIONS

In a first instance, it can be concluded that it is possible to improve the performance of the CDM market, by simplifying the registration procedures to reduce high transaction costs and by making flexible the criterion of legal additionality, financial and co-benefit aggregation. It could also be envisaged the inclusion of the Land Use Land Use Change and Forestry (LULUCF) activities regarding the enlargement and inclusion of the forestation and reforestation activities.

In a second level, it was shown that NAMAS converge in many aspects with the sectoral CDM characteristics, which originally aimed to increase their benefits with the reduction of the transaction costs. However, there is an important difference concerning the financing: NAMAS can or cannot be financed by the Annex I countries, while the CDM has as focus the financing by Annex I countries.

In COP 16, there was neither progress in that financing matter nor in the CDM renewal after 2012 and its expansion through a sectorial framework. This constitutes itself in a lost opportunity, since the CDM has had an important role in financing innovating and emblematic projects. On the other hand, a lack of definition on circumstances where NAMAS could be financed was witnessed. Ideally, in the developing countries' point of view, the negotiations should advance for the renewal and increase of the CDM, as well as for the definition of the conditions under which there will be financing for NAMAS, without high transaction costs.

In this current stage, important uncertainties remain as if the next negotiations will lead to a higher volume of resources to finance growth of low carbon in the developing countries. We do not know how the resources available for the CDM will combine – or not – with resources available for NAMAS. Considering that there are important deadlocks on the future of the Kyoto Protocol and that, on the other hand, there is no consensus either on NAMAS nor on their financing, we cannot discard the worst scenario of total lack of financing. It would be inconceivable if the future negotiations did not achieve any of the two objectives. The two parallel negotiation ways, AWG-KP and AWG-LCA, conceived to come to a more comprehensive agreement on the climate, are being used in a strategic manner by the Annex I countries, with non- explicit conditions are being introduced so that national interests overcome the global interest of reaching a true world agreement capable to take to the GHG stabilization.

The principle of common, but differentiated, responsibilities has been an important element to guarantee the equity in the negotiations between developed and developing countries and the UNFCC conception itself has been molded to comply with this criterion, which should be presented as nonnegotiable.

Brazil, on one hand, presents high potential of increasing its use of the CDM in several different sectors. On the other hand, the country, through its mitigation actions included in its PNMC, presents reduction targets in its ambitious emissions, in which financing through CDM is predicted. It would be very important if the future negotiations advanced for the continuation of the Kyoto Protocol and that the financing to be made available for NAMAS as additional resources. These factors are requirements so as there to be a global agreement on the future of the international regime on climate change.

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CHAPTER 9

DEVELOPMENT, COOPERATION AND TRANSFER OF LOW CARBON ENERGY TECHNOLOGIES

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1 INTRODUCTION

This chapter aims to evaluate the stage of development of several energy technologies with low greenhouse gases (GHGs) emissions and investigate the interest in technology cooperation between Brazil and other countries, both industrialized and developing countries. The analysis presented can also contribute to international negotiations related to those technologies that can be potentially attractive to global efforts to mitigate GHG emissions from the production and use of energy.

This chapter is based on supporting studies conducted by CGEE in partnership with IEI, which involved the active participation of public stakeholders, particularly the Ministries of Science and Technology (MCT), Environment (MMA) and Foreign Affairs (MRE), the private sector, represented by the National Confederation of Industry (CNI) through workshops held by CGEE, and also interviews with experts. It is important to observe that the material in this chapter represents the situation during the period 2008-2009 and the dynamic nature of technological development should be considered since then.

In section 2, we briefly describe the stage of development of the technologies used for electricity generation, followed by those used for fuel production and finally the "interface" technologies. In section 3, summary tables present opportunities for technology exchange and the development stages of low-carbon (or low GHG emission) energy technologies.

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2 LOW GHG EMISSION ENERGY TECHNOLOGIES

The criterion used in the selection of the low-emission energy technologies to be examined focused on each technology's potential to mitigate global GHG emissions and to meet the Brazilian energy market, based on the methodology developed in the studies mentioned in the introduction. They are listed below, accompanied by a brief description of their stage of development, the main actors and countries involved, as well as the potential interest of development and transfer between the parties.

Technologies to generate electricity from natural gas and coal: Brazil is interested in receiving modern technologies based on these fuels, including from developing countries such as South Africa, China, India. Brazil has technological expertise in the area of pulverized coal. The country also has industrial facilities for this technology in operation. However, there are no initiatives or research on the so-called ultra-supercritical systems using coal. In the case of large-size gas turbines, this technology is already well dominated by a limited number of large multinational companies on a commercial scale. The interest in small gas turbines recently started to increase in Brazil, where there are already existing research groups and companies developing products, which increases the scope for international collaboration in applied research, development and manufacturing.

Technologies for electricity generation from nuclear power: Brazil has expertise in the area of fuel production, particularly at the enrichment stage. The possibility of exporting know-how to enrich uranium with domestically developed centrifuges in compliance with security policies and agreements ruling this area can be considered. Advanced nuclear reactor technologies (Generation III+and IV) are not mastered in Brazil, but there is some knowledge about generation II. These are areas in which there is interest in performing maintenance work and in participating in development projects.

Photovoltaic and high temperature solar thermal generation: there is great interest in developing and prospecting more advanced technologies in these areas, and in promoting cooperation agreements with world-class centers of excellence, with the aim of expanding the training of human resources, enabling the exchange of information (such as experiences, standards, measurement and support) and promoting the development of products and implementation of cooperative projects. In relation to solar photovoltaic, Brazil has a large industrial park that extracts and processes quartz into metallurgical-grade silicon, but there are no companies that transform it into solar-grade one or that manufacture solar cells and systems, despite the research and development activities in this area. Electricity generation from high-temperature solar thermal processes is an area of low technology mastery in Brazil. There is emerging research on the subject and some researchers involved. However, the international trend in Concentrated Solar Power (CSP) technologies is moving towards the demonstration and market stage, which may be attractive for Brazil.

Wind energy: one of the fastest growing energy sources worldwide and whose technological advances are rapidly entering into the market. Brazil has every interest in more actively monitoring these developments. There is a need for the development and adaptation of software, technologies and materials best suited to Brazilian conditions. There is plenty of room to increase research and development (R&D), innovation and the nationalization of components. There are already some industries operating in the country, including through technology transfer agreements. Brazil also has an industrial structure that is potentially able to meet the domestic demand for new turbines and their components, as well as to compete in the international market. The main countries with highly developed technologies are Germany, Denmark, the United States and Spain. Among developing countries, China and India already have significant programs in manufacturing and installation of wind turbines.

Combustion and gasification of biomass: gasification technology is still developing internationally, but Brazil has a keen interest in participating in this development and its application. The 2030 Energy Plan already includes the introduction of integrated combined cycle gasification in the ethanol sector. Also, there are research, development and innovation groups working with this subject in universities, public research centers and, more recently, initiatives in the industrial sector (Sugarcane Technology Center – CTC and Vale Energy Solutions – VSE), including with the development of prototypes. It is a particularly strategic area that can benefit from more international cooperation with research centers in the United States and Europe. The academic and industrial knowledge that Brazil has in advanced biomass cogeneration systems allows it to be an important actor in industrial and technological cooperation, and thus holds knowledge which can be transferred to countries in both developing and developed countries.

Hydroelectricity: medium and large hydropower is a mature technology in Brazil and worldwide. As for the small hydropower plant (SHP), there is great potential for technological development in Brazil and the world, particularly in developing countries, even though the technology is already in the marketing phase. There is domestic knowledge about the whole production chain, including the areas of design optimization of hydraulic turbines and civil engineering, and most of these activities are currently carried out by private companies. The Brazilian industrial and technological park is able to provide competitive equipment up to 10 MW. In terms of technology transfer, this is an area in which the country can export knowledge, products and services to countries in both developing and developed countries.

Hydrogen: hydrogen is already produced in Brazil, but its use on a larger scale for energy purposes requires progress to reduce costs. This is true not only for Brazil and there are possibilities of joint development between Brazil and several countries in the north and some in the south, as has been explored under the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). Brazil has some knowledge in the areas of hydrogen production technologies (electrolysis of water, reforming of ethanol and natural gas) and some types of fuel cells (Polymer Electrolyte Membrane – PEM for stationary applications and small size) with centers and research groups working in the area. Also, there are already small technological businesses developing and manufacturing products enabling them to participate in international technology exchange.

Natural gas (liquefied natural gas – LNG and gas to liquids – GTL): Although the LNG technology is already used on a commercial scale in the world, Brazil still has limited knowledge in this area. Currently, major efforts are directed towards the acquisition of natural gas liquefaction and regasification technologies. There is a research center, namely, the Petrobras Centre for Research and Development Leopoldo Américo Miguez de Mello (Cenpes/Petrobras), which has acquired knowledge and surveyed the state-of-the-art technology of LNG, but there is no industrial capacity yet in this area. In the case of GTL technology and even coal to liquids (CTL), there is relatively restricted knowledge in the country residing with Cenpes, although some universities and other research centers also have research and development programs in these areas. There is no industrial capability in Brazil.

First and second-generation ethanol: this is a completely mastered technology in Brazil which may be transferred to other countries (North and South), including know-how for its integration with the distribution system of oil products. Likewise, the use of bagasse to generate electricity and the integration of this generation with the national electricity system is in earnest progression, representing an additional attraction for international diffusion. Second-generation ethanol is at the R&D and early demonstration stages, and still requires fundamental research. Brazil is home to several researchers and centers where most of the knowledge is housed, also including some industries in this sector. The Brazilian Bioethanol Science and Technology Laboratory (CTBE) was recently created. It can be said that Brazil is likely to transfer knowledge to developing countries and benefit from collaborative research with both Northern and Southern countries.

Low-temperature solar thermal energy conversion: Brazil masters the technology of conventional flat plate collectors. It would be important to develop other more sophisticated technologies, as well as other applications: refrigeration, air conditioning, selective surfaces, evacuated tubes and automated manufacturing processes. Even though there is knowledge and technological capability in universities, there are no coordinated efforts or extensive interaction with companies. It is also necessary to promote the modernization of the national industry, with more quality control, product certification and technical assistance. Brazil would benefit from more cooperation with developing and developed countries (China and Israel, for example).

Charcoal: Brazil is currently the world's largest charcoal producer and has a prominent technological position, even though there is a need to incorporate advances – especially to increase the efficiency of the carbonization process. Brazil has, therefore, the opportunity to transfer technology to other countries, especially in the regions of Latin America, Africa and Asia, which consume great amounts of plant charcoal. There are national and multi-national companies in the country dedicated to the production of charcoal for the steel industry.

Biodiesel: it can generally be said that biodiesel is a commercial product, but it needs subsidies for its production. Its cost is not yet competitive with conventional diesel, but there are continued technology advances. Brazil has active research groups throughout the whole biodiesel production chain. And there are opportunities to transfer national technology abroad, as well as further exchanges and cooperation with other major global producers (Germany, for example). Brazil also has an industrial sector, with national companies, capable of producing equipment and biodiesel.

Carbon Capture and Storage Technologies: although at the international level these technologies are still in early R&D stages, there is already a strong Brazilian interest, particularly from Petrobras. In 2006, Petrobras created a Thematic Network for Carbon Capture and Climate Change and established the Center of Excellence in Research and Innovation in Petroleum, Mineral Resources and Carbon Storage (CEPAC). All technologies that constitute Carbon Capture and Storage (CCS) – capture, transport, storage and monitoring - demand attention and cooperation with other countries (from the North). There is also an expectation of the development in Brazil of carbon capture and storage from renewable energy sources (Renewable Carbon Capture and Storage – RCCs) in order to, for example, capture and store CO_2 from fermentation tanks for ethanol production.

Smart grid technologies: these are under development in the world. Australia, the United States and the European Union are investing in pilot projects, including not only technical but regulatory reforms that facilitate the development of the market for these technologies. Aspects such as interconnection for distributed generation, storage systems, real-time load management systems, automation, among others, are focus areas for the development of these technologies. Brazil has already some knowledge and good capabilities in universities, Cenpes and the Electric Power Research Center of Eletrobras (Cepel/Eletrobras). Moreover, it is essential to leverage more penetration of energy sources such as solar photovoltaic, wind and carriers, such as hydrogen, and also to incorporate these technologies into buildings. This is an area in which Brazil still has great interest in receiving advanced technology and knowledge from Northern countries, and integrating them into the Brazilian strategy for the dissemination of renewable energy sources in other developing countries.

Recent growing interest in lithium batteries for automotive purposes: the advantages of this technology will facilitate the further diffusion of electric vehicles. This technology is in the demonstration phase and predominantly mastered by multinational companies related to the automotive industry. Brazil has capability and companies that manufacture several types of batteries.

Social technologies: Brazil has over many years invested in certain technologies that were able to transform the energy market with significant social impacts. The case of the introduction of liquefied petroleum gas (LPG) in replacement of firewood is one example (like ethanol fuel). There was a concern to transform the existing market by creating suppliers, distribution companies and sales points for new stoves and a subsequent further market consolidation. There are about 2 billion people in the world who still use firewood for cooking, mostly in Africa and Asia. This fact presents an opportunity to take this know-how to these countries and also to envisage the possibility of introducing other cleaner fuels for this purpose, as is the case of ethanol which could also be produced in small distilleries (another technology mastered in Brazil). Brazil has invested about R$ 100 million annually in energy efficiency programs for low-income populations. These programs have been conducted by electric utility providers and have contributed to foster the internal market of suppliers of more efficient equipment, lamps, refrigerators and solar water heaters for residential use. Other initiatives are being developed for urban and peri-urban populations in situations of several logistical difficulties and conflicts. So there is know-how to implement such programs on a large scale and this can be an item to be transferred to other developing countries.

3 FINAL

This concise analysis is summarized in tables 1 and 2 (attached). Table 1 summarizes the status of the technologies examined with regard to opportunities for technology transfer from and to Brazil, both in relation to developing countries and industrialized countries. Table 2 outlines the information about the stage of development of these technologies in Brazil and the internal capability to transfer or receive technologies, considering the competence of research, development and innovation (R,D&I) groups operating in the country, as well as companies (product, equipment and services) established in the Brazilian market. Finally, there is a caption that explains the information used in table 2.

As can be seen in table 1, Brazil is well positioned to offer technologies and services in several areas to other developing countries. The groups of technologies identified in this case range from the so-called social[1] technologies to first-generation biofuels, biomass gasification, cogeneration systems, to the production of hydrogen and fuel cell systems for small businesses. Biomass production processes and technologies for its conversion into charcoal are areas where Brazil has dominion over and that can be transferred to many other developing countries that use this energy source, both in the residential and industrial sectors.

As for industrialized countries, the export list of equipment and technology services is smaller but still important. Brazil has a wide technology mastery of the entire production chain of first-generation biofuels (ethanol) and exhibits some advances in second-generation technologies, for which more cooperation could be crucial for Brazil to accelerate the mastery of this knowledge. Brazil also has expertise to transfer advanced biomass cogeneration systems and the process of converting biomass into charcoal to industrialized countries.

Table 2 maps the stages of various technology groups both in the world and in Brazil. The traditional stages of the innovation chain[2] were considered, the knowledge status and the performance of the Brazilian research centers, industrial sectors and the current market were analyzed, as well as an assessment of the general degree of technology mastery in Brazil. Some specific comments about Brazil were also included for each group of technologies. The caption used in table 2 shows the four category levels used for each criterion analyzed. The information in table 1 supports the summary chart presented in table 1.

In short, Brazil masters areas such as hydroelectricity and biomass (ethanol and charcoal). For some technologies of cleaner and more efficient combustion of coal, natural gas usage, capture systems (CCS) and solar energy at high temperature, there is still a large technological gap in this country. Some of these technologies are already commercially available in the international market, such as natural gas (large turbines) and pulverized coal, and therefore require a very different effort from those at earlier stages of development.

1. Herein understood not only as the technologies themselves, but also the diffusion programs of solar water heating systems to low-income consumers, LPG and rural electrification.

2. Basic research, demonstration, deployment and commercialization (GRUBB, 2004).

Overall, Brazilian research centers possess good scientific and technological knowledge in virtually all the groups of energy technologies analyzed, however, industrial training does not follow the same trajectory. This is the case with most advanced combustion and gasification technologies, with processes involving the conversion of solid fuels and gas to liquid fuels (Fischer-Tropsch) and in solar photovoltaic and thermal low temperature.

Finally, it is noteworthy that new energy technology developments usually require capital-intensive and sizable industrial infrastructure. The existence of markets, both internal and external, for its dissemination thus becomes essential.

The success of public policies to accelerate the introduction of modern energy technologies with low GHG emissions will thus depend on a more comprehensive and transparent coordination between areas of strategic importance, namely: climate, energy, industry and science and technology.

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ANNEX

TABLE 1
Table summary of opportunities for technology transfer

Technologies for electricity generation	Transfer of technology from Brazil		Transfer technology to Brazil	
	South-South	South-North	South-South	North-South
Natural gas				
Turbines (large)	No	No	No	Yes
Microturbines	No	No	No	Yes
Coal				
Pulverized (critical, supercritical and ultrassupercritical)	No	No	Yes	Yes
Gasification (Integrated Gasification Combined Cycle – IGCC)	No	No	No	Yes
Atmospheric circulating fluidized bed	No	No	Yes	Yes
Nuclear fission (generations III and IV)				
Fuel production	Yes	Yes	No	Yes
Reactors	No	No	No	Yes
Solar				
Solar photovoltaic (silicon)	No	No	Yes	Yes
Solar thermal (high temperature)	No	No	No	Yes
Wind power	Yes	No	No	Yes
Biomass				
Gasification of biomass	Yes Δ	No	No	Yes
Advanced biomass cogeneration system	Yes	Yes	No	Yes
Hydroelectricity				
SHP (small)	Yes	No	No	Yes
Medium and large	Yes	No	No	Yes
Hydrogen				
Fuel cell	Yes	Yes	Yes	Yes
Production and storage	Yes	Yes	Yes	Yes

(continues)

(continued)

Fuel and heat	Transfer of technology from Brazil		Transfer technology to Brazil	
	South-South	South-North	South-South	North-Nouth
Natural gas				
LNG (liquefaction and regasification)	No	No	No	Yes
GTL (gas-to-liquid)	No	No	Yes	Yes
Coal				
CTL (coal-to-liquid)	No	No	Yes	Yes
Ethanol				
First generation	Yes	Yes	No	No
Second generation	Yes	Yes	No	Yes
Solar energy	Yes	No	Yes	Yes
Charcoal	Yes	Yes	No	Yes
Biodiesel	Yes	No	No	Yes
Interface technologies				
CCS – Carbon Capture and Storage	Yes Δ	No	No	Yes
Smart Grid	Yes Δ	No	No	Yes
Storage (batteries)	Yes Δ	No	No	Yes
Social technologies				
Stoves and cleaner fuels – LPG/ethanol cooking	Yes	No	Yes	Yes
Electricity for rural and low-income energy efficiency	Yes	No	Yes	Yes
Thermal Solar Heating for low-income	Yes	No	Yes	Yes

Source: CGEE (2009b).
Note:= Opportunity for technology transfer from Brazil to South country with the participation of North country.

TABLE 2
Detailing the status of selected technologies in Brazil and the world

	World		Brazil				
	Stage of development in the world	Expected commercialization	National mastery degree	Centers of excellence	Industrial capability	Market	Interesting for the country to master the technology?
Electricity generation							
Technology for power generation from natural gas (large turbines)	Commercialization	Not applicable	1	1	0	3	Technology already mastered and researched by private companies
Technology for power generation from natural gas (microturbines)	Demonstration	2020	1	1	Not applicable	2	Brazil lags behind with respect to the world; area for international cooperation in applied R&D
Pulverized Coal	Commercialization	Not applicable	1	1	2	2	Technology already mastered and researched by private companies
Coal-fueled Integrated gasification combined cycle (IGCC)	Demonstration	2030	1	3	Not applicable	1	Global trend; low potential in Brazil due to the low quality of the domestic coal. Interesting to hold knowledge
Coal-fueled atmospheric circulating fluidized bed (CFBC)	Demonstration	2020	1	3	2	2	Due to the domestic coal characteristics, this technology has good future potential for the country
Nuclear Fission (generations III and IV)	Commercialization	Not applicable	2	3	3	3	No reactors construction in the country
Hydroelectricity	Commercialization	Not applicable	3	3	3	3	It has industrial and service park installed with domestic technology; equipment production capacity for hydro projects up to 10 MW (SHP)
Solar photovoltaic (Si)	Deployment	>2050	2	3	0	2	Solar-grade silicon and solar photovoltaic industry; production of renewable, environment-friendly energy due to the Brazilian existent high solar energy potential

(continues)

(continued)

	World		Brazil				
	Stage of development in the world	Expected commercialization	National mastery degree	Centers of excellence	Industrial capability	Market	Interesting for the country to master the technology?
Wind power	Commercialization	2050 (it is commercially competitive for onshore)	1	3	2	3	The country has great potential; complementarity of sources (hydro-wind); wind industry installed in Brazil
Solar thermal high temperature	Deployment	>2050	0	0	0	0	The country has potential in some regions and may engage in in the production of goods with higher added value in the foreseen large international market
Gasification of biomass	Demonstration	after 2050 (large size)	2	3	Not applicable	2	Technology easy to construct. Possibility of co-firing
Hydrogen: fuel cells	R & D	>2050	1	2	2	2	Increase in the efficiency of the production of electricity and heat. Potential and opportunity for Brazil to become a producer of high-value components
Heating and Fuels							
Ethanol (first generation)	Commercialization	Not applicable	3	3	3	3	Brazil pioneered the world. There is a solid industrial park and can transfer technology
New technologies for ethanol production (second generation)	Demonstration	2015	3	3	3	3	Brazil is at the forefront (acid and enzymatic hydrolysis)
Solar thermal (low temperature)	Commercialization	2045-2050	2	2	3	3	Brazil has an important and consolidated industrial park. But in terms of higher aggregated technological level (ultrasonic and laser welding and evacuated tubes, for example), there is still an important path to follow

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	World		Brazil				
	Stage of development in the world	Expected commercialization	National mastery degree	Centers of excellence	Industrial capability	Market	Interesting for the country to master the technology?
Liquefied Natural Gas (LNG)	Commercialization	Not applicable	0	0	0	2	The energy research center of Petrobras, Cenpes, is in the process of exploring the state-of-the-art of the technology
CTL and GTL: Fischer-Tropsch process	Deployment	2020	1	3	0	2	Cenpes is the only research center with activities in Brazil; there are research groups in universities; there is no industrial capability
Hydrogen: production and storage	R&D		1	2	0	2	Production of hydrogen from the reforming of renewable-based ethanol to explore the Brazilian comparative advantages
Charcoal production	Commercialization	Not Applicable	3	2	3	3	The expansion of the Brazilian steel industry can be followed by efficiency gains in charcoal production and use of charcoal production byproducts.
Biodiesel production	Deployment	2040	2	3	3	3	The national biodiesel program created a market for the fuel demanding scientific and technological advances; makes possible the integration with family agriculture and reduction on diesel imports
T, D and end use							
Smart Grids	Demonstration		1	3	0	2	Interface technology. Important to be developed in conjunction with distributed generation technologies (wind, PV and others)
Electric Cars	Demonstration	2015	1	3	0	2	It is expected that this technology revolutionizes the automotive industry, mainly powered by a lithium battery

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	World		Brazil				
	Stage of development in the world	Expected commercialization	National mastery degree	Centers of excellence	Industrial capability	Market	Interesting for the country to master the technology?
CCS	R & D	after 2050	1	3	Not applicable	2	USA: it is expected that in 2012 the first pilot plant on industrial scale start running
			Social technologies				
Stoves and cleaner fuels LPG/ethanol cooking	Deployment	–	3	3	3	3	Brazil has expertise on market transformation, as was the case of the introduction of LPG and ethanol fuel. It produces and has national technology
Electricity for rural and low-income energy efficiency	Deployment	–	3	3	3	3	The power distribution companies in Brazil are carrying out several rural electrification and energy efficiency programs throughout the country
Thermal Solar Heating for low-income	Deployment	–	3	3	3	3	Some power distribution companies are implementing solar heating systems as substitutes of electric showers. There are national manufacturers with lower cost systems

Brazilian degree of technology mastery	Centers of excellence	Industrial capability	The market	Interesting for the country?	Implementer process
0: no knowledge in the area	0: There is no research center in the area	0: no industries manufacturing equipment	0: no market or future prospects	Qualitative analysis	R&D
1: some knowledge in the area	1: There are some initiatives (research groups)	1: there are multinational companies	1: there is potential, but small existing market	Qualitative analysis	Demonstration

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Brazilian degree of technology mastery	Centers of excellence	Industrial capability	The market	Interesting for the country?	Implementer process
2: expertise in the area	2: There are nucleus of research	2: there are few national industries	2: there is market, but low future potential. Or there is no market, but high potential	Qualitative analysis	Deployment
3: at the forefront of knowledge	3: There are research centers	3: There is industry expertise	3: there is market and future potential	Qualitative analysis	Commercialization

Source: CGEE (2009b).

CHAPTER 10

TRADE BARRIERS AND CLIMATE POLICIES

Ronaldo Seroa da Motta*

1 INTRODUCTION[1]

Current concentrations of greenhouse gas (GHG) emissions in the atmosphere are already worrisome, and studies imply that expenditure on the mitigation of these emissions is economically justifiable to avoid a global average temperature rise of over 2ºC (STERN, 2007). This goal was part of the Copenhagen Accord signed at the Conference of the Parties (COP15) in Copenhagen, and was later incorporated into the text of the United Nations Framework Convention on Climate Change (UNFCCC) or simply "the convention", as it will be referred to hereafter, at COP 16 in Cancun, Mexico.

On the one hand, the Copenhagen Accord is only a resolution of COP 15, and not a treaty. Thus, the national commitments reported therein to achieve the 2°C trajectory, even if sufficient, will not be mandatory or binding under the Convention. On the other hand, despite the higher legal *status* of the COP 16 decision it does not clarify how this objective will be accomplished. In brief, there is no new global agreement where national mitigation efforts are recognized by the climate convention and that points to an effective reduction of emissions in line with what science recommends as necessary.[2]

The Brazilian targets for controlling greenhouse gas emissions established by the National Climate Change Policy (PNMC) – a reduction between 36.1% and 38.9% of projected emissions by 2020 – which have been reported to the Copenhagen Accord, demonstrate a willingness of country to voluntarily contribute to the global effort.

Despite this global regulatory gap, just as Brazil other countries are taking unilateral actions. In this context, confrontations with competitive global economic forces may require, for national targets to be met, the imposition of sanctions on imports from trading partners who do not undertake mitigation

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1. A review of the literature of impacts on Brazilian trade was originally presented in Seroa da Motta (2010).

2. See chapter 15 of this book for an analysis of the goals of Copenhagen and Cancun.

efforts as, for example, suggested by recent regulation proposals in the European Community (EC) and the United States.

This possibility creates opportunities for discriminatory trade practices that not only accomplish the environmental aims that justify them, but that also reduce the welfare of the nation that imposes them as well as of those that are sanctioned. Although this zero-sum game of trade protectionism is widely recognized by experts, as seen in other circumstances and contexts, this does not prevent these actions from being implemented.

This chapter will review recent empirical literature that analyzes the effects of trade barriers within a climate scope. With this purpose, the chapter begins with a summary of the international negotiations on climate change, followed by an analysis of the contexts under which these barriers have been applied. Next, studies that estimate the economic, trade and environmental effects from cases that simulate trade barriers are summarized. In this part, impacts on the Brazilian economy in absolute terms and relative to the country's main trading partners are emphasized. The final remarks sum up the topics discussed in this chapter.

2 NEGOTIATIONS UNDER THE CLIMATE CONVENTION

The coordinated efforts among nations to combat global warming are sheltered in the UNFCCC, of the United Nations (UN). As the current above natural concentration of greenhouse gas levels is a result of past economic activities, the principle of common but differentiated responsibilities was adopted in the Convention.

This principle recognizes: *i*) the responsibility of each country is different, due to the contribution of past emissions to the climate problem, and *ii*) the need to guarantee economic growth in developing countries. Based on this principle, the Kyoto Protocol was signed in 1997, in which 37 developed countries[3] pledged common reductions of 5.2% of their emissions between 2008 and 2012 compared to 1990 levels. The targets of each country were also differentiated, with the major targets falling on the European Community member countries, Japan, the United States and Canada.

The enormous differences in mitigation costs among countries and the importance of the participation of developing countries led to the adoption of mechanisms that would enable attainment of national Kyoto Protocol targets through mitigation actions outside national borders, such as:

- Carbon emission caps markets for transactions among developed countries.

3. Developed countries listed in Annex I to the Convention that appear almost entirely in Annex B of the Kyoto Protocol, and since then are called Annex I countries.

- Project-based mechanisms: Joint Implementation (JI), among developed countries, and the Clean Development Mechanism (CDM), between developed and developing countries.

Although the Kyoto Protocol represents early global collaboration, its reduction targets were insufficient to reverse the trend of increasing concentration of gasses in the atmosphere.[4] And if the standards and levels of growth persist, countries like China, India and Brazil will soon have an important responsibility, and without their contribution fast and effective global action will be much more difficult.

Hence, the Conference of the Parties (COP 15) of the Convention, held in December 2009 in Copenhagen, had ambitious aims, such as to:

- Expand mitigation targets by developed countries to 40% in 2020 and 80% in 2050 compared to 1990 levels.
- Include voluntary targets for developing countries that are monitorable, reportable and verifiable.
- Allocate resources to enable developing countries to finance their voluntary contributions and offer assistance in the adaptation process.

As known, the result achieved fell short of the anticipated objectives, and only resulted in the approval a resolution called the Copenhagen Accord. This document affirms commitment to limiting average temperature increases to 2°C and to make submissions of national emissions every two years. In terms of targets, the agreement only requests that its signatories submit the commitment proposals announced during the conference.

Although the major polluters, including the United States, Japan, the European Union, China, India and Brazil, have already submitted their proposals with goals and targets, these distinct metrics are not binding and therefore are not mandatory under the convention.

3 TRADE BARRIERS

In this fragile international cooperation scenario, some countries are proposing and putting in place national climate laws and policies that apply unilateral targets. Concerned about a possible loss of competitiveness and effectiveness of national climate efforts, developed countries tend to penalize imports of products that were not produced under similar conditions to reduce emissions. The justification for these measures is that emissions control in one country encourages production

4. Considering that the first commitment period of the Kyoto Protocol expires in 2012, only the countries of the European Community as a whole are achieving their goals.

or consumption displacement to the country where the polluting costs are lower. This possibility is called escape or leakage.[5]

This penalty takes the form a border adjustment mechanism to equalize the costs of imported goods with domestic production. This mechanism typically adopts a regulatory instrument that could be a tax on emissions or the purchase of licenses.

Moreover, the possibility of these subsidies resulting in increased protectionism for energy-intensive sectors far beyond the necessary to correct for regulatory differences was observed in a study by Kee, Ma and Mani (2010), which analyzes the increase in exports of energy intensive sectors in countries with GHG regulation. The authors execute an econometric study for the period 1998-2005, with a trade database from the Organization for Economic Cooperation and Development (OECD), in which they correlate pairs of exports by gross domestic product (GDP) intensities between two countries, controlling for variables such as the existence or not of GHG emissions regulation and subsidies resulting from this regulation.

The results indicate that the increased exports observed in these subsidized sectors in countries with regulation, are largely due to the existence of the subsidies. In other words, countries associated with the regulation of greenhouse gases have actually increased protection of these sectors, and consequently distortions in international trade, in addition to what is justifiable to correct the effects of unilateral national regulation.

As we shall see, this trade mechanism has even been considered in the literature as a measure to correct the effect of "free-riding" and to encourage global cooperation, but only recently have empirical studies efficiently and effectively pointed out the problems.

However, even in cases where the costs of protection *vis-à-vis* the dimension of the leaks are not entirely favorable, it seems that this supposed protection is politically inevitable for a political composition favorable to the approval of a regulatory framework for mitigation.[6]

Article 10 (b) of the policy of the European Union Emission Trading System (EU ETS), which governs the EU carbon market, allows protection of sectors that, with the regulation of EU-ETS, suffer loss of competitiveness because of leaks. This protectionism can take the form of either the free distribution of emission rights or the inclusion of import rules in sectors where leaks are

5. In the environmental economics literature this process is referred to as the *pollution haven effect.* See reviews in Copeland and Taylor (2004) and Brunnermeier and Levinson (2004).

6. See, for example, Tamiotti *et al*. (2009).

identified, favoring countries with commitments similar to the European Union in the regulation of GHG. However, how the leak and its correlation with loss of competitiveness will be measured is up for debate, as well as what the EU will consider to be comparable in terms of regulation in other countries.

This application is already taking shape in civil aviation policies, which state that as of 2012 all airlines operating in the European Union with more than 243 flights at a station between 2006 and 2008, or annual emissions above 10 thousand tons of $CO_{2,}$ are to offset their emissions via the European Union Emissions Trading System (EU ETS). This rule includes foreign carriers from countries that do not have similar policies to implement mitigation of emissions.[7]

In the case of the United States, initiatives on GHG regulation passed to Congress such as the Clean Energy Law (Waxman-Markey Bill), was approved by the House of Representatives in 2009, and its substitute (The American Power Act or The Kerry & Lieberman Bill) was sent to the Senate, have not been approved in either of the houses of Congress and do not have much chance of success. The primary aim of these laws is energy security and reducing the dependence on imports in the U.S. energy matrix, based on massive expenditures on research and development (R&D) in clean/alternative energy. To combat global warming, both bills prescribe a carbon market with targets for CO_2 reduction in relation to 2005, according to the following schedule: 2020 = 17%, 2030 = 42% and 2050 = 83%.

Although the new version revised by the Senate confirms the project schedule approved in the House (Waxman-Markey Bill), it amplifies the magnitude and scope of subsidies – particularly for the protection of some sectors damaged by leaks – which will facilitate accession by members of Congress.[8]

In the bill pending in the Senate, for instance, the regulator will have a mandate to, as of the period 2020-2023, identify leaks that were not solved with free allowances (rebates) and require that in such cases, imports also participate in the carbon market (International Reserve Allowance Program) through the purchase of emission rights. The procedures for measuring emissions, obligations and prices would be the same as those applied to domestic sectors and would be completed with the purchase of allowances.

7. This initiative is also in disagreement with the Chicago Convention, which regulates international air transport and does not allow unilateral restrictions.

8. Proposed in May 2010.

The criteria for identifying leaks are not as vague as the Waxman-Markey Bill because it specifies the goal to protect sectors: *i*) in which more than 30% of global production takes place in countries outside the international agreements of bilateral or multilateral control of greenhouse gases to which the United States is a member, and *ii*) that have an emission intensity greater than that of similar industries in the United States.

In other words, there is a criterion for identifying sectors to protect from countries that do not accede to the agreements. As these criteria are more precise, the U.S. could now be reducing the uncertainty of the Waxman-Markey Bill, which predicted the possibility that sanctions could be imposed according to a global agreement under the Convention, which would not amend to a global agreement a guarantee that developing countries would be free of sanctions. With the new law aimed at removing sanctions, trading partners must participate in an agreement to combat global warming to which the United States is part, and therefore considered of interest to the country.

In short, as in the current context of negotiations there is no global agreement in which the United States participates, these legislative initiatives clearly demonstrate the willingness of the country to make efforts towards a low-carbon economy, but by taking advantage of safeguards against leaks in the shape of subsidies and trade sanctions that may in addition be used to reach agreements of national interest.

As highlighted Senator John Kerry in a presentation on the initiative's website:[9]

> In order to protect the environmental goals of the bill, we phase in a WTO-consistent border adjustment mechanism. In the event that no global agreement on climate change is reached, the bill requires imports from countries that have not taken action to limit emissions to pay a comparable amount at the border to avoid carbon leakage and ensure we are able to achieve our environmental objectives.

Although the U.S. legal initiatives discussed above still face major opposition in Congress and approval seems remote, they exemplify how these barriers are associated with the unilateral actions of regulating greenhouse gases. Moreover, there is also an expectation that these subsidies and trade barriers are consistent with the rules of the World Trade Organization (WTO). However, as we shall see, this expectation is not free of controversy.

9. <http://kerry.senate.gov/americanpoweract/pdf/APAShortSummary.pdf>. US Senate, Washington, 16 maio 2009.

4 CONSISTENCY WITH WTO RULES[10]

Article 3.5 of the Climate Convention states that "Parties should cooperate to promote a supportive and open international economic system" and that "Measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade" (UNFCCC, 1992). Although it was not a specific theme of the conference agenda, there was a discussion at COP 15 on the implementation of this article, with the United States wanting to interpret it as an acceptance of trade restrictions that do not result in arbitrary or unjustifiable discrimination or disguised restrictions on trade. India and China wanted an interpretation that prohibits such restrictions. One proposal, led by Brazil, condemned sanctions without prohibiting them, provided that they obey the principle of Article 3.5. All these initiatives aimed at limiting the discussion of trade barriers associated with the regulation of GHGs under the Convention and therefore immune to the interpretations of the WTO.[11]

The provisions of the Agreement on Subsidies and Countervailing Measures (SCM) may be relevant in questioning the allocation of free allowances that national policies tend to implement to protect local industry, as a form of subsidy.

WTO rules prohibiting discriminatory and quantitative restrictions on imports contain the principles of MFN and domestic equivalent treatment. As for environmental issues specifically, their justification can be admitted to the exceptions identified in Article XX that allows the adoption of barriers that are linked to the protection of natural resources as long as two conditions are met. First, a very clear connection must be established between the declared goal of environmental policy and the border measures in question. Second, the action cannot be a "measure of arbitrary or unjustifiable discrimination" or a "disguised restriction on international trade".

So, as put by Tamiotti *et al.* (2009), there are two major challenges to the implementation of border measures, namely: *i*) to provide a clear justification for border measures – whether carbon leakage or competitiveness losses, and *ii*) to determine a "fair price" to be applied on imported goods to bring their prices in line with domestic costs.

In addition, there are two specific WTO articles that address food security and health, animal and plant safety. Both try to identify how to fulfill the need to implement standards while at the same time avoiding disguised protectionism.

10. See Tamiotti *et al*. (2009) for a global perspective and Naidin, Gadelha and Lemme (2009) for the Brazilian case.
11. See Neto, Lembo and Bonomo (2010).

One of these is the agreement on food safety, animal health and phytosanitary standards (The Sanitary and Phytosanitary Measures Agreement – SPS) which allows countries to define their health or safety standards. These should be applied only to the extent necessary to protect human, animal or plant life, and should not arbitrarily or unjustifiably discriminate against countries where identical or similar conditions prevail.

To ensure that technical barriers do not create unnecessary obstacles to international trade, the Technical Barriers to Trade Agreement (TBT) guides technical barriers at borders such as standards, labels and certifications that are related to the consumption of the product and result from a regulation in the importing country and applies equally to domestic production. There is an understanding that environmental issues related to production processes are regulated in the producer country, because they do not affect the welfare of the importing country.

In principle, CO_2 emissions relate to the production process, because they are not directly present in the final good. In the context of climate change, as the impacts of emissions are global, there is an attempt to link them to the product, given that all countries are affected by emissions and, therefore it is argued that a barrier could be applied. Although this thesis is consistent about the causality of the impacts, national emissions are not equal according to the principle of common but differentiated responsibilities from the climate convention. This principle, as discussed earlier, faces implementation difficulties in the climate convention itself.[12]

In short, even if according to WTO rules motivations of an environmental nature guarantee adjustments at the border for traded goods, the correlation between emissions and the product in the case of climate change is not that trivial. Therefore, the application of these climate scope adjustments will certainly be a disputed object within the organization and/or equivalent trade retaliation.

5 EFFECTS OF CLIMATE TRADE BARRIERS

As noted, in spite of the potential loss of welfare and restrictions that may result from the WTO, the main justification for adjustments of carbon content at the border (ACCBs) for national legislators in the midst of domestic GHG regulation, is to protect the competitiveness of the economy to equalize the costs of imports to domestic production.[13]

12. The classification of the Intergovernmental Panel on Climate Change (IPCC) for greenhouse gas emissions is divided on energy use, process and product use. Therefore, the emission energy sources are neither process nor product, which may motivate the Committee on Trade and the Environment (CTE), WTO, soon to adopt a broader approach in this regard.

13. Known as *the level playing field*.

This mechanism generally seeks to apply to imports the same rules adopted domestically. If national regulation was accomplished via a tax on carbon, the ACCB would be an equivalent tariff. In the case of regulation by tradable emission permits, as in a *cap* & *trade* market, imports would be required to purchase the necessary permits.

There is literature that identifies the application of ACCB in GHG regulation as an incentive for cooperation and to penalize the "free-rider".[14] This would ensure the effectiveness of unilateral actions in reducing the global concentration of these gases in the atmosphere by not allowing countries that lack similar mitigation measures to increase their emissions.

Thus, the effects of these barriers can be evaluated from economic, commercial and environmental points of view. To provide some indication of the magnitudes and biases of the above identified impacts, we next describe the methodology and analyze the results of some studies that were conducted to simulate impacts of ACCB in the context of unilateral regulation of greenhouse gases.

