EXECUTIVE SUMMARY

CLIMATE CHANGE MITIGATION

Contribution of Working Group 3
to the *Primeiro Relatório de Avaliação Nacional*
of the *Painel Brasileiro de Mudanças Climáticas*

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TABLE OF CONTENTS

INTRODUCTION

This document contributes information to the discussion among various segments of national society on the costs, benefits and means of transitioning to a low greenhouse gas (GHG) emissions society. The work is the result of volunteer efforts of more than 100 authors, including coordinators, authors, contributors and reviewers that belong to the national scientific-technological community, from universities, research centers, government agencies, industry and non-governmental organizations, selected exclusively on the basis of merit. [GT3 1]

The main findings are presented according to the sequence of volume 3 of the *Primeiro Relatório de Avaliação Nacional (RAN1)*, which is divided into four chapters: Introduction (Chapter 1), Structuring Themes (Chapter 2), Pathways for Climate Change Mitigation (Chapter 3) and Evaluation of Policies, Institutions and Financial Resources (Chapter 4).

In 2010, Brazil reduced emissions of greenhouse gases to 1.25 gigatons of CO2 equivalent (GtCO2eq), compared with emissions of 2.03 GtCO2eq in 2005. If success in combating deforestation is maintained, it should be possible to meet the voluntary mitigation commitments set for 2020 by the Brazilian government. After 2020, additional mitigation measures will be required due to the increasing trend of emissions from fossil fuel burning in the country.

Analysis of the recent evolution of global emissions and needs for mitigation underscores the gap between the goals to limit emissions already approved by major emitting countries, and the trajectory compatible with stabilizing the temperature at 2 °C above the pre-Industrial Revolution level, causing great uncertainty about the feasibility of achieving this goal, set by the Conference of Parties (COP15) of the United Nations Framework Convention on Climate Change (UNFCCC), in Copenhagen. [GT3 1.3]

In the case of Brazil, the results of the emissions estimates based on the updated methodology of the *2º Inventário Nacional de Emissões Antrópicas de Gases de Efeito Estufa*, the 2nd national inventory of anthropogenic emissions of greenhouse gases, produced by the Ministry of Science, Technology and Innovation (MCTI), show that in 2010, Brazil cut emissions of greenhouse gases to 1.25 $GtCO_2eq$, compared with emissions of 2.03 $GtCO_2eq$ in 2005. [GT3 1.3]

In this context, the following points are emphasized: 1) the feasibility of achieving the voluntary commitment to mitigation set out in the *Política Nacional de Mudanças Climáticas (PNMC)*, Brazil's national policy on climate change, by 2020, thanks to the success of actions to combat deforestation; 2) the trend toward renewed growth of Brazilian emissions after 2020, due to increased emissions from burning fossil fuels, if no additional measures of mitigation are adopted and 3) the need to discuss scenarios of mitigation of Brazilian emissions after 2020, including additional mitigation measures beyond control of deforestation. [GT3 1.4]

ORGANAZING THEMES

Risks, Uncertainties and Mitigation

Immediate actions to stabilize GHG emissions should be adopted, since the benefit of immediate action to mitigate climate change outweighs the cost of inaction. In view of the multiple dimensions of risk and uncertainty of climate change, its governance should be established based on three pillars: precaution, prevention and risk management.

The refinement and dissemination of consistent and useful scientific information to guide policy for mitigation of GHG emissions are important challenges. [GT3 2.1] Scientific communication about the risks and uncertainties of climate change that is clear, objective and directed to the interlocutor can contribute to the definition and implementation of policies, plans, strategies and actions capable of reducing GHG emissions, and promoting sustainable development of the country.

Studies in Brazil highlight important points for evaluation and reflection, even considering the uncertainties related to mitigation of GHG emissions and the impacts of climate change. These involve the increased frequency of extreme events at certain times of the year in the country, and greater magnitude of their impacts, such as droughts followed by floods in the northern region, which have affected populations living in the state of Acre, and heavy rains causing deaths in municipalities of the state of Rio de Janeiro and in Florianópolis, the county town of Santa Catarina, among others.

It additionally worth to be noticed the potential discontinuity of some important economic activities (see *GT2* Report), such as the generation of hydroelectric power, port activities, river navigation and agriculture, and potential change in the country's ecosystems. Studies on the *Amazônia* biome and the semi-arid region of Brazil pointed out this last disruption, with consequent migration of human and animal populations (see also the *GT2* Report). All these consequences call for the potential co-benefits of actions to mitigate GHG emissions, even with the uncertainty of climate sensitivity.

