Second National Communication of Brazil to the United Nations Framework Convention on Climate Change

Brasília 2010

FEDERATIVE REPUBLIC OF BRAZIL

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Second National Communication of Brazil to the United Nations Framework Convention on Climate Change

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Ministry of Science and Technology
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Programs And Actions Related to Sustainable Development

A. PROGRAMS CONTAINING MEASURES TO MITIGATE CLIMATE CHANGE

1 Programs And Actions Related to Sustainable Development

Some of the programs and actions related to sustainable development are related to the use of renewable energy and energy conservation and/or efficiency. These programs contribute towards Brazil having a "clean" energy mix, with low greenhouse gas emission levels per energy unit produced or consumed.

Major programs related to sustainable development include the production of sugarcane ethanol and biodiesel as fuels for vehicles. For Brazil, these practices represent extremely feasible and sustainable options to reduce fossil fuel consumption in order to mitigate greenhouse gas emissions, generate income, create jobs, and promote development and transfer of technology while strengthening the country's environmental integrity.

Sugarcane ethanol is currently the biomass energy option with the greatest productivity per unit of area while having the best energy balance, which is the ratio between energy output (ethanol and mechanical, thermal and electric energy) and the fossil fuel consumed in the production chain (CGEE, 2009).

The Brazilian electrical sector takes on special characteristics not only as one of the largest hydroelectric producers in the world, but also the exceptional participation of hydroelectric power in meeting its electric power needs. Although only about 36% of the country's estimated hydroelectric potential has been harnessed, approximately 85% of Brazil's power was generated by hydroelectric plants in 2009.

Other important programs aim at combating energy waste, indirectly contributing towards the prevention of greenhouse gas emissions. Major programs include the National Program of Electrical Energy Conservation – Procel, created in 1985; the National Program on the Rationalization of the Use of Oil and Natural Gas Products - Conpet, created in 1991; and the National Program for Efficient Public Lighting – Reluz, created in 2000.

Also, great progress is being made by other renewable energy sources, which promotes reductions in greenhouse gas emissions and have enormous potential for the development of Clean Development Mechanism – CDM project activities.

1.1 Sugarcane Ethanol in Brazil

The History of Alcohol as a Fuel

The history of biofuels in Brazil was predominantly marked by the rise, fall and resurgence of the sugar and alcohol industry. Brazil only discovered ethanol as an attractive energy option in the 20th Century, after centuries of living with the sugarcane agro-industry. Between 1905 and the end of the 1960s, several attempts were made by the sugar and alcohol industry to promote ethanol as a fuel. However, only in the mid 1970s were bases created to intensify the use of ethanol fuel.

Pro-alcohol, launched in 1975, was the country's response to high oil prices and the drop in sugar prices abroad. The injection of resources from international and national financing, as well as fiscal incentives, quickly drove the sugar and alcohol industry and was responsible for reducing Brazil's dependence on imported oil.

Evolution of the National Alcohol Program - Proalcool

Pro-alcohol was created on November 14, 1975[54], with the objective of stimulating ethanol production, aimed at meeting the needs of domestic and foreign markets and the automotive fuel policy. In accordance with the decree that created the program, ethanol production from sugarcane, cassava or any other input should be encouraged by expanding the offer of raw materials.

Sugar production costs in the country are some of the lowest in the world, which enables Brazilian producers to compete in highly favorable conditions in the international market. Brazil has more than a 20% share in world sugar production. However, the market is volatile and prices oscillate greatly.

The steps in sugar and in alcohol production only differ after the use of the treated and cooked juice, which can be fermented to produce alcohol or crystallized for sugar.

The decision to produce ethanol from sugarcane takes into account government policies, besides the aspects men-

54 Decree nº 76,593, November 14, 1975.

tioned above. The decision was made in 1975, when the Federal Government decided to encourage alcohol production to replace pure gasoline, with the objective of reducing oil imports, which were a great weight on the foreign balance of trade at the time. Sugar prices on the international market were not remunerating Brazil's exports appropriately at the time, which contributed towards implementation of the alternative fuel program.