6 EFFECTS ON WELFARE

Government intervention in international trade to protect industries affected by increased competition from imports is common, and usually takes the form of a tax on imports, such as a tariff.[15] The desired tariff, or the optimal tariff, to protect the threatened sectors should be exactly that needed to realign prices and quantities of domestic production and imports to a desired level. That, in the case of emissions regulation, would entail achieving the level that prevailed before regulation.

The consensus in conventional economic literature, however, is that the application of a tariff in the aggregate will result, in almost all cases, in a loss of welfare that may be superior to the competitiveness gains. For example, if the country is a price taker in the international market, the tax would reduce the welfare of the economy because it would entail revenue losses.[16] There would be welfare losses in the export sector in relation to protected sectors, and in the final consumption not realized in these protected industries due to the lower opportunity costs of the international prices.

Even if the country could significantly affect international prices so that the imposed tariff would not cause consumption losses, this advantage would only be permanent if there were no retaliation from trading partners. In the case of a widespread retaliation scenario, not only would the desired protection not be

14. See, for example, Ismer e Neuhoff (2007), Babiker e Rutherford (2005) and Kemfert (2004).
15. You can always use a quantitative restriction that would generate the same effect as a tax.
16. Small country assumption.

achieved, but all countries would lose from lower production and consumption at higher prices. Typically, the gains from imposing barriers are concentrated in protected industries.

A study by Dissou and Eyland (2009) simulates the impacts on the Canadian economy due to adjustments of carbon content at the border, applied to energy-intensive industries (pulp and paper, chemical, rubber, cement and metallurgy and non-metallic products) that could be imported if Canada adopted a carbon tax of \$ 40/tCO_2.

The simulation is performed on three scenarios: one in which only domestic production pays a tax of \$40/t$CO_{2,}$ a second in which this tax is also levied on the CO_2 content of imports, and a third in which a tax on imports is determined endogenously, given the general equilibrium effects in energy-intensive sectors resulting from changes in relative prices of imports in order to realign the competitiveness of domestic production of energy-intensive industries to the level observed before tax. The first scenario is called partial equilibrium ACCBs and the second is called general equilibrium ACCB.

The simulation of these scenarios is performed using a computable general equilibrium model (CGE) static for the 2004 Canadian economy, under the *small country hypothesis* assumption, with a breakdown of 15 sectors including energy production (coal, oil and derivatives, gas and electricity) and energy-intensive industries (pulp and paper, cement and non-metals, chemicals and rubber and metal). The results are presented in relation to the reference scenario, that is, before applying the carbon tax.

TABLE 1
Carbon tax impacts on industry demand in the Canadian economy (CAN \$40/tCO_2) and ACCB

	Increased domestic production over imports		
Sectors	Without ACCB	ACCB partial equilibrium	ACCB general equilibrium
Agriculture	0.6	0.2	-0.6
Coal	0.3	0.7	1.1
Mining and other	0.4	1.0	1.8
Electricity Generation	-31.7	-30.8	-29.6
Gas	7.1	8.0	9.0
Pulp and paper [1]	-8.2	1.2	0.0
Graphics	1.9	0.3	-0.6
Other manufacturing	5.3	3.1	1.3
[1] Chemical and rubber	-17.7	-12.5	0.0
Cement and nonmetallic [1]	-2.4	24.5	0.0

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	Increased domestic production over imports		
Sectors	Without ACCB	ACCB partial equilibrium	ACCB general equilibrium
Metallurgy [1]	-5.9	-1.7	0.0
Transport	-8.9	-8.1	-7.1
Services	3.4	3.9	4.5
Oil	10.5	11.4	12.6
Natural gas	16.5	17.4	18.6
Gasoline	-11.8	-11.2	-10.6
Diesel	-13.3	-12.9	-12.4
Liquefied petroleum gas	13.6	13.3	12.1
Other petroleum products	18.1	18.1	17.6

Source: Table 3 in Dissou and Eyland (2009).
Note: [1] Energy-intensive sector.
Table 1 presents the results in terms of competitiveness, estimating the increase in domestic demand for Canadian imports which would be the aim of the ACCB. As the aim would be to return to the demand levels before GHG regulation, it is observed that for the general ACCB (product of an optimization), the ratio is zero for energy-intensive sectors. As pointed out by Dissou and Eyland (2009), the partial scenario of ACCB, on the contrary, there would still be significant losses of domestic production in chemical (12.5%) and significant gains in cement (24.5%) industries.

Table 2 presents the aggregate impacts on the Canadian economy. In this economy, the authors note that domestic regulation of GHG, *per se,* results in a reduction of income, purchasing power of wages and household consumption, which would entail a loss of welfare equivalent to 0.91% of GDP. In ACCB scenarios, these losses increase to 1.19%. In short, the aggregate income, wages and consumption fall more with the implementation of the ACCB than without it, and even a little more in case of the general ACCB.

TABLE 2
Impacts on Canada's economy of a carbon tax (CAN $40/tCO$_{2)}$ and ACCB

Aggregates	Without ACCB	ACCB by CO $_2$ content	ACCB optimal tariff
GDP – market prices	- 12:27	- 00:28	- 0.30
Imports	- 1.04	- 2.19	- 3.10
Exports	- 0.93	- 1.95	- 2.76
Exchange rate	0.40	0.39	0.43
Rate of return on capital	- 3:42	- 3.63	- 3.84
Nominal wage	- 1.04	- 1.32	- 1.65
Disposable income of families	- 1.19	- 1.41	- 1.67
Household consumption	- 1:58	- 1.82	- 2:07
Loss of welfare (% of GDP)	- 0.91	- 1.04	- 1.19
Industrial emissions	- 22.76	- 22:51	- 22:17
Household emissions	- 13:14	- 13:28	- 13.45
Total emissions	- 21.10	- 20.91	- 20.66

Source: Table 3 in Dissou and Eyland (2009).

As shown in table 2, the application of the ACCB, in addition to causing economic losses, would not generate environmental gains, because the total emissions are reduced less than without ACCB, since its application leads to import substitution. In short, the benefits of trade sanctions are restricted to protect industries that compete with imports.

7 EFFECTS ON COOPERATION

As discussed above, some literature recommends trade sanctions as a mechanism to induce cooperative strategies in the global effort to mitigate GHG emissions by changing the utility functions of each country not to participate in global agreements. However, as exports of CO_{2-}intensive products are only part of exports and these, in turn, a part of the national product, the magnitude of the ACCB will have to be significant for the loss of trade to justify, at least in the short term, changes in the non-cooperation costs. This magnitude will have to vary in each country not only in accordance with the participation of these sectors in exports, but also according to $CO_{2.}$ intensities.

For example, countries with high adoption fees and small participation in international trade – particularly in the CO_2 intensive sectors – could only be affected by this mechanism if they face too restrictive ACCBs, probably even above the requirements imposed on domestic production in the importing country. Thus, the design of an ACCB effective in encouraging cooperation may be discriminatory in relation to domestic production and among countries according to their international trade profiles, features that would hamper consistency with WTO rules and generate strong retaliatory reactions.

This possibility was analyzed by Tian and Whalley (2010) where the authors adopt a numerical game theory model to "free-riders" to simulate the strategies of participants in a global agreement on climate change, in the presence of an ACCB in the form of an import tariff on CO_2 content.[17] In the simulation, Brazil, Russia, India and China (BRICs) guide their strategies by comparing, within the period 2006-2056, the present value of the difference between their trade loss with ACCB against the present value of their future economic losses that would occur in the absence of a global agreement that would raise the global temperature by 50°C in 2050. Thus, in this simulation, each country decides to participate only when this difference is close to zero. The study analyses a scenario in which all OECD countries have adopted an ACCB and another scenario in which this adoption only takes place in the United States, the European Union and Japan.

17. These results do not depend on whether these advantages result from efficiency differentials or specific national policies.

As India is a net importing economy, these sanctions would not create any incentive. For the other countries, Brazil, Russia and China, table 3 shows the level of taxation at which the difference of losses equals zero, thus leading each country to follow the participation strategy.

TABLE 3
Rate threshold for inducing cooperation
(In %)

Country	Imposed by all countries	Imposed only by the United States, the European Union and Japan
Brazil	240	6370
Russia	75	270
China	260	922

Source: Table 4 in Tian and Whalley (2010).

As Tian and Whalley (2010) emphasized, the results in table 3 indicate that tariff levels would have to be very high to induce the cooperation of these countries in accords that they judge not of their interest.

In the Brazilian case, an average tariff of 240% on exports would be required or, even higher, 6370%, if the penalty is restricted to the United States, the European Union and Japan. The percentages for China when punishment is imposed by all countries, and percentages in all cases involving Russia, are smaller than those in Brazil, but still very high. The result of a much higher rate for Brazil can be explained by the low CO_2 intensity of our exports and by the equally low trade openness of the country in comparison to the other BRICs. Thus, only a very high tariff rate would generate significant economic costs.

The percentage differences between countries can be explained by differences in CO2 intensities and in international trade participation. The authors also perform a sensitivity analysis for some parameters such as the discount rate, damages and export and import elasticities, and confirm that in all cases high rates still persist.

In summary, this simple simulation indicates that Canadian economy trade barriers to inducing cooperation and adoption of global agreements will have to be elevated and differentiated across countries, which would certainly result in greater difficulties for acceptance within the WTO and would, indeed, invite trade retaliation.

8 EFFECTS ON TRADE

Even if trade sanctions do not lead to a global agreement, their adoption will impose trade and probably total productivity losses on affected countries. The magnitude of these losses should be proportional to the degree of trade openness and intensity of CO_2 of export sectors in each country.

The study by Mattoo *et al.* (2009) simulates these economic impacts on national trade and productivity with a global dynamic general equilibrium model (Envisage) developed by the World Bank with a disaggregated climate module for 113 countries (or 15 regions) and 21 sectors – highlighting the steel, pulp and paper, chemical and the petrochemical and rubber and plastics sectors.

The study simulates the impact of the application of an ACCB resulting from unilateral mitigation action from rich countries (European, U.S. and Japan) in 2020 to reduce by 17% GHG emissions compared to 2005 levels. This target mimics the first stage of the legislative bills in progress in the United States, analyzed in previous sections. The adopted scenarios also include, as well as in the U.S. legislative proposal, the adoption of subsidies to threatened domestic production in the form of offsetting of incurred mitigation costs (rebates).

Additionally, there is a scenario which analyses two tax bases for the ACCB, namely: by CO_2 content of imports and of domestic production. The value of the ACCB is equivalent to a \$60 /tCO_2 tax on direct and indirect CO_2 content from both products and processes. This value is a reference for an emission allowance equilibrium price that would prevail in the U.S. market if there were a carbon target of 17% in 2020 in relation to 2005. Thus, this value is simulated as the ACCB tariff to be applied by all countries.

The first results estimate the magnitude of the leakage to avoid sanctions. These estimates are presented in table 4, in relation to 2020 emissions and, as Mattoo *et al.* (2009) emphasize, their magnitudes are minor. It is to be noted in this table that the global leakage from the BRICs would represent an emissions increase between 0.6% and 0.8% in relation to 2020, while global emissions would be significantly reduced by 9.3%. The application of the ACCB imports content, which provides greater prevented leakage, would lead to an emissions level reduction in the BRICs of only 1% to 2%, which would increase the global reduction to 10.9%.

TABLE 4
ACCB leakages with U$60/t$CO_2$ for 17% reduction by 2020
(In %)

Scenarios	**Brazil**	China	India	Russia	World
Without ACCB	**1.3**	0.6	0.8	0,6	-9.3
ACCB imports content	**0.6**	-1.7	-1.6	-0,9	-10.9
ACCB domestic content production	**0.8**	0.0	0.3	-0,1	-9.8
ACC domestic production and subsidy	**0.8**	-0.3	-0.2	-0,1	-10.0

Source: Table 3 in Mattoo *et al*. (2009).

These magnitudes of prevented leakage, however, are contrasted with the impacts on trade. Table 5 presents the results of the study for the various scenarios on the impact on exports of the BRIC countries and the world.

Table 5 initially shows that there will be losses in world trade of 1.3% in the case of domestic regulation, even without ACCB. As expected, those losses increase with ACCB. The ACCB by content of imports affects world trade more than (10.2%) by content of domestic production (3.6%). However, as pointed out by the authors, there is a significant difference in losses among countries. As for ACCB by imports, Brazil is by far the least affected, only 2.4% against 15.8% in China and around 7% in Russia and India. These national differences are explained by sectoral differences in CO_2 intensities and values of exports.

However, the difference between Brazil and the other BRICs almost disappears if the ACCB is by content of domestic production, while world losses fall to 3.6% those of BRIC countries remain at around 2%. This is due to the fact that in this case American sector contents set the ACCB total value and not the import contents, which dissipates the differences in carbon intensities among the BRICs.

TABLE 5
ACCB impact on exports with US $60/t$CO_2$ for a 17% reduction by 2020
(In %)

Sectors	Brazil	China	India	Russia	World
	Without ACCB				
Agriculture	-3.1	-1.3	-0.3	3.4	-1.6
Energy	-1.9	-0.2	6.3	-6.0	-6.1
e Industries	7.6	6.7	6.4	11.5	-0.7
Other Processing Industries	-2.0	-2.3	-2.7	1.1	-1.0
Other Industries	1.6	0.3	1.5	1.1	-0.5
Services	1.6	1.5	-1.4	7.6	0.0
Total	**-0.4**	**-0.7**	**-0.2**	**-0.8**	**-1.3**

(continues)

(continued)

Sectors	Brazil	China	India	Russia	World
ACCB Content For Imports					
Agriculture	-10.8	31.0	25.7	20.7	-16.3
Energy	-4.1	-1.0	13.8	-7.2	-11.9
Energy-intensive Industries	-2.2	-16.6	-9.7	-19.7	-14.6
Other Processing Industries	3.7	-21.6	-18.3	-6.9	-12.4
Other Industries	-8.1	-2.1	-3.2	3.6	-9.0
Services	9.4	46.3	25.3	35.1	3.9
Total	**-2.4**	**-15.8**	**-6.5**	**-6.7**	**-10.2**
ACCB for domestic content					
Agriculture	-2.3	-1.0	1.7	6.9	-5.1
Energy	-5.6	-0.2	10.7	-6.5	-8.2
Energy-intensive Industries	-4.2	-3.3	-0.7	2.8	-5.7
Other Processing Industries	-1.8	-3.5	-4.1	3.2	-3.5
Other Industries	-0.6	-1.6	0.6	1.9	-2.7
Services	6.8	6.9	3.3	13.2	0.6
Total	**-2.1**	**-2.7**	**-1.4**	**-2.1**	**-3.6**
ACCB for domestic content & subsidies					
Agriculture	-3.0	-2.4	-4.1	6.6	-2.0
Energy	-9.2	-4.4	-3.3	-6.8	-5.2
Energy-intensive Industries	-6.0	-7.0	-6.4	-0.4	-1.9
Other Processing Industries	1.9	-0.9	-0.6	5.0	-1.0
Other Industries	-2.4	-2.3	-5.5	4.2	-1.5
Services	13.2	11.0	6.9	19.7	1.1
Total	**-1.4**	**-1.0**	**-0.7**	**-2.2**	**-1.2**

Source: Appendix 6 *in* Mattoo *et al.* (2009).

As noted by the authors, considering that exports are only a part of the domestic product of each country, the impacts of these trade losses generate negligible losses in domestic products (table 6).

With lower relative losses in its exports, Brazil has increased its competitiveness compared to other BRIC countries and could, in the presence of an ACCB, as shown in table 6, experience even a small increase in the product, between 0.6% and 0.8%, while the other BRIC countries generally suffer reductions.

Moreover, these results confirm the conclusions in Section 7, which indicate that only a very high-tax ACCB would induce significant losses for BRIC countries to change strategies in relation to adopting global agreements that they do not consider favorable.

TABLE 6
Impacts on product (%) with ACCB $ 60/tCO_2 for a 17% reduction by 2020

Cenários	**Brazil**	China	India	Russia	World
Without ACCB	**1.3**	0.6	0.8	0.6	- 9.3
ACCB imports content	**0.6**	- 1.7	- 1.6	- 0.9	- 10.9
ACCB domestic content production	**0.8**	0.0	0.3	- 0.1	- 9.8
ACC domestic production and subsidy	**0.8**	- 0.3	- 0.2	- 0.1	- 10.0

Source: Appendix 5 *in* Mattoo *et al.* (2009).

Although the results presented in table 5 indicate that losses for the different Brazilian tax bases are not too disparate or too high, there is a significant asymmetry among the analyzed sectors. We can observe, for example, that with ACCB by import content, Brazilian industry in aggregate manages to increase its exports by 1.9% due to the growth of non-energy intensive sectors, while the energy-intensive ones lose 2.2%. Exports of agriculture and energy, however, suffer higher reductions of 10.8% and 4.1%, respectively.

ACCB by domestic content, however, results in export losses in all industry sectors with an aggregate loss of 2.5%. As expected, the energy-intensive sectors are the ones that lose most (-4.2%). The energy sector also increases its loss to 5.6% over the previous scenario. As for agriculture, by contrast, export losses are reduced by a factor of five, falling to 2.3%.

This asymmetry between agriculture and the other sectors in relation to the taxable basis of the ACCB is due to the above average CO_2 intensity of agriculture compared to other countries.[18] So much that, as can be seen in table 5, Brazil is the only country to lose agricultural exports from the import content scenario (10.8%), while the other BRIC countries even benefit.[19]

Finally, as observed in table 5, both in the case of Brazil and other BRIC countries, only the service sector increases its exports in the presence of ACCB in the two taxable bases and with subsidies. This result should be considered with caution as it may be affected by relatively low participation in international trade and the difficulty to accurately estimate CO_2 intensity of services.

In short, the low-carbon energy matrix of Brazil enables smaller exports losses of Brazilian industry compared with other BRIC countries if the ACCB taxable basis is set by import content basis. Partly due to the inclusion of transport emissions, Brazilian agriculture could suffer great losses, particularly if the taxable basis is set by import content. However, it is noteworthy, as previously described,

18. Due to transportation and chemical inputs.

19. This asymmetry shows lower standard deviation for product.

that the proposed ACCB bills in the U.S. relate to domestic content. In this case, Brazilian agriculture would be much less affected and the impacts on Brazilian industry would not be very different from those in emerging economies.

Another important result shown by Mattoo *et al.* (2009) is that the use of subsidies to domestic energy-intensive sectors together with trade sanctions further highlights the impact of trade in these sectors, as seen in the values of table 5, with almost no gain in prevented leakage, as shown in table 4. This low environmental performance can enhance the protectionist feature of these subsidies.

A similar study by Fischer and Boehringer (2010) uses a static global and regional multisector CGE model with the reference year 2004. Its goal is to analyze the impacts of ACCBs when applied by the United States and the European Union together and separately. The scenario would be a unilateral 20% reduction of CO_2 emissions compared to 2004 in these countries, with unilateral ACCB applied on the carbon content of imports with and without subsidy (rebate). The tariff value represents the price of an emission allowance in a *cap & trade* market in each region.[20] Although the results are presented only in images that make it difficult to accurately compare the values, they confirm, in general, the main conclusions of Mattoo *et al.* (2009), namely that: *i*) the leakage avoided by ACCB is low, *ii*) the total losses of exports in developing countries are not high, although they may be high in fossil energy intensive sectors, and *iii*) there is no loss in national product of exporting countries sanctioned by the ACCB.

Although the study confirms that Brazil is the least affected among the BRICs, this difference disappears with China, for example, if sanctions are imposed only by the European Union. In fact, China loses less with the sanctions imposed only by the United States than if they were imposed in conjunction with the European Union.[21]

There are no predictions for agriculture, but for industry the estimates are more optimistic than those of Mattoo *et al.* (2009), because they admit that Brazilian exports from energy-intensive sectors, excluding non-ferrous, would grow even with a tax based on CO_2 content.

In Fischer and Boehringer (2010), we observe again that the combination of ACCB and subsidy increases trade losses without a proportional increase in avoided leakages.

20. Estimated as US$ 60,00 and US$ 125,00 por ton of CO_2, respectively, in USA and CE.

21. According to the authors, this difference would occur because of lower carbon intensity of the European Community, which requires mitigation costs higher and higher intensity of trade in the region *vis-à-vis* the profile of Brazilian exports.

9 FINAL REMARKS

In this study, we analyzed recent empirical literature on the effects of trade barriers due to domestic regulation of greenhouse gases. The main conclusions of the these studies can be summarized as follows:

- The lack of a global agreement and the existence of unilateral initiatives create incentives for the adoption of trade barriers (ACCB).
- The objectives of ACCBs would be to: *i*) prevent leakage *(free riding)* in global efforts, *ii*) induce changes to adopt global agreements, and *iii*) protect the competitiveness of CO_2 intensive sectors.
- The WTO indicates that an ACCB related to domestic GHG regulation is compatible with multilateral trade rules if its need is proven and priced correctly.
- Besides being of little significance, leakages prevented by restrictions on imports are proportionally much lower than the impacts on trade.
- Only ACCBs with high tariffs on imports would induce a change in cooperation strategies of developing countries to sign an agreement deemed unfavorable.
- The use of subsidies to CO2 intensive sectors, even in the absence of trade sanctions, has generated protective effects, allowing for increased exports of these sectors in OECD countries with national regulation of greenhouse gases.
- Studies that simulate the application of ACCB by rich countries indicate that the impacts on trade would be differentiated among emerging economies. Except for agriculture, Brazil would experience lower losses because of lower CO_2 intensities, thus increasing competitiveness, particularly in industry. As such, trade barriers would not generate significant losses in domestic product.
- These differences between Brazil and other BRIC countries will be reduced, however, when the taxable basis is determined by domestic production content of rich countries.
- In these studies, results indicate that sectoral effects on Brazilian exports are also distinct and dependent on the taxable basis. Agricultural and energy export losses will be higher than industry losses, including energy-intensive sectors.

The effects on Brazilian imports discussed in this chapter may be further minimized, particularly in the energy and agriculture sectors that rely on ambitious GHG national control targets.

However, the studies reviewed above are limited to the initiatives so far in discussion and generally consider a short time horizon and currently established costs. Moreover, they adopt global models with geographic and sectoral aggregation that influence parameters and their calibration. Therefore, it is important to deepen the analysis executed in this study with an evaluation disaggregated by sector and a sensitivity analysis of the demand and emission parameters.

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CHAPTER 11

VULNERABILITY OF BRAZILIAN MEGACITIES TO CLIMATE CHANGE: THE SÃO PAULO METROPOLITAN REGION (RMSP)*

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1 INTRODUCTION

Projections indicate that if the expansion pattern of the São Paulo Metropolitan Region (acronym RMSP) continues along historical lines, the urban area in 2030 will be approximately 38% larger than today, with increased risks of floods and landslides affecting the population as a whole, especially the poorest.

The risks will be further elevated by higher temperatures and the associated increase in frequency of rainfall events, especially in the summer. Preliminary studies project that between 2070 and 2100, an average temperature increase of 2 ° C to 3 ° C can double the number of days with heavy rainfall (above 10 mm) in São Paulo (MARENGO *et al*, 2009).

These risk scenarios were presented in the report *Brazilian Megacity Vulnerability to Climate Change: Metropolitan Region of São Paulo* and refer to analyses that show impacts and vulnerabilities in the present and the future,

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with projections for 2030 through the application of a projection model of urban expansion. Additionally, the application in this study of a new terrain/ hydrological model known as *Hand (height above the nearest drainage*, (Nobre *et al*, 2011)*,* allowed the mapping of areas susceptible to floods and landslides.

According to the report, coordinated by the Earth System Science Center (CCST) from INPE, if this urban expansion process takes place, in 2030 more than 20% of these new areas of expansion would be susceptible and could eventually be affected by natural disasters caused by heavy rains. Approximately 4% of the predicted expansion areas may be at risk of landslides. Therefore, taking into account the process of future urban expansion, the consideration of more intense, frequent and prolonged rainfall events becomes critical in the analysis of risk scenarios and existing vulnerability conditions.

In addition, changes in temperature trends indicate that the region will have more hot days, less cold days, more warm nights and less cold nights (MARENGO et al, 2009). These projections may generate significant impacts, such as the intensification of heat island effects that affect the dispersion of pollutants. The concentrations of certain pollutants are expected to increase, especially the gases and particles generated through atmospheric photochemical processes (CETESB, 2006).

The study also suggests measures of adaptation, involving a set of actions that cities in the metropolitan area and their public and private institutions can apply in seeking solutions to the impacts they will suffer. Actions include greater control and oversight of present construction in risk areas, investments in public transport, especially railways, guarantees in terms of conservation of natural resources such as wetlands and areas of permanent protection along rivers - through the implementation of linear parks as proposed by the São Paulo city council and the state government - and investments in research for climate models, the quantification of the benefits of adaptation to climate change, among others.

In 2008, we reached an important milestone with more than 50% of the world population living in cities. This means that approximately 3.4 billion people are concentrated in urban areas and this percentage may reach 60% in 2030. Most of this growth will occur in developing countries (UNITED NATIONS, 2008).

In Brazil, more than 80% of the population lives in urban areas (IBGE, 2010) and rapid urban growth has created fragmented spaces with large spatial segregation, exacerbating social inequality and environmental degradation (GROSTEIN, 2001).

The impacts generated by the interactions between urbanization and climate change can be grouped into two categories: *i)* those originating in urban areas that negatively effect climate, and *ii)* those originating from climate change that negatively effect urban areas (XIAOPEI et al., 2006).

By 2004, the number of global megacities had reached 25 – of which two are in Brazil, the São Paulo metropolitan region and Rio de Janeiro. Densely populated, extensive and complex megacities bring challenges of unprecedented scale for the whole society, particularly for mayors, administrators, planners and those responsible for providing basic services and infrastructure (MRC MCLEAN HAZEL, 2006).

In general, significant changes in local climate are generated by the way these urban areas develop, through uncoupled interventions like intense vertical growth, soil compaction and sealing, suppression of vegetation and watercourses. Considering the fast pace of urban expansion and the delay in the implementation of adequate infrastructure to support the rate of growth of such cities, there is a lack of preparation for the expected effects of climate change (ROSS, 2004).

Thus, the case of the São Paulo Metropolitan Region is presented in this introduction. Section 2 outlines a description of the methodology used in the vulnerability analysis for the RMSP. Section 3 presents a summary of climate projections derived from the Eta-CPTEC 40 km regional climate model and reveals changes for the climate in the region. In section 4, floods and landslide hazards are mapped applying the *Hand* model. Section 5 presents the projection results for 2030, achieved through the application of an *urban expansion projection model*. And finally, in section 6, questions related to adaptation measures in the RMSP are addressed.

2 METHODOLOGY

Climate change unleashes impacts of increasing severity in megacities like São Paulo, mostly linked to climatic variations caused by the way natural resources were appropriated and by environmental degradation caused mainly by urban expansion. The scientific community has an important role in the generation of knowledge and in the creation of scientific information databases that will assist the identification, development and implementation of effective responses to improve adaptation capacity and reduce vulnerability.

In 2009, two panels on the subject were organized by the CCST/INPE and by the Population Studies Centre (NEPO/UNICAMP). These were established with input from national and international experts concerned with the evidence of climate issues in contemporary urban environments, including researchers, managers and decision makers from state and municipal agencies, in the areas of urban and environment management.

These gatherings produced the report *Brazilian Megacity Vulnerabilities to Climate Change: Metropolitan Region of São Paulo* and more recently a second report addressed the problems of the Rio de Janeiro Metropolitan Region (RMRJ).

The scenarios presented in the São Paulo study refer to the urban expansion predicted up to 2030 and the associated climate scenarios. The CCST Climate Change Research Group ran these scenarios, as part of the regionalized climate scenarios for South America. As such, the study provides data and analysis that exemplify the current impacts and projections for 2030 through the application of an urban expansion model, which identified areas that could be occupied in the future if the pattern of land-use persists. For the prediction of future natural hazards, maps from the urban expansion model were crossed with a terrain map created using the *Hand* model.

The *Hand* model allows the identification of areas susceptible to floods and landslides. While some mapping techniques use simple and easy to implement measurements, such as Euclidean distance, they do not always represent the conditions on the ground. The *Hand* algorithm, or vertical distance to the nearest drainage, uses a new approach based on terrain normalization relative to the drainage, a generalizable measure that allows accurate representation of terrain according to classes of stationary hydrological nature (NOBRE *et al.*, 2011; RENNÓ *et al.*, 2008).

Hydrological characterization is obtained by estimating the relative height difference between each grid point on the terrain and along a connecting flow path, the closest point of drainage associated with a running stream. The normalized HAND topology is then classified according to distance to the stream, which results in the grouping of hydrologically similar areas in the landscape, based on drainage potential, and produces maps with strong hydro-ecologic relevance (NOBRE *et al.*, 2011).

The study, however, exceeds the limits of a simple diagnosis and points to solutions that must be founded in public policy. The panels suggested adaptation measures involving a set of actions that cities and institutions should consider when seeking solutions to the impacts and danger threats. To propose adaptation measures to make cities more resilient, it is essential to recognize potential hazards, risks and impacts. The panels and the report were supported by the Strategic Program Fund of the United Kingdom, the Brazilian Research Network on Global Climate Change (Rede Clima) of the Ministry of Science, Technology and Innovation (MCTI), the National Institute of Science and Technology for Climate Change (INCT-MC) and the FAPESP Research Program on Global Climate Change (FAPESP-PFMCG).

2.1 Multidisciplinary Database

The panels were structured with four main groups of experts:

- *Technical Team:* composed of researchers from INPE and UNICAMP.
- *National experts:* researchers from different areas of knowledge that have experience with climate change in urban areas
- *Managers and decision makers:* representatives state secretariats, municipal and local government agencies
- *International experts:* researchers dedicated to vulnerability and climate change issues, with experience in megacities.

A database gathering information from different public planning and research bodies was built during the months preceding the panel discussions. The data provided by agencies and research institutions enabled the assembly of a broad-based and geo-referenced repository of information on land use, urban expansion, conservation areas, river system, among other issues, which served as the basis for discussions. The results organized in the report were subsequently submitted for criticism at two validation *workshops* held in November 2009, in Rio de Janeiro and São Paulo.

Apart from INPE and UNICAMP, the participating institutions were: the São Paulo State University (UNESP), the Alberto Luiz Coimbra Institute of Postgraduate Studies (COPPE), the Federal University of Rio de Janeiro (UFRJ), the São Paulo University (USP), the Getulio Vargas Foundation (FGV), the Botanical Garden of Rio de Janeiro, the Oswaldo Cruz Foundation (Fiocruz), the Institute for Technological Research (IPT), the Metropolitan Studies Centre (CEM), the Forest Institute (IF), the São Paulo City Council (PMSP), the Geo-Rio/City Council Foundation of Rio de Janeiro, Pereira Passos Institute (IPP), the São Paulo Company of Metropolitan Development (Emplasa), the Brazilian Institute of Geography and Statistics (IBGE), the Environmental Company of São Paulo (CETESB), State Center for Statistics, Research and Training of Civil Servants of Rio de Janeiro (CEPERJ).

3 CLIMATE CHANGE AND BRAZILIAN MEGACITIES

A major concern of contemporary society in relation to future climate projections relates to possible changes in the frequencies and intensities of extreme weather events. Heat waves, heavy precipitation, droughts and other weather extremes, have been the subject of great interest to researchers because of their enormous impacts on populations, resulting in high material costs, and in many cases, loss of life (MARENGO *et al*, 2009).

In this context, social and regional inequalities impose a series of challenges. Megacities like São Paulo and Rio de Janeiro have numerous social and environmental problems associated with patterns of development and transformation of space, which have been aggravated by the temperature increase and intensification of extreme weather events.

Among the most alarming extreme events are those related to heavy precipitation. The RMSP and RMRJ, with more than 30 million people (about 16% of the population), often suffer effects of extreme rainfall causing floods, landslides and consequently loss of life. Between 1950 and 2003, the frequency and intensity of rainfall increased in the southeastern and southern Brazil, including the cities of São Paulo and Rio de Janeiro (MARENGO *et al*, 2009).

The experts analyzed indices of extreme events and forecasts for annual precipitation and annual average temperature up to 2100. Average annual temperature, predicted against the backdrop of high global GHG emissions at the end of this century, is expected to increase by 2°C to 4°C in all analyzed fields. Related to temperature changes, the models agree with all projected trends including: an increase in the number of hot days, a decrease in the number of cold days, an increase in the number of warm nights and a decrease in cold nights (MARENGO *et al*, 2009).

While projections on changes in air temperature and extremes temperatures are considered reliable, changes in rainfall and rainfall extremes may still show uncertainties. This is due to climate model difficulties in representing some physical processes related to rainfall formation at higher resolutions. In addition, climate models do not include changes in land use and urbanization effects (MARENGO *et al*, 2009). A synthesis of climate projections derived from the Eta-CPTEC 40 km model is presented RMSP in Chart 1. Through the arrows, we can observe variations in the periods analyzed.

CHART 1
Summary of climate projections derived from the Eta-CPTEC 40 km regional model for RMSP

	Present Observed	Present Simulated	2030-2040	Conf.	2050-2060	Conf.	2080-2090	Conf.
TEMP	↗	↗	↗	High	↗	High	↗	High
HOT NIGHTS	↗	↗	↗	High	↗	High	↗	High
COLD NIGTHS	↘	↘	↘	High	↘	High	↘	High
HOT DAYS	↗	↗	↘	High	↗	High	↗	High
COLD DAYS	↘	↘	↗	Average	↘	High	↘	High
HEAT WAVES	Not observed	↗	↗	Average	↗	Average	↗	High
TOTAL RAIN	↗	↗	↗	High	↗	Alta	↗	High

(continues)

(continued)

	Present Observed	Present Simulated	2030-2040	Conf.	2050-2060	Conf.	2080-2090	Conf.
INTENSE RAINFALL	↗	↗	↗	Average	↗	Average	↗	High
RAIN > 95TH	↗	↗	↗	Average	↗	Average	↗	High
RAIN DAYS > 10MM	↗	↗	↗	Average	↗	Average	↗	High
RAIN DAYS > 20MM	↗	↗	↗	Average	↗	Average	↗	Average
CONSECUTIVE DRY DAYS	↘	↗	↘	Average	↗	Average	↗	High

Source: Center for Earth System Science CCST / INPE (2010).
Note: TEMP = air temperature.

4 THE RMSP AND CLIMATE

The RMSP has a population of approximately 20 million inhabitants, in a territory the size of 8,051 km$_2$. The highest population density is in São Paulo city, which shelters nearly 11 million inhabitants or 61% of RMSP citizens, in an area of 1,051 km^2 (SEADE, 2009). In addition, the municipalities of Guarulhos, Osasco, Santo Andre and São Bernardo do Campo each have more than 500,000 inhabitants (PMSP, 1999).

Approximately 40,000 companies and 5.7 million passenger cars (21% of the national totals) are registered in the region. The 12 million public vehicles, in addition to 8.1 million independent vehicles contribute to the total of 30.5 million trips made per day. Around 3 million vehicles circulate the streets of the capital each day (PMSP, 1999).

According to the official inventory (CETESB, 2009), vehicles and industries are responsible for the emission of 2418 mil tons of air pollutants (including gas and particles) per year. Currently, vehicles are responsible for more than 96% of the CO, HC and NOx emitted to the atmosphere. For SO_2 the industries are associated to the emission of 68% and vehicles of 32%. Inhalable particles (particles with aerodynamic diameter less than 10 micra) are emitted by vehicles (40%), industries (10%), soil suspension (25%) and secondary aerosol (25%). Dense urbanization is a significant source of heat.

The densest parts of the metropolitan area tend to be the warmest, and temperature decreases as urban density declines. Pollutants also affect radiation and energy balances, especially because particulates are most composed of secondary organic particulates, black carbon and metals. Among the gases it is important to point out the importance of tropospheric ozone (O_3) and carbon dioxide (CO_2) to the radiative[1] balance in urban areas. Tropospheric ozone is formed from

1. Energy from exchanges of heat between the Earth and the atmosphere.

photochemical reactions involving the NOx and Volatile Organic Compounds (VOC). As already mentioned these compounds that are the precursors for the photochemical reactions are emitted by the vehicular fleet (MARTINS & ANDRADE, 2008). The heavy-duty fleet running with diesel is responsible for the NOx emission and the light-duty vehicles, running with gasohol or ethanol are responsible most of the emission of VOC and CO (CETESB, 2009).

The urban climate in RMSP is one of the most critical in Brazil. The central area of São Paulo, for example, with many buildings, narrow streets and confined courtyards, forms the center of the urban heat island (PMSP, 1999).

Buildings, roads, and other infrastructure replace native vegetation, and urban areas become warmer than their rural surroundings, forming an "island" of higher temperatures. The magnitude of surface urban heat islands varies with seasons, due to changes in sun intensity as well as ground cover and weather (OKE, 1987).

The expansion beyond the Tamanduateí basin produced neighborhoods (Mooca, Tatuapé, Água Rasa, Carrão, Vila Formosa, Penha e Vila Matilde) with high population density and a very small percentage of green areas. The marginal Tiete and Pinheiros, with Bandeirantes Avenue and State Avenue contribute to the passing of more than 1,200,000 vehicles. The volume and speed of vehicular traffic determine the degree of air pollution concentration (PMSP, 1999).

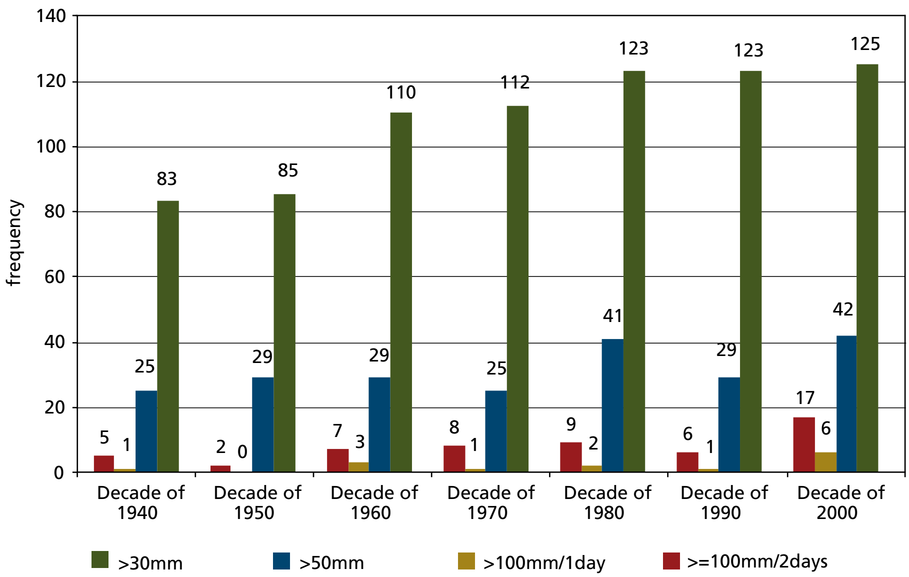
Crossing the Pinheiros river towards the western zone (Raposo Tavares and BR-116), with altitudes ranging from 720 meters to approximately 800 meters is a climate unit privileged by green areas. In this area, neighborhoods have high standard houses, high incomes and good infrastructure, like Cidade Jardim and Morumbi, and the presence of vegetation provides a milder microclimate. Trees remove part of the carbon monoxide (CO) and particulates emitted by vehicles. Houses, commercial and institutional areas are removed from the great transportation arteries which produce the additional benefit of increased ventilation and air circulation (PMSP, 1999).

Crossing the Tiete to the north, structurally aligned by the Tiete River Valley, it is possible to identify the Cantareira and Jaragua hills (900 to 1,000 meters) that enhance the dispersion of pollutants because of atmospheric flows. In general, the metropolitan region is composed of a mosaic of different surface temperatures, as is the municipality of São Paulo (PMSP, 1999).

4.1 What will change?

The São Paulo Metropolitan Region, which already suffers from floods every summer, may experience an increased number of days with heavy rainfall by the end of the 21st century. Total rainfall of over 30 mm/day has the potential to cause severe flooding. Total rainfall above 50 mm/day, virtually nonexistent before the 1950s (Graph 1), usually occurs two to five times a year in São Paulo.

GRAPH 1
Incidents of heavy rainfall in São Paulo per decade (mm/day from 1933 to 2009)



Source: CCST/INPE (2010).

Increased urbanization in combination with global warming events predicts that extreme rainfall will occur more frequently in the future, increasingly affecting wider areas of the RMSP.

4.2 Where and how vulnerable is the RMSP

According to Brooks (2003), vulnerability to climate change is primarily defined as a function of the character of the perturbation. The focus is directed towards the physical manifestations of climate change (temperature, rainfall, etc), the likelihood and frequency of its occurrence and the effects on human systems. In order to understand and reduce human vulnerability, it is necessary to know where and how climate will affect these systems (LIVERMAN, 2001a).

From this perspective, the most vulnerable to climate change are those people living in exposed areas. The nature of social vulnerability will depend on the type of hazard to which the human system in question is exposed: although social vulnerability is not a function of hazard severity or probability of occurrence, certain properties of a system will make it more vulnerable to certain types of hazard than to others. Therefore, vulnerability is not only a function of the physical characteristics of climate events, but more importantly an inherent property of society determined by factors such as poverty, exposure, inequality, gender patterns, access to health care and housing etc. (BROOKS, 2003).