Development and Equity

There is a strong interaction between the concepts of equity and sustainable development, primarily with regard to medium and long-term analyses, inherent to the issue of climate change.

On the international level, there are important themes in the context of climate change. One of them is the new development indicators with guidelines that focus on the use of metrics considering, in addition to GDP, social impacts, costs of environmental assets and services compromised in the production of goods and services, the national income level and the population's access to public services, such as water supply, sanitation, health, education, mobility and culture. [GT3 2.2.2.2]

The focus on consumer sectors and not only on the productive sectors of society, and the issue of equity (intra- and inter-generational), involving the division of responsibilities with respect to global climate change, are also relevant. Historical responsibility translates into an important analysis of inter-generational equity in regard to climate change, based on the argument of diachronic justice, which indicates that there is a moral obligation to protect the interests of future generations.

It is impossible to reduce GHG emissions significantly if the criteria of global carbon space use are not changed. Inequalities in the contemporary world are not only ethical as they were during the first half of the 20th century; they now have dimensions of materials and energy. In the case of climate change, one approach is to establish criteria for occupation of this global common good of the human species, that being the global carbon space. The current inequality of emissions is incompatible with the conquest of the material conditions necessary for development of countries and individuals who still live in poverty. It is true that technological innovation plays an important role, and, in fact, in recent years, contributed so that each unit of value placed into the world market has relied on notable decline in emissions. However, the growth of production and consumption more than offset, in absolute terms, this relative decrease. To rely only on technical progress to reduce emissions does not seem compatible with the urgency conveyed by the data from the main scientific studies on the subject. [GT3 2.2.2.3]

Mitigation policies have to outline tangible rates of decline in emissions by the highest emitting countries (taking into account, at some level, past emissions). These policies must also outline the intense processes of international cooperation aimed at changing the technical bases of supply of goods and services, maintaining the perspective of the urgent need to decarbonize the world economy as a whole. [GT3 2.2.3.1]

Driving Forces, Trends and Mitigation

In 2010, GHG emissions in Brazil began to be determined by the level of demand and composition of the energy supply (use of fossil fuels) and agriculture. Thus, mitigation policies should act on these two vectors, although emissions from deforestation remain significant.

Mitigation is a pool of actions to limit the long-term magnitude and/or rate of climate change by reducing anthropogenic GHG emissions and increasing the capacity of carbon sinks. It involves adjustments toward a less carbon-intensive pattern of production and consumption, such as changes in the use of natural resources and fossil fuels out of the adoption of alternative energy sources and energy efficiency. To reconcile this objective with the need for growth and development of the country is a challenge for Brazilian society as a whole. [GT3 2.3.1]

Evidence indicates that, in Brazil, social and economic development entails increased GHG emissions, mainly from the use of fossil fuels, agricultural activities and land use changes. [GT3 2.3.2.1]
The expansion of energy consumption in the Brazilian economy is an important element of GHG emissions. In addition to energy consumption by industries, services and housing, transportation is a major source of emissions in Brazil, due to the country's size and dominance of trucking for transportation of cargo.

Urban growth also impacts emissions from transportation in cities. Traffic congestion in large Brazilian cities should also result in higher emissions, not to mention about its effects on public health. Brazil is known for having a so-called clean energy matrix, meaning to produce low GHG emissions; however, the future expansion of energy supply tends to change these characteristics. GHG emissions resulting from land use changes and agricultural activities also represent important sources of emissions in Brazil. [GT3 2.3.2.3]

PATHWAYS TOWARD CLIMATE CHANGE MITIGATION

Assessment of Transformation Pathways

In Brazil, the paradigm shift from a traditional economy to one that is low carbon has many low-cost opportunities, including energy efficiency measures such as adopting small hydroelectric and bagasse from sugar cane fueled plants to reduce deforestation, among other options.