A brief summary of Pro-alcohol includes four distinct phases:

Initial Phase (1975 to 1979)

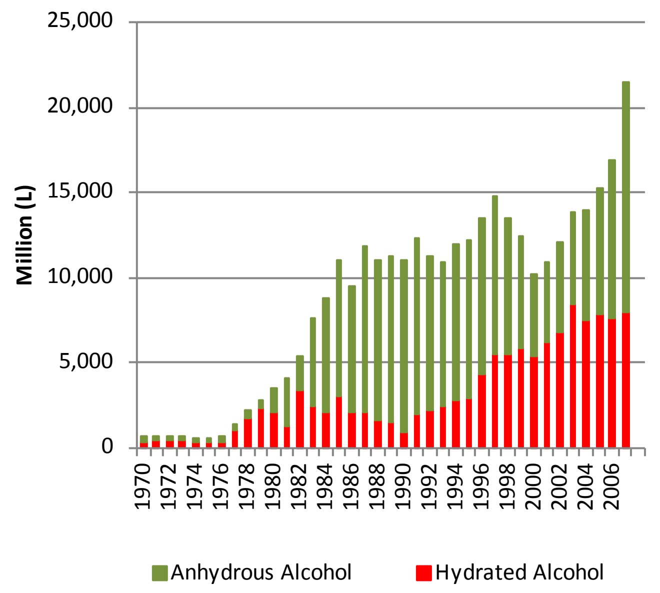
The effort was mainly directed at producing anhydrous alcohol for mixing with gasoline. In this phase, the main effort was up to the annexed distilleries. Annual alcohol production grew from 600 million liters (1975-1976) to 3.4 billion liters (1979-1980) (Figure 1.1). The first cars exclusively powered by ethanol appeared in 1978.

In order to implement the Pro-alcohol Program, first, a process for transferring funds gathered from parts of gasoline, diesel and lubricants was established to compensate for the cost of alcohol production to make it feasible as a fuel. A price fixation mechanism was also established that tried to make it economically indifferent for producers to produce sugar or anhydrous alcohol. The Sugar and Alcohol Institute was responsible for fixing the prices for both products. Thus, a price parity relationship was established between alcohol and sugar for the producer and financing incentives were created for the fuel production's agricultural and industrial phases. With the advent of the hydrated ethanol vehicle, starting in 1979, relative price policies were adopted for hydrated ethanol fuel and gasoline at the gas station in order to stimulate use of the renewable fuel.

Affirmation Phase (1980 to 1986)

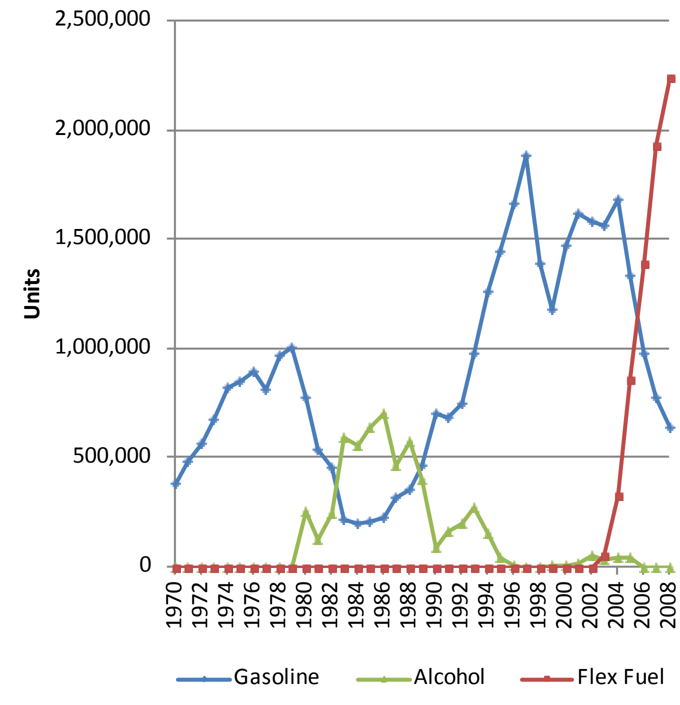
The barrel of oil went up threefold in the second oil crisis (1979-1980) and product purchases began to represent 46% of Brazil's import schedule in 1980. The government then decided to adopt measures for full implementation of Pro-alcohol. Entities were created like the National Alcohol Council - CNAL and the National Executive Commission on Alcohol - CENAL to speed up the program. Alcohol production reached a peak of 12.3 billion liters in 1986 and 1987 (Figure 1.1), exceeding the government's initial annual goal of 10.7 billion liters by 15% for the end of this phase. The proportion of ethanol-powered cars in the total number of Otto cycle (passenger and mixed use) automobiles produced in the country jumped from 0.46% in 1979 to 26.8% in 1980, reaching a high of 76.1% in 1986 (Figure 1.2).