In the case of RMSP, the drainage system plays an important role where many problems have been observed: the dimensions of drainage channels are inadequate to permit the free flow of water bodies; waste materials in different proportions have been found blocking drainage channels; in general drainage channel problems range from the occurrence of streets flooding to environmental deterioration[2]. Basically, the worsening of the drainage problem has always been tied to the occupation of the fluvial plain and the poor environmental quality of urban spaces, further provoked by the elimination of vegetation, soil impermeability, land occupied by slums (in areas discarded by market speculation), illegal settlements in protected areas with increased areas of risk along watersheds, etc.

The areas most susceptible to flooding refer primarily to fluvial plains which do not exceed slopes over 5 meters. According to DAEE (2009), the situation worsened as more streams were transformed into straight channels, and despite all the interventions, flooding increased in frequency and intensity over time.

Basically, the worsening of drainage problems has always been linked to the occupation of the Tiete River plain. A correlation between the areas most affected by sewage pollution to the main roads, slums, buildings and deforested areas was also carried out. We found that one of the most polluted areas of the basin corresponds exactly to the fluvial plain of the Tiete, Tamanduatei, Pinheiros and Aricanduva River basin, among others around the central area of RMSP.

4.3 The main risk scenarios

4.3.1 Floods

Apart from the damage and inconvenience suffered by those directly affected, flooding in the Alto Tiete basin will produce wider effects, stretching beyond regional boundaries, with devastating effects on the state and national economy.

The metropolitan areas have come under intense pressure to respond to federal mandates to link land-use planning, transportation, and environmental quality; and from citizen concerns about managing the side effects of growth such as urban expansion, congestion, housing affordability, and loss of open space.

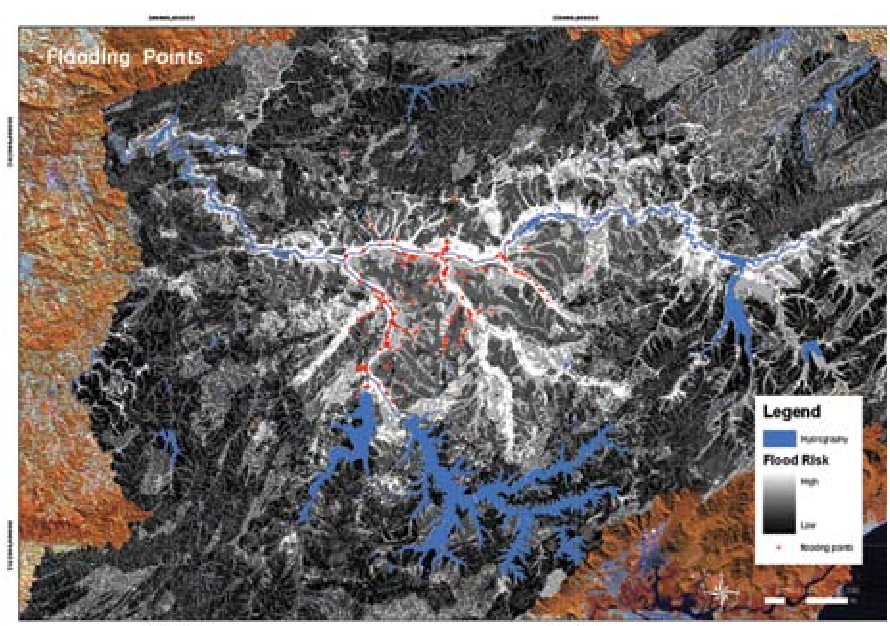
2. From the Avenue Plan of Prestes Maia, in 1930, taking advantage of the lowlands for the construction of the road system has been integrated as a routine solution, aiming to expand the road infrastructure. Thus, gradually the water system of the city of São Paulo was transformed into its road system. The situation worsened as more streams were channelized and, despite all the interventions, flooding has increased over the years in frequency and intensity (DAEE, 2009).

The planning models used by São Paulo planning organizations were generally not designed to address these questions, creating a gap in the ability of planners to systematically assess and respond to these issues. Land-use planning and control measures were not executed in an integrated manner, perpetuating the emergence of new risk scenarios.

For the risk analysis, the *Hand* model was used because it also records terrain declivity. The terrain hazard data was analyzed in relation to rainfall distribution equal to 30 to 50 mm/day. Classes of land use were also considered in terms of risk characteristics. The impacts of flooding were estimated as affecting dwellings, industrial activities, commercial business, public and private services, urban transport and road systems.

A map was produced (Figure 1) using basin characteristics including catchment area, percentage of catchment covered with impervious surfaces, and length of primary water course through the catchment and slope.

FIGURE 1
Areas susceptible to floods in the Tiete Basin



Source: Points of flooding provided by the Emergency Management Center (CGE, 2010).

4.3.2 Flooding with high-energy flows

Geomorphic and climatic conditions in areas with irregular topography, especially the geomorphological compartments of hills and hillock in the peripheral regions of RMSP, allow the occurrence of flooding with high-energy flows, that is, water in great volumes and velocities, due to the large declivities of marginal lands of top portions of drainage valleys, triggered by high rates of instant localized rainfall.

Flooding of this type can cause significant destruction of buildings and urban infrastructure, extensive material damages, and put into risk the physical integrity of people living in riverside areas. Several human occupations along streams subject to flooding of this type can be severely affected by these events. The erosive nature of flooding processes tends to cause silting downstream, thus perpetuating conditions related to flooding.

4.3.3 Runoff with high dragging potential

In the RMSP, most notably in São Paulo city, public policies for channeling streams and constructing public roads in valleys gave rise to the risk scenarios related to runoff processes along these routes in urbanized basins. Runoff processes occur in both consolidated areas and in the outlying areas of the metropolitan region and are characterized by large accumulations of water with great destructive power and drag.

Hydrological risk scenarios expose many people and their property to high-risk conditions. Major vulnerabilities associated with loss of life are located in peripheral areas, while economic and material losses are centered in urban neighborhoods.

4.3.4 Garbage dumped in rivers

About 6,000 households in the metropolitan region throw garbage directly into watersheds, contributing to clogging and sedimentation (PMSP, 1999). In addition, solid waste is carried by runoff, captured by watercourses and carried to the lower portions of terrain, i.e., where sediments and garbage are deposited.

These sites are located, in general, on the river Tiete, at dramatically lower slopes. With the increase of intense rainfall, reservoirs and watercourses suffer serious damage, since they are not designed to exclude the entry of garbage and sediments.

4.3.5 Landslides

For risk analysis of landslides, the *Hand* terrain map aggregated with slope data was analyzed in relation to rainfall distribution equal to or greater than 100 mm/day. The classes of land-use were also considered and assessed in terms of risk characteristics (with help from the six experts from the IPT - Technological Research Institute).

The parameter considered was slopes with above 30 degrees declivity. The instability of hills is related to episodes of extreme rainfall, in terms of intensity and volume, usually triggered by rainfall events above 100 mm onto unstable terrain. The risk of landslides has been generated from an algorithm defined as a function of the slope, rainfall distribution and land use categories[3].

Landslide risk areas, caused by settlement on hillsides,[4] are mainly concentrated in areas of recent urban expansion. This has mainly been observed in the last three decades and is attributed to the geotechnical occupation of land that is more susceptible to landslides in remote areas of RMSP.

About 30 % of the population (2.7 million people) in the city of São Paulo lives in shantytowns, slums and precarious housing, which are generally occupied illegally. Slums alone are estimated to house 1.6 million people. The majority of slums are concentrated in hazardous areas (ROSS, 2004).

Over 50 % of the slums in São Paulo city are concentrated in the Southern zone (Jardim Angela, Capão Redondo and Campo Limpo) and many are at risk to landslides. In other districts of São Paulo, risk areas are distributed in the Western Zone (Butantã and Jaguaré), Northern Zone (Perus, Jaraguá and Brasilândia), and in the Eastern Zone (Sapopemba, São Mateus and Itaquera). The Northern Zone for example, contains 327 slums, a majority of which are located in steeply sloped areas that were once covered by the dense vegetation of the Serra da Cantareira. There is also a significant concentration of slums in the Eastern Zone (around 344) subject to similar conditions.

Other municipalities of the RMSP that are vulnerable to landslides in the Upper Tietê Basin are - Northern Region: Guarulhos, Mairiporã, Caieiras, Francisco Morato, Franco da Rocha, Eastern Region: Ferraz de Vasconcelos and Guararema, Southern Region: Maua, São Bernardo do Campo, Santo André, Diadema, Ribeirão Pires, Rio Grande da Serra, Embu Guaçu and Juquitiba; Western Region: Santana do Parnaíba, Osasco, Carapicuíba, Barueri, Itapevi, Jandira, Taboão da Serra, Embu, Itapecerica da Serra and Cotia.

Among the natural disasters that occur in Brazil, those associated with landslides cause the most fatalities. Data from the systematic survey

3. Urban areas always present some risk of flooding and landslides when rainfall occurs. Buildings, roads, infrastructure and other paved areas prevent (hinder) rainfall from infiltrating into the soil. Heavy or prolonged rainfall produces very large volumes of surface water, which can easily overwhelm drainage systems. In well-governed cities, this is rarely a problem because an appropriate drainage system is built into the urban area, with complementary measures to protect against flooding – for instance the use of parks and other areas of open space to safely accommodate floodwaters from unusually serious storms. Most residential areas in RMSP have no drainage system installed and rely on natural drainage channels.

4. The landslide risk areas are mainly located on lands in geomorphological compartments of crystalline rock on the Embu Ridge, surrounding the sedimentary basin of São Paulo; and in the São Roque Ridge, where the relief is mountainous with intense surface process dynamics (high energy).

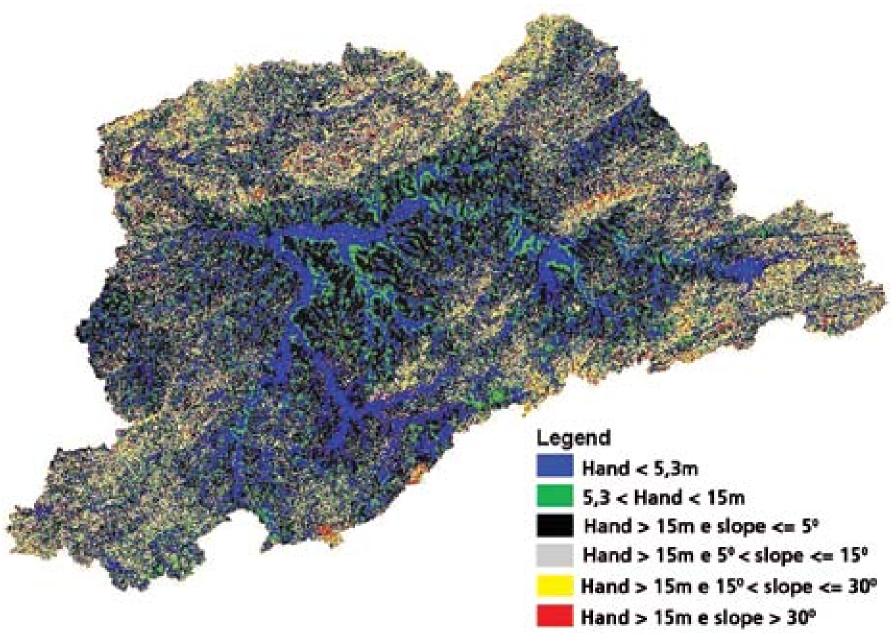
conducted by the Geological and Technological Research Institute (IPT) of São Paulo (between 1988-2009) identified a total of 1,457 deaths. Of this total, 220 deaths occurred in São Paulo State, the second largest number of victims of such accidents, behind Rio de Janeiro with 509 fatalities in the same period.

5 PROJECTIONS FOR 2030

Through the application of an urban expansion projection model onto the H*and* maps, impacts and vulnerabilities are presented in the risk scenarios. This landscape study identifies the potential risks if current patterns of land-use and settlement are perpetuated.

The *Hand* model (Figure 2) is a drainage-normalized version of the Digital Terrain Model (DTM). Through the *Hand* model it is possible to estimate flood hazard employing its equal potential isolines as probability predictors of flood reach. All confluences of drainage lines on the field are captured by this model, and from the meeting of two or more rivers it is possible to know where the water will accumulate and which areas are susceptible to flooding (NOBRE et al, 2011).

FIGURE 2
Hand model applied in the RMSP

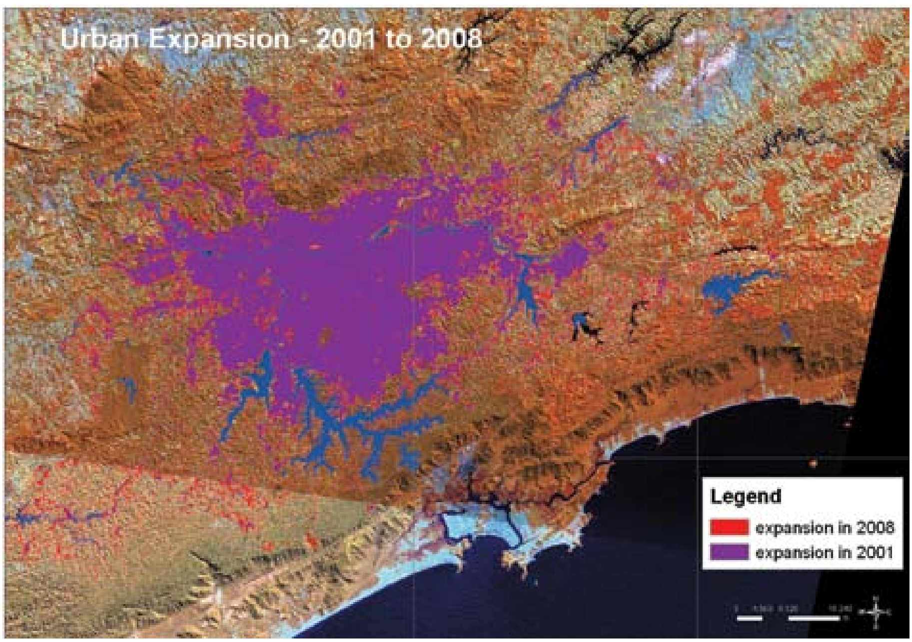


5.1 Urbanization and the spread of risk areas by 2030

To estimate future risks it was necessary to analyze the pattern of urban expansion through remote sensing techniques by comparing the data from Landsat satellite images between 2001 and 2008. In turn, we calculated the areas and identified the rate of growth. Subsequently, we generated a model of urban expansion for 2030 by interpolation techniques. This model of urban expansion was integrated with the slope classifications of the Hand model to identify future risk areas.

As such, the years from 2001 to 2008 were mapped and compared through remote sensing techniques (Figure 3), using satellite images Landsat ETM + (orbit 219 076). The areas in red refer to urban expansion in 2008.

FIGURE 3
Urban expansion from 2001 to 2008

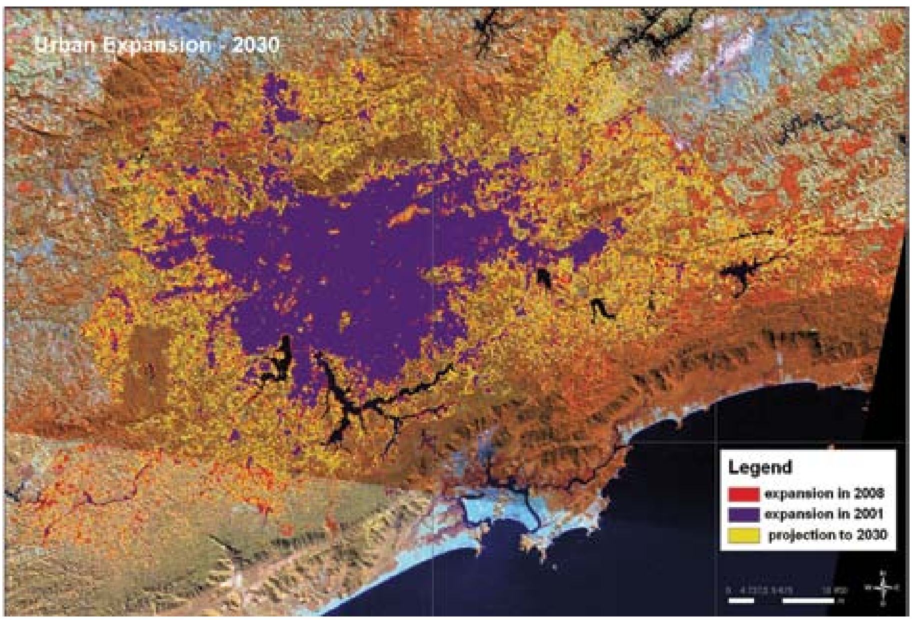


Source: Image from Landsat 7 TM + satellite orbit point 219/76 and 219/77.

As observed similarly by Ross (2004), the urban expansion of the metropolitan region spread more than 80 km from east to west and about 40 km from north to south. Twenty of thirty-nine municipalities are spatially connected, and constitute an urban fabric almost completely compacted with buildings and pavement. The region where these changes are felt most intensely, with urban occupancy rates exceeding 80%, corresponds to the portion of Pinheiros and Tiete rivers. The process of urbanization, however, is already disfiguring the rest of the Tiete basin.

Floods and landslides are expected to affect widely and with greater intensity and severity, people or families living in higher risk environments especially slums. Summarizing, the analysis of expected urban expansion by 2030 (Figure 4) indicates that the risk scenarios, and vulnerabilities to surface dynamic processes triggered by severe weather events such as floods at fluvial plains and landslides on hillsides, will get worse. Such estimates are based on the expectation of an increasing number of irregular settlements in risk areas.

FIGURE 4
Urban expansion of the metropolitan region in 2030



Source: Image from Landsat 7 TM + satellite orbit point 219/76 and 219/77.

The urban expansion model based on historical data from Landsat satellite images (2001-2008) allowed visualizing the effects of site, neighborhood, accessibility and policy impacts on the metropolitan territory. The trend is that the current urban area of São Paulo experiences few changes, but in contrast the surrounding areas will be occupied which exert strong pressures on natural resources.

If this process actually takes place, there will be new risk areas and vulnerability will intensify both in relation to flooding and landslides. Assuming that the estimated 2030 area will undergo an expansion of approximately 38.7 % (i.e. a total area of 3,254.23 km2) the risks of flooding will increase significantly. In this case, over 20% of the total area of expansion would be susceptible, and possibly affected.

Considering steeper slopes with angles exceeding 15º and 30º (obtained through the integration between *Hand* and the *Urban Expansion Model*), the risk of landslides may affect approximately 4.27 % of the areas of expansion in 2030.

5.2 Adaptation measures in the RMSP

The local and regional assessment of vulnerability to climate change indicates that increasingly early adaptation measures in appropriate scales will be essential.

One important measure is related to transport systems. The metropolitan railway system is an alternative of significant importance to reducing the number of vehicles in the road system including the freight transport that crosses São Paulo, and could reduce emissions and atmospheric pollution significantly.

Thus, investments in the expansion of subway lines and railways should be encouraged, since they carry large amounts of passengers and reduce the number of vehicles on streets and avenues.

It is clear, however, that there is no effort to expand the development of the railway system in Brazil. One of the main barriers are highways (the Brazilian transport matrix). One solution to reduce travel distances and circulation of trucks in São Paulo would be the implementation of intermodal transport systems. Warehouses located on the highways would be connected to railroads, harbors and airports.

Also with regard to adaptation measures, another important aspect refers to the balance of water in the soil. Urban interventions that result in sealed surfaces alter conditions of water circulation in the soil. Therefore, information is required on reservoir depths, groundwater movement, and infiltration rates. Intensified processes of dissolution and leaching cause the destruction of soil structures, resulting in a change in the water regime.

A solution presented by the São Paulo city council to reduce the rate of soil sealing was the establishment of linear parks. In addition to expanding green areas in São Paulo, these parks will help improve soil permeability, minimize flooding, and protect rivers and streams.

The Secretariat of the Environment has a Fund for Urban Development (FUNDURB), with R$ 38 million for the development of five parks. Funding for the construction of six other parks also provided by the secretariat should be obtained through environmental compensation.

In the Tiete Basin, the state government is providing resources for the development of an extensive linear park with large reservoirs that will "reproduce" the function of wetlands covered by vegetation, increasing the water holding capacity during floods. The park design includes the recovery of 3.8 million m^2 of riparian forests of the Tiete river.

The effective preservation of Carmo Park (area of protection) is another extremely important adaptation measure. The park contains a set of fragments of vegetation covering almost the entire Aricanduva river and some of its tributaries.

Another fundamental issue would be to quantify the benefits of adaptation to climate change, which seems to be a much needed alternative to the feasibility of actions. Recently, a similar experiment was conducted by DAEE (Department of Water and Energy of São Paulo) (DAEE, 2009).

In this experiment, high traffic areas were evaluated in terms of costs caused by interruption of vehicle flows in the event of flooding. For private vehicles, the values range from R$ 0.26/ km to R$ 0.78/ km. In the case of freight vehicles, the costs of traffic congestion range from R$ 1.50 / km to $ 3.00 / km.

The average time lost by passengers and drivers during traffic congestion caused by flooding is three hours and is estimated to correspond to R$ 6.00 / hours / passenger (cars) and R$ 2.00 / hours / passenger (bus and truck).

The climate change adaptation process begins with awareness of environmental risk, technological and social projects. According to the IHDP (2010), while various organizational actors may be involved in these changes, interventions should also consider concerned stakeholder and beneficiary groups. Here the relevant knowledge and experience comes not only from organizational development but also from interdisciplinary research and development experience in the areas of social change, communications, community development, participatory approaches and other related disciplines.

It is essential to build a space of negotiation that involves public and private sectors, as well as the third sector.

5.3 Guidelines for sustainable development in the RMSP

It is important to understand what aspects of the status quo can be changed so that capacity development can take place. Different actors in change processes have different powers and exert different influences. The applicability of adaptation measures depends on national circumstances and the sector context. Thus, some guidelines were suggested:

Public sector

The government should establish an assessment considering the main aspects of climate dimensions in the decision making process in order to establish public policies:

- Expanding capacity for systematic observation and climate modeling.
- Implementation of the monitoring climate network in the RMSP.

- Assessment of climate change impacts on human health, promoting measures to reduce and prevent these impacts.
- Organization of a climate database, incorporating time series.
- Development of studies about "urban heat islands"
- Establish practices to promote energy efficiency in all sectors and municipalities.
- Investments in emergency training with action strategies.
- Attracting investments for implementation of clean development mechanism (CDM) projects and other mechanisms of the international carbon market.
- Analysis, promotion and implementation of economic incentives for productive sectors that make commitments to reduce GHG emissions or their absorption by sinks - with the expansion of the remaining forest areas or reforestation and implementation of effective measures for maintenance of carbon stocks.
- Implementation of the Macrodrainage Plan in the Tiete River basin, involving all municipalities in the metropolitan region
- Development of studies about the consequences of rising temperatures and changes in hydrological regimes of the Tiete River basin.

Information tools and management

- Local Government should publish an Integrated Action Plan for implementation of common objectives – with involvement of the all sectors of society.
- Local Government should also publish a announcements with information about measures taken to reduce the impacts of and to allow adaptation to climate change using national or international methodologies, when applicable or acceptable.
- The studies and research should be funded by the National Climate Change Fund (FNMC), among other public and private funds.

Command and control instruments

Together, DAEE, civil defense and municipal governments should develop instruments for controlling and restricting pavement and impermeable surfaces in urban areas of the Tiete River basin such as:

- To restrict the proportions of pavement during the construction of buildings - new construction - in areas with steep slopes and areas of protection, through licenses control, and suspension of works, as well as offering tax incentives for those who respect settlement rules .

- To impound or prohibit the construction of buildings that could result in impacts on surface runoff.
- To implement an alert system to prevent flood and landslide accidents in the Tiete River basin, involving the whole population, civil defense and local agencies.

Economic instruments

- The Departments of Finance and Planning should be required to quantify the benefits of adaptation to climate change. In this case, to produce official documents about costs and benefits, for example: the reduction of disease rates and mortality caused by floods, landslides and droughts.
- The evaluation of costs and benefits should be audited by an agency or a specialized organization, which would be legally responsible for the results of the audit.

6 FINAL CONSIDERATIONS

The RMSP is facing a great challenge, as the environmental consequences of urban interventions and the lack of control can be tragic. This is clear given the consequences of extreme events such as floods, landslides and others.

Section 4 of this chapter outlined the changes in hydrological regimes and urban drainage systems, as well as the pollution of rivers, coupled with inappropriate land use and impermeability of the Tiete River Basin. This resulted in a metropolitan area that is severely affected by flooding problems.

As mentioned, this basin is similar to a large climatologically heated basin, producing tons of pollutants originating from industries and vehicle traffic. This is a structural problem that will persist, as a result of successive previous policies and current options. Projections for 2030 show that new areas of risk and vulnerability will intensify.

Thus, policies that support the division of lots, urban use and land settlement play an important role in setting goals that lead municipalities towards a development compatible with available resources and natural features, including climate characteristics.

The risks and their magnitudes will depend on the severity, frequency, and distribution of events related to climate change; yet, the scale and frequency with which climate phenomena reproduce have not been precisely defined. The scales of climate models are not compatible with urban scales, and technical approaches are not able to specify the number of future events.

Approaches need to be more precise with the development of hydrological models, with continuous meteorological surveys, time series, among other alternatives and variables. Thus, such knowledge could help to understand the relationship between the problems caused by climate change and urban expansion patterns that affect, for example, civil defense actions, local government decisions, etc.

As mentioned by Waddell (2000), broadly speaking, government agencies influence the land development process through a combination of land use regulations and infrastructure provisions. These are frequently combined into packages that attempt to foster a development pattern in ways that promote planning objectives.

The use of the "*hand model*" and the "*urban expansion model*" in the RMSP context describe different 'scenarios' where assumptions about hazards that can be input into the model to examine the potential consequences on outcomes such as urban form, environmental risk, density, and land use patterns etc.

In other words, the models allow the visualization of a hypothesized future. They do not assume that a particular vision can be realized, but facilitate exploration of the trade-offs that may be involved in attempting to avoid the disasters, given the range of possibilities in terms of policy demands, costs and consequences. The models do not attempt to 'optimize' policy inputs, but rather facilitate interactive use to support integrated and participatory planning.

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CHAPTER 12

THE CLIMATE JUSTICE DISCOURSE IN BRAZIL: POTENTIAL AND PERSPECTIVES

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Igor Ferraz da Fonseca**

1 INTRODUCTION

The Climate Justice discourse has been adapted from the Environmental Justice concept and created from the idea that Climate Change impacts affect different social groups in various ways and intensities. Some cases of climate injustice can be related to desertification, extreme climate events (such as thunderstorms, heat waves etc.), sea level rise, among others. In this text, we argue that although events related to climate injustice are noticeable in Brazil, the Climate Justice discourse has not been broadly adopted in the country.

The text is organized in six sections, including this introduction. In Section 2, we present the Environmental Justice concept and a summary of its history. Then, we discuss the idea of Climate Justice and describe how this discourse has been socially constructed. In Section 4, we evaluate to what extent the Climate Justice concept has been incorporated in the analysis of extreme climate events in Brazil. This assessment is based on documental research of the main newspapers from São Paulo and Rio de Janeiro about floods and landslides that took place in these cities in December 2009 and April 2010, respectively. The results indicate that the media, society and impacted communities have not identified links between environmental injustice incidents, extreme climate events and Climate Change. After, we describe the first attempts to discuss the relationship among these elements in the Brazilian context. Finally, we propose a strategy that associates the idea of Climate Justice with the claims of impacted communities, that could bring about various benefits to such communities as well as to Brazilian society in general.

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2 THE ENVIRONMENTAL JUSTICE MOVEMENT

The Environmental Justice concept has been proposed as an alternative to the environmental management paradigm (Bullard, 2004). According to Environmental Justice advocates this managerial paradigm, which has been dominant in the current environmental discourse, defines environmental problems solely as environmental pollution or as scarcity of natural resources. Along these lines, every person would be equally responsible for resource depletion and environmental destruction, and similarly, different social groups would be evenly affected by environmental contamination (Acselrad, Mello, & Bezerra, 2009).

Alternatively, Environmental Justice advocates argue that social groups have different levels of responsibility regarding the depletion of natural resources and, more importantly, that social inequality defines levels of exposure to environmental risks (Acselrad, 2004). In other words, their argument is based on the assumption that vulnerable groups are excluded from the policy formulation process and, therefore, are negatively affected by decision making procedures concerning environmental issues (Ikeme, 2003).

Along these lines, according to the African-American activist Florence Robinson (apud Roberts & Toffolon-Weiss, 2004) an environmental injustice takes place when a person, or persons, are negatively affected by an environmental burden, which does not impact other people in the same intensity, in order to promote an alleged social welfare. According to Ikeme (2003), assuming that all people have equal rights, claims for Environmental Justice aim to mitigate existing or potential injustices in the distribution of environmental benefits or losses, as well as, to end partial or unfair decisions.

In order to reach these objectives, the Environmental Justice paradigm proposes that public policies, risk reducing strategies and infrastructure programs must be based on approaches that are holistic, geographically oriented and committed to social participation and community empowerment (Bullard, 2004).

The Environmental Justice movement is based on a few general principles. First of all, it opposes policies based on the displacement of risk and pollution. Instead of adopting the "not in my backyard" (NIMBY) strategy, they advocate for the not in anybody´s backyard (NIAMBY) approach. As a result, polluting activities should not be displaced from one country to the other, and instead, groups responsible for such activities would have to abolish pollution sources and promote changes in the production and consumption model. At the same time, Environmental Justice advocates argue for a "just transition", which should be negotiated with workers of polluting industries so that the movement towards a cleaner society does not create unemployment among these workers (Acselrad et al., 2009).

These proposals have been negotiated for more than 50 years. The Environmental Justice movement began in the United States in the1960s, its origins being associated with the movement against chemical hazards. This movement also criticized the location patterns of pollution sources and their physical proximity to specific communities. This debate grew in the 1970s, when workers' unions, environmental groups and ethnic movements started discussing environmental issues in an urban context. Nevertheless, in 1982, the struggle against a hazardous waste disposal site, designed to receive the carcinogenic polychlorinated biphenyl in Warren County, North Carolina, called public attention to the geographic distribution of health hazardous facilities. Five years later, research organized by social movements concluded that ethnicity was the variable that best explained the distribution of hazardous waste disposal sites in the United States. This research was a milestone in the debate about pollution, race and poverty and, in 1991, during the First National People of Color Environmental Leadership Summit; the principles of Environmental Justice were discussed and defined (Acselrad, 2004; Bullard, 2004).

In this sense, the origins of the Environmental Justice discourse are closely related to race and ethnicity. As Roberts and Toffolon-Weis (2004) mention, environmental injustice claims have been presented in various ways depending on the community affected. On the one hand, the idea of Environmental Racism has been used to involve ethnic minorities, such as African descendents and indigenous peoples. On the other hand, the concept of Environmental Justice has also been adopted in cases involving broader and more heterogeneous communities.

The Environmental Justice Movement in Brazil, nevertheless, has emerged more recently. In 1998, Brazilian Non-Governmental Organizations (NGOs), researchers and workers' unions invited American representatives to take place in the "Summit on Environmental Justice", though it had little impact. Three years later, social movements organized the "International Colloquium on Environmental Justice, Labor and Citizenship", which had a broader attendance and was the starting point of the Brazilian Environmental Justice Network – BEJN (Acselrad et al., 2009).

The BEJN is a forum for debate and political mobilization organized by social movements, workers' unions, environmental organizations, ethnic groups and faculty members. The network aims to develop collective actions that challenge environmentally unjust situations, promote the exchange of expertise among groups that face environmental problems, and inspire scientific research that contributes to Environmental Justice in Brazil (RBJA, 2010a).

3 THE CLIMATE JUSTICE MOVEMENT

The debate on the vulnerability of particular groups to Climate Change is also present in the Environmental Justice discourse. The concept of Climate Justice refers to existing differences in the levels of exposure to impacts and responsibility for the causes of Climate Change. The studies of the Intergovernmental Panel on Climate Change (IPCC, 2001, 2007a) indicate a high level of inequality related to the impacts of Climate Change, which mobilizes the international movement for Climate Justice. This movement believes that those least responsible for greenhouse gas (GHG) emissions suffer the most severe impacts of Climate Change. In order to combat this problem, they call for policies and initiatives that, based on the ethics of human rights, reduce the vulnerability of groups that are disproportionally affected by Climate Change (Ebi, 2009; Roberts & Parks, 2009; Shepard & Corbin-Mark, 2009; Tyree & Greenleaf, 2009). According to Saunders (2008), the Climate Justice Movement is a singular initiative because, for the first time, large organizations not necessarily concerned with environmental issues are getting involved in the environmental debate.

The Climate Justice movement recognizes that Climate Change affects everyone; nevertheless, it argues that the intensity of the impacts and the capacity to adapt to the consequences of such impacts vary across social groups. These differences can be associated with the territory where these groups live (e.g. small islands), or with a particular natural resource they use (e.g. seasonal rivers). Additionally, there are other aspects that increase the resilience[1] of social groups to the impacts of Climate Change, such as, access to infrastructure and public services (e.g. health, education, housing etc.). Social groups that face higher levels of economic vulnerability are also more vulnerable to various events, such as floods, droughts, water scarcity and increase in food prices. These events are becoming more frequent and intense due to Climate Change, and are likely to occur even more regularly in the future, and thus increasing the challenges these groups will have to deal with.

The metaphor of "spaceship earth" (Boulding, 1966) proposes that environmental impacts equally affect all "crew members" that share the same space on a planet with limited resources. Along these lines, and adopting the managerial paradigm, this metaphor could be applied to the Climate Change issue, and it could be argued that any person in any country would be affected by Climate Change. Although extreme climate events will affect high income social groups, they possess the appropriate material resources to develop adaption strategies. Conditions to implement infrastructure improvements, higher income

1. We define resilience as the resources and abilities that make it possible for social groups to resist disturbances in the social structure. These disturbances can be associated with the political, social, economic or environmental realms (Folke, 2006).

to be spent on more expensive food, and better access to technology and health services are elements that make these groups less vulnerable to Climate Change than low income ones. Therefore, it could be argued that, on our ship, there are first class passengers, third class passengers, and those who travel in the cargo compartment (Bursztyn, 1995).

The differences we identify when comparing social groups in a national context, can also be recognized in the international arena. Some countries are more vulnerable to Climate Change than others, and as indicated by the IPCC models, the most severe consequences of Climate Change will impact Latin America, Africa and South Asia (IPCC, 2007b). For example, the worst droughts might take place in Sub-Saharan Africa; sea level rise will have more intense impacts for the Pacific Islands, Bangladesh and the Nile Delta; and the most severe hurricanes are likely to take place in Central America, Asia and Africa (Roberts, 2009). In addition, the increase of extreme climate events, particularly changes in rain patterns, may increase the occurrence of water-related diseases in the Southern hemisphere, worsening living conditions for these populations (Ebi, 2009). These geographic conditions are intensified by material aspects, such as income to promote adaptation programs, but also have linkages with institutional and governance elements, like the political capacity to implement proper public policies (Brooks, Adger, & Kelly, 2005; Ebi, 2009; Engle & Lemos, 2010; Twomlow et al., 2008).

As a result, during the United Nations Framework Convention on Climate Change (UNFCCC) meetings, the debate on Climate Justice has occurred mainly between the Southern and the Northern hemispheres. On the one side, are the industrialized countries that are responsible for the majority of historical GHG emissions, that suffer smaller climate risks and have more adaptive capacity to Climate Change. On the other side, are the countries of the Global South that carry less responsibility for historical GHG emissions, experience higher risks of suffering the worst impacts of Climate Change and have a limited capacity to develop adaptive infrastructure against these effects (Ikeme, 2003).

Considering the inequalities associated with Climate Change, Ikeme (2003) argues that groups of countries are adopting very different perspectives in the way they define problems and possible solutions. On the one hand, countries from the South are focusing on the distributional aspects of impacts, responsibilities and costs. Along these lines, they argue that historical emissions play a fundamental role in defining current (mitigating or compensating) responsibilities; that the "right to emit" must consider population size, and that decision-making ought to be based on cooperative and participatory processes. On the other hand, northern countries are fundamentally looking for economically efficient solutions to reduce environmental impacts, instead of taking into account a historically fair distribution of the mitigation and adaption costs. In this sense, they propose a homogeneous reduction of emission based on abatement costs and payment capacity.

Furthermore, Climate Justice advocates question the way that international instruments created to deal with Climate Change issues are being put in place; for example, their attitude towards the Clean Development Mechanism (CDM) scheme is very negative. First of all, they argue that CDM only evaluates projects based on GHG abatement and total cost, ignoring environmental impacts not related to Climate Change – such as local pollution, community displacement, workers' health etc. Also, CDM does not evaluate which interests or social groups are benefited by the carbon credit market. Finally, there is no strategy to ensure that projects that reduce GHG emissions in the short-term will help to create a more socially and environmentally fair society in the future.

From a broader perspective, the Climate Justice movement also claims that CDM adopts the international development paradigm, and is limited to technology transfer from North to South. Hence, they argue for models that respect the traditional way of life and historical contexts of countries in the South, in order to promote technology development adapted to local realities. There are also groups that criticize CDM because it does not accept the idea of paying for the non-extraction of oil or for non-deforestation, which these groups consider effective ways to avoid the concentration of GHG in the atmosphere. Although some of these problems are expected to be solved by programs to Reduce Emissions from Deforestation and Forest Degradation (REDD), there are indigenous groups that question current REDD proposals, arguing that they do not fully respect Convention 169 of the International Labour Organization, particularly concerning indigenous peoples rights to be previously informed about projects that impact their way of life. Finally, Climate Justice advocates criticize the fact that most CDM financial resources are invested in countries that already have considerable levels of institutional, technological and social capacities, such as China, India and Brazil, instead of benefiting the poorest countries (Larrea & Warnars, 2009; Lohmann, 2008; Mcmichael, 2009).

The Climate Justice movement, however, does not limit its criticisms to the injustices associated with Climate Change impacts and the way international organizations are dealing with the issue. Moreover, they identify limitations in the international trade framework and the overall capitalist system, which does not seem capable of dealing with the issue properly (Storm, 2009).

Along these lines, the Environmental Justice discourse seems to borrow some ideas from the Ecologically Unequal Exchange concept when proposing that the disproportional increase in material and energy flow from the South to the North, can be contrasted with the displacement of GHG emissions from the North to the South. Based on this assumption, it is argued that thanks to international trade and the displacement of carbon-intensive activities to the South, countries from the North are giving a false impression of moving towards a low-carbon economy (Martinez-Alier, 2007; Roberts & Parks, 2009).

In order to resolve the above mentioned issues, the Climate Justice movement defends a radical overhaul in the Climate Change negotiation process. It argues for the implementation of policies that ensure a significant decrease in the emissions of GHG and local co-pollutants, the protection of vulnerable communities, and the construction of a just transition to a green economy, which includes retraining and placement of workers from carbon-intense industries (Shepard & Corbin-Mark, 2009). In this sense, the Climate Justice movement argues that, more than an environmental problem, Climate Justice must be dealt with as a human rights issue (Roberts & Parks, 2009; Saunders, 2008).

4 VIEWS OF EXTREME CLIMATE EVENTS IN BRAZIL

As different authors have mentioned (Ikeme, 2003; Roberts, 2009; Saunders, 2008), the Climate Justice discourse has been used more often at the international level. While this debate goes on, we notice very little discussion in Brazil at the domestic level, in spite of many extreme climate events that could be described as episodes of climate injustice.

Although it cannot be explicitly stated that the floods and landslides that are occurring in urban centers in Brazil are consequences of Climate Change, models do forecast that such events will become more frequent in the Southern and Southeastern Regions. Specialists expect an increase between 5% and 10% in the amount of rainfall in the Southern Region and that storms will be more intense in the Southeast (CEDEPLAR/UFMG & Fiocruz, 2009). In recent years, cities like São Paulo and Rio de Janeiro have gone through some extreme climate events. Many people died as a consequence of these episodes, especially poor people, who live in risk areas and whose living standards contribute minimally to Climate Change. Although this situation could be defined as an example of climate injustice, the discourse has not been linked to these events.

As a proxy of social perception, we examined articles published by the main newspapers in the two cities – *O Globo*, in Rio de Janeiro, and *Folha de S. Paulo*, in São Paulo. In both cases, we read the articles about the floods and landslides, and evaluated which elements were used to explain and assess the causes of these events. We considered all articles published from the day when the event was first announced until one week after it ended. As such, we assessed articles about the

São Paulo floods between 2nd and 19th of December, 2009, and about the Rio de Janeiro floods and landslides between 5th and 15th April, 2010.