The transformation scenarios developed for Brazil's transition from a traditional to a low carbon economy use top-down, bottom-up and hybrid models. These tools are intended to describe different pathways (scenarios) and costs so that the *mitigation potential* of the Brazilian economy in the short and medium-term (depending on the timeframe of each study) can be estimated. [GT3 3.1]

To evaluate scales of GHG reduction that could be adopted, a concept of potential mitigation was developed. It is expressed in cost per unit of avoided or reduced carbon dioxide equivalent emissions. Such potential can be differentiated in technical, economic and market terms. [GT3 3.1]

The main results indicate that energy efficiency measures have the lowest costs for mitigation, and in some cases, negative marginal cost of abatement. Some renewable sources such as small hydroelectric plants (SHP) and power plants fired with bagasse from sugar cane also have these characteristics. New technological developments related to measures such as carbon capture and storage (CCS) and energy generation from new, renewable sources such as solar (photovoltaic or concentrated solar power (CSP), are among those with the highest costs, requiring investments in research and development, and introduction of regulatory incentive mechanisms. Wind energy (and all its renewable sources more generally, with the exception of hydroelectricity) is relatively expensive, but several incentives were recently implemented that increased their competitiveness. [GT3 3.1]

Measures related to land use changes had the greatest mitigation potential, including recent major reduction of deforestation. [GT3 3.1]

Energy Systems: Generation of Electricity

Brazil has huge potential for generation of electricity from renewable sources; however, emissions from the sector will leap from 30 MtCO2eq in 2011, to 69 MtCO2eq by 2021.

Historically, Brazil has always had an electricity matrix based on the massive use of hydroelectric power. Its thermal component is still relatively small, and this component does not exceed 30% of the energy supply in any of the available scenarios constructed for 2020.

Brazil's *Plano Decenal de Energia 2021*, the country's ten-year energy plan for 2021, (PDE 2021) signaled that new auctions to be conducted beginning in 2013 would not consider newer thermoelectric uses of fossil fuels that are major emitters, only natural gas, nor from 2021. However, the fact that hydroelectric power licensing remains to be fully laid out led to the recent announcement of an auction for coal power.

Even in the PDE 2021 scenario, emissions from the electricity power sector would jump from 30 MtCO_2eq in 2011 to 69 MtCO_2eq in 2021, without accounting for emissions from isolated systems. This significant increase in the amount of emissions, of about 130% in a decade, would increase the electricity sector's share in the total emissions from energy production and use from 7.6% to 10.8%, still a relatively low level. [GT3 3.2]

The potential of raw energy resources in the country for power generation is enormous and mostly based on renewable sources, particularly hydroelectricity and wind power. Biomass, centered on bagasse and urban waste, can also make a significant contribution. Solar energy, although still applicable only in some niches, has unlimited potential. Among non-renewable sources, the country has significant reserves of uranium. Brazil also has natural gas, the lowest emitting fossil fuel, as well as coal reserves that, despite not being of the highest quality, if coupled with the geological capture, may also contribute, in the long run, to an electrical matrix with low GHG emissions levels. [GT3 3.2.2]

In the market segments of transmission and distribution, several actions can help make reduce emissions by the energy sector, such as:

- policies and programs for energy efficiency, and combating waste from the supply side;
- a proper development of electrical interconnections;
- a hydroelectric power generation with adjustable speed;
- decentralized power systems and distributed generation;
- advanced storage systems, and
- the use of new technologies for automation and control associated with the use of increasingly advanced and comprehensive characteristics of information technology within the concepts of intelligent network and resulted in improvements in both, the use of renewable energy and the distribution system. [GT3 3.2.2.2]

The emission reduction policies presented in the *Plano Nacional de Mudanças Climáticas,* Brazil's national climate change, list the key mitigation actions for the energy sector. It focused on energy efficiency and reduction of losses, the promotion of both solar heating and photovoltaic energy, cogeneration (especially with bagasse from sugar cane), aggregation of 34.46 gigawatts (GW) in new hydroelectric plants and auctions for wind power and sugar cane bagasse specifically. [GT3 3.2.4.1]

Among the commonly used policies for renewable energy, such as premium rates (feed-in tariffs), quotas, the held of auctions for specific purposes and net metering, Brazil has opted for the last in the case of small projects and for auctioning the large-scale ones. The country still does not have a long-term policy for this field as there is no legal provision requiring a periodic undertaking of specific purpose auctions.

Similarly, one can not yet say that there is a policy for energy efficiency in the country as the various initiatives practiced do not configure coordinated, systematic and sustained action during a period, with planned investments and physical targets integrated into planning the sector, and consequently, in its national policy. These are necessary ingredients to characterize a national energy efficiency policy.