Figure 1.1 Evolution of Ethanol Production (in millions of liters) – 1970 to 2006



Source: BRASIL, 1986; BRASIL, 1990; BRASIL, 2001; BRASIL, 2008a.

Figure 1.2 Production of light vehicles (in units)



Source: Anfavea, 2009.

Stagnation Phase (1986 to 1995)

The international oil market scenario is altered in 1986. Barrel prices for crude oil fell from US$ 30-40 to US$ 12-20. This new period, called the "oil counter-crisis", put hydrocarbon fossil fuel replacement and efficient use of energy programs in check around the world. In Brazil's energy policy, its effects were felt starting in 1988, coinciding with a period of shortages in public funds for supporting alternative energy programs, resulting in a significant decrease in investment volume for domestic energy production projects.

The supply of ethanol was unable to accompany the exceptional growth in demand. In 1985, sales of ethanol-powered cars exceeded 95% of total Otto cycle vehicle sales for the domestic market. After that, the low ethanol prices, fixed by the government, due to the fall in international oil prices, impeded any increase in domestic production of the product. However, consumers continued to find ethanol prices attractive, when compared to gasoline, as well as the maintenance of lower taxes on ethanol-powered vehicles, when compared to those powered by gasoline. This combination of discouraging ethanol production and encouraging its demand generated the 1989-1990 off-season supply crisis. It is worth underscoring that in the period prior to the supply crisis, ethanol production and sugar production and exporting, which had their prices fixed by the government, were discouraged. Annual ethanol production remained at practically constant levels, from 1985 to 1990, at around 12 billion liters.

Despite the program's great success in the 1970s and 1980s, the ethanol supply crisis at the end of the 1980s, together with the reduction in incentives for its use, caused a significant decrease in demand in following years, and consequently in the sales of automobiles powered by this fuel.

Other reasons must also be pointed out that contributed towards the reduction in ethanol-powered vehicles. At the end of the 1980s and beginning of the 1990s, the international price for a barrel of oil fell significantly. This continued for the next ten years, along with a tendency by the automobile industry to manufacture globally standardized models and motors, in their gasoline versions. In the beginning of the 1990s, the importation of automobiles (gasoline and diesel) was permitted and an incentive policy was introduced for vehicles of up to 1000 cc (popular cars) which, until 1992, only considered gasoline-powered vehicles.

The ethanol supply crisis obliged the country to make punctual importations of ethanol and methanol[55] to guarantee market supply during the 1990s.

55 Methanol used in the MEG mixture: 60% of hydrated alcohol, 33% methanol, and 7% gasoline.

Redefinition Phase (1995-2000)

Anhydrous and hydrated ethanol fuel markets were now free in all phases, with production, distribution and resale, and prices were determined by supply and demand. The Interministerial Sugar and Alcohol Council – CIMA[56] was created to administer policies for the sugar and alcohol sector.