We summarize in Tables 1 and 2 the typology used to classify the arguments presented by the newspapers. We define "Engineering" as the issues associated with problems in the municipal drain systems or linked to extensive use of asphalt, concrete and other impervious materials in the city. By "Land use", we refer to the occupation of risk areas – like slopes and floodplains – considered unsuitable for housing. The item "Urban management" includes solid waste collection, maintenance of ditches and channels, and other public services. We classify the arguments as "Weather" when the articles mention that events were due to "rains above average" or climate events such as *El Niño* or *La Niña*. Finally, "Climate Change" is used when the articles explicitly relate Climate Change to the extreme climate events.

This typology only considers the possible causes of the events, and it does not evaluate the actors that the newspapers considered "responsible" for the incident. For example, when we classify an argument as "Land use", we include both articles who blame the poor communities who "choose" to live in risk areas and texts which criticize local government for "allowing" people to build their houses in these places.

TABLE 1
Main causes associated with the floods in São Paulo, according to "Folha de S. Paulo"

Topic	Article	Editorial	**Total**
Engineering	16	4	**20**
Weather	4	0	**4**
Urban Management	8	3	**11**
Climate Change	1	0	**1**
Land use	10	9	**19**
Total	**39**	**16**	**55**

Source: Folha de S. Paulo (2009).

Considering the information presented in Table 1, from the 55 arguments used as possible causes for floods, the majority were associated with "Engineering" (33%) and "Land use" (18%). If we evaluate articles and editorials separately, it is possible to identify some differences. On the one hand, common articles are more likely to focus on "Engineering" issues; while on the other hand, analytical texts more often consider "Land use" problems. "Weather" and "Climate Change" are rarely mentioned as possible explanations for the events.

The divergence between the debate on extreme climate events in Brazil and the concern about Climate Change is concerning. In the São Paulo case, the episodes occurred simultaneously with the COP 15 in Copenhagen (7th – 18th December), where there was much talk about Climate Justice. Not even this "coincidence" was enough to inspire Brazilian newspapers to connect the episodes in Brazil with Climate Change or Climate Justice.

In Table 2, we use information from *O Globo* to evaluate public perception of the floods and landslides that happened in Rio de Janeiro in April 2010. The results indicate that, in Rio, the episode was more frequently related to "Land use" (57%); which was the most common rationale both in articles and editorials. Similar to the São Paulo case, there were few references to "Climate Change" (3.6%).

In Rio, during the first three days after the flood, explanations focused mostly on "Weather", "Engineering" and "Urban management". On the third day (7th April), there was a massive landslide in Niterói (a city within the Rio de Janeiro Metropolitan Area), where more than 50 houses were destroyed. The area known as Morro do Bumba was an old dumping site, on which low-income families had built their houses. This disaster made "Land use" the main topic discussed in the newspapers. Considering only the editorials, there were two that mentioned "Climate Change". In one of them, a representative from the State Secretariat for the Environment mentioned how the events affected people from different social groups, but he did not mention explicitly the idea of Climate Justice.

TABLE 2
Main causes associated with the floods in Rio de Janeiro, according to "O Globo"

Topic	Article	Editorial	**Total**
Engineering	9	2	**11**
Weather	4	0	**4**
Urban Management	5	1	**6**
Climate Change	0	2	**2**
Land use	25	6	**31**
Total	43	11	54

Source: O Globo (2010).

In spite of this editorial, our analysis indicates that Brazilian newspapers very rarely associate Climate Change with the extreme climate events that take place in the country. If we assume that these floods and landslides can be considered concrete examples of climate injustice, we could argue that Brazilian society has not adopted the Climate Justice discourse in the debate about extreme climate events and social vulnerability.

5 VULNERABILITY AND CLIMATE CHANGE IN BRAZIL: BUILDING CONNECTIONS

Although our research indicates that the Climate Justice concept has not been used in the assessment of extreme climate events, some organizations are trying to draw the attention of public opinion to the relationships between socio-environmental sustainability and Climate Change. In this section, we describe some of these attempts.

As an effort to explain how Climate Change affects Brazilian cities, a project called *!sso não é normal* (This is not normal) created a website where they publish texts, photos and videos that illustrate how Climate Change has impacted everyday life in São Paulo city (O Estado de São Paulo, 2010). The project mentions the different aspects of Climate Change, such as heat waves, increased rain intensity, and higher risk of epidemics. Nevertheless, the project suggests that every São Paulo dweller is equally at risk of being affected by these events and does not mention the possibility that some social groups may be more vulnerable than others. The project has also developed similar information for Santa Catarina State and the Northeastern Region, two areas which have been suffering various impacts from extreme weather events.

A second initiative to bring the debate on Climate Change and vulnerability to the public was started by a research network, which included the National Institute for Space Research, the University of Campinas, the University of São Paulo, the State University of São Paulo and the Institute for Technological Research, also in São Paulo. This network published a report about the vulnerability of Brazilian mega-cities to Climate Change, with focuses on the São Paulo Metropolitan Area (C. A. Nobre et al., 2010) [2].

The results indicate that, if average temperatures in São Paulo rise by 2 - 3º C, the number of episodes of intense rain (above 10 mm) may double and rain intensities above 50 mm, which were nonexistent before the 1950s, may happen up to five times a year. As a consequence, floods will become more frequent and will impact larger areas in the future. In contrast to the previously described project, this report mentions that there are more than 1.6 million people living in the São Paulo Metropolitan Area slums, which are mainly located in risk areas such as flood plains or unstable hillsides. The study goes on to warn that these people will suffer more disproportionally from the increased rain intensity.

Although these two initiatives attempt to connect Climate Change and vulnerability, an essential aspect of the Climate Justice concept, we argue that they have not adopted this discourse. Firstly, the projects do not mention explicitly the idea of Climate Justice, or even Environmental Justice. Secondly, although

2. A summary of this study is presented in Chapter 13 of this book.

they are concerned with Climate Change and vulnerability, they do not criticize the unequal development model adopted by contemporary societies, a basic assumption of the Climate Justice movement.

Nevertheless, this concern is present in a third initiative. This example consists of a series of radio programs, created and webcasted by the Brazilian Environmental Justice Network, in June 2010 (RBJA, 2010b). These programs argue that the current development model is not only unable to promote social equity, but is also responsible for many environmental contradictions and for Climate Change. In spite of their concerns with local realities, the programs have not been able to call the general public's attention to the Climate Justice issue.

6 CLIMATE JUSTICE IN BRAZIL: SOME PERSPECTIVES

Although the Climate Justice discourse is still marginal in Brazil, we expect this debate to become more intense in the near future. Therefore, we argue that social groups affected by extreme climate events should include this discourse in their claims. We believe that the adoption of this concept in Brazil could create at least three positive outcomes.

First of all, it must be understood that Brazil already plays an important role in the international forums that debate climate issues. Therefore, if Brazilian social groups assume this discourse, the concept would gain much more visibility in such forums.

Secondly, acceptance of the Climate Justice discourse might increase the chances that the claims of affected groups are heard. Typically, communities impacted by extreme climate events have little influence over the decision-making process (Sze et al., 2009). Nevertheless, as the debate on Climate Change is present in social and political agendas at the national and international levels, the debate could strengthen their claims.

Finally, we argue that defining tragedies associated with extreme climate events as effects of Climate Change could change the course of some public policies. White-Newsome et al. (2009) present some preventative strategies adopted in Michigan (USA) to reduce heat-wave related mortality rates. In contrast, extreme climate events have created catastrophic social and economic impacts among vulnerable communities without fueling the debate on Climate Change. Ignoring that such events are not fortuitous is a barrier to real planning against extreme weather events. For example, in 2011, one year after the episodes were described in this text, more floods and landslides took place in the Friburgo area in Rio de Janeiro state, resulting in more than 900 deaths.

As studies indicate that extreme climate events will become more intense in the near future, delays in the definition of a new line of actions will only increase the negative social, economic and environmental impacts of these events. Therefore, if decision-makers realize the relevance of connecting recent floods and landslides to Climate Change, it is possible that they will turn current corrective policies into structural policies designed to reduce vulnerability and to adapt to Climate Change.

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CHAPTER 13

CLIMATE CHANGE AND VULNERABILITY TO DROUGHT IN THE SEMIARID: THE CASE OF SMALLHOLDER FARMERS IN THE BRAZILIAN NORTHEAST

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1 INTRODUCTION

By means of empirical and creative learning, human populations have established good relations with their local environment throughout history. This process of adjustment by human societies to an ever-changing environment is called adaptation. The term has its roots in biological evolution. It was later seized by a few streams of theoretical sciences to justify eugenic positions such as social Darwinism (WATSON, 2005), or as a concept to explain the dynamics of cultural processes in ecological anthropology and cultural ecology (ORLOV, 1980, MORAN, 2008). In the past two decades, the term adaptation became an issue in interdisciplinary debates on climate impact research (HEAD, 2010; SMIT &WANDEL, 2006; SMIT *ET AL,* 2000; SMITHERS & SMIT, 1997) and gained new epistemic approaches from different fields of knowledge. In this context, adaptation can be understood as the adjustment of human and natural systems in response to climate stimulus - current and expected - or its effects, which explores opportunities or moderates harm (PARRY *ET AL.,* 2007:6).

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As a result of the repercussions that this issue has generated in society, many efforts have been made to provide decision makers with integrated systems of vulnerability assessment to guide public policy and the employment of priority action, especially by the multilateral agencies of the United Nations (UN) but also some national governments - Canada, the United Kingdom, Australia, Sweden, and the Netherlands, for example. (YUSUF & FRANCISCO, 2009; AGO & ALLEN CONSULTING GROUP, 2005). For instance, in 2004, the United Nations Development Programme (UNDP) launched the *Disaster Risk Index.* In this index, risk was calculated by dividing the number of victims of a certain disaster – for example, earthquakes and floods – by the population exposed to the hazard. Then, experts selected 26 indicators, and carried out statistical analyses to estimate risks. Among the results, it was shown that rural populations were confronted with the risk of local impacts as a result of climate change and environmental degradation, and also that their ability to cope with these impacts was being eroded by globalization.

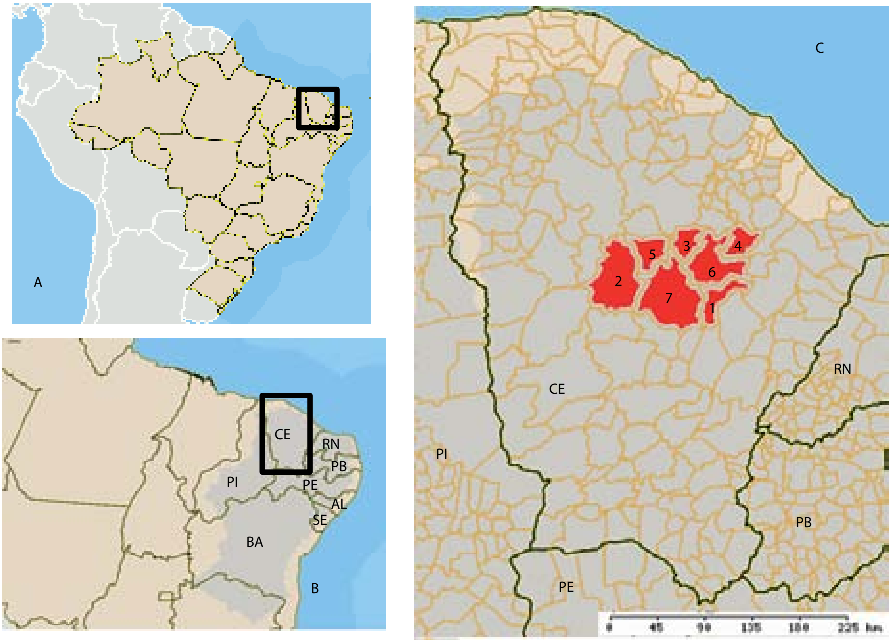
Lonergan (1998) proposed an overall index of vulnerability, composed of 12 indicators. The index covered social aspects (e.g. dependence on food imports and infant mortality), economic (per capita income) and institutional (e.g. degree of democratization). Diffenbaugh et al. (2007) developed an index to measure the socio-climatic exposures of countries around the world. For this purpose, they integrated indicators of climate exposure with those of poverty, demography and health, resulting in a map that revealed that the most populous and poor nations were the most vulnerable to climate change, and thus echoing the inequities in the debate over the responsibility of the causes and the distribution of consequences. At a national level, O'Brien et al. (2004) developed a system for assessing the vulnerability of agriculture in India. In its conceptual framework, the authors adopted the notions of adaptive capacity, sensitivity and exposure, and selected specific indicators for each of these. In addition to climatic factors, a globalization variable was adopted as an aspect of exposure and incorporated into the evaluation system.

In Brazil, interdisciplinary approaches to vulnerability are still incipient, lacking studies that link the multiple dimensions and scales of human vulnerability to global environmental changes. The Ministry of Science and Technology (MCT) published a study that integrates a series of climatic and socioeconomic indicators to assess the risks of outbreaks of certain diseases (e.g. malaria, yellow fever and Leishmaniasis) related to climate change. The result was the Epidemiological Vulnerability Index at state level for Brazil (BRASIL, 2005).

The improvement of indicator systems to assess vulnerability and responsiveness of human systems to environmental changes (climate) is a response to the growing demand for accurate information, which have spatial/ temporal relations to quality for decision making (BARTELMUS *ET AL*, 2005). The representativeness of the indicator, as well as its relevance and significance, depends on the researcher and the limitations and objectives of the evaluation. On the one hand, models are sought in which a compilation of variables is sufficient to represent a complex reality, however on the other hand, models must be simple enough so that the information can easily be communicated to users. Therefore, indicators are measurable reflections of reality, which can be used as a reference in decision making, but should not be considered as absolute representations of reality. Every system of indicators reflects a particular set of perceptions and values used in the evaluation and aggregation of inter-dimensional and inter-scale aspects (WILBANKS, 2007).

This chapter proposes and discusses a set of indicators to assess the vulnerability of smallholder agriculture in Brazil to drought. The State of Ceará and seven of its municipalities located in the semiarid micro-region of Quixeramobim (MRSQ) were selected for the application of the system of indicators (figure 1). This proposal was based on the intention to develop a vulnerability assessment tool with the following characteristics: simple, easy to use for decision makers while at the same time being sufficiently representative of reality. To achieve this purpose, the database must be reliable and easy to access by actors in local and federal governments. Keeping this in mind, the database selected is the last Brazilian Agricultural Census (2006) compiled by the Brazilian Institute of Geography and Statistics (IBGE), which is available to the public free of charge through IBGE's Automatic Recovery System (Sidra). The Human Dimension of Climate Change approach is adopted in this paper. In this context, three concepts are key to guide the analysis: *climate change, vulnerability and adaptive capacity.*

FIGURE 1
Location of the semiarid micro-region of Quixeramobim in the State of Ceará, Brazil



■ Sertão de Quixeramobim Microregion

1 - Banabuiú 2 - Boa Viagem 3 - Choró 4 - Ibaretama 5 - Madalena 6 - Quixadá 7 - Quixeramobim

Source: Adapted by the authors from <http://www.mma.gov.br>.
Note: Location of municipalities (red) in Brazil (A), semi-arid region (B) and Ceará (C). The gray area corresponds to the semi-arid territory (B and C). *Northeastern States covered by the semi-arid region*: Alagoas (AL), Bahia (BA), Ceará (CE), Paraíba (PB), Pernambuco (PE), Piaui (PI), Rio Grande do Norte (RN), and Sergipe (SE).

2 THEORICAL FRAMEWORK

2.1 Climate Change

In the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)* (PARRY et al., 2007), climate change refers to *any change in climate over time, of either natural or anthropogenic origin.* This definition will be adopted here, since when observing extreme weather or uncommon atmospheric phenomena it is not possible to distinguish which portion is due to human actions and what results from natural climate variability.

In this study, the spatial and temporal distribution of drought is considered as being the climatic "exposure" factor to which smallholder farming is subjected. There will be no distinction between the nature of the causes – whether natural or human. However, the need for strategies to mitigate greenhouse gas emissions are recognized, in parallel with adaptation strategies, in order to reduce the risks posed by anthropogenic global warming.

2.2 Vulnerability

The concept of vulnerability has its roots in the risk-hazard approach developed within the scope of North American Physical Geography (MARADOLA & HOGAN, 2004). Hazard refers to the threat itself – to natural or social systems – that certain natural events represent. On the other hand, risk refers to the future probability of a hazard occurring (CASTRO, 2002). When a hazard or threat occurs, it is called a disaster.

It is important to point out that natural hazards exist at the interface between society and nature. They are determined by the coexistence of human system adjustments (adaptation) and the impacts of natural environmental events such as droughts, floods, earthquakes, tsunamis and volcanic eruptions (MARADOLA & HOGAN, 2004). In this context, vulnerability is understood as the *susceptibility of human systems to natural phenomena* and is often associated with specific loss or damage (MORTON, 2007; PARRY *ET AL*, 2007). However, climatic events are only one of the features implicated by multidimensional vulnerability (FORD *ET AL,* 2011; HEAD, 2010; CUTTER & FINCH, 2008; SMIT &WANDEL, 2006; SMIT *ET AL,* 2000).

In this chapter, vulnerability is understood as a function of three attributes: sensitivity, adaptive capacity, and exposure. Exposure relates to the quality of climate dynamics (nature, magnitude and frequency). Sensitivity emerges from the interface between the weather event and the characteristics of socioeconomic systems (e.g. settlement location and livelihood), reflecting the susceptibility of the system – in terms of damage or impact – to a particular disturbance (FINAN & NELSON, 2001).

2.3 Adaptive Capacity

The concept of adaptive capacity can be understood *as the socio-ecological systems' ability to manage, accommodate and recover from any environmental*[1] *disturbance* (SMIT & WANDEL, 2006), among these, weather disturbances. This concept has an interdisciplinary nature and its construction is based on the boundaries of natural and social sciences, determined by two fundamental aspects: the diversity of adaptation options and the possibility to access them (NORBERG *ET AL,* 2008). The first aspect refers to the system's capacity for innovation, creation and learning, while the second concerns the ability of self-organization. In socio-ecological systems, adaptive capacity is associated with aspects of governance that

1. Environment is understood in this study in a broader sense that considers natural, social, cultural, political, institutional and economic features.

allow rapid transitions between options, whenever responses to environmental changes are needed (HOLLING & MEFF, 1996).

The strengthening of institutions and organizational landscapes (social capital, legislation, information flows, availability of funds, learning capacity and accumulated knowledge) is essential for adaptation, by reducing vulnerabilities and preparing human systems to cope with environmental variations (EAKIN & LEMOS, 2010). In this context, the existence of other characteristic elements of good governance such as accountability is also favorable.

DIETZ *ET AL*(2003) suggest an adaptive governance that takes into account the following four elements: *i*) providing comprehensible information to decision-makers; *ii*) conflict management and compliance with rules, and legitimized norms by the actors involved in resource management - including the use of economic instruments that complement those of command and control; *iii*) availability of physical, social, institutional, and technological infrastructure; *iv*) institutional flexibility associated with the ability to learn and rethink rules and standards in accordance with environmental changes.

Therefore, the vulnerability of human systems to climate change will not depend only on the magnitude and frequency of current or future climatic stimuli, although these are determinant factors of vulnerability assessments. Strategies focused on improving social and economic conditions, as well as strengthening institutions, already are adaptive.

3 SMALLHOLDER FARMING IN BRAZIL

Populations associated with smallholder or subsistence farming have great vulnerability to climate change. The term smallholder farming has several interpretations and definitions in the literature (MORTON, 2007). For the purposes of this work, the definition will be determined based on the criteria adopted by the National Program for the Strengthening of Smallholder Farming (*Programa Nacional de Fortalecimento da Agricultura Familiar* - PRONAF) – managed by the Ministry of Agrarian Development (*Ministério do Desenvolvimento Agrário* - MDA) – the major funding program for the sector in Brazil.

The production chain of smallholder farming holds fundamental economic importance in Brazil, and is responsible for about 10% of the gross domestic product (GDP) (GUILHOTO, 2007). This economic sector has greater importance in some states and municipalities than in others. In the 2006 Brazilian Agricultural Census, there were 4,367,902 establishments considered smallholder farms, accounting for 84.4% of total farm properties in Brazil. However, this number represents only 24.3% of the area occupied by farm establishments in the country, revealing a large concentration of land in Brazil.

Another significant fact revealed in the census is that smallholder farming occupies 75% of the workforce in the agricultural sector (12.3 million), demonstrating the importance of the sector in employing rural labor. Furthermore, smallholder farmers are responsible for the production of the majority of the items in the consumer basket of Brazilian families, accounting respectively for 87%, 70% and 58% of the national production of cassava, beans and milk.

The creation, implementation and coordination of policy instruments that can strengthen the adaptive capacity of smallholder farmers are key processes in this context. However, the existence of a political-legal framework (i.e. legislation, plans, and lines of credit, among other examples) is on its own ineffective unless accompanied by a favorable political-institutional context (EAKIN & LEMOS, 2010; SMIT & WANDEL, 2006).

Credit lines from federal lending programs, for example, can be powerful tools in the adaptive process, if well-applied. It is necessary to find networks within which credit can flow from the source to concrete investments at a household or establishment level. Furthermore, it is important to mention that there are risks of undesirable outcomes, such as debts or inadequate allocation of resources, which can increase socio-economic vulnerabilities rather than diminish them (SMIT *ET AL,* 2006; HEAD, 2010).

The distribution of resources across the regions of Brazil suggests regional differences in the abilities of smallholder farmers and institutions involved in accessing funds, in particular the PRONAF. The public resources set aside for this program[2] has increased from $2 billion (2002) to more than $8 billion (2007) (DIEESE, 2008). However, its distribution was not uniform and some regions have benefited more than others from this line of credit (Table 1).

In the 2006-2007 agricultural year, 38% of this fund was destined to the Southern Region of Brazil. This region also received more funding for farm cooperatives in 2006 (Table 2), despite only representing 19% of smallholder establishments. This is due to the fact that small agricultural properties in the Southern Region had already established strong cooperative production systems in the past. The Southeastern Region also stands out by capturing 21% of PRONAF's resources and about 45% of the funding allocated for cooperatives in 2006.

The Northeastern Region, where the State of Ceará and the municipalities analyzed in this chapter are located, is located at the other extreme. Although the region contains 50% of all smallholder farming establishments, it only received 25% of PRONAF's resources (Table 1) and a mere 1.5% of resources allocated for cooperatives (table 2) during the 2006-2007 agricultural year.

TABLE 1
Number of agricultural establishments in smallholder agriculture, the amount of resources allocated by PRONAF - Brazil and Major Regions, 2006-2007

Brazil and large regions	Number of smallholder farming establishments		Resources from PRONAF (R$)	
	Absolute (R$)	%	Absolute	%
Brazil	4,367,902	100	8,424,000,000	100
North	413,1	9	822,000,000	10
Northeast	2,187,295	50	2,064,000,000	25
Southeast	699,978	16	1,808,000,000	21
South	849,997	19	3,160,000,000	38
Central-West	217,531	5	571,000,000	7

Source: Department of Statistics and Socioeconomic Studies (DIEESE, 2008).

TABLE 2
Funds to cooperatives - Brazil and Major Regions, 2006

Brazil and large regions	Funds to cooperatives (2006)	
	Absolute (R$)	%
Brazil	4,450,684,000	100
North	5,785,000	0.1
Northeast	67,786,000	1.5
Southeast	1,994,894,000	44.8
South	2,243,135,000	50.4
Central West	139,085,000	3.2

Source: Dieese (2008).

This raises a question: why is the allocation of resources not proportional to the size of the local population of smallholder farmers? In this paper we suggest that several factors related to the adaptive capacity (learning, knowledge and self-organization) are involved. Far from explaining them all, only a few factors are listed below and incorporated into the proposed system of indicators.

4 CASE STUDY: CEARÁ AND MUNICIPALITIES

It is possible to identify three main levels for assessing vulnerability and adaptive capacity of the smallholder farming sector to climate change. The first level is the agro-productive system, in which the family's survival relies on the quality of production. The second level adopts the perspective of the agricultural establishment, of the farmer and his family, analyzing the socio-economic and political-institutional fragilities focusing on the local scale. The third level analyzes the vulnerability of smallholder farms from the municipal perspective, jointly observing socioeconomic and institutional indicators of the establishments.

The Northeastern Region, and in particular the Semiarid Region, is known for its severe socioeconomic problems related to long periods of drought and dry season. The great drought of 1877-1879, for example, killed thousands of people in the State of Ceará and many other lives were lost in other parts of this region (LLEMOS *ET AL*, 2002).

The semiarid micro-region of Quixeramobim has a history of political manipulation and neglect of local organization of production. Composed of seven municipalities (Banabuiú, Boa Viagem, Choró, Ibaratema, Madalena, Quixadá e Quixeramobim), this micro-region is located in the area where the main economic activities (cattle and cotton) of the State of Ceará were developed until the early 1980's. Currently, these activities are no longer present in the region. Cotton processing factories were closed and abandoned due to declining yields attributed to a boll weevil plague – a beetle that feeds on cotton buds and flowers. Most of the cotton farmers and cattle ranchers moved to the Central-Western Region of the country, taking with them the economic resources and workers from this part of Ceará.

Currently, the principal municipalities of the semiarid micro-region of Quixeramobim mainly rely on income from the services sector and government transfers. Circa 15% of Quixeramobim municipality's GDP comes from agricultural activities and 62.71% from the service and public sectors. Quixadá, another municipality within the micro-region, follows the same economic trend: 12.69% of the GDP comes from agriculture and 78.53% from services (IBGE, 2010). The increasing vulnerability of the region is undeniable. The impacts of extreme weather events are being felt with increasing intensity and are causing severe economic losses (PALL *ET AL*, 2001). Climate variability generates instability, which goes beyond the local perspective. The climate, historical relations of political power and an increasing social protection network encourages migration to urban areas and thus exacerbating urban problems such as: urban overcrowding, labor market saturation, poor sanitation, poor land use and environmental impacts – e.g., increased garbage production and air pollution.

5 SYSTEM OF INDICATOR FOR VULNERABILITY ASSESSMENT

With the objective of assessing the vulnerability of smallholder farming to drought, a system of indicators is herein presented and discussed using the semiarid micro-region of Quixeramobim as a case study. Three attributes of vulnerability were defined: sensitivity (S), adaptive capacity (AC) and exposure (E). Consequently, relevant socioeconomic, institutional, and climate indicators were identified and distributed among the three attributes of vulnerability (Box 1). The 2006 Brazilian Agricultural Census provided the data source for sensitivity and adaptive capacity indicators, while information provided by the Ceará Foundation for Meteorology and Water Resources (*Fundação Cearense de Meteorologia e Recursos Hídricos* - Funceme) were used to analyze the exposure attributes. The institutional and socio-economic indicators are relative – percentages - to one of the following variables: the total number of agricultural establishments, the municipal population, or income of smallholder farms.

BOX 1
Aspects of vulnerability and socio-economic and institutional indicators considered

Vulnerability of smallholder farming	Attribute of Vulnerability	Indicator	Source
	Sensitivity (S)	Dependence of smallholder farm income on crop and animal production	Censo Agropecuário Brasileiro 2006 (Sidra – table 1.116 e 1.117)
		Municipal population engaged in smallholder agriculture	Censo Agropecuário Brasileiro 2006 (Sidra – table 1.113)
		Establishments with access to water	Censo Agropecuário Brasileiro 2006 (Sidra – table 1.442)
		Establishments with rainfed farming	Censo Agropecuário Brasileiro 2006 (Sidra – table 1.819)
	Adaptive capacity (AC)	Smallholder system product diversification	Censo Agropecuário Brasileiro 2006 (Sidra – table 949, 1.224, 1.226 e 1.227)
		Establishments in which the producer is the landowner	Censo Agropecuário Brasileiro 2006 (Sidra – table 1.109)
		Establishments in which the administrator can read and write	Censo Agropecuário Brasileiro 2006 (Sidra – table 1.101)
		Establishments in which the producer is a member of an association or union	Censo Agropecuário Brasileiro 2006 (Sidra – table 854)
		Establishments that receive technical assistance	Censo Agropecuário Brasileiro 2006 (Sidra – table 1.101)
		Agricultural establishments with access to electricity	Censo Agropecuário Brasileiro 2006 (Sidra – table 843)
	Exposure (E)	Aridity Index (AI)	Funceme, 2010
		Annual distribution of rainfall	Funceme, 2010

Source: preparation by the authors.

5.1 Climatic Exposure

The Northeastern Region has the lowest average annual rainfall in Brazil, less than 400 mm a year (INMET, 2010; CPTEC, 2010). The main environmental limitation to smallholder farming is water stress. Therefore, a large part of the smallholding farmers in this region practice rainfed, that is, unirrigated agriculture.

Climatic exposure reveals itself locally and it is specific to the scale of analysis. Since the objective of this study is to discuss a system of indicators to assess smallholder farming's vulnerability to drought, some climatological indicators were selected as a *proxy* for exposure. It is important to point out that potential changes in the variables due to climate change were not incorporated in this analysis due to uncertainties in relation to future local dynamics. However, general expectations point to a higher degree of aridity as global average temperatures rise during the twenty-first century (INPE, 2010; MARENGO, 2007).

The aridity index – one of the indicators used in this study – reflects the relationship between precipitation and potential evapotranspiration. When the index is larger or equal to 1, it indicates average precipitation equal to or greater than the potential evapotranspiration. In this case, the index is classified as humid. Values smaller than 1 indicate less precipitation than the rate of evapotranspiration, and represent – in a decreasing order of aridity – categories of moist sub-humid, dry sub-humid, semiarid and arid. The classification methodology follows UN recommendations, taking into account the historical average rainfall (1975-2002) and evapotranspiration of 119 stations with at least 20 years of data. In order to incorporate the AI in the exposure analysis, the categories were normalized between 0 and 1, attributing the value of 1 to the arid category (maximum exposure to drought on the adopted scale) and 0 for the moist category (minimum exposure to drought on the adopted scale). The remaining categories received intermediate values (sub-humid humid: 0.25; dry sub-humid: 0.5, semiarid: 0.75).

As a proxy for the temporal distribution of rainfall throughout the year, we used the average number of months of rain during the period of 12 months as a percentage. Next, the values were converted into their decimal form. The lower the number, the greater the water stress. The more temporally concentrated the rainy season, the smaller the flexibility for sowing and planting until the crop starts to develop successfully. This indicator complements the quantitative approach of the water balance implicit in the IA (table 3).

TABLE 3
Indicators of climatic exposure: aridity index and temporal rainfall distribution

Municipality	Aridity Index	Annual Distribution of Rainfall
Banabuiú	0.75	0.29
Boa Viagem	0.75	0.25
Choró	0.63	0.25
Ibaretama	0.5	0.33
Madalena	0.63	0.33
Quixadá	0.75	0.33
Quixeramobim	0.75	0.25

Source: adapted by the authors from FUNCEME, 2010.

The exposure indicators reveal three vulnerability groupings in the micro-region. The municipalities of Quixadá, Quixeramobim, Banabuiú and Boa Viagem are part of the group with higher climate exposure. Situated in the interior of the country, they present a high aridity index, with rainfall concentrated during only three months of the year. Choró and Madalena compose the second group, with similar aridity indexes and a four-month rainy seasons. The third, and last group, is in fact represented by only one municipality, Ibaretama, which is closer to the coast, and thus occupies a more humid area with a four-month rainfall period.

5.2 Sensitivity

There are some aspects of vulnerability that are inherent in the structure and intrinsic processes of socio-ecological systems. Agriculture is an emblematic case because the foundation for the activity is the agro-productive system, which is invariably dependent on environmental conditions such as temperature, nutrient availability and access to water. Given these features, it is naturally more susceptible to natural disturbances (drought, salinity, erosion and deforestation) than other economic sectors such as services and industry.

In this context, smallholder farming is a special case, since the importance of its maintenance involves not only food production, but also the maintenance of particular cultural and social practices (LEMOS *ET AL*, 2002). At the same time, people involved in smallholder farming have limited access to financial and human resources, and manufacturing infrastructure, making its adaptive capacity smaller than that of corporate farming (with better access to funding and manufacturing infrastructure).

From this perspective, a public manager may perceive agriculture as an activity that increases local vulnerability, preferring to prioritize the expansion of other activities with greater added value and less dependence on environmental variations. However, in this study, the strategy of reducing the importance of smallholder agriculture in local economic dynamics will not be considered as an alternative to reduce local vulnerability to climate change. Instead, we assume that this type of agriculture should be promoted and strengthened, in spite of its natural sensitivity to climate conditions. In order to achieve this, a key step is to identify and measure important aspects of the agricultural sector related to smallholder farming.

The proportion of the population employed in smallholder farming is a good indicator of sensitivity, since it shows the size of the municipal population whose income depends directly on agricultural systems influenced by climate conditions. In the municipalities of the semiarid micro-region of Quixeramobim, most of the workforce is engaged in smallholder agriculture. This feature stresses the proportion of the population whose livelihoods and economic activities are exposed to extreme weather conditions. Indirectly, social and economic networks established by smallholder farmers are also affected.

TABLE 4
Sensitivity indicators
(In %)

Brazil/state/ micro-region/ municipality	Population employed in smallholder farming	Participation of crop and livestock production in the income of smallholder farming	Establishments with rainfed farming	Index of access to water for human consumption
Brasil	7	75	94	0.57
Ceará	12	70	93	0.47
MRSQ*	24	53	96	0.58
Banabuiú	21	55	91	0.67
Boa Viagem	34	53	98	0.73
Choró	38	31	97	0.57
Ibaretama	24	54	96	0.61
Madalena	29	92	99	0.42
Quixadá	15	50	96	0.43
Quixeramobim	23	47	95	0.51

Source: Censo Agropecuário Brasileiro 2006/IBGE.
*Semiarid micro-region of Quixeramobim.

The second indicator adopted shows the percentage of income from smallholder farming that is directly related to plant and animal production. The more dependent the family's income is on these products, the more sensitive they are to extreme climate events and climate variability. Finally, the last two sensitivity indicators refer to access to water for human consumption and agricultural use. Rainfed (unirrigated) agriculture and human populations whose water supply is limited are considered more susceptible to severe drought. Thus, the proportion of farms with rainfed agriculture and agricultural establishments without wells and/or water tanks were used as *proxy*.

5.3 Adaptive capacity

Some of the aspects of sensitivity are likely to be moderated, since they are determined directly by the internal process of socio-ecological systems. However, this moderation ability depends on the quality of systems to act preventively and react satisfactorily to a climate disturbance. Diversification of production is an interesting strategy to dilute risk in extreme settings with high rates of environmental variation. The larger the number of production activities practiced in an agricultural establishment, the greater is its adaptive capacity. Therefore, an indicator of agricultural diversification was constructed. To do so, we selected the most common production activities in the region. For agricultural production, we considered the cowpea bean and black-eyed bean, cassava and corn. And for livestock farming, we considered chickens, goats, and cattle.

The diversity of crops and livestock represents the range of ecological strategies for maintaining production in face of climate oscillations. The cowpea bean, for example, is well-adapted to the semi-arid climate, considering an average annual rainfall quota of 250 to 500 mm a suitable amount for cultivation (EMBRAPA, 2010). On the other hand, corn yields, an important crop for smallholder farming in Ceará, have been substantially affected during El Niño years, when drought conditions were more severe in the Semiarid regions (SUN *ET AL*, 2007).

Another important aspect of adaptive capacity is the legal ownership of land. Evidence of property rights is an important aspect in accessing credit sources, such as PRONAF. Although not mandatory, the presentation of an ownership title accelerates the process of obtaining public credit, as well as serving as collateral for private loans. In Brazil, 37% of smallholder farmers declared that they were not the landowners. In Ceará, this percentage reached 67% of all producers. In this regard, there is a large diversity among the municipalities in the semiarid micro-region of Quixeramobim. While in Ibaretama 42% of smallholder farmers do not own the land where they work, in Quixadá this percentage reaches 72%.

TABLE 5
Indicators of adaptive capacity
(In %)

Brazil/state/ micro-region/ municipality	Number of smallholder farmers who are landowners	Managers of the agricultural establishment who can read and write	Establishments that receive technical assistance from cooperatives or government	Diversification of the smallholder production Index	Establishments with access to electricity	Establishments whose managers participate in associations and cooperatives
Brasil	63	75	14	0.26	93	16
Ceará	43	56	10	0.31	89	2
MRSQ*	34	57	13	0.37	82	2
Banabuiú	40	58	5	0.41	87	0

(continues)

(continued)

Brazil/state/ micro-region/ municipality	Number of smallholder farmers who are landowners	Managers of the agricultural establishment who can read and write	Establishments that receive technical assistance from cooperatives or government	Diversification of the smallholder production Index	Establishments with access to electricity	Establishments whose managers participate in associations and cooperatives
Boa Viagem	34	51	5	0.38	86	1
Choró	28	59	3	0.46	72	0
Ibaretama	58	61	3	0.39	97	12
Madalena	32	59	23	0.36	95	0
Quixadá	28	53	17	0.35	71	6
Quixeramobim	36	52	20	0.35	83	0

Source: Censo Agropecuário Brasileiro 2006/IBGE.
*Semiarid micro-region of Quixeramobim.

Moreover, the adaptive capacity of smallholder agriculture depends largely on two factors: a) the capacity of producers and their families to be collectively organized and access key information, b) having financial and human resources to implement adaptive strategies. Thus, the institutional context to which smallholder farmers belong is crucial.

As mentioned above, access to public policies aimed at smallholder farming depends on a number of requirements. Access to credit, for example, often require the presentation of a proposal issued by the State Agency of Technical Assistance and Rural Extension. Isolated families (not frequently visited by these agencies) tend to have more difficulties in obtaining access to credit. Technical assistance in the semiarid region of Brazil faces difficulties that are important to point out. There is often a lack in methodological renewal, insufficient numbers of qualified staff, and weak institutions.

According to the data presented in Table 5, about 10% of the agricultural establishments in the State of Ceará received technical assistance from cooperatives or from the government. This percentage is below the national average of 13.9%. Among the municipalities considered in this case study, Quixadá, Madalena, and Quixeramobim had the best performance with 17%, 23% and 20%, respectively, of establishments aided by technical assistance. The other municipalities presented performance below the average measured in Brazil and in Ceará, ranging between 3% and 5% of establishments aided by technical assistance.

Furthermore, skills and collective and individual characteristics related to access to information and resources also contribute to the enhancement of the adaptive capacity of individuals and local social systems. Knowing how to read and write is essential for an independent producer to get access to information available in print and/or electronic media in order to empower himself/herself to exercise his/her citizenship rights, which can consequentially lead to climate change adaptation.

Cooperativism and associativism are relevant because they are both related to access to public policies, and to achieving large-scale production to enter the market. Participation in associations, cooperatives, and unions such as syndicates of rural workers, and fishermen's associations, plays a key role in getting access to social benefits such as pensions and agricultural insurance. This also reflects the formation of social networks based on ties of solidarity, which is fundamental in the process of physical and psychological resistance, and recovery during, and after weather catastrophes.

In Brazil, 16% of farms have at least one person linked with cooperatives or associations, but in the State of Ceará this proportion is substantially lower (2%). A similar situation persists in municipalities in the semiarid micro-region of Quixeramobim. In 2006, none of the farms in Banabuiú, Quixeramobim, Madalena, and Choró had at least one person related to cooperatives or associations. In Ibaretama, however, 12% of establishments had at least one person participating in cooperatives or associations.

Access to electricity is another important aspect that contributes to the adaptation of smallholder agriculture to drought. Not only does electricity allow the producer to refrigerate and stock food in times of shortages, but it is also essential in various stages of food processing, a limiting factor in adding value to items produced by smallholder farmers. Furthermore, access to media such as television, radio and telephone is also limited by the lack of electricity. Even though federal programs of rural electrification (*Luz no Campo and Luz para Todos*) have invested in expanding the distribution of electricity in rural areas over the past two decades, a significant portion of the population have no access to energy in their agricultural establishments.

In Brazil, 93% of farms had electricity in 2006, but in the State of Ceará this value is slightly lower (89%). Among the municipalities in the semiarid micro-region of Quixeramobim, a different situation is revealed. In Ibaretama and Madalena over 95% of the establishments have access to electricity, in Choró and Quixadá only 70% of the properties were provided with electric power.

6 FINAL CONSIDERATIONS

This study sought to discuss a set of indicators to assess the vulnerability of smallholder farming to drought in the Brazilian Semiarid Region, in order to contribute to the discussion on integrated indicators assessment systems. This kind of system contributes to operationalize complex concepts such as vulnerability and provide tools to support decision making. This scientific effort is notable for showing that, in addition to the climate determinants, vulnerability is also influenced by socioeconomic and political-institutional drivers. Building adaptive capacity by improving socioeconomic conditions and strengthening formal and informal institutions is a key strategy in reducing local vulnerabilities.

However, the availability of resources, the existence of good socioeconomic conditions and a favorable political and institutional context for adaptation are insufficient to reduce the vulnerabilities of smallholder farming. Individual and collective characteristics specific to each smallholder and community, are also fundamental – that is: proactive and planned attitudes within the scale of the establishment; social capital within the community and/or cooperatives, and quality channels of communication through which information reaches the smallholder farmer. These qualitative aspects are more difficult to measure given the subjective evaluation criteria. This is one of the limitations of top-down approaches. Considering that the materialization of the adaptation will take place on a local scale, a more consistent diagnosis of vulnerability requires primary data collection in communities (*bottom-up* approach).