In terms of potential for abatement of emissions from energy use (in the sectors of energy consumption and generation, excluding the segment of land transportation and waste), estimates of potential average annual reduction in the country converge at 85-92 $MtCO_2eq$, between 2010 and 2030. For the electricity sector, average annual reductions of around 7 to 10 $MtCO_2eq$ are indicated for 2030. [GT3 3.2.3.1]

In the context of sustainable development, it must be recognized that energy policy, the primary focus of which has been energy security, has had other objectives such as to offer lower tariffs and universal access. Also, to a lesser extent, it has pursued to reduce GHG emissions and other air pollutants, develop national technology, create jobs and industrial leadership, as well as to export goods and services, among other co-benefits.

Transportation

Among the options for mitigating GHG emissions from the transportation sector are the adoption of technology for the reduction and/or rational use of motorized transportation, the promotion of travel modes with greater energy efficiency and the use of less carbon-intensive energy sources, such as biofuels.

Regarding CO_2 emissions from fossil fuel consumption, road transportation accounts for the largest share of emissions. According to estimates for 2020, this mode may emit about 60% more than in 2009, reaching approximately 270 millions of ton of CO_2. [GT3 3.3.1]

Options for mitigating CO_2 emissions can be found in policies, practices and technological options for the reduction and/or rational use of motorized transportation, promotion of travel modes with greater energy efficiency, and use of less carbon-intensive energy sources, such as biofuels. [GT3 3.3.2]

The energy consumed in the transportation of cargo and passengers tends to grow continuously and gradually, following growth rates of GDP and national per capita income. Brazil has struggled to establish a pattern of sustainable development in transportation by promoting mitigation actions. This has been done to divert the growing trend of energy consumption to a model that uses less fossil fuel.

The *Plano Setorial de Mitigação e Adaptação à Mudança do Clima para o setor de Transporte e Mobilidade*, Brazil's sectoral plan for mitigation and adaptation to climate change for the transportation and mobility sector, is an integral part of Brazil's strategy to mitigate and adapt to climate change, and aims to contribute to mitigation of GHG emissions. It intends to expand cargo transportation infrastructure and greater use of more energy-efficient modes. The plan also calls for the increased use of efficient urban public passenger transportation systems. [GT3 3.3.3]

Brazil has the potential to mitigate CO_2 emissions in the transportation sector, primarily because of its unbalanced transportation matrix with an emphasis on road transportation for both cargo and passengers. There is also the possibility of improving the quality of fuels and/or use of biofuels from different sources. [GT3 3.3.4]

Technological risks, environmental uncertainty and uncertainty of social acceptance of actions to mitigate GHG emissions, and costs for adapting transportation infrastructure, which is behind throughout the country, should also be mentioned. Further, there are social barriers to substituting the road travel mode, and to renewing vehicle fleet related issues. [GT3 3.3.4]

Obtaining the benefits for sustainable development from actions related to mitigation of CO_2 emissions in the transportation sector is complex, because it involves behavioral aspects and provision of adequate infrastructure, more efficient vehicles and appropriate technology.

Buildings and Built Environs

Buildings consumed the most electricity in 2010, surpassing the industrial sector. There is a marked difference in energy consumption in residential areas among Brazilian regions, but in general, consumption by this segment is low compared to those of developed countries. Mitigation strategies should involve improving energy efficiency of buildings, and diversification of the energy matrix, including renewable sources, focusing on the energy transition process of the poorest sections of the population.

Of all the energy produced in the world, industrial activity consumes approximately 37.5%, buildings 15.9%, the transportation sector, 19.3%, and losses and the energy sector, 27.3%. The energy consumption of buildings has grown globally. Because a substantial portion of the energy consumed by buildings comes directly or indirectly from fossil fuels, they are responsible for a large part of GHG emissions, about 36% of CO_2 emitted in respect to total energy consumption. Based on data from 2006, there is a global trend of growth in energy consumption by buildings of around 30% by 2030. [GT3 3.4]

In Brazil, industry (including agriculture) consumed 38.9% of total energy, buildings about 15% (including residential, commercial and public sectors), and the transportation, 28.3%, in 2010. However, in regard to electricity, buildings were responsible for the most energy consumptions that year (47.6%) by surpassing the industry.