According to the National Association of Motor Vehicle Manufacturers (Anfavea, 2000), ethanol-powered vehicle production remained at 1% from 1998 to 2000. The stimulus given to hydrated alcohol use in certain classes of light vehicles, such as official cars and taxis, caused a debate among specialists in economics, contrary to the incentives, and specialists in the environment, who favored the incentives for ethanol use. Law 10.464, of 2002, established a minimum percentage of anhydrous alcohol in gasoline between 20% and 25%.

Current Phase

More than thirty years after the beginning of Pro-alcohol, Brazil is experiencing a new expansion of sugarcane fields with the objective of offering the alternative fuel on a large scale. Planting is advancing beyond the traditional areas of inland state of São Paulo and the Northeast and into areas once occupied by pastures. This new increase is not a movement commanded by the government, like at the end of the 1970s, when Brazil found ethanol to be the solution to face the abrupt increase in prices of imported oil. The race to expand units and construct new plants is driven by private enterprise decisions, convinced that ethanol will now play an increasingly more important role as a fuel in Brazil and in the world.

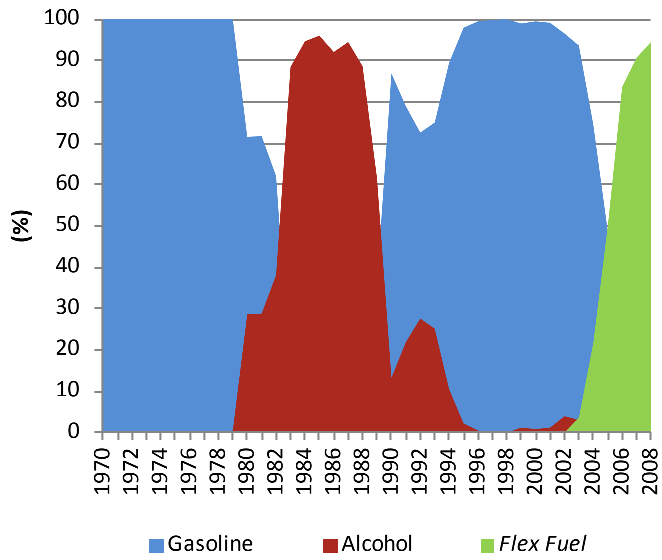
The technology for flex fuel motors breathed new energy into domestic ethanol production. The car that can be powered by gasoline, ethanol or any mixture of the two fuels was introduced in the country in March 2003 and it quickly attracted the consumer. Nowadays, the option is offered by almost every model produced in the country and flex-fuel automobile sales now exceed gasoline-powered auto sales in the domestic market. The behavior of oil prices in the international market leads to industry belief that this share is going to grow even more. The relationship between ethanol and gasoline prices depends on several variables, such as region and period of the year/harvest.

The acceptance of flex-fuel car by consumers was much faster than the auto industry expected. Flex-fuel cars represented 94.2% of all new car licenses in 2008, while the

56 Decree nº 3,546, of July 17, 2000.

share for gasoline-powered cars was 5.8% according to the National Association of Motor Vehicle Manufacturers – Anfavea (Figure 1.3).

Figure 1.3 New Automobile Licensing (%)



Source: Anfavea, 2009.

1.1.1 Perspectives for Ethanol

As in the oil crises of the 1970s, the world is striving to find a long-lasting solution to its energy problem. Environmental concerns joined stock reductions and increases in fossil fuel prices to stress the value of renewable sources with lower greenhouse gas emissions.

Brazil's energy sector has been undergoing several changes, such as the attempt at resuming projects that take into account the environment and job market. Using the United Nations Framework Convention on Climate Change as a reference, ethanol fuels play an important role in energy strategy for sustainable development.

The emergence, around the world, of new types of vehicles and motor technologies (such as flex fuel vehicles) has caused important changes in the traditional attitudes of the automobile industry and other players in the market.