The political-institutional framework in Brazil is ready to help smallholder farmers to adapt to climate change. The challenge is to understand the local context in a transverse and multidimensional manner, mainstreaming adaptation to climate change into development planning and policies. The effective inclusion of this issue in the agenda of discussions and priorities at the different levels and scales of government is necessary. Another challenge is the formation and strengthening of research and innovation networks. In this sense, the promotion of dialogue between institutions and researchers that work on related topics is an important aspect to build complementarity between studies and research, as well as to further collective advances through the exchange of experiences and results.

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PART II

BRAZIL AND THE INTERNATIONAL CLIMATE CHANGE REGIME

CHAPTER 14

COST-BENEFIT ANALYSES OF CLIMATE CHANGE

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1 INTRODUCTION

The average global temperature is already about 1ºC above pre-industrial levels and climate change is already being felt through more intense and frequent droughts and floods. The Intergovernmental Panel on Climate Change (IPCC) established in its fourth report that in order to achieve a stabilization at between 2°C and 2.4ºC above pre-industrial levels, emissions should be reduced by between 50% to 85 % by 2050, compared to 2007 (IEA 2008, IPCC, 2007). The predicted scenarios resulting from the stabilization at 3ºC above pre-industrial levels are a lot worse than the ones for 2°C in terms of water stress, loss of biodiversity, disappearance of coral reefs, reduction of agricultural productivity, ocean acidification, droughts, floods, hurricanes and rising sea levels (Houghton, 2009). To stabilize temperatures at 2ºC above pre-industrial levels the concentration of greenhouse gases (GHG) in the atmosphere should be below 450 parts per million (PPM) of carbon dioxide equivalent (CO_2e), and there is still some 50% uncertainty about whether this concentration would be enough to keep warming at 2°C (HOUGHTON, 2009).

The United Nations Environment Program (UNEP) estimated emissions reduction patterns which would be consistent with a probable chance of limiting global temperature increase to 2ºC. This pattern includes a 50 % - 60% reduction by 2050 compared with 1990 levels, with a future downward trajectory that is even more drastic (UNEP, 2010). This means that mitigation efforts will be enormous and will require investments to enable a radical transformation of production structures and consumption behavior, with significant renovation of the capital stock and its technological content.

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This effort may require immediate action, because there is climate inertia at several levels. First, as GHGs have residence times in the atmosphere ranging from years to millennia, there is a delay between emissions reductions and reductions in the GHG concentration in the atmosphere[1]. Second, there is another delay between the stabilization of GHG concentration and temperature stabilization, especially in the oceans. Third, sea levels also respond with delay to changes in temperature.

From an economic and social perspective, there is also inertia. As the maturation time of investments in infrastructure generally involves decades, investments made today may constrain the development of a country to carbon-intensive technologies. Investments in infrastructure and urban structures, for example, have medium-term impacts on emissions of related sectors. This is the case, for example, of the construction of coal-fired power plants or transportation systems (DIETZ; MADDISON, 2009).

Climate change can cause substantial economic damage, particularly to infrastructure and to agricultural activities, by affecting ecosystem services which are essential to human life and to the economy, such as the regulation of hydrological flows and rainfall patterns. A one meter sea level rise by the end of this century would endanger the lives of 60 million people and $200 billion in assets in developing countries (WORLD BANK, 2009a). Even assuming an increase of only 2ºC, some estimates imply that between 100 and 400 million people could starve (EASTERLING *ET AL.,* 2007) and between 1 and 2 billion people may no longer have access to enough water for survival (IPCC, 2007).

On the one hand, the accumulation of GHGs in the atmosphere is mainly related to the development process of rich countries. Today, rich countries contain a sixth of the world population, but account for two thirds of current GHG emissions (WORLD BANK, 2009a). On the other hand, developing countries that have a small historical contribution to current GHG concentrations in the atmosphere are the ones that will suffer the worst damages. Some estimates indicate that these countries should bear 75% to 80% of losses (WORLD BANK, 2009a). This is due to various characteristics of developing countries, such as a high economic dependence on ecosystem services due to the importance of agriculture and mining in the economy, populations that are more exposed to risk and with vulnerable economic conditions, and low economic and institutional capacity to deal with the problems. It was estimated that a 2ºC warming could lead to losses of around 4%-5% of gross domestic product (GDP) in countries in Africa and South Asia and only a minimal GDP loss in rich countries, leading to overall global losses of about 1% (NORDHAUS, 2007; STERN, 2007, YOHE

1. Roughly speaking, the permanence of CO_2 in the atmosphere is considered one century.

ET AL.,2007). Thus, the absence of an adequate response to the problem deepens the social and economic gap between rich and poor.

A strategy to avoid dangerous climate change, according to all studies reviewed, will involve significant amounts of resources, both for mitigation and adaptation. Therefore, the current debate is centered on the time-line of mitigation and adaptation strategies, namely: where and when mitigation and adaptation actions should be taken and with what priority. By comparing the costs of action to mitigate climate change and the possible costs of inaction, one can derive the adequate mix of consumption and investment flows to adaptation and mitigation. This will be key to allow policy makers to design adequate policies. It must be clear to them that there is a trade-off between investing less in mitigation and adaptation now and in the future: investing less in adaptation now will require more investment in adaptation in the future and the acceptance of larger climate impacts, some of which could be harmful or unpredictable.

It is clear in the current debate that, in order to avoid dangerous climate change, on the one hand, rich countries can and must reduce the carbon intensity of their economies. On the other hand, developing countries, that still have unmet consumption needs, should pursue a more sustainable growth path. Of course, the change in the development paths of these countries should be specific to national circumstances, and will depend on the extent of financial and technology transfer from developed countries.

Investing in mitigation and technology transfers to developing countries are strategies that not only promote equity - in line with the objectives of the United Nations Framework Convention on Climate Change (UNFCCC) - but also make economic sense from a global perspective, since many mitigation actions in these countries are of low cost.[2]

Moreover, there are mitigation opportunities that do not harm economic growth, but are not implemented due to market failures such as high costs of access to information or lack of credit for the initial investment, not to mention barriers related to specific local business norms that can prevent the diffusion of more efficient technologies. Thus many mitigation opportunities may be implemented without adversely affecting economic growth and various markets are even expected to become more dynamic in the context of climate change. Moreover, many mitigation actions have several co-benefits. This is the case of strategies to reduce emissions from forest deforestation and degradation (REDD), that protect local biodiversity (WORLD BANK 2009a, UNEP, 2011), or the

2. In these countries, there are still mitigation options with negative costs that were not yet internalized due to lack of appropriate financing or technological barriers.

substitution of diesel or gasoline through ethanol or electric cars, that reduce public health costs due to the reduction of local pollution.

In light of this major global problem and the need for decisions to be taken to address it, economic science has developed models that attempt to quantify the difference between the cost of mitigation actions (and its benefits in terms of avoided negative impacts) and the costs of inaction, with the aim of calculating the optimal mitigation strategy from an economic perspective. However, modeling and valuing impacts and comparing them with mitigation costs is not free of controversy.

Several studies have been conducted using a range of different methodologies and databases and the lack of convergence of their results reflects the uncertainty that still exists in cost-benefit analyses on climate change. This uncertainty is also reflected in discussions on the national and the international political arenas regarding the regulation of greenhouse gas emissions. This chapter attempts to summarize this debate and its major controversies. Section 2 presents the rationality behind the pioneering models and reviews their main results, which tend to propose a more gradual mitigation path. Then, in section 3 we discuss the Stern Report, which raised severe criticisms of previous work and supported more intense immediate action. Section 4 reviews the discussion that followed the Stern Report, pointing out the major criticisms of its assumptions and the impact that this discussion had for the future development of economic studies on climate change. In the final remarks we conclude the chapter with some analysis of the challenges that climate change economics faces today and its relationship to policy recommendations.

2 THE ECONOMICS OF CLIMATE CHANGE

Climate change is considered one of the negative externalities that is most difficult to handle because it is more complex and uncertain than most other externalities analyzed in economic theory. Its causes and its possible consequences are related to almost all economic activities and affect all people, countries, ecosystems and biodiversity. The uncertainties about the possible consequences of climate change are so great, and the time horizon over which current emissions will be relevant are so long, that the usual tools for decision-making under uncertainty may not be appropriate (DIETZ; MADDINSON, 2009; TOL, 2009). In this context, modeling and comparing the risks and uncertainties related to climate change have been one of the biggest challenges faced by economists in recent times. Their analysis aims to offer policy recommendations to decision-makers and to society as a whole in order to avoid dangerous climate change (WEITZMAN, 2007).

Cost-benefit analysis of investments in climate change mitigation or adaptation actions necessarily begin with the establishment of assumptions about future emissions, the pattern of warming expected from these and about the behavior of other variables in light of temperature changes - level sea, for example –of changes in the concentration of greenhouse gases - ocean acidification and increased photosynthesis, for example - and the indirect effects of these factors, such as changes in ecosystem evapotranspiration.[3,4] Then, the models try to translate into economic terms the consequences provided by the climatic models. The decisions about the most efficient pattern of emissions reductions is based on the equalization of the marginal cost of lowering consumption based on the need of reducing emissions and the marginal benefit of less climatic risks - all that in present values.

The economic models that form the basis of these climate change cost-benefit analyses are based on standard economic growth theory. They intend to be simple enough to be mathematically tractable. Their basic framework is: to maximize social welfare, calculated as the sum of the utility of all individuals in all periods of time (using the present value of some measure of income or consumption calculated based on any discount rate defined), subject to the projected climate conditions (weighted by the probability of each). For practical reasons, the utility of all individuals of each region is aggregated into a single representative individual in each one and multiplied by the population of the region. Each model usually includes a few regions in the world (between 10 and 20). The representative individuals live for hundreds of years or even forever. Their welfare depends exclusively on their aggregate consumption of goods and services[5] (DIETZ; MADDISON, 2009). As outcomes, the models predict investment and emissions growth patterns that maximize the social welfare function. That is, they try to find investment and consumption patterns that, considering the present and future costs and benefits,– brought to their present value by a discount rate – provide the greatest possible welfare for individuals.

Considering that public policies are able to change future consumption patterns, future emission paths, expected gas concentrations and impacts compared to a business as usual scenario (BAU) (scenario without mitigation and thus a baseline for comparisons), different policies - and lack thereof - can be compared using a social welfare function that is able to rank the resulting welfare from each scenario. These assessments are made using integrated assessment models (IAM), which are computer simulation models of multiple equations that combine

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3. Sum of surface evaporation and transpiration by vegetation. This concept is important to understanding the dissipation of heat and humidity transfer between ecosystems and the atmosphere, for example, in cloud formation.

4. In addition to greenhouse gases, climate models currently used by the IPCC - available at: <www.ipcc.ch> - also consider emissions of aerosols (particles that reflect the incident light or interfere in the formation and cloud condensation) or alteration of albedo (characteristic of surfaces to reflect incident sunlight), due to changes in areas covered with snow, ice or forests, for example, or even the impact of cloud reflections, reportedly a key source of uncertainty in the 4th Assessment Report of IPCC.

5. Income and consumption of goods and services that include physical, social and environmental aspects – in some cases. Note that when using measures of income or consumption, models are indirectly also measuring employment.

dynamic economic relations with the dynamics of the geophysical environment to analyze the economic effects of climate change (WEITZMAN , 2007).

There are different approaches regarding the identification and measurement of costs and benefits of policies to mitigate emissions. These differences arise due to the different normative assumptions made concerning, for instance, national interests, economic behavior patterns, risk aversion degrees, as well as the type of scientific data used, modeling strategies used and predictions about future learning curves (NORDHAUS, 2007). As will be discussed in more detail below, the discount rate chosen also has a major impact on each model's results. The higher the assumed discount rate, the greater the individual preference for present consumption at the expense of future consumption. Thus policy recommendations of a model with a high discount rate tend to support higher present consumption and the postponement of investment in mitigation and adaptation.

Tol (2009) compiles the results of most recently published papers by authors of mainstream climate change economics and searches patterns and consensus among them. In common, most revised models assume a doubling of GHG concentration levels and a temperature increase concentrated in the second half of the twentieth century.

The first consensus identified is that the negative impact on well-being related to the doubling of GHG concentrations in the atmosphere is relatively small - a few percentage points of GDP. However, Tol (2009) states that the costs are not negligible and that, as losses would affect the economies forever, efforts to avoid these costs would be justified. The second consensus among the reviewed authors is that there would be small short-term economic gains – up to the middle of the century, due to temperature increases between 1°C and 2°C - followed by substantial losses in the long term. These benefits would be concentrated in the temperate zone, where most of the world's GDP is found, and are largely related to reductions in heating costs and reduced cold-related illnesses. According to the author, in the short term gains in these rich areas exceed the losses in the poorest areas, which will be mostly adversely affected.[6] It is important to note how this view differs from the opinion of most of the media, general public and climate change negotiators, as will be discussed later.

6. Many of the assumptions made by authors who came to these conclusions are controversial and criticized by many others. Some assume a large reduction in mortality due to the warming of cold areas. This would represent a large gain, as there are authors who derive life value from per capita income. Thus, many consider this assumption morally offensive, because life in a rich country is worth more than in poor countries (ACKERMAN, STANTON, 2010). In the case of environmental goods and services, for example, many models assume that these are perfectly substitutable by man-made goods and services and also that their relative prices are constant. Sterner and Persson (2008) show that relative prices of environmental goods and services should rise as their availability is reduced by climate change. And, as already implied by Daly (1977) and Perrings *et al*. (1995), natural capital substitutability can be limited by some minimum inventory level that is necessary to create capital. The problem that still exists is how to formally incorporate the degree of substitutability in models.

The third identified consensus is that adverse impacts of climate change will be concentrated in the poorest regions. Finally, the author highlights that there is a consensus that the uncertainty level of predicted impacts, in particular the most extreme, is very high. Tol (2009) points out however that it is much easier to imagine a disastrous scenario than a great economic boom due to climate change. Therefore, uncertainty should be well-modeled to reflect this bias on its probability distribution, so that policy recommendations also reflect it.

Despite some variation in the results among mainstream studies and the controversy over some of the assumptions, overall conclusions have proved to be consistent and robust, and common to several modeling strategies, namely that the optimal emissions reduction pattern would be a modest decrease in the short term, with greater reductions in the medium and long terms. This approach became known as the "climate ramp" or the gradualist approach (NORDHAUS, 2007).

Based on studies focused on the total costs of mitigation, adaptation and inaction, one can calculate the social cost of carbon (SCC), which is the net present value of the marginal cost generated by one unit of GHG emissions. From the point of view of possible public policies, this value would be equal to a tax rate that would internalize the social costs of emissions in the economy and lead society to adopt the emissions reduction trajectory that maximizes welfare.[7] According to Tol (2009), there are over 200 SCC estimates that are based on nine estimates of the total cost of carbon.

The discount rate used is still the largest source of variation among different SCC estimates. Other important factors behind the differences are population growth and emissions projections, the specification of cost functions, the way regional effects are aggregated and the way uncertainty is modeled (TOL, 2009).

Tol (2009) concluded that economists do not yet have enough knowledge to say with certainty whether the proposed spending to combat climate change is economically justifiable. Evidence of this great uncertainty is that the overall average of the SCC estimates is USD 105/tC, while the median is USD 29/tC and the mode USD13/tC.

3 THE STERN REPORT

The greatest effort to overcome the high degree of variability among different studies and remove the caveats of the pioneering research was a paper commissioned by the British Government to analyze the state of the knowledge on the economics of climate change. The Stern Review (STERN, 2007) as it became known,

7. Known in economic literature as Pigouvian tax. See, for example, Seroa da Motta (2006).

received major attention in the media and has been used by several stakeholders in the climate change arena to argue that it would be economically rational to strengthen immediate mitigation and adaptation.

The Stern Report made a comprehensive literature review on the environmental and physical impacts of climate change and developed an integrated assessment model (IAM) aimed at estimating an optimal carbon price.

Like other studies, the paper follows the traditional cost-benefit analysis methodology comparing the costs of mitigating with the costs and risks of inaction and recommends that some kind of restriction on GHG emissions should be established. Stern (2007) thoroughly describes the damages that may occur due to GHG concentration and temperature increases, and also how damages will be concentrated in the poorest regions, e.g. drastic reductions in agricultural crop yields in Africa. He also illustrates the potential damage by providing data on environmental problems such as loss of biodiversity due to expected global warming.

His greatest contribution, however, is to go beyond the typical analysis of mean events that will occur with large probabilities and to explicitly consider the risk of occurrence of extreme or catastrophic events, which have low probability of occurring, but that could produce devastating effects, such as the melting of polar ice caps.

Thus, the study seeks to convince the reader of the problems related to the issue before entering into more formal economic analysis. The research emphasizes the central role that the precautionary principle should have, arguing that we should "buy an insurance" against possible natural disasters as soon as possible, thus opposing what had been supported by previous studies recommending a gradualist approach based on analysis of the most likely expected costs and benefits.

Using an IAM based on PAGE 2002, Stern (2007) also criticizes previous models because they use very high discount rates and presents a long discussion about moral and ethical arguments that led him to choose a lower discount rate. Overall, the report argues that it would be unethical to consider the welfare of future generations less important than that of the present generation.

The Stern Review has gained extensive notoriety because it reaches conclusions that differ from most of the previous economic literature, among other reasons. Not only are its conclusions and policy recommendations distinct, but they are also more in line with those propagated by the majority of NGOs, environmental groups and countries that support more ambitious actions to avoid dangerous climate change.

Stern (2007) clearly states that all analysis of his study lead to the unequivocal conclusion that the benefits of ambitious and immediate action to combat climate change outweigh its costs. This is at odds with previous economic literature which recommends a more gradual approach. The report states that if the world continues in the BAU scenario, there may be disruptions in economic activities in the second half of this century which could be of a similar magnitude to the world wars and the economic crisis of 1929. So, taking immediate action would also be a strategy to foster economic growth and welfare in the long run.

The report also emphasizes that the sooner actions are taken, the lower their costs are and the greater their advantages. It also states that, given that climate change is already a reality, actions to promote adaptation are also essential. Moreover, the report emphasizes the trade-off between more mitigation now and more adaptation in the future.

The central conclusions are that: if society does not act quickly enough, the costs and risks of climate change are likely to be equivalent to a 5% loss in global GDP each year, now and forever. Going even further, the report lists other factors that if considered together in the analysis, may increase this percentage to 20%. Among these are: direct impacts on the environment, ecosystem services and human health, possible feedback effects on various phenomena and special weighting between the various regions to put more weight on losses in poor regions, since the impact on these is disproportionately higher because of their greater vulnerability to climate change (STERN, 2007).

In order to estimate mitigation costs, Stern (2007) uses both: a bottom-up approach based on sector costs and a computable general equilibrium (CGE) model. Both analyses indicate a mitigation cost of about 1% of global GDP per year until 2050. That is, mitigation costs would be much lower than the costs of inaction (5-20%), which underpins the recommendations for immediate and strong action to combat climate change.[8]

4 THE IMPACTS OF THE STERN REPORT

Given that the Stern Report – even using basically the same data and the same analytical framework – reached different conclusions and policy recommendations, it has raised criticisms from several scholars. Among the main criticisms are those made by Nordhaus (2007) and Weitzman (2007).

These critics of Stern (2007) also point out the good qualities of the report. Nordhaus (2007) for example highlights the importance of the Stern Review to show the world that climate change policies must be designed considering economic and

8. In Margulis, Dubeux and Marcovitch (2010), a group of Brazilian scientists and institutions, based on the Stern Report, estimate adaptation costs in various sectors of the economy in a BAU scenario for 2050. In line with Tourinho, Seroa da Motta and Alves (2003), they also estimate the macroeconomic effects of carbon taxes and show that negative effects would be concentrated in specific sectors.

environmental aspects simultaneously. Moreover, he compliments the report for emphasizing the need for a carbon price in order for actors to internalize the externality generated by GHG emissions in their consumption and investment decisions.

Weitzman (2007) states that another merit of the Stern Review is in the intuitive argumentation that it is important to explicitly consider the uncertainties of rare and extreme climate disasters that are potentially disastrous and difficult to quantify. This, according to the author, could justify the study's methodological choices. In addition, the report praises the author for recognizing the importance of adaptation actions, in addition to mitigation, and for making the cost-benefit analysis popular among non-economists.

There are several factors that explain the difference in the results of Stern (2007) in comparison with other studies that preceded it, but at least two gained greater prominence in the literature. First, several authors classify the text as a political text, not an academic text. Therefore, it does not necessarily reflect existing literature in a balanced way, but rather it prioritizes papers in line with its intended policy recommendations (NORDHAUS, 2007; WEITZMAN, 2007). These critical authors argue that Stern would have used only studies that calculated low mitigation costs and high climate change damage costs.

Second, and most prominently, is the criticism that the results crucially depend on the assumption of a very low discount rate and a very specific welfare function.[9]

Theoretically, the discount rate is composed by one component that reflects the pure time preference that individuals have because of their finiteness and another one specifically related to individuals expectations of future consumption. Stern (2007) equals the pure time preference component of the discount rate to 0 arguing for ethical inter-generational equity[10] and also estimates a very low opportunity cost of future consumption (1.4%). By using this very low discount rate, the author thus places a heavy weight on future generations compared to the present. The difference in the results caused by the choice of discount rate is drastic. For example, a loss occurring 100 years from now, discounted to its present value by 6%, as suggested by authors such as Nordhaus (2007), is 100 times smaller than if discounted at Stern's rate (1.4%).[11]

9. In this case, the difference is how to treat the elasticity of consumption. The literature always considers an elasticity greater than 1 to internalize that consumption has diminishing marginal utility. Stern (2007) chooses an elasticity equal to one. In this case, any consumption variation brings the same marginal utility.

10. It uses arguments from distributive justice ethical theory from John Rawls' seminal work. Nordhaus (2007) notes that this approach is not a consensus among philosophers, economists and politicians. In contrast, other ethical principles would lead to very different statements.

11. We may aggregate the positions of those who adopt a strategy described by using the market interest rates to drive efficiency in investment decisions in time, as in Nordhaus (2007) and those who use a more normative approach with parameters based on ethical principles to ensure a "fair" allocation of resources between the generations, as in Stern (2007).

Dasgupta (2006) also criticizes Stern's choice for the two components of the discount rate. He emphasizes that the choice of the second component would theoretically lead to very high levels of savings that have never been observed in history.

To support his criticisms of the Stern Review, Nordhaus (2007) estimates the optimal SCC using the DICE-2007 model - which is different from that used by Stern (2007) (the PAGE 2002 model) – using the same discount rate and welfare function as Stern (2007). His results are very similar to those of Stern, which leads the author to conclude that Stern's results depend very strongly on these two assumptions. The author also asserts that the policy recommendations of the report "will not survive the substitution of assumptions that are more consistent with the real interest rates and savings rates in today's marketplace".

Moreover, he argues that if we take the world per capita GDP growth rate used by Stern (2007) and project the future world per capita GDP, we will see it increase from the current USD 10,000 to USD 130,000 in two centuries. The author then raises the question of how ethical it would be to reduce our consumption now to improve the welfare of future generations. With a discount rate close to 0, as Stern (2007) used, "uncertain" losses that may occur hundred years hence, in present values, become large in terms of today's per capita consumption (NORDHAUS, 2007).

On the other hand, Weitzman (2007) argues that the discount rate used by Stern (2007) may not be so wrong. According to him, uncertainty about the discount rate is not considered in most models. By incorporating uncertainty about which discount rate to use given that we do not know which sectors will be more affected and which risk level to use, his results lead to the adoption of an intermediate rate between Stern's 1.4% and other authors' 6% to 7% of between 2% and 4%. This could lead to an intermedite sense of urgency. The author points out however that despite disagreeing with Stern's assumptions, he actually does not know which rate should be assumed. He even says that "it is not an exaggeration to say that the biggest uncertainty of all in the economics of climate change is the uncertainty about which interest rate to use for discounting".

In a recent paper, Acemoglu *et al.* (2009), argue that Stern (2007) and other models do not capture the technological development process that takes place through innovations. That is, they do not consider the effects that technological changes may have over time, or, in other words, they do not consider technology to be an endogenous factor in their models. Technological changes may be, for example, induced by a carbon tax or by subsidies on clean technologies. If the models were able to capture this, mitigation costs would probably be reduced after a certain period, decreasing the influence of the discount rate on model results.

The World Bank (2009a) recently reviewed several models on climate change economics. The vast majority of these agree that the BAU scenario would be disastrous. Their main results predict that costs of inaction are greater than mitigation costs for a 2.5ºC temperature increase but the same consensus cannot be observed for a 2°C temperature increase. Authors in line with the "climate ramp" typically conclude that the optimal temperature increase in terms of cost-benefit could be greater than 3ºC, unlike the 2ºC objective pursued by the UNFCCC.[12]

According to the World Bank (2009a), we can divide the estimated costs of avoiding dangerous climate change into two groups depending on the time horizon considered - medium and long terms. Most mitigation costs estimates for the medium term adopt the assumption that mitigation will be done where and when it is the cheapest. This would entail spreading mitigation investments across various countries and sectors fast enough to avoid future emissions. In reality, this kind of attitude depends on a global agreement. If countries do not establish such cooperation, mitigation costs may be considerably higher than estimated.

For long-term analysis, models reviewed by the World Bank (2009a) estimate that annual mitigation costs by 2100 could be between 0.3% and 0.7% of global GDP and 0.5% to 1.2% of developing countries' GDP. In terms of adaptation, although there are fewer available studies and their comparability is low, adaptation investment needs in developing countries will be between USD 75 and USD 100 billion annually (WORLD BANK, 2009b).

In addition to total estimated mitigation and adaptation costs, it is necessary to calculate how high upfront investments would be. The funding needed is typically larger than total costs, since many of the upfront investments generate savings in operational terms - such as fuel - that will take place in the future. Therefore, additional problems are imposed on governments and companies. McKinsey & Company (2009) estimated developing countries' financing needs by 2030 at USD 563 billion - much higher than their mitigation costs estimates of USD175 billion. This investment need, although high, would represent only 3% of total BAU investments and would be feasible for world financial markets (WORLD BANK, 2009b).

In this context, creating financial instruments that separate the one who pays from where emissions are effectively reduced is essential to generate economic efficiency. If not, lots of mitigation opportunities in developing countries (65% to 70%) may not take place by 2030 (WORLD BANK, 2009a). A stream of

12. Hof, Den Elzen and van Vuuren (2008) show that, using the same models that recommend 3°C, the extra cost of achieving 2°C instead of 3°C is only 0.5% of world GDP per year. Choosing this additional investment to avoid further disasters would be like buying an "environmental insurance" in order to move from the economic optimum to what natural sciences recommend.

appropriate funding for developing countries - combined with technology transfer and capacity building - can ensure low-cost mitigation combined with economic growth and a more sustainable development.

In short, there are numerous difficulties in comparing mitigation and adaptation costs with costs of inaction. Concerning theoretical uncertainties, we can highlight questions about: technologies that will be available in the future and its costs; adaptive capacities of societies and ecosystems; future damages to the economy and infrastructure; and discontinuities, thresholds and extreme points of some natural phenomena.[13] On the ethical side, main difficulties include how to weigh possible benefits and losses to populations with different welfare levels and risk exposure levels both spatially (between countries and regions today) and over time (present and future generations). Concerning aspects that are difficult to measure, many potential social problems related to mass migrations and political conflicts can have disastrous consequences, but are very difficult to predict. In addition, it is complicated to value loss of life, habitats and other things that are not captured by market prices such as ecosystem services.[14]

5 FINAL REMARKS

Analysis of the economics of climate change has provided important insights to inform decision makers, international negotiators as well as public opinion. Even though often not explicit, these studies underpin opinions of various stakeholders in the national and international arena. Model conclusions, although not discussed in detail at the negotiating table, guide the positioning of most countries. Some countries use the ones they think are the most technically sound, while others rely on those with results that best align with their political positions.

The great uncertainty that still surrounds the cost-benefit models and the highly divergent conclusions and policy recommendations have impacts on global negotiations. We can draw parallels between national positions and model conclusions. While some countries like the United States support a gradualist strategy in line with the recommendations of Nordhaus (1994) and Tol (2009),

13. Weitzman (2009a) recently showed that the uncertainty is even greater and mathematically more complicated than previously thought. If one explicitly includes in the models the existence of catastrophic scenarios that are unlikely to happen, policy recommendations could change towards more immediate emission cuts. The author also states that traditional analysis may be misleading decision-makers with their apparent concreteness, but they actually hide many arbitrary choices and their findings may have serious consequences.

14. Given the various methodological problems and controversies of cost-benefit calculations, some authors argue that marginal abatement costs estimates (MAC) would be more reliable in several aspects. First, they are based on prices of goods and services that are traded in markets and do not require valuations of dimensions such as human life or environmental services. Second, each element of the abatement curve reflects only the cost of one technology or innovation. Third, the horizons are shorter, which reduces the role of the discount rate (ACKERMAN *et al*., 2009). However, MAC calculations also present some difficulties, among which one could highlight its dependence on oil prices. For more details, see McKinsey & Company (2009).

among others, the European Union (EU) and Brazil support more ambitious and immediate actions in line with Stern (2007). Therefore, the United States has avoided adopting restrictive policies on GHG emissions that would increase, for example, fossil fuel prices and has adopted only generous clean energy subsidies. Countries with aggressive policies to combat climate change implement policies to restrict emissions in conjunction with subsidies.

Since there is still lots of uncertainty, it is important to further develop this research agenda in order to support political discussions. Supported by further improvements, decisions may become increasingly scientifically sound, and less based on ideology. Analysis of the economics of climate change provides an important contribution to the debate by explicitly including factors related to social welfare and their various nuances in time and space in the discussions. Complementing natural science studies, such assessments are essential to inform decision makers and the population that the legitimizes decisions taken.

The question of how to calculate economic and social costs and benefits related to climate change is among the greatest challenges faced by the economic science in recent years. As a global problem, which is difficult to reverse and has long term consequences, the analysis must include, first, findings from natural sciences studies – which also include high uncertainty levels - about environmental problems located in different countries with different time horizons. Moreover, economic models must evaluate how all these predictions will directly and indirectly impact existing infrastructure, population welfare in different locations and over time, in addition to making assumptions about the adaptability of societies to new realities. On top of all these difficulties is the problem of which discount rate to choose.

The extreme lack of knowledge about the low probabilities of potential catastrophic events that may occur imposes an additional challenge for economic modeling. Economists are used to deal with mean effects analyses. With regards to climate change, explicitly including uncertainty in models is crucial for sound policy recommendations. Accordingly, a key question to be answered is whether economists should continue to study mean effects with high probabilities, or change their focus to calculating the costs and benefits of guaranteeing minimum welfare standards for today and for the future. This would lead to policy recommendations such as investing in mitigation and adaptation that minimizes the chance of extreme events that would only happen with low probabilities. Such an attitude can be compared to buying a "climate insurance".

Although the cost-benefit analyses are very useful for evaluating the size of the problem, policymaking should also rely on other analysis and principles. For example, the precautionary principle, which states that "when there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective and feasible measures to prevent environmental degradation" is an argument supporting immediate action to prevent possible environmental damage for which we still do not have complete knowledge. On the other hand, an excessive reaction may result in stagnant economic development - particularly for the poorest countries.

In short, despite the uncertainties involved in climate change economics cost-benefits analysis, it is important to highlight the existing converging points, such as the need to establish some sort of carbon price and the recognition that not only mitigation but also adaptation is an important issue and that whatever mitigation path is chosen, it is necessary to find economic instruments and incentives to minimize its costs.

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CHAPTER 15

THE TARGETS OF THE COPENHAGEN ACCORD AND THE CANCUN AGREEMENTS

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1 INTRODUCTION

The current concentration of greenhouse gases (GHG) is already a concerning problem, and there is no sign of a solution in the short term. Scientists estimate that the average global temperature will increase between 1.8º C and 4.0º C by 2100, causing a sensible to drastic change in the environment (IPCC, 2007). Many studies postulate that it is worth spending the necessary amounts on mitigating emissions to avoid an increase of more than 2º C.[1]

With the mandate to find an outcome for this problem and to come up with a deal for after the first commitment period of the Kyoto Protocol (KP), which expires already in 2012, and to do so in a more inclusive way, Parties under the United Nations Framework Convention on Climate Change (UNFCCC) met between 7th and 18th December 2009, in Copenhagen, Denmark, for the 15th session of the Conference of the Parties of the Convention (COP 15) and the 5th session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP 5).

The aim in Copenhagen was to conclude a negotiation agenda given by the so called Bali Action Plan (BAP): A shared vision for long-term cooperative action, including a long-term global goal for emission reductions, to achieve the ultimate objective of the Convention; enhanced action on mitigation of and adaptation to climate change; enhanced action on technology development and transfer to support action on mitigation and adaptation as well as the enhanced action on the provision of financial resources and investment to support this actions. All that presupposes terms of quantified emission limitation and reduction objectives, by all developed country Parties, and nationally appropriate mitigation actions by developing country Parties, supported and enabled by technology, financing and capacity building, provided by developed country Parties.

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1. See, for example, Stern (2007) for an international analysis or Margulis et al. (2010) for Brazil. Chapter 17 in this book summarizes these and other studies.

Negotiations took place under a subsidiary body under the Convention, established and known as the *Ad Hoc* Working Group on Long-term Cooperative Action under the Convention (AWG-LCA) and a similar subsidiary body under the Kyoto Protocol (AWG-KP), which aim to find agreement on a second commitment period under the KP.[2]

Results achieved at COP 15 were far from reaching these postulated targets. There was no agreement on a document capable of binding all Parties, resulting in the so-called Copenhagen Accord, signed by some Parties, of which the chair merely 'took note' since it fell short of the necessary consensus aspect needed to be considered a Convention Document, and consequently lacked a legally binding status.

As a result, the mandates of the *ad Hoc*, AWG-LCA and AWG-KP groups were extended to the 16th meeting of the Conference of the Parties (COP 16), held in Cancun, Mexico, from 29th November to 10th December 2010. As will be demonstrated, the main achievements in Cancun were related to improvements and the insertion of principles, objectives and mitigation goals from the Copenhagen Accord in the Convention text, restoring some confidence to the process and promoting a solid base for the upcoming negotiation outcomes of the next meetings (COP 17 and CMP 7), to be held in Durban, South Africa.

The present chapter will begin by summarizing the main results of the 15th and 16th sessions of the Conference of the Parties in Copenhagen and Cancun, which are also discussed in detail in other chapters of this book. Following this summary, we will present an analysis of the mitigation targets submitted by Parties to the Copenhagen Accord, that were later reaffirmed in the Cancun Agreements, and we will discuss their implications for further negotiations and their contributions to the common goal of limiting global warming to between 1.5º C and 2.0º C.

2 THE GLOBAL CLIMATE NEGOTIATIONS

During the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro on 3-14 June 1992, the UNFCCC, or the Convention[3], as it will be referred to throughout the remainder of this chapter, was adopted. The Convention entered into force on 21 March 1994. Today, it has near-universal membership, with 195 Parties – countries that ratified the Convention. The principal objective of the Convention is the stabilization of greenhouse

2. The main technical questions are discussed in the Subsidiary Bodies: Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI).

3. The full text of the Convention on Climate Change is available at http://unfccc.int/key_documents/the_convention/items/2853.php

gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Among the commitments of the Convention, developed country Parties shall provide assistance to developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting adaptation costs to those adverse effects.

As the current concentration of GHG above the expected levels for the geological phase of our planet results from past economic activities, the principle of common but differentiated responsibilities and respective capabilities was established in the Convention. This principle recognizes that there are differentiated responsibilities, due to the disparate historical emission amounts across countries.

In this context, the same principle established that developed country Parties should take the lead in combating climate change and the adverse effects thereof. Thus, developed country Parties should reduce their domestic emissions and assist developing country Parties in their mitigation actions and in reducing their vulnerability[4] to climate change effects.

This commitment only took place in earnest since 1997, the year Parties to the Convention approved the Kyoto Protocol, which established that industrialized countries would reduce on average 5.2% of their emissions in relation of what each of these countries where emitting in 1990. The emission reduction targets where also differentiated among developed countries, with the EU, Japan, USA[5] and Canada having the most ambitious targets.

Countries listed in Annex I to the Convention, most of which are developed countries, and most of which are also listed in Annex B of the KP, are generally referred to as Annex I country Parties. Analogously, developing countries, not listed in those Annexes, are referred to as non-Annex I country Parties.

Given that the cost of reducing emissions differs greatly from country to country, the possibility to reduce emissions abroad was given to Parties through emission reduction obligations, measured in “Kyoto units” (in tones of CO_2), in the form of emission allowances, capture or Certified Emission Reductions (CERs). The KP allowed three flexibility mechanisms for Annex I country Parties to achieve their targets: emissions trading and two project-based mechanisms, Joint Implementation (JI, among Annex I Parties) and the Clean Development Mechanism (CDM, between developed country Parties and developing country project hosts).

4. Vulnerability in terms of low income and/or the extent to which a country will suffer from climate change consequences. As an example, there is an “Alliance of Small Island States” (Aosis) working as a political pressure group in this sense.

5. The US did not ratify the Protocol after all.

While Carbon Trading and JI are mechanisms that enhance the cost-effectiveness of developed country emission reductions, CDM allows this efficiency gain through country parties with emission reduction targets and country parties without this obligations, which are benefited through technology transfer and foreign investment from Annex I country Parties.[6]

Despite the first commitment period of the KP being a first attempt at global cooperation, its targets are not only insufficient, but also may not be fully reached[7]. The implementation of the KP is based on commitment periods. The first began in 2008 and ends in 2012. Bearing this in mind, the integrity of the actions of the Protocol depends on whether or not there is a second commitment period. This has been at the center of the negotiations process in recent years, mainly during COP 16 in Cancun. On one side are country Parties that recognize the KP as a great advance and defend the necessity of at least a second commitment period, with more ambitious reduction targets by Annex I country Parties. On the other side, are countries that criticize the KP for not obligating all major economies, including rapidly developing large countries, to assume similar efforts in terms of emission reduction.

On the side of the defenders of the KP and of the establishment of a second commitment period, are mainly developing countries including Brazil, which plays a critical role in the negotiations. On the side of Parties not willing to commit to a second commitment period, mainly Annex I country Parties, some negotiators claim that the KP is not the only possible response to climate change. One strong argument is that the KP was not able to bring the major polluter, namely the US, to participate in its efforts, nor obligate emerging economies whose recent emissions are comparable to the highest emitters listed in the Annex I, to reduce or stabilize their emissions (which, to some degree, ignores the necessary minimum consumption levels of their populations).

In this context, the consensus emerges that it is necessary to include the emerging economies in a global treaty that ensures continuity of the KP. Because if the economic growth levels of countries like China, India and Brazil keep on course, they will soon carry a considerable share of the responsibility for global climate change. So, without the contribution of these emerging economies, an efficient and rapid global response to climate change will be much more difficult.

This reality was recognized already during the BAP negotiations, at COP 13, which aimed to find a solution until COP 15, as outlined below:

- More ambitious targets for developed countries, which could reach values such as 40% by 2020 and 80% by 2050;

6. For a discussion on this topic for Brazil, see Seroa da Motta (2002).

7. Considering the end of the first commitment period in 2012, only the EU seems to be reaching its targets.

- Voluntary actions, in the form of Nationally Appropriate Mitigation Actions (NAMA) by developing country Parties, intended to reduce the inclination of the emission growing curves of non-Annex I country Parties, in a measurable, reportable and verifiable manner;
- Provision of financial resources and investment to support mitigation actions in non-Annex I countries, as well as to support actions for adaptation and technology transfer.

Despite the fact that the BAP does differentiate between developed and developing country Parties, the key issue is how to balance the efforts between Parties, considering their respective responsibilities and capabilities. That is, the share of each Party in the carbon budget, that reflects desired total global emissions.

As stated before, the results achieved during COP 15 were far from reaching the expectations. A legally binding agreement for all Parties was not possible, the so-called Copenhagen Accord being merely a letter of intention of some Parties of which the COP secretariat 'took note'. Nevertheless, in this document signatory states agree to a 2º C global warming limit.

Despite the fact that the Copenhagen Accord achieved great adhesion[8], its existence was only recognized, and has no legally binding effects. Even if the targets written in the Accord were sufficient to limit climate change to +2º C, it would not warrant any compliance. The Accord states that developing countries should adopt NAMAs in the context of sustainable development with the objective of reducing emissions by 2020. Developed countries shall assist developing countries in the implementation of the NAMAs through finance, technology transfer and capacity building, considering national circumstances and capabilities.

Progress was made in the Conference in terms of the establishment of directions for the negotiation of the Reduction of Emissions from Forest Deforestation and Degradation mechanism (REDD), which focuses in the maintenance of carbon stocks.

The lack of definition of financing rules and sources, how to measure, verify and report NAMAs, and how technology transfer should take place, made COP 15 a huge frustration for those who believed that the meeting could be the milestone of a new era in the fight against climate change.