Biomass consumption is the 4th largest consumer, for the most part being firewood used for residential cooking. In the residential sector, there is a marked difference in electric energy consumption between the Brazilian regions. The southeast is responsible for more than half of domestic consumption (53.6%) and 45.1% of liquefied petroleum gas. However, total energy consumption in the Brazilian residential sector, according to the Balanço Energético Nacional, the country's national energy balance, is low compared to energy consumption of European or American residential sectors. [GT3 3.4]

Assessment of the current situation of energy consumption of Brazilian buildings and their GHG emissions points to major knowledge gaps: a) there is no single methodology for assessing the thermal performance of building systems; b) there is no definition of limits of the thermal comfort zone for different regions of the country; c)there are no studies that correlate type, geographic location and other variables with energy consumption; d)there are no studies of energy saving and insulation; e) there are no studies that determine parameters for integration of natural and artificial lighting, and f) there are no digital climate data available for a large number of Brazilian cities. [GT3 3.4.6]

Industry

Brazilian industry can play an important role in national efforts to mitigate the emission of greenhouse gases. For this, it is essential to encourage energy efficiency measures in this sector, replacement of fossil fuels with energy sources with lower emissions and renewables (biomass/solar), and the adoption of new industrial processes that are less energy-intensive. Despite this significant mitigation potential being economically viable, barriers need to be removed through combined sectoral and intersectoral policies in order to make such opportunities viable.

The Brazilian industrial sector currently accounts for a significant portion of energy consumption, representing around 38% of total energy consumption in the country, as well as GHG emissions, which are responsible for about 24% of Brazil's total emissions in 2005. If Brazil's total emissions are considered (including those due to land use changes and waste treatment, among others), the participation of the industrial sector is close to 5%. [GT3 3.5.1]. The prospects for growth in this sector point to maintain this level of importance in both the medium and long terms.

Additionally, several studies indicate the high potential for reducing GHG emissions in this sector, which makes it vital to alternatives for mitigation efforts by industry. For example, it is estimated that the technical potential for abatement by 2030 is more than 1.5 billion ton cumulated which corresponds to almost five times the total emissions of industry in 2005. It is worth noting that the sum can be seen as a maximum ceiling of cumulative abatement and that the feasible economic and market potential – considering economic aspects of the market barriers – is naturally lower than this estimate. [GT3 3.5.4]

To promote alternatives that are less intensive in GHG emissions, the opportunities identified indicate that the strategy to promote mitigation by Brazilian industry should include:a) policies and incentive mechanisms for replacement by more efficient, less carbon-intensive technologies, in addition to, adoption of more efficient processes in industrial expansions with state-of-the-art technologies available; b) the replacement of high carbon-intensive traditional fuels h by lower emitting sources, for example, biomass and solar energy; c) the promotion of recycling practices, and e) the use of materials with efficiency and beyond the current levels. [GT3 3.5.5]

A more detailed analysis of these options indicates that the promotion of energy efficiency measures – especially thermal applications in the industry – and the replacement of non-renewable biomass can contribute to achieve approximately 80% of this potential. However, the contribution of each measure differs by industry segment, depending on their specificities, suggesting that incentive mechanisms may combine sectoral and intersectoral policies to increase the likelihood of success in encouraging industry's adoption of alternatives with lower GHG emissions. [GT3 3.5.5]

Regarding the effectiveness of the measures, analysis of the curves of marginal abatement costs associated with each measure indicates that almost 50% of the potential mitigation of GHG emissions in the industry shows negative costs, which means that under current conditions, they already appear quite attractive, and most of the energy efficiency initiatives are in this situation. [GT3 3.5.4.1]

Failure to realize this potential signals the existence of barriers that need to be overcome, indicating the need to develop additional policies for their use, and the most appropriate approach will depend on the set of alternatives to mitigate GHG emissions.

There is still great need for large and recent national studies on the mitigation of CO2 emissions in Brazilian industry, which suggests high scope for future studies on this specific topic in the country.

Agriculture and Forestry

Agriculture and forestry already account for over one third of Brazil's total emissions of greenhouse gases, and the tendency is to increase. However, there are many opportunities for mitigation, especially pasture recovery and expansion of commercial forests. Uncertainties in the estimates indicate the need for further research.

A large part of GHG emissions by the agricultural sector in Brazil is from the national cattle herd, and management of soybean, corn, sugar cane and rice, which together occupy more than 70% of the national agricultural acreage. From 1990 to 2005, there was an increase of 37% of emissions in the sector, primarily methane and nitrous oxide, the result not only of growth of livestock and planted acreage, but also increased use of technologies so that production increased much more than land use for production in the same period. [GT3 3.6.31]

Despite the loss of carbon from soil used for crops and pastures is computed directly for agriculture in national inventories, results from research in Brazil indicate that it is an important process associated with annual crop planting and the vigor of foragers. There are still few studies researching methane and nitrous oxide, but this permits, for example, the suggestion that enteric methane emissions from cattle grazing on *Brachiaria* pastures, common in Brazil, are close to the global emission factor from IPCC guidelines (Tier 1) but that direct nitrous oxide emissions, primarily those counted in latosols, are lower than estimates for inventories with this same guideline.