Also as stated previously, expectations of an effective treaty were transferred to COP 16 in Cancun. Nevertheless, yet again this objective proved not possible,

8. The complete list of Parties agreeing to the Accord can be found under http://unfccc.int/meetings/copenhagen_dec_2009/items/5262.php

although the agreement did improve some of the ideas in the Copenhagen Accord. During COP 16, the agreed principles and objectives in the Copenhagen Accord were given more detail in the Convention text and more progress was made in achieving consensus in the broader negotiation process.

Furthermore, the 2º C ceiling for global warming was made official during COP 16, and the necessity was recognized to consider, in a first revision, an enhanced ambition level for a long term target of temperature stabilization at just 1.5º C above preindustrial levels (UNFCCC, 2010a). Furthermore, the Cancun Agreements incorporate the targets and NAMAs of almost all countries.

A registry shall be set up to record NAMAs seeking international support and to facilitate matching of finance, technology and capacity-building support for these actions. Developing country Parties were invited to submit to the secretariat information on NAMAs for which they are seeking support, along with estimated costs and emission reductions, and the anticipated time frame for implementation. Internationally supported mitigation actions will be measured, reported and verified (MRV) domestically, as will domestically supported ones, but will also be subject to international MRV, both in accordance with guidelines to be developed under the Convention.

The negotiations in Cancun also advanced in establishing guidelines for REDD, defining its framework, establishing a phased approach and suggesting that Parties propose strategies to control deforestation that can be incorporated in the mechanism to be adopted. In this sense, developing country Parties are requested to develop national strategies or action plans and national forest reference emission levels, as well as robust and transparent national forest monitoring systems for monitoring and reporting avoided deforestation and forest degradation action results (UNFCCC, 2010a).

Regarding financing, the Green Climate Fund, committed by developed countries in the context of mitigation actions with transparent implementation and a goal of raising USD 100 billion per year from 2020 to address the needs of developing countries, was adopted. The Fund shall be governed by a Board of 24 members, comprising an equal number of members from developing and developed country Parties. Representation from developing country Parties shall include representatives of relevant United Nations regional groupings and representatives of small island developing States and the least developed countries. The UNFCCC invited the World Bank (WB) to serve as the interim trustee for the Green Climate Fund and whether the WB will continue to be the trustee shall be subject to a review three years after the operationalization of the Fund. The design of the Fund will be created by a Transitional Committee, which shall have 40 members, 7 of which from Latin America (UNFCCC, 2010a).

Regarding adaptation, COP agreed that an intensified implementation of actions is needed to reduce vulnerability and increase resilience of developing countries, taking into account the needs of those who are particularly vulnerable. The agreement states that adaptation should be performed in accordance with the Convention. The Cancun framework for adaptation was also considered, including an adaptation committee and a work program on losses and damages. The parties are invited to submit to the secretariat, by 21 February 2011, their views on the composition, modalities and procedures for that committee (UNFCCC, 2010a).

The most controversial issue of COP 16 has been the definition of a second commitment period for the KP, due to declarations of countries (Japan and Australia) contrary to such a resolution as expressed during the negotiation process. The decision seems, including the recent informal meetings in Bangkok, to indicate the continuity of the work under the AWG-KP for the results to be adopted "as soon as possible" avoiding thus a gap between the first and second commitment periods. Thus, proposals of emissions reduction targets to be adopted by Annex I countries were submitted[9]. These countries are urged to increase their ambition levels. The decision also states that emissions trading and the flexibility mechanisms based on projects should continue to be available.

As noted earlier, the results of the negotiations of COP 15 and 16 are the subject of other chapters in this book, which discuss in detail the issues Namas, REDD and KP.

3 GOALS OF THE COPENHAGEN ACCORD AND THE CANCUN AGREEMENTS

Although there is controversy about the legally binding enforcement power of the national goals listed in the Copenhagen Accord, which were included in the Decisions of Cancun, there is also an issue related to comparability of the different metrics used in the proposals.

It would be ideal if the units of national commitments were comparable in order to facilitate coordination of the global effort. The metric which offers the best monitoring and verification capacity is one that indicates a percentage of emission reduction relative to some already established base year , which allows the estimation of a budget for future emissions that will result in increases in temperature up to a previously set limit. Voluntary emission reductions in developing countries, whose measurement is based on a deviation from a trend of future emissions, do not allow an accurate budget estimate, because they depend

9. These commitments were submitted to UNFCCC in March 2011, and can be verified under UNFCCC (2011a).

on a hypothetical unverifiable base-scenario[10]. Finally, there are also targets for carbon dioxide (CO_2) emissions intensity per unit of income (per capita or sector), offered by some developing countries that do not specify an amount of emissions but only a technical relation.

In this way, large polluters diverged in the metrics of their targets listed in the Copenhagen Accord. As shown in Table 1, developed country Parties had to follow the metric of the KP which utilizes a percentage of emission reductions relative to the emissions in a base year, but almost always with safeguards as to the existence of a global agreement with binding participation of all major emitters, and in some cases, with different levels of ambition, conditioned to the level of ambition of other countries. However, even these countries did not adopt a common base year, as is the case of the KP, thus further complicating the comparison of efforts.

For example, the European Union (EU), which for various reasons associated or not with global warming and other environmental concerns, has adopted a growth model with expensive or renewable energy - compared to other major emitters - and therefore already has a low carbon trajectory, proposes to set clear quantitative targets and broader participation of other countries. Thus, the EU reported a target for reducing GHG emissions by 2020 of 20% under 1990 levels, which could rise to 30%, depending on the reductions assumed by other major emitters of greenhouse gases[11]. Table 1 lists the targets provided by some of the major emitters among developed countries.

TABLE 1
Goals of the Copenhagen Agreement in developed countries

Countries	Emissions reduction targets for 2020 (%)	Base year
Australia	5-15	2000
Canada	17	2005
European Union	20-30	1990
Japan	25	1990
Norway	30-40	1990
United States	17	2005
Russia	15-25	1990

Source: UNFCCC (2010b).

10. The verification of the trajectory shift can only be done if the national emissions of the base year had been reported through inventories.

11. There was even an initiative by the environment ministers of Great Britain, France and Germany suggesting a 30% reduction target without conditionality.

Japan, with the ambitious goal of reducing emissions by 25% by 2020 compared to 1990 levels, also conditioned its commitment on the participation of major emitters of greenhouse gases.

The United States is committed to a modest goal of 17% under 2005 levels, but that could reach 30% in 2025, 42% in 2030 and 83% in 2050[12]. In any case, the implementation of these commitments will depend on the approval of the Senate, where the debate is questioning issues ranging from effects on the competitiveness of the economy to the very evidence of global warming[13].

Developing countries (non-Annex I), which have no targets under the KP, adopted different measurements, in the form of deviations from their growing emissions trend, as an attempt to alleviate future emissions as illustrated in Table 2. These commitments by developing countries, besides being difficult to quantify, are still constrained in most cases to the contribution of financial resources and technology transfer by developed countries or even the possibility of trading emission reductions under the CDM. In some cases, unconditional commitments are made and only additional levels of ambition of these factors are conditioned.

For example, Brazil that in addition to its clean energy matrix has succeeded in controlling deforestation, committed to voluntary targets to reduce by 36.1% to 38.9% its projected emissions for 2020[14].

TABLE 2
GHG emissions – Following the Namas proposed by developing countries in the Copenhagen Accord
(In %)

Countries	Deviation from the trend of projected emissions for 2020 (%)
South Korea	30
Mexico	30
South Africa	34
Indonesia	26
Brazil	36.1 to 38.9

(continues)

12. This goal is even more modest than the goal proposed by the US for the first commitment period of the KP, that was not ratified.

13. The Clean Energy Act of the United States (Waxman-Markey Bill) passed the House in 2009 and its recent substitutive (The American Power Act or The Kerry & Lieberman Bill) sent to the Senate. This legislation aims first at energy security by reducing dependence on imports in the U.S. energy matrix, based on massive spending on research and development (R&D) in clean energy, and the creation of a carbon market. Nevertheless, due to the new composition of the US Congress, with a Republican majority, much difficulty is expected for approving any GHG emissions regulation in that country.

14. For a detailed discussion of these goals, see Seroa da Motta (2010).

(continued)

Countries	Deviation from the trend of projected emissions for 2020 (%)
Reduction of CO_2 intensity of gross domestic product (GDP) projected for 2020 (%)	
China	40-45
India	20-25

Source: UNFCCC (2010b).

China and India, on the other hand, adopted CO_2 intensity reductions of their GDP. In China, emissions accompany the rapid growth of the economy, favoring a rapid technology transformation, but hampering the adoption of absolute targets. Thus, China's proposal was to achieve a reduction of 40% to 45% by 2020 in the intensity of CO_2 per unit of income compared to 2005.

This type of measure, although reflecting possible advances in technology, does not allow accurate prediction of the scale of emission reductions in these countries, as this will depend on the trajectories of their production. India, in turn, which still has a very low per capita emissions intensity, has committed to a reduction of CO_2 emission intensity per unit of income of 20% -25% compared to 2005.

In short, in the Copenhagen Accord and in the decisions taken in Cancun, there are several metrics for reported Namas and goals. On the one hand, there are those defining a budget of emissions measured against the observed emissions in a certain year (1990, 2005 etc), although whose magnitudes vary depending on the commitments undertaken by other countries. On the other hand, there are those that estimate future budget as a shift in the trend of future emissions and also others, based on emissions intensity per unit of income, which do not condition their commitments on commitments of others, but also do not set a budget.

Thus, the suggested commitments do not allow a direct and unambiguous comparison, which greatly hinders a compatibility test between mitigation efforts across countries.

4 THE CLIMATIC EFFECTS OF THE GOALS ESTABLISHED IN COPENHAGEN AND CANCUN

The Copenhagen Accord and the decisions taken in Cancun establish that deep cuts in emissions are needed to keep global warming to a maximum of 2º C. It is not clear however, whether the proposed arrangements in individual countries listed in its annexes, when summed up, are sufficient to achieve an emissions trajectory consistent with the maximum temperature increase proposed.

The UNEP study (2010) reviews several models that attempted to answer this question and consolidates its results. Analyses were based on proposals submitted by individual countries attached to the Copenhagen Accord, which although not legally binding as pointed out above, were almost entirely confirmed by Parties in the decisions taken in Cancun[15].

First, the study concludes that in a baseline scenario (BAU - acronym for business as usual), annual global emissions projected for 2020 would be 56 Gt CO_2 eq - an increase of 11 Gt CO_2 eq compared to 2005 emissions of 45 Gt CO_2 eq. In dissonance with this projection, the study estimates that the annual global emissions consistent with a probable chance of limiting the temperature increase to 2 º C would be approximately 44 Gt CO_2 eq (with a confidence interval of 39 to 44 CO_2 eq)[16]. Comparing these two scenarios, this implies that a gap in annual emissions of approximately 12 CO_2 eq was identified, that represent a failure of mitigation efforts in meeting the maximum temperature goal.

Then the study examines to what extent the country proposals included in the agreement may help to reduce emissions from the BAU scenario, by leading global emissions toward the required emissions scenario. And does this considering three aspects, namely:

1. If countries will implement their "unconditional commitments" (with lower ambition levels) or "conditional" ones (higher ambition). This distinction stems from the fact that several countries have conditioned their more ambitious emission reductions on the provision of financial resources by rich countries or the more ambitious actions of other countries.
2. How the accounting rules for emissions from Land use and Land use change sector (LULUCF) will be used and how they can weaken targets for industrialized countries. This could occur if emission reductions are accounted for activities in this sector that would occur even in the absence of emission targets.
3. If excess emission allowances remaining from the first commitment period of the KP could be extended to the second commitment period and used by industrialized countries with the aim of achieving their goals proposed in the Accord.

The report then combines these requirements by creating four different scenarios of compliance with the individual Party proposals and evaluates to which extent each would help close this gap. For the first aspect listed above, the evaluation differentiates between the achievement of "unconditional" and "conditional" goals, as previously explained. For aspects 2 and 3, the classification differentiates "lenient rules" from "strict rules" regarding maximization of the use

15. The goals under the Cancun Agreements were submitted on March 2011, not being yet analyzed in depth. For more detail, see UNFCCC (2011a, 2011b).
16. The study refers to 'likely chance' for probabilities greater then 66%.

of emission credits over the first KP commitment period, and the use of lenient rules regarding the accounting of LULUCF otherwise identified as strict. Thus, the following scenarios of global annual emissions for 2020 are formed, based on the degree of implementation of the commitments made in the agreement:

- Unconditional targets and lenient rules, would lead to emissions of 53 Gt CO_2 eq (3 Gt CO_2 eq below BAU) and a difference of 9 Gt CO_2 eq emissions in relation to what is needed.
- Unconditional targets and strict rules, would lead emissions to be reduced to 52 Gt CO_2 eq and the difference would still be 8 Gt CO_2 eq.
- Conditional targets and lenient rules: emissions of 51 Gt CO_2 eq and a difference of 7 Gt CO_2 eq.
- Conditional targets and strict rules (maximum implementation): emissions reduced to 49 Gt CO_2 eq and a remaining difference of 5 Gt CO_2 eq.

Thus, the best deployment scenario would lead to a reduction in global emissions of 7 Gt CO_2 eq relative to BAU, but still leave a void of 5 Gt CO_2 eq to reach the objectives stated in the agreement. This is equivalent to, for example, current annual emissions of the entire transportation sector.

UNEP (2010) also raises some issues that were not taken into account in the estimates, which could nevertheless affect global emissions significantly by 2020. Taking other uncertainties into account, the reduction achieved in each scenario is explained to be even lower if industrialized countries use offsets as part of the emissions reductions of Namas proposals by developing countries to meet their commitments. On the positive side of uncertainty, if major funds are made available to developing countries, emissions reductions may be higher.

Furthermore, the study points out that achieving the goal of 44 Gt CO_2 eq annual emissions in 2020 does not guarantee the long-term target of 2º C. On the contrary, this temperature rise in the long term is associated with a specific pattern of changes in emissions that includes the assumption that global emissions will peak before 2020. After this year, robust reductions in emissions along a mandatory trajectory that results in 50 % -60% reductions below 1990 levels, would be required by 2050, as well as negative GHG emissions by the energy and industrial sectors starting in the second half of the century.

That is, besides the weak legal status of the agreement (which was partially resolved in Cancun), even if all countries do implement their maximum commitments, there would still be a gap in emission reductions, in relation to what would be necessary for achieving the climatic goal of the Accord - which is also recommended by science.

5 FINAL REMARKS

The result achieved at COP 15 fell far short of the postulated objectives. A new binding agreement for all Parties was not achieved. It was possible, however, to draft the so-called Copenhagen Accord, in which many Parties confirm the commitment of limiting temperature increase to 2° C, and propose the creation of financing mechanisms and to reduce deforestation and forest degradation. COP 16 in Cancun, certainly aided by public pressure, further advanced these results and brought them into the official text of the Convention, defining specific details and creating a solid foundation for agreements to be reached at the next Conference of the Parties, COP 17, to be held in Durban, South Africa.

Thus, the negotiation platform is based on the current terms of the Cancun agreements, as well as national targets submitted to the Copenhagen Accord and confirmed in Cancun, and expectations about the continuity of the KP.

The quantitative targets of the Copenhagen Accord and the Cancun agreements, even if implemented in the most strict sense, represent an insufficient emission reduction in order to achieve the global goal of 2° C. On the contrary, not only do current targets leave a gap of emission reductions required by 2020 of 5.9 GtCO 2 eq per year, but also leave great uncertainties about emission standards after 2020. As a complicating factor in the negotiations, the existence of various forms of measurement in the targets and actions submitted to the Accords, which does not allow a direct and clear comparison of national targets, greatly complicate an evaluation of the compatibility of mitigation efforts among countries. Thus, a variety of national, regional and local actions with different formats are possible - partnerships between public and private sectors, in local or regional scope, even among subsets of countries.

For example, with bilateral and international treaties, not necessarily global, such actions could undergo periodic reviews, requiring continuous adjustments of trajectories[17]. This arrangement would entail, among other problems, more difficulties to accurately quantify reductions made by each country and negotiations about the "fair" carbon budget to be occupied by each.

From the geopolitical perspective of the Convention, on the one hand, the polarization between the U.S. and China will have to be resolved in order to achieve a new agreement with ambitious goals. On the other hand, these two countries may, regardless of the evolution of the negotiations in the scope of the Convention, choose strategies adapted to a competition constrained environment, through the creation of barriers to trade and through technological competitiveness.

17. For an analysis of the incentives of this polycentric form of governance, see Ostrom (2009).

The establishment of trade sanctions has not advanced during COP 16, but some countries have developed proposals of national climate laws that penalize the import of products from countries that do not have emission reduction schemes recognized by the Climate Convention. The justification for these measures is that the penalty of emissions in one country encourages its shift to another where the cost for GHG emissions is lower. This possibility is called leakage[18].

Another possibility is that this confrontation is driven to conquer international markets. The United States holds the largest stock of human capital on the planet and is the undisputed leader in science and technology. China is still building its stock of physical capital using technologically advanced new capital. Thus, these two countries, which have created barriers to the long-awaited global agreement, promise to invest in carbon productivity gains. This means increasingly less carbon per unit of income generated[19].

Thus, in spite of possible advances in the next Conference of the Parties to the Convention, the world's economic leaders may engage in a market strategy within a new competitive green growth paradigm, resulting in significant indirect effects for all countries. Although evidence shows that we are entering a new technological paradigm, market failure will persist and existing regulatory incentives may not be sufficient to avoid an unwanted increase in global temperature.

18. See, for exemple, Matoo et al. (2009).

19. One recent study of Dechezleprêtre et al. (2009), for example, shows that the US leads the patent registrations on low carbon technologies and that China had the greatest increase rate in these registrations in the last decade. This knowledge can already be noticed by leading wind and solar energy projects and CH_4 destruction.

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CHAPTER 16

CLIMATE CHANGE NEGOTIATIONS FROM AN INDUSTRY PERSPECTIVE

Paula Bennati*

1 INTRODUCTION

The negotiations within the scope of the United Nations Framework Convention on Climate Change (UNFCCC) are treated as the climate negotiations in this study, with increasing impacts on individual country economies whether developed or developing. This chapter examines the issues from a private sector perspective, more specifically the Brazilian private sector.

The central concept of international analysis is the inherent difficulty of climate convention negotiations to reach a global accord. Overall, this chapter demonstrates how changes in the global economic context have impacted climate negotiations, focusing the debate on what we all in fact desire: growth or economic development.

From this general international view, analysis centers on the degree and nature of the international commitments that affect the Brazilian private sector, as well as the mode of participation in negotiations.

In the domestic arena, this analysis focuses on private sector participation in developing and implementing measures to combat climate change in Brazil. As this chapter clearly demonstrates, more robust participation is necessary given the themes currently being negotiated and the country's socioeconomic situation.

Governance of domestic public policy on climate in Brazil is also treated in this chapter, taking the National Policy on Climate Change (PNMC) as the key concept for analysis. Emphasis is placed upon the importance of developing and implementing this policy in a participatory manner that takes into account the converging interest in the country's growth.

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Overall, this study concludes by demonstrating that in order to make progress in negotiations, increased business involvement is necessary in the drafting and implementation of foreign and domestic policies.

Notwithstanding the need to strengthen channels of dialogue with the state, the industrial sector has made great contributions to the country, providing positive responses to the challenge of less carbon-intensive growth.

Section 2 analyzes the climate convention, with an emphasis on the outcomes of the most recent Conference of Parties (COPs). Section 3 discusses private sector positions within the national and international context of recent Brazilian legislation on climate change. Finally, Section 4 presents final remarks and recommendations.

2 THE EVOLUTION OF THE CLIMATE CONVENTION NEGOTIATIONS

The Framework Convention on Climate Change (UNFCCC) signed during Rio-92, was based on difficult negotiations because of the new topics it covered, particularly because the cost of mitigation measures directly impacted the economic growth objectives of countries that participated in the summit.

Thus, in 1992, climate negotiations ended up dividing the world into three blocs: "*Developing countries,* which expected new and additional financial resources and technology transfer in order to implement the measures that required greater resources;" *Rich countries,* particularly the European Community (EC), "which had already made progress in reducing emissions and to whom the expenses suggested to achieve the initial goal did not seem prohibitive;" and other rich countries, especially the United States and oil producing countries, which "saw the possibility of achieving the suggested goals without excessive economic sacrifices" (LAKE, 2007, p. 73).

However, in order to present the international community with a position aligned with the central theme of Rio-92 (Sustainable Development), all countries – or at least the most important economies – would be required to join the United Nations Framework Convention on Climate Change (UNFCCC).

Convergence was achieved at that time by the omission of specific greenhouse gas (GHG) emissions reductions targets in the language of the convention, thus enabling the vast majority of countries present to sign the treaty, including the United States, that had maintained a position that opposed quantitative reduction targets. This solution, although it would prove unsustainable in the long term, was viewed as the first major step toward global sustainability.

In fact, at that time most countries were not prepared to adopt GHG emissions reduction targets, and those that met all the conditions to lead other parties toward a less carbon-intensive global economy remained opposed to any proposal that could be minimally translated into emissions reduction commitments.

The global economic scenario in 1992, however, was quite different from what it is today. Take for example China, which is both a prodigious emitter of GHGs and an innovator making strides toward the next stage of its economy. Currently, with coal firing still representing two thirds of the electricity generation that is driving China's economy in an impressive upward curve, the communist government has invested heavily in clean technology – though the seriousness of this commitment is challenged by many experts – and wind power is the second largest source of electricity generation in the country (LASH, 2010).

Estimates demonstrate that if China maintains its current growth in renewable sources, it can surpass its goal of raising renewable energy use to 15 percent of the energy matrix by 2020 (currently 7 percent, versus 47 percent in Brazil), and achieve this objective through a combination of incentives and legislation (LASH, 2010). During the Cancun COP 16, the head of the Chinese delegation said in plenary that the demand for a greener model is motivated by the perception that development based on intensive energy consumption and GHG emissions is not sustainable in the long term.

The rapid and considerable changes in the global economic picture also directly impact climate negotiations, either by bringing about the extinction of old and the creation of new country blocs, uniting efforts to reach common objectives, or by creating specific channels of dialogue for the discussion of certain topics.

Following the successful conclusion of two major agreements, namely the Kyoto Protocol and the Bali Action Plan, two negotiating tracks were established: the Convention track for developing and developed countries that had not ratified the Kyoto Protocol, i.e. the United States; and the Kyoto Protocol track for Annex 1 developed country parties to the Convention.

The *two tracks of negotiations* format proposal was well-received in Brazil, which coupled with the Road Map and Bali Action Plan, form a valuable set of tools that aim to achieve a multilateral agreement and brings the United States into formal negotiations on the future of the regime.

2.1 Growth or economic development?

This quick analysis of climate negotiations calls for an examination of the sustainable development concept, which implicitly raises the necessity to find a "middle way" that balances the needs of the planet through support from three equally important pillars: justice or social relevance, reasonableness or ecological prudence, and economic viability.

In this sense, it is necessary to think about what we really want: development or economic growth? In growth, change is quantitative, while in development, it is qualitative. It is unreasonable to reduce the concept of development to mere economic growth, measured only in terms of *per capita* income or gross domestic product (GDP), which does not consider social variables such as access to education and the promotion of health, or considerations related to environmental protection. We would thus be strengthening a system that has proven insufficient and untenable because it lacks balance with the other two pillars.

The report titled, *Our Common Future,* also known as the *Brundtland Report,* defines sustainable development as:

> (...) A transformation process in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are in harmony and strengthen the present and future potential in order to meet human needs and aspirations (CMMAD, 1991, p. 49).

The transformation process referred to in the *Brundtland Report* demonstrates that economic growth and emissions reduction are not mutually exclusive, but will only be possible through a progressive – and immediate – de-carbonization of the economies of developed countries and promotion of growth in emerging countries, as well as development based on activities with low carbon intensities.

In the final analysis, it is only economic development that will ultimately lead the world down the path to sustainability. With a country's production capacity at the pinnacle of economic growth, the private sector stands as a central player in discussions about the new low-carbon economy.

2.2 Climate negotiations and the Brazilian industrial sector

The current negotiating agenda is of special interest to the private sector, which will be responsible for covering most of the costs of mitigation through massive investments in clean energy and technology, though with state as a necessary counterpart.

Fortunately, the negotiating process has evolved in a manner that demands more participation from countries in the presentation of proposals and the construction of agendas. Two relevant agreements, the Kyoto Protocol and the Copenhagen Agreement, are illustrated here to demonstrate the shift in approach that climate negotiations have undergone.

The Kyoto Protocol is founded on a *top-down* approach, in which the commitments made by countries at the international level should be internalized nationally. The Copenhagen Agreement, in turn, favors a *bottom-up approach,* in which measurable, reportable and verifiable voluntary mitigation efforts should be the basis for evaluating national efforts to mitigate GHG emissions. If the *bottom-up* approach is understood as the trend in climate negotiations, then private sector participation in negotiations gains relevance.

2.3 COP 16

As a basis, the current status of negotiations, namely the last Conference of Parties (COP 16) held in Cancun, is examined to better understand the importance of the private sector in this process, whether it be through influencing the definition of positions defended by the country in the international arena or through compliance with the commitments made.

Overall, the results achieved at COP 16 met the parties' expectations; safeguarding the public governance of the UNFCCC process – by not sinking the multilateral regime – and re-establishing confidence in the Convention process.

But decisions on important agenda items were deferred to COP 17, in particular those of an emergency nature dealt with under the Kyoto Protocol (*Ad Hoc* Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol - AWG-KP). Important elements that were not addressed in decisions include agreement on a long-term global goal for reducing emissions (2050) and a peak-year global emissions goal (ideally between 2015 and 2020), although the need for agreement in this direction has been recognized.

The decision hailed as a major breakthrough of Cancun was establishing the threshold at a 2 °C global average temperature increase by 2050, compared to pre-industrial levels, which is the limit for avoiding harmful consequences of climate change. This limit must still be fully aligned with the conclusions of the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC), which states that emissions of greenhouse gases should peak by 2015, so that global average temperature increase is limited to 2 °C (IPCC, 2007).

Regarding the second commitment period of the Kyoto Protocol, the Agreement provides that the Cancun negotiations should continue and be finalized to ensure that there is no gap between the first and second commitment periods of the Protocol. In practical terms, this means that the final decision should be adopted at COP 17, to be held in Durban, because the Protocol's first commitment period ends in 2012.

The Kyoto Protocol is not the main focus of this chapter and analysis of the continuity of the Protocol's second commitment period is discussed in detail in Chapter 20 of this publication. It is important to note, however, that this analysis leads back to the central issue addressed at the beginning of this chapter: the segregation of countries, with the future of the Protocol as background, for setting more ambitious GHG emissions reductions targets for Annex I countries and possibly new commitments for non-Annex I countries.[1] Because it is a crucial issue for the continuation of negotiations on other agenda items, the convention's credibility will be at risk if COP 17 does not reach an effective agreement on the regime's future.

2.3.1 Negotiation items relevant to the private sector

Some key elements that were agreed in Cancun can be translated not only as important tools for an agreement on future commitments of the parties, but also as indicative pathways for countries to establish domestic policies: *i)* setting 1990 as the baseline year for calculating emission reductions; *ii)* permission to use the countries' reference years for their own purposes; *iii)* permission for developed countries to use emission trading mechanisms and project-based emissions, as well as forestry and land use to achieve reduction targets, and finally; *iv)* that the global warming potential (GWP) of greenhouse gases will be provided by the IPCC.

At the same time, another advance was achieved in the area of technology that directly affects the industrial sector and can ultimately increase its level of engagement with government, in what is referred to as Institutional Arrangements. The Expert Group on Technology Transfer (EGTT) was terminated and a new technology framework created, which includes the Technology Executive Committee (TEC) and the Network & Climate Technology Centre (CTCN).

The important role of the Clean Development Mechanism (CDM) in the process of reducing GHG emissions was reinforced in Cancun. Furthermore, the need for structural reforms to make space for new projects, modeled on the Program of Activities (PoAs), and the need to standardize baselines were recognized.

"In Brazil, the CDM has achieved unquestionable success. More than 415 Brazilian projects developed under the scheme are already reducing approximately 7.5% of Brazil's non-forest emissions" (MIGUEZ *et al.,* 2010). The country remains in third position in terms of total CDM projects and emissions reduction amounts. At the sectoral level, five project activities related to adipic acid production should be recognized as decreasing almost all nitrous oxide emissions in the Brazilian industrial sector.

1. *Annex I* is a list of 40 countries and the European Community, listed in *the climate convention,* which made commitments under Kyoto Protocol to reduce GHG emissions. The *non-Annex I countries* (developing countries) are those who have committed to take on binding targets for emission reduction, although some adopt voluntary actions in this regard.

Other items on the agenda can be cited because of their importance to current negotiations, although currently they are neither directly nor immediately significant to the productive sector. They are:

- Reducing Emissions from Deforestation and Degradation (REDD): Key elements were agreed upon in Cancun related to the mechanism and its structure, leaving important technical discussions for COP 17 in Durban.
- Establishment of three new specific financial organs: The Green Climate Fund; The Transitional Committee, to manage the fund; and the Standing Committee, to oversee financial flows.
    - Because the Green Climate Fund is intended for less developed countries, climate financing flows in Brazil should, according to experts, be derived from initiatives such as the World Bank, the German Development Bank KfW, and the Brazilian Development Bank (BNDES), and not from funds linked to the Convention (DEL PUPO *et al.*, 2010).
- International air and maritime transport *(bunker fuels)*: divergence among parties was focused mainly on the applicability of the principle of *Common but Differentiated Responsibility* (CBDR). Many developing countries argue for its applicability in the sector, maintaining that developed countries should take the lead in emissions reductions. Developed countries, however, claim that the application of this principle in the negotiations would adversely affect the competitiveness of its industry and would represent discrimination, damaging the principles governing international transport.

One issue that has received special attention by Brazilian negotiators is the preservation of free trade, currently threatened in climate change discussions. The absence of definitions from the World Trade Organization (WTO) Doha round increases the risk of proliferation of protectionist policies established in the name of climate change.

Unilateral measures would lead to retaliation if a country were to raise tariff and non-tariff barriers in response to measures taken by another country. This form of protectionism may also undermine global economic growth (essential for the development of low-carbon projects), as well as represent a barrier to political understanding between countries, thus greatly hindering the development of long-term solutions, especially with regards to investment and technology development, both of which are fundamentally important to develop a low-carbon economy.

2.4 Indirect positive impacts

One cannot expect multilateralism to solve all the political and economic dilemmas linked to climate change, especially given the rapid and substantial changes in the global economic scenario, as mentioned above, but its indirect and immediate results should be recognized.

The various international meetings that take place around climate change issues, inside and outside the UNFCCC process, have been increasingly seen as important channels of dialogue to conduct business of various magnitudes, for the establishment of partnerships between businesses and nongovernmental organizations (NGOs), and for the expansion of social networks. Bilateral and regional agreements have been responsible for projects associated with significant GHG emissions reductions, technology transfers, capacity building, and strengthening the market for carbon credits, which have gained internal, regional and global strength.[2]

It is worth noting a report titled, *Global Governance (GG 2020)*,[3] by academics from Berlin, Shanghai and Washington, DC. This study seems to confirm a trend suggesting that if the negotiation process is not capable of producing a comprehensive multilateral agreement, a coalition of countries with higher ambitions, led by the European Union, would act independently to become a new global leadership front.

This new leadership would encourage other countries and non-state actors, such as regions, cities, businesses and NGOs, to form an alliance to complement the Convention process. In this case, the Climate Convention could develop a governance structure to Measure, Report and Verify (MRV) emissions reductions and other actions taken by individual countries, specifically *Nationally Appropriate Mitigation Actions (NAMAS).*

3 PRIVATE SECTOR PARTICIPATION IN BRAZIL

Having analyzed the issues under negotiation that affect the private sector, it is incumbent upon us now to analyze the participation of this sector in the process of drafting policies that are advocated in the international arena, as well as those that are set internally in order to fulfill Brazil's international commitments.

3.1 The Climate Convention

Given the central role of the private sector in implementing policies to combat climate change, it becomes necessary to create a formal environment for technical

2. Examples of signed agreements or partnerships: Innovative Business for Climate and Energy Policy (IBCEP) and Climate Action Partnership (USCAP), represented by companies and environmental organizations.

3. The mentioned report was prepared by 24 members of the Program GG2020, divided equally between academics from Germany, China and the United States.

discussions regarding the negotiations and to establish potential executive bodies governing financing and technology transfer mechanisms, in order to implement the Climate Convention (CNI, 2010).

Internal policies should be established based on national growth objectives, in synch with overall mitigation targets, so that they can be transformed into effective actions across the country.

In this context, it would be up to the private sector to make concrete proposals that would be incorporated into the planning and implementation of domestic policy, as well as in defining the position of the country in Convention negotiations. A participatory process that requires maturity on the part of all actors is essential for success, and is also extremely interesting and positive in economic, social and environmental terms for the country.

It is of paramount importance, however, that the commitments made in the international arena are compatible with internal objectives. Unfortunately, this "harmony" has not been seriously considered in current negotiations. While efforts in this regard have been acknowledged, there is clearly still a long way to go. "The Copenhagen Agreement does not permit a direct and unequivocal comparison between national targets, which greatly hinders the ability to judge the compatibility of mitigation efforts among countries" (SEROA DA MOTTA, 2010).

Be that as it may, it is clear that the process of shaping public policy on climate change cannot occur only at the government level. Huge resource investments are required to tackle the problems, address the scope of the impact of climate change in different locations and sectors, and to meet the need for a set of actions in the economic and regulatory arenas. All segments of society will have to engage in an economic and environmental transition.

3.2 National Policy on Climate Change

There is an urgent need to strengthen the public governance process on climate change in Brazil. Despite the effort and competence of the various actors involved in the issue, debate and decision-making are needed in a coordinated manner between government, the private sector, civil society, and academia.

A first step toward this empowerment was taken through the publication of Decree 6.263/2007, which created the Inter-ministerial Committee and the Executive Group on Climate Change (MIC). This committee has fulfilled its main function to forward Bill nº 3.535/2008 to Congress, establishing the National Policy on Climate Change, comprised of diverse legal theory passed in the "race" leading up to the Copenhagen conference.

It is necessary, however, for the government to inform society of what will be necessary for national compliance with its international commitments. In Brazil, external commitments must be compatible with those established by the National Policy on Climate Change (Law 11.127/2010): voluntary targets of 36.1 percent to 38.9 percent emissions reductions, based on projected emissions growth by 2020.

Prior to implementing the national climate legislation (PNMC), particularly the Mitigation and Adaptation Sector Plans necessary to achieve the voluntary goals described above, the creation of a central body, a special secretariat directly linked to the Presidency, would be appropriate.

Formed in equal parts by government, civil society, the private sector, and academia, this body would coordinate the debate on the subject and establish the sectoral plans and other regulatory requirements of the national policy. A qualified agency for the analysis and production of data could be linked to this body, ensuring the incorporation of existing structures in the country, and in particular those mentioned by national policy and other scientific institutions, which play an important role in the context of production and interpretation of data on vulnerability and adaptation, technology, equipment, processes and management related to the reduction of greenhouse gases.

It is important to remember the convention's ultimate goal – to inform national policies to ratify decisions taken within its scope – which is to allow and encourage development with low GHG emissions, providing economic, social, and environmental gains for all of Brazilian society.

4 FINAL CONSIDERATIONS

It is essential that all countries are aware of their responsibilities in the promotion of measures that will be effective and achieve long-term responses to the challenges. Creativity is necessary, as well as the recognition that there is no single format that will satisfy the various interests involved.

Internationally negotiated agreements should give emerging economies flexibility in defining and implementing public policies aimed at long-term economic and social development and the cost-benefit maximization of actions to combat climate change (CNI, 2010).

The new agreements should reflect current economic realities and scientific achievements, allowing for innovative, more inclusive and cooperative arrangements. Resorting to protectionism would be a grave error because solutions appear to point in the opposite direction: to increasing trade and quality of life, both in developed and developing countries.

The general industry perspective is that countries must take on urgent commitments across various issues in the arenas of investment, markets, and technology. Until this happens, it will be difficult to expect innovative ideas and projects on a global scale that effectively contribute to solving the problem, since long term investment and action are necessary precursors.

International cooperation should serve to build capacities and transfer new and additional financial resources and clean technologies on a two-way street between developed and developing countries, directed based on relative availability, namely demand. Here, emphasis is placed upon the importance of South-South cooperation, bilateral agreements between countries and private entities, the strengthening of regional blocs, and public-private partnerships.

The interaction between the private sector and government in negotiating international climate change disciplines has proven insufficient. Despite participating as observer to international negotiations, there is no formal technical channel between the private sector and government in which the business sector can discuss and explain financial and technical contributions on international policy discussions in the climate arena.

Thus, it is clear that to make progress in negotiations, greater business involvement is necessary. Governments could take advantage of the structure and experience of the private sector and this, in turn, could expand its portfolio of activities. Cooperation between the private sector and the state would facilitate the implementation of mitigation and adaptation to climate change, and would promote the implementation of policies in these areas.

Many international decisions directly impact the strategies that domestic industries must develop to meet challenges related to managing GHG emissions. It is important to follow a standardized methodology for the establishment of the baseline year, metrics for gases, and to ensure at the outset the use of criteria for Monitoring, Reporting and Verification (MRV), which are still not completely defined under the UNFCCC.

A new definition of commitment periods for emissions reduction targets for developed countries under the Kyoto Protocol is a fundamental element for industry to continue to invest in Kyoto market mechanisms, in particular the CDM, whoose maintenance and improvement are of great importance to the Brazilian industrial sector.

The State's regulatory role and support for the development of low-carbon technologies are crucial, as is stimulating the use of renewable energy, encouraging energy efficiency programs, and developing specific technologies, among other examples.

In any case, the challenge permeating discussions about climate change is long term and requires great creativity, integrity and dedication to confront. Solutions should accompany changing economic and political contexts in countries, as demonstrated by the example of China earlier this chapter, that when signing the Kyoto Protocol in 1997 was not the power (built on fossil fuels) that it is today.

The world is confronted by a new, complex theme where decisions reverberate in all sectors of the economy. Scientists, technicians, engineers, managers and entrepreneurs must all be trained. Hence, it is imperative to increase awareness and promote quality debate on the issues throughout Brazilian society. We are increasing understanding along the process, everyone is taking a seat on the train that is steaming ahead: We are learning by doing.

The use of tools such as tax incentives and tradable permits to promote green innovations and investments, are also essential, as well as investment in capacity building, training and education. It is important to strengthen international governance and global mechanisms to support the transition.

For industry, it is essential to choose more practical and positive directions, which clearly demonstrate pathways to achieving a new low-carbon economy, without affecting sector competitiveness. Strengthening technical skills and building intellectual networks across business-lines are essential and indispensable in the transition to clean technologies and new ways of doing business (CNI, 2011).

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CHAPTER 17

THE KYOTO PROTOCOL AND THE CURRENT NEGOTIATIONS OF THE INTERNATIONAL REGIME ON CLIMATE CHANGE

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1 INTRODUCTION

The process of negotiating the future of the international regime on climate change has been conducted based on two tracks of negotiation, the so-called Bali road map established at the Conference of Parties (COP 13), the United Nations Framework Convention on Climate Change (UNFCCC) held in December 2007 in the city of Bali, Indonesia. Two *ad hoc* working groups were established to facilitate this process.

The Parties to the Kyoto Protocol, in accordance with Article 3, § 9 of the Protocol, agreed that the commitments to limit or reduce emissions of greenhouse gases (GHG) by Parties included in Annex I in relation to periods subsequent to the first, should be established at least seven years before the end of current commitment period of 2008 to 2012. So in December 2005 during the Conference of Parties serving as the Meeting of the Parties to the Protocol (CMP 1) held in Montreal, Canada, established the *Ad Hoc* Working Group on Further Commitments for Annex I Parties to the Kyoto Protocol (AWG-KP).

At the aforementioned COP 13, UNFCCC Parties agreed to establish the Bali Action Plan, which includes the process of full, effective and sustained implementation of the Convention through long-term cooperative action now, up to and beyond 2012. At the time, the goal was to achieve an agreement with the intention to adopt a decision at COP 15, that would be held in Denmark in December 2009. COP 13 also decided that this process would be conducted by the Ad Hoc Working Group on Long-Term Cooperative Action in the Framework of the Convention (AWG-LCA).

As such, these *ad hoc* working groups composed the two tracks of negotiation: the AWG-KP was the track for negotiating future commitment targets of the Annex I countries under the Kyoto Protocol, while the LCA was established as the track for further enhancing the implementation of the Convention.

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The Copenhagen Conference, despite not having reached a result that allowed the definition of a future climate change regime in the manner expected, decided to keep the two ad hoc working groups, and therefore the results obtained so far by means of negotiations on a technical level were taken on board in the negotiation process under way. The agreed outcome from the AWG-LCA, officially linked to the Bali Action Plan, was the decision to extend the completion deadline to COP 16. The so-called Copenhagen Agreement, sewn in the political sphere, tried to unblock the work by the AWG-LCA, but there was no consensus for its acceptance and COP 15 only took note of the document. Regarding the parallels between the two tracks of negotiation, the decision to extend the completion deadline for CMP 6, was also taken under the AWG-KP.