As agriculture contributes about 35% of total GHG emissions in Brazil for the base year 2010, it also presents many possibilities to mitigate these emissions. The scenario for 2020 evaluated the recovery of 15 million hectares of pasture, increased direct planting of crops on 8 million hectares and expansion of commercial forestry plantations on 3 million hectares while also eliminating the burning of sugar cane for harvesting, use of additives in the diet of cattle, swine waste treatment and reduction of nitrogen fertilization by microbial inoculants. [GT3 3.6.3] Scientific research estimates that the use of these techniques has the potential to mitigate between 163.3 and 248.5 Mt CO_2eq in 2020. [GT3 3.5.6.2]

The recovery of pasture and the expansion of industrial forest plantations account for much of this perspective. Uncertainties increase with the inclusion of soil as a drain of atmospheric CO_2, and techniques such as the use of microbial inoculants and treatment of swine manure, though these last two have the least impact on the mitigation potential of the sector. Additionally, although the weight of positive externalities is usually large, cultural and technological barriers may be obstacles to adoption of these practices by producers. [GT3 3.6.3]
Land Use and its Changes

Land Use and its Changes

Although in transition, a significant portion of national emissions of CO_2eq still links to changes in land cover and use, such as deforestation and burning. Improving land management in Brazilian biomes to include the diversity of soil covers would benefit the maintenance and increase of stocks for other environmental services. Mitigation policies may include greater control and supervision of human activities, as well as positive incentives such as payments for environmental services and education.

This section addresses the main environmental impacts expected for each biome due to climate change, with a focus on key mitigation measures. For almost all biomes in Brazil, reduction and control of deforestation and mechanisms for environmental compensation such as Payments for Environmental Services (PES), Reducing Emissions from Deforestation and Forest Degradation (REDD+), increased agricultural productivity, land planning and fire control stressed mitigation initiatives to lower carbon emissions and increase its stocks. Such strategies also have co-benefits in terms of adaptation and reduction of impacts. For example, the preservation of forest cover in the *Amazônia* biome and its carbon biomass stock in the equivalent range of 4.4 to 1.1 gigatons contribute other important functions that directly influence the albedo, temperature, and local and global atmospheric circulation patterns. [GT3 3.7.1.1, 3.7.4.1]

The *Cerrado* biome [GT3 3.7.1.2, 3.7.4.1] is being strongly affected by demand for wood for charcoal, and clearing new areas for livestock and agriculture. In that region, the reduction of burnings for pasture maintenance, for example, could prevent the emission of 1.69 MtCO_2eq (accumulated between 2003 and 2008), while the entire area occupied by human activities until 2005 (nearly 50% of the original area) represents a total emission of 379 MtCO_2eq (twice the estimated emissions until 1990), making clear the expansion of deforestation and changes in land use.

In the *Pantanal* [GT3 3.7.1.3, 3.7.4.1], deforestation relates to livestock, agriculture and steel/mining activities, in that order. About 35% of the methane emitted from this biome is from cattle/pasture production. Forms of mitigation in this biome include appropriate pasture management, and avoiding the removal of vegetation cover and soil loss by erosion.

In the *Caatinga*, decreased vegetation cover is due mostly to droughts and impacts of the climate phenomenon of El Niño, and desertification appears in virtually all future scenarios for this biome. Such phenomena, when associated with suppression of native vegetation and agricultural practices unsuitable to the semiarid region (for example, the use of mechanization on heavy soils and inadequate water content), accentuate the process of soil compaction and erosion.