For the level of ambition generated during 2009, the Copenhagen Accord left many gaps and came out short of the expectations it had created. The drafting of the agreement involved 29 countries and included the direct participation of several heads of state in a number and importance level never before recorded in the history of the Convention on Climate Change. But that was not enough to reach a consensus on the future of the international regime on climate change. Rather, the agreement was officially rejected in plenary by various Parties to the UNFCCC as soon as it was submitted for adoption, based on several procedural irregularities that were reported throughout the Conference, that as previously mentioned only ended up taking a note of the agreement.

The challenge of promoting a policy dialogue between the political agreement, that led to disagreement and rejection in Copenhagen, and the results achieved throughout the difficult years of negotiation, since 2005 in the case of the Kyoto Protocol, and since 2007 in the case of Bali Action Plan, has been taken up successfully by the Mexican Presidency of COP 16/CMP 6, that through an inclusive and transparent process of negotiation was able to resume confidence in the international negotiation process under the UNFCCC.

Especially with regard to the negotiation process of the Kyoto Protocol, the mandate of the *ad hoc* group is to establish the second commitment period of the Protocol and subsequent commitment periods after 2012, in accordance with Article 3, § 9 to the Protocol, as mentioned above.

Although the negotiating process is advanced in technical terms, as the AWG-KP had started its work two years earlier, this process was hindered by the lack of progress in the parallel work of the AWG-LCA. The opposing views of many Parties on various of the issues under negotiation were creating hurdles impeding compromises that would permit the agreement of a consensual solution. However, the process of the AWG-LCA at COP 16 in Cancun, Mexico, was further advanced and managed to achieve a comprehensive decision, where the major issues that impeded progress (the so-called *crunch issues*) towards the attainment of decisions on all issues under negotiation were resolved. These issues were resolved through a negotiation process conducted by the Mexican Presidency, which was attended by several ministers from selected countries, culminating in a package of decisions that were adopted without discussion *(take or leave),* with the legal objection of only one country (Bolivia). This situation leads to a new legal discussion on the definition of consensus, probably during 2011 and certainly the topic will be further discussed in Durban.

Unfortunately, the process of negotiating the second commitment period for the Kyoto Protocol was delayed to allow finding a solution for the impasse in the negotiating track of the AWG-LCA and, therefore, no significant advance was achieved in the Kyoto track. This is cause for concern, considering that the pledges to the second commitment period of the Protocol shall be established by an amendment to Annex B and consequential amendments. Therefore, there is a need for these amendments to be ratified by all country Parties that adopted the amendments to the Protocol, which will be time consuming. Coupled with the completion of the work of the AWG-KP being postponed to the CMP 7 in Durban, South Africa, there will be only one year left for the ratification process to take place without a gap between the end of the first commitment period of the Protocol – which covers the period 2008-2012 – and the beginning of the second.

2 THE CONFERENCE OF THE PARTIES IN THE QUALITY OF THE MEETING OF THE PARTIES TO THE KYOTO PROTOCOL, CMP 6, CANCUN, MEXICO

Negotiations in Cancun began with Japan's chief negotiator stating that his country would not agree at all with an agreement that favored the continuation of the Kyoto Protocol, with the consequent definition of targets for the second commitment period after 2012. This statement stunned the audience with its non-diplomatic tone and due to the very delicate time period after CMP 5. It should be noted that other Annex I countries with an opposing view to the second commitment period of the Kyoto Protocol, including Russian Federation, Australia and Canada were working discreetly and constructively in Cancun, not blocking the negotiations.

In legal realm, there was agreement to revise or update proposals contained in the negotiating text, but there was no attempt to discuss the implications of a possible gap between the first and second commitment periods. This scenario is possible if there is no agreement at CMP 7 or, in the case of an agreement, if the ratification process is not finished by the end of 2012.

It should be clear that unlike reported by the press, especially the European press, the Kyoto Protocol will not expire in 2012, because it has no expiration clause. Rather, Article 3, § 9, contains the provision that the negotiation of subsequent periods would start seven years before the end of the previous period, and in accordance with this provision a decision was taken in 2005 in Montreal.

Misleading discussions of a Kyoto Protocol expiration date led the public to believe that there would be no legal instrument after 2012, resulting in a favorable environment for the Annex I countries in the negotiations to create a movement to accept the single agreement under AWG LCA. This hypothetical single agreement would be weaker than the Kyoto Protocol in nature, because it would probably not have legally binding clauses like those existing under the Kyoto Protocol. In addition, the widespread expectation of the expiration of Kyoto could facilitate non-compliance by Annex I countries with their first period commitments, to the extent that the moral constraint of non-compliance would be mitigated by the alleged expiration of the protocol, and thus lowering the political cost of withdrawal.

3 DECISIONS IN CANCUN

The AWG-KP made two decisions in Cancun, with specific attention to forests (FCCC/KP/AWG/2010/L.8/Add.2).

The major decision (FCCC/KP/AWG/2010/L.8/Add.1) on the Kyoto Protocol consisted of six operative paragraphs in which the Conference of the Parties serving as the Meeting of Parties to the Protocol (CMP):

1. Agrees that the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol shall aim to complete its work pursuant to decision 1/CMP.1 and have its results adopted by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol as early as possible and in time to ensure that there is no gap between the first and second commitment periods.
2. Requests the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol to continue its work referred in paragraph 1 above on the proposals contained in document FCCC/KP/AWG/2010/CRP.4/Rev.4.
3. Takes note of quantified economy-wide emission reduction targets to be implemented by Annex I Parties as communicated by them and contained in document FCCC/SB/2011/INF.1; (The content of the table in this information document is shown without prejudice to the position of the Parties or to the right of Parties under Article 21, paragraph 7, of the Kyoto Protocol.).
4. Urges Annex I Parties to raise the level of ambition of the emission reductions to be achieved by them individually or jointly, with a view

to reducing their aggregate level of emissions of greenhouse gases in accordance with the range indicated by Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Climate Change 2007: Mitigation of Climate Change, and taking into account the quantitative implications of the use of land use, land-use change and forestry activities, emissions trading and the project-based mechanisms and the carry-over of units from the first to the second commitment period;

5. Agrees that further work is needed to convert emission reduction targets to quantified economy-wide limitation or reduction commitments.

6. Also agrees that:

   a) In the second commitment period the base year shall be 1990, or the base year or period determined in accordance with Article 3, paragraph 5, of the Kyoto Protocol, for the purpose of calculating assigned amounts; in addition, a reference year may be used by a Party on an optional basis for its own purposes to express its quantified emission limitations and reduction objectives as a percentage of emissions of that year, that is not internationally binding under the Kyoto Protocol, in addition to the listing of its quantified emission limitations and reduction objectives in relation to the base year.

   b) Emissions trading and the project-based mechanisms under the Kyoto Protocol shall continue to be available to Annex I Parties as means to meet their quantified emission limitation and reduction objectives in accordance with relevant decisions of the CMP as may be further improved through decisions to be adopted based on the draft text contained in Chapter III of document FCCC/KP/AWG/2010/CRP.4/Rev.4.

   c) Measures to reduce greenhouse gas emissions and to enhance removals

   d) resulting from anthropogenic land use, land-use change and forestry activities shall

   e) continue to be available to Annex I Parties as means to reach their quantified emission

   f) limitation and reduction objectives, in accordance with draft decision 2/CMP.6.

g) The global warming potentials used to calculate the carbon dioxide equivalence of anthropogenic emissions by sources and removals by sinks of greenhouse gases listed in Annex A for the second commitment period shall be those provided by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol together with other methodological issues based on the draft text contained in chapter IV of document FCCC/KP/AWG/2010/CRP.4/Rev.4.

h) Further work on the consideration of information on potential environmental, economic and social consequences, including spillover effects, of tools, policies, measures and methodologies available to Annex I Parties shall continue on the basis of proposals contained in chapter V of document FCCC/KP/AWG/2010/CRP.4/Rev.4.

In the AWG-KP, differently from the AWG-LCA, the main issue on which there is no consensus is on the continuation of the Kyoto Protocol itself. The various chapters that contain the details of the technical options do not have any issue on which negotiations are stalled, but unlike the AWG-LCA, there is no political interest to solve these technical issues that would lead to the conclusion of the AWG-KP, without conclusion of the AWG-LCA.

Thus, the solution adopted in the decision quoted above was similar to that used by the AWG-LCA to resolve impasses and remove certain negotiating obstacles. As the great obstacle, represented mainly by Japan, is setting targets for the second commitment period and, thus, the continuation of the Kyoto Protocol, the solution was to insert the consensus already existing in the AWG-KP, in order to transmit a positive message for the continuation of the Protocol, the desire of all non-Annex I Parties and Norway, and sometimes ambiguously manifested by the European Union.

In this sense the decision was positive, because CMP 6 defined the continuation of the AWG-KP to complete its work, made note of the targets (without prejudging the right of Japan and other Annex I Parties to join the second period commitment), urged for increased level of ambition in the upcoming negotiations and reaffirmed the use of mechanisms and forest activities as a means to meet quantified commitments, offering clear signals to the market and setting 1990 as the base year for the second Kyoto period, or in accordance with some countries (economies in transition) with Article 3. § 5.

Although there is a clear definition of the continuity of Kyoto, the continuation of international mechanisms, in particular the clean development mechanism (CDM), is conditional on the existence of quantified commitments, thus increasing the demand to maintain the Protocol for the continuation of these mechanisms.

The adoption of this solution, although lacking in significant advances, buys more time for the AWG-LCA to propose a better and more concrete definition. However, waiting for these negotiations to develop could to a certain extent imply a waste of time in the adoption of the second commitment period, thus jeopardizing the continuity between the first and second periods, given a possible adoption in late 2012 or even 2011, without a meaningful process of ratification by Annex I Parties.

The union of all non-Annex I Parties in favor of the Kyoto Protocol is the only force able to link the progress in the AWG-LCA track to the seamless continuation of the Protocol between commitment periods. This was reflected in the last preambular paragraph of the decision, which makes this connection with the adoption of a decision under the AWG-LCA.

It is worth noting that Brazil coordinates the Group of 77 (G-77) and China under the AWG-KP, and that the Brazilian government has expressed publicly through statements by former president Lula and current president Roussef, full support for the continuation of the Kyoto Protocol, and this is a condition for having a global agreement on the future of the international regime on climate change.

In the second decision, concerning forests, the CMP:

1. Affirms that the principles contained in paragraph 1 of decision 16/CMP.1 continue to govern the treatment of land-use, land-use change and forestry activities; (the following principles govern the treatment of land-use, land-use changes and forestry:

    a) That the treatment of these activities be based on sound science.

    b) That consistent methodologies be used over time for the estimation and reporting of these activities.

    c) That the aim stated in Article 3, paragraph 1, of the Kyoto Protocol not be changed by accounting for land use, land-use change and forestry activities.

    d) That the mere presence of carbon stocks be excluded from accounting.

    e) That the implementation of land use, land-use change and forestry activities contributes to the conservation of biodiversity and sustainable use of natural resources.

    f) That accounting for land use, land-use change and forestry does not imply a transfer of commitments to a future commitment period.

    g) That reversal of any removal due to land use, land-use change and forestry activities be accounted for at the appropriate point in time.

h) That accounting excludes removals resulting from: *i*) elevated carbon dioxide concentrations above their pre-industrial level; *ii*) indirect nitrogen deposition; and *iii*) the dynamic effects of age structure resulting from activities and practices before the reference year).

2. Agrees that the definitions of forest, afforestation, reforestation, deforestation, revegetation, forest management, cropland management and grazing land management shall be the same as in the first commitment period under the Kyoto Protocol.

3. Requests the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol to consider, in time for possible inclusion in the second commitment period of the Kyoto Protocol, if appropriate, whether a cap should be applied to emissions and removals from forest management and how extraordinary occurrences (called force majeure) whose severity is beyond the control of, and not materially influenced by, a Party can be addressed; 4. Also requests each Annex I Party to submit to the secretariat, by 28 February 2011, information on the forest management reference level inscribed in appendix I to this decision, including any update to replace the value, in accordance with the guidelines outlined in part I of appendix II to this decision.

4. Decides that each submission referred to in paragraph 4 above shall be subject to a technical assessment by a review team in accordance with the guidelines outlined in part II of appendix II to this decision, and that outcomes of the technical assessment will be considered by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol at its next session.

5. Requests the secretariat, subject to the availability of funds, to organize the technical assessments referred to in paragraph 5 above.

6. Also requests the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol to continue its consideration of definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the Kyoto Protocol for application in the second commitment period.

7. Similarly to what was expressed previously regarding the first decision, the forest decision also almost reaches a consensus on how to define the technical aspects involved. Therefore, the decision lists the existing consensus in the group, with a breakdown on how to deal with forest management, which was a major impasse.

Also similar to the first AWG-KP decision, what has been done with regards to the forest topic included buying time for the decisions in the AWG-LCA track to develop, and again there is a risk of discontinuity between the first and second commitment periods.

4 THE IMPASSE ON THE FUTURE OF THE PROTOCOL

Japan argues against the second commitment period of the Kyoto Protocol because the Annex I countries that have ratified the Kyoto Protocol are responsible for 28% of current total global emissions (without citing the reference year or the source of information and including, probably, only carbon dioxide emissions), and the Kyoto Protocol does not include the two largest emitters (the United States – part of Annex I to the Convention, but has not ratified the Protocol, and China – non-Annex I).

As Japan belongs to the umbrella group, its position probably represents that of the group, providing a means of forcing China towards a quantified emissions limitation or reduction in the second commitment period of the Protocol. Negotiators from Japan also argue that the absence of the United States in the Kyoto Protocol, and the uncertainty about the binding regime under the AWG-LCA that that would force the United States to assume commitments for the entire American economy, equivalent to the ones being assumed under Kyoto, creates a situation that exempts the United States from efforts comparable to European (or Japanese) efforts to combat climate change, resulting in additional costs for the latter and a consequent loss of economic competitiveness.

China, like other countries in the BASIC group (Brazil, South Africa, India and China), reaffirmed on many occasions that it will not assume any quantified commitments under the Kyoto Protocol, because climate change is the result of cumulative historical emissions by the developed countries (the Brazilian proposal in 1997 estimates the historical responsibility of Annex I Parties as greater than 85%) and not the result of emissions at a given point in time, i.e., the argument of 28% of current emissions is not consistent with the historical responsibility of developed countries. Moreover, these countries expanded and developed their economies without emission or environmental restrictions. Additionally, the pressure on developing countries, especially the major emerging economies, to assume targets in the second commitment period of Kyoto is seen as an attempt to halt or slow the progress of these countries, focusing on reducing or even removing competitive advantages and increasing the cost of production in these emerging countries. This arrangement would entail a new form of colonialism.

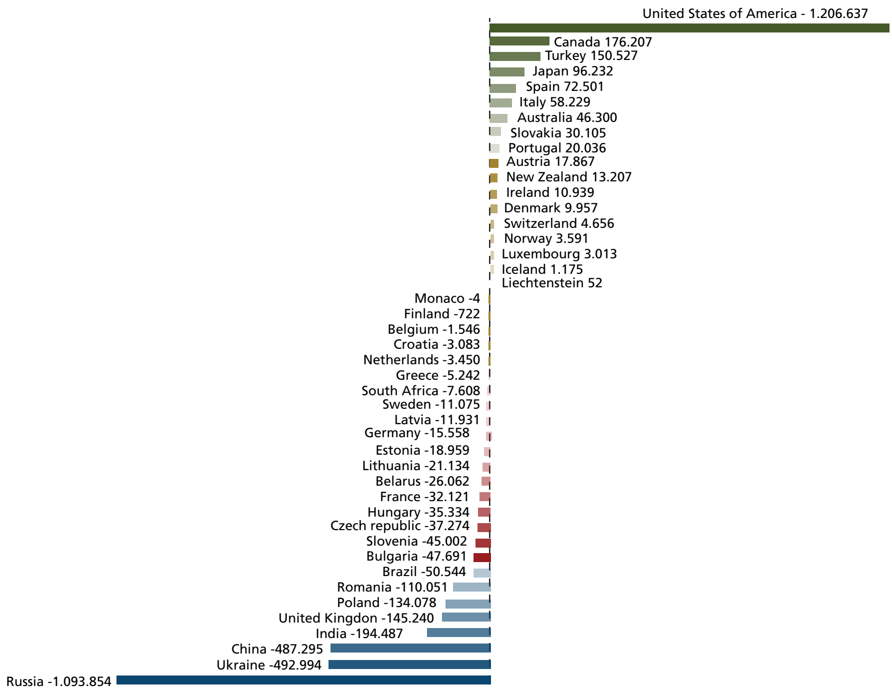
It is no coincidence that the discussion of targets for the second commitment period of the Kyoto Protocol has become a North-South dispute, with the only exception of Norway taking a leading position consistent with the greater historical responsibility of developed countries. This North-South division also represents a reaction of Japan to the vigorous growth of China and a possible loss of regional hegemony. Collectively, the developed countries may also fear that a possible second commitment period without the participation of major emerging developing countries would accelerate the loss of global hegemony.

Another factor that complicated the negotiations of the second commitment period was the 2008 financial crisis caused by mortgage loan problem in the U.S. (the *subprime* crisis), and the securitization of these north American assets impacted the countries of Europe and Japan. As the crisis persisted until early 2011, developed countries were slowing down their economies and the consequent reduction of anthropogenic activity implied reduced emissions and an easy path to meet the goals of the first commitment period. This scenario reduced the pressure from developed country citizens with regard to climate change issues.

Added to this, are increasing disputes among countries on economic competitiveness, the threat of loss of hegemony by developed countries due to the economic crisis in their own territories and the rapid growth of emerging countries. These elements lead to a backlash from European and Japanese companies, to oppose new mandatory targets for emission reduction that will raise their competitive prices and still favor emerging countries like China, India and Brazil, as major suppliers of credits from CDM activities. In this scenario, those companies would be providing support allowing major competitors to advance in their markets through the creation of indirect subsidies to developing countries, thus reducing the costs of emerging countries by means of these “carbon credits”.

GRAPH 1

Distribution of emissions in 2008 and Kyoto Protocol targets in 2012 for Annex I countries and reductions of CDM projects for the BASIC countries (-1,576,810 t CO_2 eq), including the United States (-370 173 t CO_2 eq)



Source: Document FCCC/SBI/2010/18.
Compiled by the author.
Note: For Annex I countries, the centerline of the horizontal axis means that emissions in 2008 are equal to targets for the first commitment period of the Kyoto Protocol. Deviations to the right means that emissions in 2008 are higher than the targets adopted in Kyoto in 1997. Deviations to the left means that emissions in 2008 are lower than the targets agreed in Kyoto.

Graph 1 compares the emission inventories of Annex I countries to their quantified commitments (annual assigned amounts) for the first commitment period of the Kyoto Protocol, and also shows the potential reductions due to project activities under the CDM that have been submitted to the executive CDM board (in any stage of CDM cycle, from validation to implementation) in the BASIC countries for reference only.

The United States has a 1.2 billion tons of CO_2 equivalent compliance deficit compared with its target agreed in 1997, and the Russian Federation and Ukraine had a 2008 surplus of about 1,6 billion tons of CO_2 equivalent. These surpluses from developed countries of the former Soviet Union and Eastern Europe are known as *hot-air,* the shorthand given by Greenpeace to targets established to limit emissions at a level greater than the emissions of those countries in 1997.

It is worth recalling that during the economic downturn in 2008 and the years that followed, many Annex I Parties reduced their emissions of greenhouse gases. This emissions decrease in Annex I countries creates a surplus to meet the 2012 targets, and thus reduces efforts to comply with the first period of the protocol. Coupled with European and Japanese companies purchasing certified emission reductions (known as carbon credits) from CDM, has resulted in a credit surplus in some countries, leading to a scenario of easy compliance with the first commitment period. Such a scenario would probably be very different for the second commitment period, with the resumption of growth in developed countries and increased costs of implementing new project activities under the mechanism, both in China, India or Brazil, given the increased marginal costs of additional reductions under the CDM.

A final aspect that complicates the negotiation of the second commitment period is the transfer of excess allowances (assigned amounts) from the first commitment period to the second in the specific case of the Russian Federation and Ukraine, whose current emissions are well below the targets proposed in 1997. When Kyoto was established, with the fall of the centrally planned economies of the former Soviet Union, the emissions of these countries were already about 70% of 1990 levels and, Russian Federation and Ukraine adopted the target of stabilizing their emissions at 1990 levels. This generated a surplus of permits, that with the consent of the other countries in the final round of negotiations in Kyoto would allow any increase in the emissions of these countries to cover a difference of up to 30% of 1990 emissions, in the case of rapid economic growth in the market-economy regime, or the sale of these units in the case of a possible deficit among Annex I Parties (established with the expectation of a US ratification of the Protocol). With the non-ratification of the Kyoto Protocol by the United States, the Russian Federation and Ukraine have no buyers for their extra allowances and therefore are not attracted by the idea of a second commitment period. The European Union is proposing that these excess units should be removed from the system, an action clearly opposed by Russian Federation and Ukraine.

Moreover proposed pledges for the second commitment period in the Russian Federation, Ukraine, Belarus and Croatia recreate the same problem (more hot-air). Brazil made a submission at the 2010 AWG-KP meeting in Bonn, Germany, proposing a possible way to solve the problem of excess units in the second commitment period. The proposal suggests that the excesses units from the last reviewed inventory could only be used to meet domestic targets, but should not be transferred to the next commitment period, pursuant to Article 3, § 13. Micronesia and the EU proposed ways to limit transfers of surplus units likely to exist at the end of the first commitment period over to the second commitment period.

The reactions of Russian Federation and Ukraine to a possible limitation of these surplus units is another factor that complicates achieving consensus in the negotiations of the AWG-KP.

5 FINAL REMARKS

The decision by the CMP 6 in Cancun represents a positive signal that the negotiations of the AWG-KP may result in an agreement at the next CMP 7 to be held in Durban, South Africa, primarily resulting from an agreement between G-77 and China and the European Union, as was also the case in Kyoto. In turn, the vocal opposition from Japan and possibly other countries of the umbrella group is a very negative signal, and the position of Russian Federation and the Ukraine (in particular the question of transfer of excess units to the second commitment period) are elements that add uncertainty to achieving consensus in Durban.

The precedent set in Cancun, where Bolivia was isolated and the Mexican presidency adopted decisions stating that consensus does not mean unanimity, leaves Japan in a potentially delicate position, since continued isolation in Durban against the Kyoto Protocol may lead to the agreement being adopted without Japan. In this sense, the positions of Russian Federation and Ukraine will be decisive.

It should be borne in mind that if an agreement is adopted in Durban, the countries of the umbrella group would have the additional political burden of withdrawing from the Kyoto Protocol, and justifying to the general public the lack of internal effort to combat global warming. This could present a serious challenge for most countries in that group in terms of domestic politics.

Finally, the negotiating document contains very few elements that need some kind of decision, i.e. this document is not an obstacle to agreement for the second commitment period. The remaining and crucial question concerns the level of ambition of Annex I Parties in the second commitment period of Kyoto Protocol, which should remain low, reflecting the view that prioritizes short-term low economic growth in developed countries. Essentially because of the 2008 financial crisis, there will be attempts to drive much of the additional effort to combat global warming to developing countries under the Convention (AWG-LCA).

Nonetheless, one can draw two scenarios for the future of the negotiations under the Kyoto Protocol:

- The optimistic scenario, in which Annex I Parties ratify the amendments to Annex B with the new figures for the second commitment period of the Kyoto Protocol, even without the presence of the United States in exchange for a more effective participation of this country and developing countries under the LCA track. This would occur under a big deal involving the two tracks, the continuation of the international effort, and preservation of the regime to combat climate change, with the goal of reversing global warming in the long run, even without high levels of ambition in the short term.

- The pessimistic scenario, on the other hand, would be the withdrawal of the umbrella group from the negotiations of the second commitment period of Kyoto and a partial agreement between the EU and the G-77 and China, which would lead to a world divided into two zones. One Kyoto group with quantified and continued efforts to fight global warming, and the "umbrella" area of the Convention without a quantified international effort, with national targets and little international monitoring of these national efforts, which together would probably lead to a reduced global effort to combat climate change over the next five years.

The search for consensus occurs in a context where countries are more aware of the problem of climate change, not only because of a better scientific foundation, but also better knowledge of costs, as well as economic and development impacts. Thus, the divergences are clearer and sharper compared to the past negotiations. Therefore, some challenges remain for countries in the pursuit of consensus over the future of the international regime on climate change. The results achieved in Cancun offer a new perspective on some of these challenges being addressed more effectively than was thought shortly after the Copenhagen Conference.

On the other hand, the failure of an agreement on the future of the international regime on climate change would lead to further rounds for defining a new scheme, which would be much more difficult than current rounds of negotiation, given the level of knowledge on the subject acquired by all countries. This new round could well extend for at least a decade, based on previous experiences with negotiating the Convention and the Kyoto Protocol, and therefore this scenario should not be considered plausible. Given the current increase of 2 to 3 parts per million by volume (ppmv) per year of CO_2 concentration in the atmosphere, the world would reach a concentration around 430 ppmv by 2020, representing a risk that countries cannot and should not accept.

CHAPTER 18

REDD AND THE CHALLENGE OF PROTECTING THE GLOBAL FOREST COVER

Thaís Linhares-Juvenal*

1 INTRODUCTION

Reducing emissions from deforestation and forest degradation (REDD) is amongst the most important contributions developing countries can make for climate stabilization. According to the fourth IPCC report published in 2007, land use change, land use and forests contributed to approximately 17% of global greenhouse gas emissions. In Brazil, according to the last national communication on greenhouse gases, this sector is responsible for 61% of emissions, whilst deforestation of the Amazon contributing the majority of this figure. The recognition of the importance of native forests to climate change mitigation led to the inclusion of REDD in the Bali Action Plan leading, on the one hand, to leverage of public and private investments for REDD, and on the other hand, to the development of specific institutional arrangements for a REDD mechanism in many developing countries.

REDD within the context of the Bali Action Plan involves not only reducing deforestation and forest degradation, but also conservation and enhancement of forest carbon stocks and sustainable forest management, and is usually referred to as REDD+. Such scope stems from the perceived need to adopt a holistic approach and address all forest dimensions, i.e. environmental, economic and social, as a means to ensure effectiveness of measures taken to reduce deforestation and forest degradation. There is a call for a REDD that promotes sustainable forest development, enhancement of local livelihoods and synergies for measures and actions that will promote multiple benefits of forests, such as preservation of biodiversity and sustainable forest products. This scope, however, implies a more complex REDD which demands strong forest governance in addition to the requirements for measuring, reporting and verification (MRV). Therefore the challenge of REDD involves defining means of implementation capable of meeting all REDD needs in a timely and cost efficient manner.

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This article will focus on the needs posed by the concept and scope of REDD forged by the Bali Action Plan and eventually agreed in XVI Conference of the Parts'(COP) of the United Nations Convention on Climate Change (UNFCCC) and discuss the implications on REDD implementation and funding. It should be noted that this article was written before COP XVI, and thus is based on the final text that emerged from COP XV in Copenhagen. The option of not updating the text was undertaken on the premise that Cancun's final text adopted by the Convention has few changes when compared with the text that emerged from COP XV. The changes mostly reflect a way forward on negotiation points that had not been resolved in Copenhagen but that reached compromise in Cancun eg, REDD as a national strategy. An appreciation of the text that emerged from Cancun will be made in the final section of this article.

As may have been noted, this article always refers to REDD and not to REDD+. In fact this is the author's perception. Once the content of REDD is no longer a matter of dispute, REDD should always be understood as defined by the Convention text approved in Cancun, i.e. encompassing all the activities for reducing deforestation and forest degradation, promoting conservation and enhancement of forest carbon stocks and sustainable forest management. Although acknowledging the jargon REDD+, it is assumed here that there is no alternative REDD and thus the plus can be deleted.

This article comprises three sections, in addition to the introduction. The second section will examine the negotiation text of COP XV seeking to identify the main characteristics of the proposed REDD mechanism. An analysis of the draft of the Ad Hoc Working Group for Cooperative Long-Term Action (AWG-LCA) on its tenth session and of Decision 4.CP.15 on the methodological aspects of REDD, allows decoding the fundamental principles of REDD under the Convention and sheds light on the critical importance of governance. The emphasis on aspects related to governance has strong implications to REDD implementation, especially funding. The financial mechanisms for REDD should not only promote the reduction of greenhouse gas emissions but also promote transformational changes that will embed a long term strategy for conservation of forest resources. In this regard, investors should be ready to allocate funds in activities with no direct correspondence to measurable reduction of emissions or enhancement of carbon stocks, at least in the initial implementation of REDD: The sources of funding for REDD will be constrained by the availability of investors for non-results based activities in a way that the initial implementation is more likely to be funded by public funds or by corporate social responsibility.

The design of the REDD mechanism in the Copenhagen text and also in the final text approved in Cancun privileges governance as a paramount means for ensuring the environmental integrity of REDD and consistency with climate change mitigation objectives. Good governance is to some extent an element for mitigating risks from REDD and leads to what this article will call the "REDD paradox". The challenge of building good forest governance is crucial for ensuring REDD sustainability and environmental integrity. The literature on natural resources management has taught us that acknowledgement of competing interests and dissemination of information on stock and consumption of natural resources are essential for a pact on the sustainable use of natural resources. The safeguards established for REDD are in alignment with the literature as well as the other references in the REDD text to requirements for REDD implementation and the needs of monitoring, measuring, information and verification. Governance percolates the overall REDD text and frames the feasibility of implementation of REDD in the different parts of the world. Many of the countries with high REDD potential still lack solid institutions capable of implementing a transparent and accountable governance structure. Investments tend to flow to countries where governance is already in place. The REDD paradox refers to the funding needed to build institutional arrangements for good governance and a consistent REDD strategy while there is a need of having good governance in place to attract funds.

The conclusion of this article will draw on the REDD text approved at COP XVI in Cancun to reflect on the future prospects for REDD. Once formally acknowledged as a mechanism for climate change mitigation under the UNFCCC, multiple experiences implemented up until 2010 will need to be reconciled in order to comply with the text agreed in Cancun. Notwithstanding its role as a mitigation mechanism, the Decision also acknowledges REDD as a mechanism for tropical forest protection. Solving the REDD paradox will require broad international cooperation to provide countries with low institutional capacity with funding to implement REDD in all its dimensions and phases until they are able to achieve measurable results. Furthermore, the challenge of promoting synergies with other forest initiatives and of strengthening the instruments for sustainable forest management, preservation of biodiversity and other ecosystems services should also be addressed. From the approval of REDD at COP XVI, a successful story of international instruments for protecting forests can be built having REDD as its cornerstone.

As a final remark regarding this article, it is important to emphasize that the present analysis is strongly based on the author's personal experience with REDD and all the ideas and conclusions presented here are exclusively her responsibility.

2 REDD IN NEGOTIATIONS

The importance of reducing emissions from deforestation and forest degradation (REDD) for an effective global agreement on mitigation and adaptation to climate change is now broadly acknowledged. REDD not only tackles a meaningful source of carbon emissions but also offers an attractive option for the voluntary engagement of developing countries in mitigation efforts, whilst promoting important social and environmental co-benefits. The introduction of REDD in the UNFCCC agenda dates from 2005 with a submission by Papua New Guinea, Costa Rica and eight more countries proposing a mechanism for reducing deforestation and forest degradation (PARKER *et al.* 2009). Two years earlier, however, researchers from Brazilian NGOs had already presented a proposal for compensated emissions reduction which sought international payments for reduced deforestation, taking into consideration a historic baseline. Since COP XIII under the UNFCCC held in Bali in 2007, the debate shifted from the relevance of REDD for climate change mitigation to the content of a REDD mechanism. Between 2007 and 2009, or more specifically between COP XIII in Bali and COP XV in Copenhagen, different REDD proposals emerged which encompassed multiple activities and means of implementation and were defined as REDD, REDD+ and REDD++.

Options of REDD scope before COP XV (Copenhagen)	
RED	Reducing Emissions from Deforestation
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	Reducing Emissions from Deforestation and Forest Degradation, Conservation and Enhancement of Forest Carbon Stocks, and Sustainable Management of Forests.
REDD++	REDD+ with the addition of reforestation, including reforestation of non-forested areas (afforestation).

In Copenhagen, a new legally binding climate change agreement could not be achieved, but the REDD mechanism proposal gained maturity. The definition of REDD scope was remarkable progress and delivered the consolidation of REDD+, acknowledging not only the importance of the mechanisms for climate change mitigation but also for conservation and enhancement of forest carbon stocks and a more holistic perspective of forests. The draft decision that emerged from Copenhagen presents progress on the safeguards for REDD, making the case for a mechanism that is focused on conservation of native forests, promotion of all types of forest values (environmental, social and economic) and respect for forest peoples. In fact, both the AWG-LCA draft decision and Decision 4/CP.15 on the methodological guidance for REDD, call for a REDD mechanism that acknowledges the complexity of forest management and the need to provide broad positive incentives to avoid international leakage (UNFCCC 2009a). By requesting Parties to address not only the drivers of deforestation and forest degradation, but also land tenure issues, forest governance issues and specific safeguards, Parties under the Convention associate the effectiveness of REDD as a mechanism for mitigation of climate change to good forest governance. Unlike other mitigation mechanisms, REDD is embedded in both micro-economic decisions, such as the decision on land use undertaken by governments, communities or land owners, and in macro policies that ensure a national commitment to forest conservation and a participatory framework for REDD implementation.

The necessity of addressing leakage and permanence to ensure the environmental integrity of the mechanism partially explains the differential treatment applied to REDD. Diversely from other projects within land use, land use change and forestry, REDD demands strong coordination among multiple actions put forward simultaneously by independent actors which should converge reductions of deforestation and forest degradation, conservation and enhancement of forest carbon stocks in a scale capable of mitigating leakage risk (DUTSCHKE, WERTZ-KANOUNNIKOFF, 2008; ELIASCH, 2008; WERTZ-KANOUNNIKOFF, KONGPHAN-APIRAK, 2009). An institutional framework to ensure accountability and to define the ultimate responsibility for the mechanism's liability is also important to address permanence. Governance is the foundation of environmental integrity of REDD. It stands, however, that the scope of REDD and the emphasis on governance is also influenced by the financial resources made available for climate change mitigation. On one hand, bridging carbon to the other socio-environmental benefits delivered by forests seems also to be one of the objectives of the REDD text, contributing to carry funds to biodiversity, improvement of livelihoods, and other benefits. On the other hand, the focus on the governance structure related to access to financial resources offer a possibility of addressing the needs of collective action for good management of common-pool resources (OSTROM, 1990; AGRAWAL, OSTROM, 2001) and therefore contribute to building better standards of global forest governance.

Although negotiations do not discuss concepts or theoretical approaches, the REDD Draft Decision Text negotiated in Copenhagen includes much of the elements preconized by the institutionalist approach to good governance of natural resources, especially common pool resources. A governance framework responsive to specific needs of the different forest countries/regions is a challenge. Recognizing the peculiar national circumstances and the different dynamics of deforestation is essential for the design of a REDD strategy capable of assigning the right responsibilities to the required coordination for achieving the proposed goals. The literature on cooperation and collective action for managing natural resources can offer a good basis for building an effective REDD strategy. The goals of a REDD strategy can only be achieved by a framework that balances provision of individual and collective benefits and the enforcement of individual and collective obligations, which should be defined within local contexts. Institutions capable of providing an action plan that reflects to some extent the preferences and interests of all stakeholders, especially the local ones[1], and capable of imposing explicit or implicit sanctions in case of non-compliance can lead to the road of positive results in reducing deforestation and degradation (KEOHANE, OSTROM, 1995; REES, 2006). REDD strategy success is thus associated with an adequate assessment of drivers of deforestation in the specific country/region and by the timely delivery of information on the dynamics of deforestation and forestry activity to all stakeholders for underpinning credible commitments for cooperation and results. In sum, the guidance that stems from the Copenhagen draft and later consolidated in the Cancun Agreements points out the need for a strong governance structure capable of settling competing interests, protecting and respecting minorities, and promoting a set of comprehensive science-based actions as a means for ensuring sustainable conservation of forest cover and its associated multiple benefits.

3 REDD CHALLENGE AND PARADOX

While the definitions of REDD scope and reference levels were advanced in the Copenhagen text, negotiations related to REDD finance made little progress. The draft text from Copenhagen acknowledges a national REDD with a subnational approach according to specific circumstances to be implemented in phases. The text is clear when stating that REDD needs a technical and institutional preparation (Phase I, readiness), a second phase for consolidation of readiness and initial results-based demonstration activities (phase II) and the full implementation phase, when countries would be able to present measurable, reportable and verifiable results (phase III). The text clearly acknowledges the importance of governance structures for REDD. By recognizing the critical role of governance, however, the REDD as defined under the UNFCCC implies less flexible possibilities for funding and creates what will be presented here as the "REDD paradox".

Phases of REDD	
Phase I (Readiness)	development of national strategies or action plans, policies and measures capacity building
Phase II (readiness and demonstration activities)	implementation of national policies and measures, and national strategies or action plans and, as appropriate, subnational strategies, that could involve further capacity-building, technology transfer results-based demonstration activities, taking into consideration the safeguards
Phase III (full implementation)	Full implementation of national strategies and action plans and measurable, quantifiable and reportable results

1. Institutions here refer not only to agencies but also to formal or informal instruments that regulate stakeholder behavior.

The adoption of the three-phased approach calls for different funding needs throughout the three phases of REDD implementation, according to the diversity of activities to be undertaken at each phase, including formulation of strategies and implementation of safeguards. Hence, a significant amount of funds should be assigned to readiness on REDD even before measurable results can be achieved... Taking into consideration the most typical funding sources, i.e. public funds, donations, development assistance and markets, it's possible to conclude that different funding sources will be available for different activities. Markets usually are more likely to pay for results with a high level of certainty. Thus during the readiness phase, market funds are not likely to be relevant and where in place might undervalue the final payment for REDD results as markets tends to set a price on their risks and the opportunity costs. Public funds can be more appropriate for the initial phases of REDD, as they are less averse to risk and have a stronger capacity of influencing the institutional arrangements that affect risk.

Apart from the different requirements of public and private funds, the relationship between good governance and capacity to access funds is critical for REDD implementation. While critical for the success of REDD and responsible for setting up institutional arrangements capable of managing REDD risks, good governance is the pillar of REDD funding. As a consequence the REDD as negotiated in Copenhagen and approved in Cancun demands up front funds for ensuring institutional arrangements capable of overcoming the obstacles that emerge from the lack of solid governance structures. The allocation of these funds, however, no matter whether public or private will always request good governance, thus the challenge.

The challenge of good governance also encompasses the paradox of good governance. Most of the countries with the largest tropical forest cover and highest REDD potential are usually countries with governance problems. Unstable political regimes, institutional frameworks inadequate to REDD's needs and weak or nonexistent monitoring and control systems are some of the governance problems found in REDD countries. The level of governance will be a key determinant for progress in REDD and might lead to an asymmetry in funding allocation. This asymmetry may prevent countries with high forest carbon stocks from receiving funds, eventually jeopardizing the goal of providing positive incentives for all the countries with tropical forest cover and the scale of REDD contribution to the overall mitigation of climate change. Notably, the two largest forest basins in the world are the Amazon and the Congo Basin where many countries are still making their preliminary efforts towards reforming the institutional framework in order to implement sustainable REDD strategies and measurable, reportable and verifiable results.

4 FINAL REMARKS

The progress of the negotiations on the role of tropical forests for climate change mitigation is consolidated in the REDD mechanism under the UNFCCC. The challenge of reducing emissions from deforestation and of protecting forest carbon stocks on a permanent basis and at a global scale is now set in the text of the Cancun Agreements adopted by the COP in its sixteenth session. The text agreed in Mexico offers few changes in relation to that negotiated in Copenhagen and defines REDD as a national strategy for reducing deforestation and forest degradation, conservation and enhancement of forest carbon stocks, acknowledging sustainable forest management as an activity consistent with these objectives. As a consequence of its comprehensive scope, the mechanism will drive the arrangements for forest management in all forest covered developing countries that opts for REDD implementation. If successful, REDD will achieve results way beyond climate change mitigation, including benefits for ecosystem services, biodiversity preservation and poverty alleviation.

The text approved in Cancun maintained emphasis on governance and on the national approach. Its approval calls for immediate dialogue among those responsible for forest management, climate change mitigation and all the other relevant stakeholders, especially those directly involved in on-going implementation of REDD activities. As a consequence of the great increase in funding for exploring REDD options after COP XIII in 2008, many initiatives and projects were implemented adopting multiple approaches and methodologies. Many of those were based on subnational approaches with scopes aligned to the Clean Development Mechanism. At the international level, many programmes and initiatives were also established to work with potential REDD countries. Working without a definitive legal framework, these international initiatives supported actions proposed by countries envisaging deforestation reduction. The United Nations Collaborative Programme- UN-REDD and the Forest Carbon partnership of the World Bank are among the main initiatives. Also remarkable is the REDD+ Partnership launched after the progress made in Copenhagen with the objective of scaling up REDD implementation. In the new scenario of an approved REDD, all those initiatives face the challenge of consolidating approaches and establishing a funding structure capable of supporting strategies and measurable, reportable and verifiable results whilst promoting the multiple additional benefits of REDD.