Mitigation measures for control and reduction of GHG emissions in the *Caatinga* include monitoring and combating desertification through a system of monitoring reduction of vegetation cover and degradation, and development of quantitative indicators of the progress of these processes, together with environmental recovery techniques. [GT3 3.7.2, 3.7.4.3]

The *Mata Atlântica* biome suffers the most pressure from human activities due to high population concentration. [GT3 3.7.2]. Mitigation solutions for this biome require urgent action by the federal government for compliance with the *Código Florestal,* the Brazilian forest code. [GT3 3.7.4.4]

For the *Pampas* biome, the suggestion is to exclude the use of fire and better management of natural vegetation areas for extensive grazing, in addition to sustainable economic exploitation since the balance between absorption and emission of carbon is stable in this system. The production of irrigated rice in this biome, with an area of 5.4 million hectares (about 50 % of national production), has high rates of methane (CH_4) emission, with an average of up to 25 mg $\pm$ 1.5 CH_4 m^{-2} h^{-1} (depending on the planting method and stage of grain maturity). Mitigation measures such as land use planning that aims to maintain conservation areas, monitor deforestation and reduce fires, all of them which in use for brief chemical replenishment of pasture areas after the winter period, are measures that can be implemented for this ecosystem [GT3 3.7.1.6.2]

Mangroves have suffered high pressure from deforestation and pollution, especially from urban areas along the Brazilian coast. This biome is considered a potential carbon sink, with storage capacity equal to that of forests located at the same latitude. The importance of studies on the export of organic carbon by mangrove ecosystems to adjacent coastal areas is to be emphasized, from the point of view of biosphere-atmosphere CO_2 flows. [GT3 3.7.1.3.7.2]

There are major knowledge gaps regarding impacts and mitigation measures for some biomes, including the *Mata dos Cocais*, with no current scientific references. In general, field measurements of carbon flows are rare, and monitoring of changes in land cover and use performed continuously only for the *Cerrado and Amazônia* biomes.

The country has extensive spatial variability. Thus, experts suggest the establishment of permanent plots in all biomes for the systematic monitoring of stock and flows of carbon in the different forest components in different regions for all biomes, as a way of acquiring information that considers the variability of soil and flora composition, as well as ensures a real diagnosis of the impacts of climate change, and development of appropriate mitigation measures. [GT3 3.7.5]

REVIEW OF POLICIES AND FUNDING INSTITUTIONS

Brazil in Global Climate Policy – Governance Challenges

Global climate change has become a primary issue in the contemporary world politics, involving governments, markets and civil society. It is a multisector issue that is no longer restricted to the environmental dimension and includes economic and safety dimensions, as well. In terms of the importance of multilateral negotiations of the United Nations, there are new international and regional arrangements that remain little explored in Brazil.

The global political economy of the climate interweaves global patterns of production and consumption, energy security, and the interests of nations, corporations and consumers, linking micro and macro dimensions of social life. Moreover, the increasing number of extreme weather events and risk of catastrophic disasters due to climate change transform the question into a threat to global security. [GT3 4.1.1]

The increased pattern of global climate change makes it one of the greatest contemporary challenges, and solutions to this issue involve changes at multiple scales and levels of global society. In this sense, interactions between international security, the global economy and climate change should be considered when constructing responses to this problem, and the broader concept to describe and analyze the responses and attempts to deal with this problem is global climate governance. [GT3 4.1.2]

Consequently, the architecture of global climate governance extrapolates the UNFCCC, including bilateral and regional agreements and private actors in the market and civil society organizations arrangements, as well as hybrid projects in which state and non-state actors participate. [GT3 4.1.3]

To define the relevant actors in climate governance is not an uncontroversial task. In Brazil, the role of countries and negotiating blocs in the UNFCCC tends to be emphasized. Other studies highlight international partners, according to their emissions. Further, the role of NGOs and other non-state actors such as national companies and transnational corporations must also be considered. [GT3 4.1.2.1]

Some studies suggest that prioritizing national interests has hindered construction of a system for mitigating climate change, and in the face of these difficulties, a reorientation of mitigation actions toward adaptation, which is more directly related to national efforts, should occur, thereby placing international cooperation as a secondary priority [GT3 4.1.3.1.2]. Such difficulties added to frustrations with the negotiation process under the UNFCCC/Kyoto Protocol have led some authors to advocate the need to seek alternatives beyond the international regime of the United Nations, such as another system with fewer actors, or a set of systems coupled with non-state governance arrangements.

The announcement of national voluntary mitigation targets in 2009 was a significant change in Brazil's foreign climate policy. Thus, Brazil is a sui-generis international actor on this issue. The country can be considered a climate power, with ambitious voluntary mitigation commitments, and a leader of the G77/China in international negotiations. At the same time, it receives and provides cooperation in several areas, combating deforestation, climate modeling, biofuels and issues related to the UNFCCC such as the development of national communications, and the establishment of designated authorities and Clean Development Mechanism (CDM) projects. [GT3 4.1.3.2.1]

At present, it seems clear that as important as the multilateral negotiations of the United Nations are developments in other arenas and climate governance dimensions: the energy-climate policies of large and medium climate powers, multilateral forums, and new international and regional arrangements (such as the G20). These other developments, however, are still little studied in Brazil, which indicates that there are in Brazil many questions and possibilities not explored in academic and political debates. [GT3 4.1]

National and Subnational Policies

Brazil has an ample regulatory apparatus related to climate change in all federal spheres. This apparatus defines governance structures, plans and instruments, and in many cases, still needs to be regulated. There is also space for articulation by federal agencies. The regions with greater vulnerability are those with few climate change policies.

An evaluation of the effectiveness, efficiency and equity of the mechanisms and policies following a period of implementation seems necessary. Aspects such as participation and transparency should be judged since the implementation and monitoring of these policies will not dispense with efforts in the legislature, federal agencies and civil society organizations. [GT3 4.2.1]

Decree No. 7.390/2010 foresaw the development of planos setoriais de mitigação, sectoral mitigation plans with actions, as well as indicators and targets to reduce emissions and tools for its compliance verification. [GT3 4.2.3] By 2013, eight of them were approved. [GT3 4.2.1]

For better knowledge of the policies and plans, it is necessary to classify them and identify their motivating factors, as well as the instruments they propose, to evaluate them from the perspective of synergies, governance, overlaps and gaps possibly created. Moreover, convergence or not with other environmental policies, such as biodiversity and water resources and compliance with other sectors, such as energy and agriculture, are key foci for analysis. [GT3 4.2.1]

To articulate these government policies, plans and programs, is essential to have effective results and resources applied, both financial and human, in a country like is Brazil, with limited resources, substantive comparative environmental benefits and considerable weakness land use, in particular by livestock, burnings and deforestation. [GT3 4.2.1]

The classification of instruments, taking into account various aspects such as technology, management, governance or command and control, is important for their understanding and evaluation. Criteria to evaluate climate policy instruments are effectiveness and its cost, distributive and institutional viability. Analysis of public policies should show the need for a consistent and viable regulatory apparatus, namely the description and explanation of the causes and consequences of government action. [GT3 4.2.1.2]

In Brazil, the literature on studies that evaluate the potential economic impacts of climate change, policies for mitigation and adaptation, is relatively new and rapidly developing. However, this literature considers possible policies not necessarily discussed by Brazilian policymakers. Nonetheless, they form part of the mechanisms commonly discussed or implemented in other countries, such as taxes on carbon emissions and markets for tradable emissions reductions (cap-and-trade) are. [GT3 4.2.2]
So that national policy has governance and is successful, it is necessary for all spheres of government and civil society to adopt targets for reduction of emissions, protection of sinks and adaptation measures. [GT3 4.2.3.1]

When examining the content of state and local policies, it is possible to identify two major objectives common to all laws: to control and reduce GHG emissions and reduce the effects of climate change (minimize vulnerabilities). It is unclear, however, what will objectively be mitigated in terms of GHG emissions, and how adaptation will be done. Most often the design of state policies does not use results reported by inventories or vulnerability studies as a reference.

According to the mapping undertaken, the most vulnerable regions are those with the least climate change policies. Moreover, the absence of regional policies can derail mitigation and adaptation measures, and hinder development of research to achieve the goals of reducing GHG emissions and minimizing local vulnerabilities. [GT3 4.2.4.1]

Investments and Financial Resources

Investment in technologies with lower GHG emissions relates fundamentally to sustainable development, which associates with greater equity, but needs appropriate financial instruments for effective implementation.

Investment in technologies with lower GHG emissions relates fundamentally to sustainable development, which associates with greater equity, but needs appropriate financial instruments for effective implementation. In addition, there are several ways to finance CDM projects that involve public or private banks, which may be national or international. Regarding the participation of government, BNDES stands out with a considerable number of programs and funding lines. Yet we can also mention the *Caixa Econômica Federal,* a commercial, state-owned bank, the *Programa de Repasse do Orçamento Geral da União*, a program for transfer of the federal budget, and the *Agência Brasileira de Inovação*, Brazil's agency to promote innovation. [GT3 4.3.3]

In the private sector, in general, the big banks stand out, sometimes associated with foreign partners.

Simulations show that sustainable development would be possible with a volume of funding that can be stimulated through the sale of carbon credits and other policy instruments (subsidies to capital for low-carbon technologies, investment financing terms and tax credits, among others). [GT3 4.3.3]

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