In 2011, a REDD more focused on carbon is expected to be implemented and a new negotiation phase concentrated on the guidelines and recommendations for implementation shall take place. Some points will be critical such as the phase boundaries and funding for the REDD full implementation phase. The Cancun Agreement clearly defined funding sources for the first two phases of REDD through bilateral and multilateral cooperation. However, for the third phase the AWG-LCA will continue to explore options. According to this financial framework for funding REDD, the bilateral and multilateral initiatives will be have to deal with the REDD paradox, i.e. allocation of funds to structuring a governance system that will ensure consistent and sustainable REDD. The performance of these initiatives will play a fundamental role in allowing countries with governance problems to receive funds for REDD implementation and establishing a governance structure that meets the needs of environmental integrity and consistency. The REDD as defined by the Cancun Agreements might be the turning point for protection of forest cover at the global level and promotion of forest values. Domestic and international efforts in this case can lead to a new development model that will privilege standing forests. The challenge is well defined and the paradox is worthy of a solution.

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CHAPTER 19

TRANSFER OF TECHNOLOGY UNDER THE CLIMATE CHANGE REGIME

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1 INTRODUCTION

Although it is true that the use of certain technologies since the Industrial Revolution has undoubtedly been responsible for the increase in environmental damage worldwide, it is equally true that the use of others can substantially reduce adverse impact on the ecosystems. These newest and most advanced technologies that are less polluting, that use natural resources in a more sustainable manner or that even help protect the environment have been termed "environmentally sound technologies" – EST.[1]

Environmentally sound technologies are considered a fundamental component of sustainable development.[2] However, the use of more advanced technologies that have a more responsible approach towards the environment is as yet extremely limited in many countries, especially developing ones. In fact, these more advanced technologies are generally available to very few, since their development requires considerable technical and financial resources, usually available only in the most developed countries. Thus, developing countries will clearly need support in gaining access to them.

In section 2, the commitments on technology transfer under the climate change regime and the difficulties related to their implementation are described, in order to present the issue in the context of the negotiations and to allow a better understanding of the challenges to be faced. In section 3, the recent evolution under the negotiation process is presented. In the final considerations, the specificities of the Brazilian position on the issue are considered, as well as the main barriers and perspectives for the future negotiations, highlighting the main points that remain to be clarified.

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1. According to Agenda 21, Chapter 34, entitled "Transfer of Environmentally Sound Technology, Cooperation and Capacity-Building", environmentally sound technologies - EST are those that "protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes." Moreover, Agenda 21 draws attention to the fact that EST are "not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures." Cf. paragraphs 34.1 and 34.3 of Agenda 21, Chapter 34, contained in UN. doc. A/Conf.151/4, 12th August, 1992.

2. Technology is a key concept in the definition of sustainable development, as introduced by the 1987 Report of the World Commission on Environment and Development. See Brundtland (1987, p. 43).

2 COMMITMENTS RELATED TO TRANSFER OF TECHNOLOGY UNDER THE CLIMATE CHANGE REGIME AND BARRIERS FOR IMPLEMENTATION

Taking all these elements into consideration, the countries present at the 1992 United Nations Conference on Environment and Development set out relevant provisions in Chapter 34 of Agenda 21, entitled "Transfer of environmentally sound technology, cooperation and capacity-building". This document states that access to and transfer of environmentally sound technology should be promoted

> (…) on favourable terms, including on concessional and preferential terms, as mutually agreed, taking into account the need to protect intellectual rights as well as the special needs of developing countries for the implementation of Agenda 21 (UN, 1992).

"Technology transfer" in the context of international negotiations can be defined as the process of transferring environmentally sound technologies from the countries and the companies that developed and produced them to recipient countries, particularly developing ones. It has been also recognized that this process can also be promoted by other legal entities that could facilitate their effective implementation and dissemination. In this context, developing countries have signed international environmental agreements – such as the Montreal Protocol and the UNFCCC –conditional on technology transfer.

Indeed, transfer of technology has been essential for the implementation of the Montreal Protocol.[3] In the case of substances that deplete the ozone layer, there is a small group of products "for which substitutes appear to be technologically feasible with limited cost increases", the substitutes in question being environmentally safe. Moreover, production of CFCs was concentrated in the United States and the European Community, and in a few large firms (mainly DuPont), which had the capability to use safe substitutes. Additionally, a relatively efficient mechanism was created to promote financial assistance and transfer related technologies to those countries that did not have the same capabilities.

However, the situation is considerably different under the climate change regime. There are no substitutes for most of the greenhouses gases not controlled by the Montreal Protocol. Despite occasionally peaks in oil prices, the supply of hydrocarbon fuels in recent decades has involved relatively low costs, which has helped shape the current fuel habits of populations. According to most economic and energy scenarios, the trend of producing primary energy from fossil fuels will continue until at least the middle of 21st century. Lower- or non- greenhouse-gas-emitting alternatives to fossil fuels are substantially more costly. Furthermore, greenhouse gases are emitted worldwide and the majority of countries are either unable or unwilling to face the high price of alternative energy sources, which are not available everywhere.

3. See Article 10A of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer as adjusted and amended by the second Meeting of the Parties in 1997.

Thus, technology is the key to addressing climate-change-related issues both from the mitigation and adaptation point of view. The major barrier against their use, in addition to the reasons mentioned in the previous paragraph, is that existing lower- or non-greenhouse-gas-emitting technologies (e.g. solar and wind energy, appliances that improve energy efficiency, etc.) are generally only available in developed countries. It is therefore very difficult for developing countries to shift away from carbon-based production and increase their levels of efficiency. Technologies and know-how that could assist in preparing for adaptation to climate change (e.g. computer models, more sophisticated engineering, etc.) are also rare in the South.

Nevertheless, there are instruments and mechanisms that could be used to stimulate the adoption of climate-friendly options at a more reduced cost, allowing developing countries to develop in more environmentally friendly way than did the current developed countries[4], leap-frogging equipment and processes that imply higher greenhouse gas emissions.

In this regard, the UNFCCC sets out a common commitment to all Parties – taking into account their common but differentiated responsibilities and their specific national and regional priorities – to promote and cooperate in the development, application, diffusion and transfer of technologies, practices and process that could mitigate greenhouse gas emissions. In the context of climate change mitigation[5], environmentally sound technologies are those that control, reduce or prevent anthropogenic emissions of greenhouse gases in all relevant sectors of economy.

Although not specifically mentioned in the text of the Convention, the need for technologies[6] related to adaptation to the impacts of climate change has become increasingly recognised as an equally important need. Since the UNFCCC establishes a common commitment to cooperate in preparing for adaptation to climate change, it is implicit that such cooperation would include the development, application, diffusion and transfer of technologies in this regard.

4. Although the Preamble of the Convention, in its paragraph 22, acknowledges that the energy consumption of developing countries will need to grow in order to achieve sustainable social and economic development, it also recognizes that there are possibilities for achieving greater energy efficiency and for controlling greenhouse gas emissions in general, through, inter alia, the application of new technologies in ways that make such an application economically and socially beneficial.

5. In fact, Article 4.1 (c) of the Convention does not mention the expression "environmentally sound technology". During the negotiations under the Intergovernmental Negotiating Committee of the FCCC, some countries lobbied for the inclusion of the expression "safe and sound" with the intention of excluding nuclear technology, given that it is generally regarded as an environmental threat, although nuclear energy does not directly emit greenhouse gases. Since some countries rely on nuclear technology to produce energy, the whole expression was avoided and only the word technology was employed. Cf. draft Article 4.1 (c), "Report of the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change on the Work of the First Part of its Fifth Session, held at New York from 18 to 28 February", contained in doc. A/AC. 237/18 (Part I), 10th March 1992, p. 31.

6. Hereinafter, the word the expression "environmentally sound technology" will be replaced with "technology" in order to avoid unnecessary repetition.

The acceptance of the common commitment set out in Article 4.1 (c) of the Convention was subject to the provision of funding to developing countries, since the development, application, diffusion and transfer of technologies is closely related to the availability of financial resources. Hence, a differentiated commitment was established aiming to ensure that developed country Parties and other developed Parties included in Annex II could provide financial resources, including those for the transfer of technology, needed by the developing country Parties to cover the costs of implementing the common commitments under the UNFCCC.[7]

Given that in the context of climate change the transfer of environmentally sound technology and know-how[8] is crucial in helping countries comply with their commitments, a specific differentiated commitment was set out in this regard, which was preceded by heated debate.

During the negotiations of the text of the Convention, the Group of 77 and China expressed the view that developed country Parties should transfer and provide developing country Parties with access to technologies and know-how on "concessional, preferential and most favourable terms", paying particular attention to the needs of the least developed countries.[9] Nevertheless, the expression inserted in Agenda 21 was not retained in the UNFCCC text that was finally adopted. Article 4.5 of the Convention indicates a vague progressive approach regarding the transfer of technology, with no definition of the terms on which such a transfer could possibly occur.[10] The Article simply states that developed country Parties and other developed Parties included in Annex II, as well as other Parties and organisations in a position to do so, shall "take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how". Moreover, the transfer of technology was not restricted to developing countries – although there is a particular reference

7. Article 4.3 of the Convention. Article 11 of the Convention also states that the mechanism for the provision of financial resources on a grant or concessional basis also includes the transfer of technology, although not specifying how it could be made operational. Developing countries have constantly complained on the conditions and limitations of the provision of financial resources under the climate change regime.

8. They include mitigation technologies by source, or to enhance removal by sinks of greenhouse gases, and adaptation technologies to reduce the adverse effects of climate change. They encompass "soft technologies", such as capacity building, information networks, training and research; and "hard technologies", such as equipment and products to control, reduce or prevent anthropogenic emission of greenhouse gases in the energy, transportation, forestry, agricultural, industry and waste management sectors. See FCCC/SBSTA/1996/4, 2nd February 1996.

9. Cf. draft Article 4.2.3, "Report of the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change on the Work of the First Part of its Fifth Session, held at New York from 18 to 28 February", contained in doc. A/AC. 237/18 (Part I), 10th March, 1992, pp. 37-38.

10. However, Article 9.2 (c) of the Convention mandates the SBSTA to identify innovative, efficient and state-of-the-art technologies and know-how and to advise on the ways and means of promoting development and/or transferring such technologies.

to these countries[11] – but applies to other Parties in general, which certainly includes other developed countries and those that are undergoing the process of transition to a market economy.[12]

It is worth recalling that the effective implementation by developed country Parties of their commitments under the Convention related to transfer of technology will have a direct impact on the extent to which developing country Parties will effectively implement their commitments under the Convention, in accordance with Article 4.7 of the UNFCCC.

It was clear since the beginning of the negotiations that implementing these provisions would be no easy task, given the numerous factors inhibiting the process of technology transfer. Attempts were made to include some provisions that would address the reduction or elimination of these barriers in the text of the Convention, but to no avail.[13]

Aware of these difficulties, at COP 1, the Parties agreed that issues related to the development and transfer of environmentally sound technologies should be considered by the Conference of the Parties to the UNFCCC at each of its sessions with the aim of providing continuous advice towards improving the operational modalities for effective technology transfer.[14] In the discussions during the first COPs, it became clear that the main difficulty involving the effective implementation of the provisions under the Convention on technology transfer was that governments have a limited role to play in this process, since the property rights to most technologies are held by the private sector.

In 1997, the adoption of Kyoto Protocol offered an opportunity for Parties to address this question. In addition to the reiteration of the commitment on technology transfer under the UNFCCC,[15] the provisions of the Protocol broaden

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11. The developed country Parties must also support the development and enhancement of endogenous capacities and technologies of developing country Parties. Cf. Article 4.5 of the Convention.

12. Ibidem.

13. In the draft text of the Article on technology cooperation/technology transfer there was a reference to the need to take appropriate steps to reduce or eliminate unjustifiable barriers against the transfer of technology, as well as the need to ensure that the protection of intellectual property rights would not hinder such transfer. Cf. draft Article 4.2.3, "Report of the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change on the Work of the First Part of its Fifth Session, held at New York from 18 to 28 February", contained in doc. A/AC. 237/18 (Part I), 10th March, 1992, p. 38.

14. Paragraph 2(a) of decision 13/CP.1, entitled "Transfer of Technology", 10th plenary meeting, 7th April, 1995; contained in doc. FCCC/CP/1995/7/Add.1, 6th June, 1995, pp. 40-41.

15. The agreed text drew on Article 4.5 of the Convention as the basis for the language contained in Article 10 (c) of the Kyoto Protocol, although the latter uses the expression "environmentally sound technologies, know-how, practices and processes pertinent to climate change", which gives a clearer indication that they are not only related to mitigation but also to adaptation to climate change. Article 11, paragraph 1 of the Protocol makes a reference to Article 4.5 of the Convention and its paragraph 2 reaffirms that the provision of financial resources includes transfer of technology.

the scope of the former instrument[16] to encompass the "formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain and the creation of an enabling environment for the private sector, to promote and enhance the transfer of, and access to, environmentally sound technologies".[17] Although still somewhat vague, this formulation does make it clear that the involvement of the private sector is crucial in enabling countries, particularly developing ones, to have access to such technologies. This recognition, which is not usual in international agreements, is a reflection of the fact that, in certain areas, governments have a limited role to play given the worldwide expansion of the market economy.

In this regard, the innovative Kyoto mechanisms, in particular the joint implementation[18] and the clean development mechanism[19], could, in principle, offer such an enabling environment for the private sector to promote and enhance the transfer of environmentally sound technologies to Parties included and not included in Annex I. However, the implementation of the projects under these mechanisms has not shown as a viable channel for transfer of technology as previously expected. The limited transfer of technology that has been verified has occurred mostly between subsidiaries of the same multilateral companies.

Nevertheless, probably due to the above-mentioned limited capacity of governments to transfer technologies that are mostly owned by corporations, in spite of the progress *vis-à-vis* the formal language of the instruments under the climate change regime, in practical terms the difficulties in advancing the implementation of the commitments related to technology transfer have remained.

In an attempt to move forward, the Conference of the Parties to the UNFCCC, at its fourth session, as part of the Buenos Aires Plan of Action, urged Annex II Parties to provide a list of environmentally sound technologies and know-how related to adaptation to and mitigation of climate change that are publicly owned. Developing countries, in their turn, were called upon to submit their priorities related to technology needs, especially those relating to key technologies in addressing climate change in particular sectors of their national economies. Moreover, the COP urged both developed and developing country

16. During the AGBM negotiating process, there were even more ambitious proposals for expanding the scope of the commitments related to transfer of technology set out in the UNFCCC. One of these proposals stated that Parties should ensure the transfer of material, equipment and technology for renewable sources of energy, including solar and biomass, to other Parties on concessional and preferential terms and that the restrictions on such transfers should be removed. Cf. Paragraph 2.2, Alternative B of Annex III, entitled "Continuing to Advance the Implementation of Existing Commitments in Article 4.1", which is part of the "Reports by the Chairmen of the Informal Consultations Conducted at the Seventh Session of the Ad Hoc Group on the Berlin Mandate", contained in doc. FCCC/AGBM/1997/INF.1, 22nd September, 1997; pp. 56-57.

17. Article 10 (c) of the Kyoto Protocol.

18. Article 6 of the Kyoto Protocol.

19. Article 12 of the Kyoto Protocol.

Parties to create an enabling environment to stimulate private sector investment in the transfer of EST and know-how to the former.

The aim of these requests was to develop a "framework for meaningful and effective actions" to enhance the implementation of Article 4.5 of the Convention.[20] However, in general, the developed countries provided little (and often unclear) information, while the poor submissions from the developing countries highlighted their lack of capacity to assess their own technology needs.

Despite these deficiencies, as a result of the consultative process on technology transfer promoted after COP 4,[21] a "framework for meaningful and effective actions to enhance the implementation of Article 4.5 of the Convention"[22] was adopted as part of the Marrakech Accords. This covered five key topics and areas for meaningful and effective actions, namely: technology needs and needs assessments; technology information; enabling environments; capacity-building; and mechanisms for technology transfer. Funding to implement the framework is to be provided through the GEF climate change focal area and the special climate change fund, which, it is worth remembering, is not yet fully operational.

The Marrakech Accords also provided for the establishment of an Expert Group on Technology Transfer (EGTT), to be nominated by the Parties,[23] charged with enhancing the implementation of Article 4.5 of the Convention, facilitating and advancing technology transfer activities and making recommendations to this end to the SBSTA. Unfortunately, this group had a very limited role in the effective implementation of Article 4.5, given that it was a group of technical nature under the SBSTA and not under the Subsidiary Body on Implementation - SBI and did not have financial resources in order to promote the effective technology transfer or, at least, reduce the existing barriers.

Since then, there have been some attempts to establish a broader technology framework under the climate change regime, including the development of methodologies for needs assessments,[24] the launch of a technology transfer

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20. Decision 4/CP. 4, entitled "Development and Transfer of Technologies", 8th plenary meeting, 14th November, 1998; contained in doc. FCCC/CP/1998/16/Add.1, 20th January, 1999, pp. 11-16, including an Annex with a list of specific issues and associated questions to be considered by the Parties.

21. This consultative process encompassed information contained in the submissions from the Parties, in the reports of three regional workshops on the issue that were organized by the UNFCCC Secretariat, and in particular in the "IPCC Special Report on Methodological and Technological Issues in Technology Transfer".

22. Annex to Decision 4/CP. 7, 8th plenary meeting, 10th November 2001; contained in doc. FCCC/CP/2001/13/Add.1, 21st January 2002, p. 22-31.

23. The EGTT comprises 20 experts, including three members from each of the developing country regions (Africa, Asia and the Pacific, and Latin America and the Caribbean), one from the small-island developing States, seven from Annex I Parties, and three from relevant international organizations.

24. Cf. "Development and Transfer of Technologies: report of the expert meeting on methodologies for technology needs assessments, Seoul, Republic of Korea, 23-25 April 2002", contained in doc. FCCC/SBSTA/2002/INF. 7., 30th May, 2002.

information clearing house,[25] and the identification of activities needed for capacity-building.[26] However, progress has been very limited. In fact, little has been achieved so far beyond assessing the enabling environments for EST transfers and the main barriers against them.[27]

Similar to the provision of financial resources, the dissatisfaction of developing countries with the issues related to the transfer of technology under the climate change regime has been constantly reiterated at every meeting of the subsidiary bodies and every session of the Conference of the Parties. Arguing that

> (…) significant steps have still to be taken in order to ensure an effective and durable implementation of [the] Convention at a time when climate change continues to have an enormous negative impact on the world's regions and populations, particularly in developing countries (MOROCCAN DELEGATION).

The structure of the Convention and the Protocol – in defining more detailed commitments for developed country Parties, while the implementation of the less detailed and stringent commitments for developing country Parties is related to the provision of financial and technical assistance – is a reflection of how the principle of common but differentiated responsibilities took a more concrete form under the climate change regime.

Two of the main means by which the principle of common but differentiated responsibilities is embodied in the climate change regime are the provision of financial resources and the transfer of technology. These means are also important tools for fostering a more effective implementation of the climate regime, since they seek to provide the less privileged with the opportunity to participate in the efforts to combat climate change, taking into account the differentiated capabilities and needs of the Parties.

Nevertheless, there are significant deficiencies and distortions related to the implementation of the regulatory framework of the provision of financial resources and technology transfer – two of the main means by which the commitments are differentiated – that pose some constraints to achieving the aims of the principle of common but differentiated responsibilities.

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25. TT:CLEAR is a web-based technology information clearing house developed by the Secretariat of the UNFCCC, with support from Parties and the EGTT, which was designed to provide information on: technology transfer projects and programs, case studies of successful technology transfer; environmentally sound technologies and know-how; organizations and experts; methods, models and tools to assess mitigation and adaptation options and strategies; relevant internet sites for technology transfer; ongoing work of the Parties and the EGTT such as issues under negotiation, documents and meetings, and implementation of the technology framework. More information is available on the website <http://ttclear.unfccc.int/ttclear/jsp/>.

26. Cf. "Capacity-building in the development and transfer of technologies: technical paper", contained in doc. FCCC/TP/2003/1, 26th November, 2003.

27. For instance, there is little data on projects under implementation or proposed for implementation in the technology transfer projects (TTProjects) section on the TT: CLEAR clearing house.

The issues related to technology transfer consist of one of the main bones of contention under the climate change regime. While developing countries have been constantly reiterating the lack of developed countries' political will as the main barrier for transferring environmentally sound technologies, the latter have claimed that they have limited power in promoting this transfer, since ESTs are primarily owned by the private sector, which completely disregards the PCBDR. Considering the main existing barriers in the transfer of ESTs, access to these technologies has been considered part of the "myth system". Sale of ESTs from developed countries to developing countries, and consequently the transfer of financial resources from South to North – which contradicts the PCBDR – is more likely to occur than their transfer.

The deficiencies and distortions under legal and other normative instruments in the context of the climate change regime summed up in the above paragraphs show that the implementation of the UNFCCC and the Kyoto Protocol has not been as effective as desired. Most importantly, these bottlenecks pose certain constraints to the reduction of inequalities among States and to the encouragement of wider participation to foster the implementation of the regime.

3 THE FUTURE OF THE REGIME: NEW HOPES OR "MORE OF THE SAME"?

Despite all these problems in the implementation of the UNFCCC and the Kyoto Protocol, an international regime is an evolutionary process and the climate change regime is under significant pressure from different actors to evolve quickly so that it can provide an effective global response to the climate threat.

In fact, a new round of negotiations on the future of the global climate change regime was launched in 2005, at COP 11, and is structured into two "tracks" of negotiations, one under the UNFCCC and the other under the Protocol.

Launched as a dialogue to improve the implementation of the Convention as a forum for discussions on how to correct the deficiencies and distortions of the legal and regulatory instruments under the UNFCCC, the "track" under the Convention evolved, given since the recognition of the need to support action in developing countries for the promotion of measures that could help reducing GHG emissions in all relevant sectors and also promoting sustainable development.

Thus, considering the urgency to improve the implementation of the Convention in order to achieve its ultimate objective in accordance with its principles and its commitments, the Bali Action Plan - BAP was adopted at COP 13, which initiated a comprehensive negotiation process to enable the "(...) full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012, in order to reach an agreed outcome and adopt a decision at its fifteenth session (…)",[28] covering among others five major issues or "pillars".

Certainly, the issues related to the implementation of commitments regarding technology transfer could not be absent among these "pillars".[29] Thus, the BAP considers that the "full, effective and sustained implementation of the Convention" should be implemented through long-term cooperation measures that could enhance "action on technology development and transfer to support action on mitigation and adaptation".[30] It is important to note that the reference does not merely refer to transfer of technology, but also to technology development. This meets a long-standing demand by developing countries of not just having the technology transferred – in fact, sold – but also having the opportunity to participate in the process of technological innovation and use the potential of endogenous technologies.

Among other elements, the BAP addresses the need to consider:

1. Effective mechanisms and enhanced means for the removal of obstacles to, and provision of financial and other incentives for, scaling up of the development and transfer of technology to developing country Parties in order to promote access to affordable environmentally sound technologies.
2. Ways to accelerate deployment, diffusion and transfer of affordable environmentally sound technologies.
3. Cooperation on research and development of current, new and innovative technology, including win-win solutions.
4. The effectiveness of mechanisms and tools for technology cooperation in specific sectors.

Therefore, the BAP initiated a new negotiation process conducted under a new subsidiary body of the UNFCCC, which was established and named the Ad Hoc Group on Long-Term Cooperative Action under the Convention - AWG-LCA. This group was mandated to conclude its activities in 2009 and present the outcome of its work to the COP for adoption at its 15th session.[31] Since then, a comprehensive and intense negotiation process has been going on with several sessions in which developing and developed countries have battled on opposite sides, defending different interests.

28. Chapeau of paragraph 1 of Decision 1/CP 13.
29. The other four "pillars" are shared view, mitigation, adaptation and finance.
30. Paragraph 1(d) of the Decision 1/COP 13.
31. Paragraph 2 of the Decision 1/COP 13

As far as the development and transfer of technology are concerned, the G-77 and China kicked-off the negotiation in presenting a comprehensive proposal encompassing both technologies related to mitigation and adaptation, as well as existing and new technologies. By claiming that the existing institutional arrangements have been insufficient to provide immediate and urgent development, diffusion, deployment and transfer of technology to non-Annex I Parties of the Convention, the proposal called for the creation of the Technology Mechanism, which should operate under the authority and guidance of the COP and be accountable to it, in order to provide means to improve the implementation of the commitments made by the Parties under the UNFCCC on the issue of technology transfer, as well as complying with the funding and capacity building related to that. The Mechanism aimed to:

- promote access, adequacy, accessibility and adaptability of the technologies needed by developing countries to enhance their mitigation and adaptation actions;
- promote adequacy and predictability of funds for technology transfer, to cover its full and incremental costs, in accordance with article 4.3 of the Convention; and
- remove barriers related to the development and technology transfer.

Such a mechanism would include an Executive Body and a Multilateral Technology Fund on climate change. This fund would provide funding to support the related technology, as determined by the Executive Body. The fund would operate under the guidance of the COP as a component of the multilateral funding mechanism also proposed by the G-77 and China.

The Mechanism would cover technologies in all relevant sectors and should strive to eliminate barriers to effective development, deployment, diffusion and transfer of technology. The proposal also talked about the importance of dealing with intellectual property rights in an intelligent and innovative way, so that they no longer constitute barriers to effective technology transfer. The Technology Mechanism would coordinate with the Financial Mechanism of the Convention to ensure the necessary financial resources. The proposal also drafted a comprehensive list of eligible activities and costs that would be supported by the latter mechanism.

As expected, the proposal presented by developing countries suffered great opposition from developed countries. The representatives of the latter reaffirmed the argument that since most of the EST is developed by the private sector, and even public programs of research and development were implemented in partnership with the private sector, the issue of property rights would be extremely problematic.

Thus, developed countries would have limited power to promote such transfers. The developing countries, on the other hand, claimed that this argument is just an attempt to do not comply with their commitments under the UNFCCC, shifting the problem to the private sector, leaving the transfer of technology under the control of market forces and subject to private sector preferences.

Indeed, for developed countries, which are the largest holders of patents on technologies considered as "environmentally sound", the current scenario, in which market forces prevail, is extremely comfortable. Many stakeholders in these countries saw the emerging concern of developing nations in mitigating greenhouse gases as an excellent window of opportunity to sell "low carbon" technology. Obviously, those countries opposed the proposal made by the G-77 and China regarding the creation of an Executive Body.

The United States, supported by the Umbrella Group[32], proposed the idea of an international centre for technology transfer, with the possible support of regional centres and a network of research centres, a mechanism that would identify technology needs and provide advice to developing countries on the channels through which technology could be "transferred". In informal meetings, their representatives did not hide the fact that they identified the World Bank as the best candidate to play the role of this centre, supported by the regional development banks in the Americas, Asia and Africa. This position highlights their view that technology should be "sold", not "transferred". In this regard, the idea of a Technology Fund, proposed by the G-77 and China, was totally against this view and it was therefore rejected. Moreover, the United States during the COP 15, made a statement against the idea of including the development of technologies under any mechanism, which contradicted the idea included in the BAP, and left even more evident that the situation considered more convenient was to maintain the dependence of developing countries in relation to technology owned by developed countries.

Another extremely controversial point during the negotiations has been the issue of intellectual property rights. The vast majority of developing countries believed it would be important that the outcome of the negotiations could address this issue so that the barriers to technology transfer could be overcome. However, it is noteworthy that some had a more moderate position than others: while some countries, such as Bolivia, insisted on the possibility of compulsory licensing, others supported the idea of using the Technology Fund to purchase licenses and other intellectual property rights. This would allow diffusion in the form of "public domain" technologies. During negotiations, developed

32. Coalition of developed countries not part of the European Union – usually, composed by Australia, Canada, Japan, Iceland, New Zealand, the Russian Federation and Ukraine.

countries have even refused to discuss this issue. The United States have said that any mention of intellectual property rights would be unacceptable to its delegation and prevent any agreement.

Such issues and many others have been extensively debated during the negotiation process under the AWG-LCA in 2008 and 2009. Given that every international negotiation is based on the composition of interests between different groups and Parties, in Copenhagen, the contact group that was dealing with this issue had made a lot of progress and some consensus was emerging towards the idea of the creation of the Technology Mechanism, which was being designed to be composed by two basic components: the Technology Committee and the Climate Technology Centre and its network. The first was an adaptation of the G-77 and China proposal, in spite of the fact that the name of Executive Body was originally the preference of this group, and the second resulted of the proposal presented by the United States and Japan. However, although the idea of the two components were acceptable to the Parties, the most controversial point came to be the relation between these two components: while the G-77 and China wanted the Centre to be submitted to the authority of the Committee, where it would be likely that the group could guarantee the majority of its membership, developed countries insisted that the two components should be independent and in a non-hierarchical relationship. What developing countries seek is that the mechanism on technology transfer that might be established could have executive functions in order to implement concrete actions, and not just be a technology advisory body or, even worse, to promote the sale of technologies, which is the predominant view among the developed countries.

Because of all these extreme controversial points, and still contaminated by the general failure of the negotiations at COP 15, it was not possible, as expected, to finalize the negotiations at this session of the Conference. As it is known, the COP 15 only "took note" of what was called the Copenhagen Agreement, which briefly mentioned that "[i]n order to enhance action on development and transfer of technology we decide to establish a Technology Mechanism to accelerate technology development and transfer in support of action on adaptation and mitigation that will be guided by a country-driven approach and be based on national circumstances and priorities". [33]

The failure of Copenhagen was a significant blow to the international community's efforts to combat climate change, and it raised questions about the utility of the multilateral processes. The negotiations under the Ad Hoc Working Group on Further Commitments for Annex I Parties in the framework of the Kyoto Protocol (AWG-KP) and the AWG-LCA – which had their terms extended by at

33. Paragraph 11 of the Copenhagen Accord, annex in the Decision 2/COP 15.

least another year – were carried out with caution based on the recognition that a new failure would be disastrous. Thanks to the skills of the Mexican Presidency in forging an agreement – this time in the form of decisions –, taking care not to repeat the mistakes of the Danish Presidency in the previous year, the COP 16 held in Cancun had a result that was, if not entirely conclusive, gave a new lease of life to the UNFCCC process. The agreed compromises under the pillars of the BAP were compiled into a single decision, entitled as the outcome of the work of the AWG-LCA. This COP decision is one of the decisions that comprise the "Cancun Agreements". The LCA agreement comprises specific paragraphs on the development and transfer of technology.[34]

The preamble to the chapter on the development and transfer of technology contained in the Cancun agreement recalls the commitments under the Convention, in particular Article 4, paragraphs 1, 3, 5, 7, 8 and 9. It also recognises that a rapid reduction in emissions and the urgent need to adapt to the adverse impacts of global climate change require the widespread diffusion and transfer of, or access to, environmentally sound technologies, and therefore, highlights the need for effective mechanisms, appropriate enabling environments and the removal of barriers in order to enhance the development and transfer of technology to developing countries Parties.

This preamble can be considered a significant victory for developing countries, especially the last sentence, which recognises the importance of developing technologies, idea rejected by the United States in Copenhagen.

It was decided that the objective related to the development and transfer of technology is to support action on mitigation and adaptation, in order to achieve the full implementation of the UNFCCC. In pursuing this objective, the technology-related needs should be nationally determined, based on national circumstances and priorities. The focus on "national determination" was primarily a victory for Brazil, which insisted in this wording, arguing that, for example, the technology of production and use of bioethanol from sugar cane, which has been a successful story of mitigation actions in the country, has been questioned by some developed countries.

Also important, not only for Brazil, but for all developing countries, was the decision that actions at different technology stages – including research and development, demonstration, deployment, diffusion and transfer of technology (the expression "development and technology transfer", in fact, would encompass all these elements) – should be accelerated in support of action on mitigation and adaptation.

34. Paragraphs 113 to 129 of Decision 1/COP 16.

As expected, in accordance with the principle of common but differentiated responsibilities, the Cancun Agreement creates obligations for all Parties. In this regard, the agreement encourages them, under Article 4, paragraph 1(c) and Article 5 of the Convention and consistent with their capabilities, circumstances and priorities, to undertake actions identified through country-driven approaches, to engage in bilateral and multilateral cooperative initiatives for development and technology transfer, as well to promote increased public and private research, development and demonstration of technologies for mitigation and adaptation.

Nevertheless, the core of the Cancun Agreement regarding the development and transfer of technology was the decision to establish a Technology Mechanism to facilitate the implementation of actions to achieve the above mentioned objective, being composed of two components previously discussed, the Technology Executive Committee and the Climate Technology Centre and its Network, which, according to their functions, should facilitate the effective implementation of the Technology Mechanism, under the guidance of the COP. The mechanism is to replace the EGTT, which mandate was terminated at COP 16.

The functions of the Technology Executive Committee shall be to:

1. Provide an overview of technological needs and analysis of policy and technical issues related to the development and transfer of technologies for mitigation and adaptation.
2. Consider and recommend actions to promote technology development and transfer in order to accelerate action on mitigation and adaptation.
3. Recommend guidance on policies and programme priorities related to technology development and transfer with special consideration given to the least developed country Parties.
4. Promote and facilitate collaboration on the development and transfer of technologies for mitigation and adaptation between governments, the private sector, non-profit organizations and academic and research communities.
5. Recommend actions to address the barriers to technology development and transfer in order to enable enhanced action on mitigation and adaptation.
6. Seek cooperation with relevant international technology initiatives, stakeholders and organizations, promote coherence and cooperation across technology activities, including activities under and outside of the Convention.
7. Catalyse the development and use of technology road maps or action plans at the international, regional and national levels through cooperation between relevant stakeholders, particularly governments and relevant

organizations or bodies, including the development of best practice guidelines as facilitative tools for action on mitigation and adaptation.

The Technology Executive Committee shall be composed of 20 expert members, elected by the COP, which will serve in their personal capacity and nominated by Parties, in order to achieve an equitable and balanced representation. It will comprise nine members from Parties included in Annex I to the Convention; three members from each of the three regions of the Parties not included in the Annex I to the UNFCCC, namely Africa, Asia and the Pacific, and Latin America and the Caribbean; one member from a small island developing State and one member from a least developed country. Decisions will be taken according to the rule of consensus.[35]

This Committee shall convene its first meeting as soon as possible after the election of its members and develop its modalities and procedures, taking into account the need to ensure consistency and maintain interactions with other institutional arrangements under and outside of the UNFCCC. Such modalities and procedures should be considered by COP 17.

The Climate Technology Centre shall, on its turn, shall facilitate a network of national, regional, sectoral and international technology networks, organizations and initiatives with a view to engaging the participants of the Network effectively in the following functions:

1. At the request of a developing country Party:
    - Provide advice and support related to the identification of technology needs and the implementation of environmentally sound technologies, practices and processes;
    - Facilitate the provision of information, training and support for programmes to build or strengthen capacity of developing countries to identify technology options, make technology choices and operate, maintain and adapt technology;
    - Facilitate prompt action on the deployment of existing technology in developing country Parties based on identified needs;
2. Stimulate and encourage, through collaboration with the private sector, public institutions, academia and research institutions, the development and transfer of existing and emerging environmentally sound technologies, as well as opportunities for North-South, South-South and triangular technology cooperation;

35. Annex IV to Decision 1/CP.16.

3. Facilitate a network of national, regional, sectoral and international technology centres, networks, organization and initiatives with a view to:
   - Enhancing cooperation with national, regional and international technology centres and relevant national institutions;
   - Facilitating international partnerships among public and private stakeholders to accelerate the innovation and diffusion of environmentally sound technologies to developing country Parties;
   - Providing, on request by a developing country Party, in-country technical assistance and training to support identified technology actions in developing country Parties;
   - Stimulating the establishment of twinning centre arrangements to promote North-South, South-South and triangular partnerships, with a view to encouraging cooperative research and development;
   - Identifying, disseminating and assisting with developing analytical tools, policies and best practices for country-driven planning to support the dissemination of environmentally sound technologies;
4. Performing other such activities as may be necessary to carry out its functions.

As can be observed, unlike the Technology Executive Committee, the functions of the Climate Technology Centre and its Network are especially vague. In fact, such functions suffer of a lack of clarity, and there are many doubts on which institution(s) could play the role of this centre.

4 FINAL CONSIDERATIONS

Brazil used the debate on the design of the Climate Technology Centre and Network to share and highlight its ideas regarding the significance of South-South cooperation, given that the capacity of non-Annex I Parties on developing new technologies cannot be underestimated. The great success in Brazil's sustainable use – environmentally, socially and economically – of bioenergy from sugar cane, by means of bioethanol and bio-electricity, is a good example of an innovative program, initiated outside developed countries, and that is able for South-South transfer (technology diffusion). Moreover, the successful experience of more than 30 years of blending gasoline-ethanol on high levels of the latter, up to 25% (E25), in Otto cycle engines, combined with the *flex fuel* engines – the latest and successful technologies, used by all assemblers of vehicles established in the country – capable of indiscriminately operating with the mix E25 or pure ethanol (E100), pave the way for the diffusion of bioethanol (in particular, the one currently produced from cane sugar), as a renewable fuel with low GHG emissions and competitive at global level. Moreover, it is worth reminding the attractiveness of the Brazilian endogenous technologies to exploit renewable energy, which corresponds to 47% of the country's energy supply, on a modern and competitive basis, while fossil fuels prevail in the world energy scene, corresponding to 87% of the demand.

Although the recent progress under the negotiation process, decision is yet to be taken on the controversial issue on the formal relation between the two components of the Technology Mechanism under the Convention. By now, the Technology Executive Committee and the Climate Technology Centre and Network will present each a report to the COP through its subsidiary bodies, the SBSTA and the SBI, on their activities and implementation of their functions, until a final decision on the relation between the two components and about the reporting system is taken. It is said in the Cancun Agreement that the two components shall relate so as to promote coherence and synergy to the mechanism. However, as already pointed out, nothing has been specified on the bases of this interaction and on the hierarchical relationship between them.

Another point where no consensus has been achieved – to the disappointment of developing countries – is the identification of priority areas. The Cancun Agreements only indicates, in a language that is quite vague, that

> (...) priority areas that could be considered under the Convention may include, *inter alia*:
>
> (a) Development and enhancement of the endogenous capacities and technologies of developing country Parties, including cooperative research, development and demonstration programmes;
>
> (b) Deployment and diffusion of environmentally sound technologies and know-how in developing country Parties;
>
> (c) Increased public and private investment in technology development, deployment, diffusion and transfer;
>
> (d) Deployment of soft and hard technologies for the implementation of adaptation and mitigation actions;
>
> (e) Improved climate change observation systems and related information management;
>
> (f) Strengthening of national systems of innovation and technology innovation centres;
>
> (g) Development and implementation of national technology plans for mitigation and adaptation.[36]

The decision adopted at COP 16, in Cancun, is a positive sign towards the expectation that the negotiations under the AWG-LCA could result in a more

36. Paragraph 120 of Decision 1/COP 16.

comprehensive and detailed agreement at the next Conference of the Parties, to be held in Durban, South Africa. However, a lot of work remains to be done so that the Technology Mechanism could be fully operational. Thus, an ambitious work program on development and technology transfer was established in 2011.

The importance of continued dialogue between the Parties in 2011 by means of the AWG-LCA was emphasized in the text of the Cancun Agreements, in order to enable the COP 17 to take the decisions necessary to make the Technology Mechanism fully operational until 2012.

As previously indicated, the impasse in negotiations regarding the relation between the Technology Executive Committee and the Climate Technology Centre and Network must be solved, as well as their communication channels. Much has to be discussed on the governance structure and on the terms of reference for the Climate Technology Centre and Network, as well as on the relationship between the centre and the network. The process regarding the call for proposals and the criteria to be used to evaluate proposals and select the host of this centre must also be discussed. The Cancun Agreement also leaves open the possibility of discussing additional functions for the Technology Executive Committee and the Climate Technology Centre and Network which require development and approval.

However, the main question still open, which is crucial to determine if the Technology Mechanism will be able to effectively implement the commitments on development and transfer of technology made under the Convention, is the relationship between this Mechanism and the Financial Mechanism. Given that, if a continuous and predictable flow of new resources in a sustainable way is not secured, all the good ideas are likely to remain only “good intentions” or “empty speech”.

An expert seminar on the Technology Mechanism was convened in conjunction with one of the AWG-LCA sessions in 2011. It is going to deal with all outstanding issues relating to the development and technology transfer and should take into account the preliminary work of the Expert Group on Technology Transfer in the previous years.

Only the recognition that rapid reduction of emissions and the urgent need to adapt to the adverse impacts of global climate change requires immediate widespread diffusion and transfer of, or access to, environmentally sound technologies is not enough. Concrete actions should be taken towards this direction, either through the promotion of technological innovation as a mean of economic and social development, either through the fear that the cost of inaction will be much higher in the future. Although hard to admit, the truth is that environmental concerns are more easily taken into account if they do not affect important economic interests, or conversely, if a decision does not bring significant economic implications.

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