Projections by the Sugarcane Industry Union - Unica, in partnership with the Sugarcane, Sugar and Alcohol Producers Cooperative of the State of São Paulo - Copersucar and the Energy Cogeneration Industry Association - COGEN (Table 1.1) point out that sugarcane production should practically double between 2010–2020, with ethanol production enjoying an increase of 150%, resulting in a volume capable of meeting domestic demand while still exporting part of the production. This projection also foresees a great increase in bioelectricity's share in Brazil's electric generation mix, jumping from 3% to 14% of the total, between 2010 and 2020.

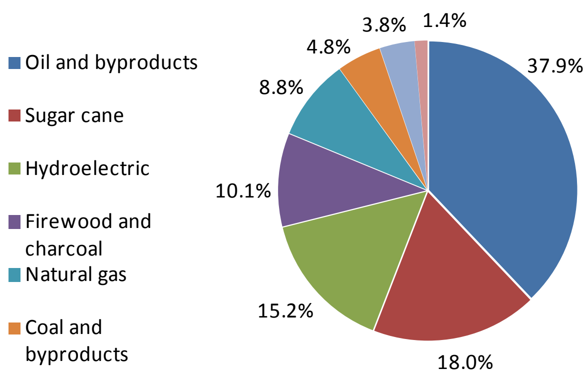
Table 1.1 Projected increase in sugar and alcohol production between 2010 and 2020

	2009/10	2015/16	2020/21
Sugarcane production (millions/tons)	605	829	1038
Sugar (millions/tons)	33	41.3	45.0
Domestic consumption and stock	10	11.4	12.1
Surplus for exportation	23	29.9	32.9
Ethanol (billions/liters)	25.7	46.9	65.3
Domestic consumption and stock	22.5	34.6	49.6
Surplus for exportation	3.2	12.3	15.7
Bioelectricity (average MW)	1,800	8,158	13,158
Share in the Brazilian electric generation mix (%)	3%	11%	14%

Source: Elaborated by Unica, Copersucar and COGEN.

Sugarcane already represents 18% of Brazil's energy mix by means of ethanol and bioelectricity. It is the second largest source of energy in the country, trailing only oil, and the top renewable source, ahead of hydroelectric power (Figure 1.4).

Figure 1.4 Brazil's energy mix



Source: Elaborated by Unica based on the National Energy Balance of 2010 (preliminary data)[57]

57 See: < https://ben.epe.gov.br/BENResultadosPreliminares2010.aspx>.

1.1.2 Economic Aspects of Ethanol

Ethanol Cost Reductions

The economic feasibility of ethanol fuel is directly linked to productivity of the sugarcane crop and the industrial yield of the production process. Over the past two decades, development and implementation of new techniques and technologies in the sugar and alcohol sector were the most responsible for reductions in production costs. It is believed that from 1976 to 2000, ethanol fuel production costs in Brazil fell significantly. Nowadays, the price practiced by producers corresponds to about 30% of the value at the beginning of Pro-alcohol. Sugar and alcohol sector productivity gains went through three distinct phases:

- Starting in 1975, a search for greater industrial productivity;
- Starting in 1981-1982, a search for greater efficiency in converting saccharose into the final product, and for cost reductions; and
- Starting in 1985, global management of agriculture and industrial production, including sugarcane planning and control, together with industrial production.
- For greater effectiveness of technological development programs, the sector has given greater emphasis to the agricultural area, since this phase concentrates 60% of ethanol production costs.

Steps of Production

<u>*In the production of sugarcane (agricultural phase)*</u>

Average productivity for Brazilian sugarcane increased from 47 t/ha in 1975 to 68 t/ha in 1996, reaching nearly 78 t/ha in 2008, and in the state of São Paulo, the largest producer, productivity is greater than 100 t/ha (BRASIL, 2009a). Several factors generated this increase.

- Select varieties of sugarcane – genetic improvement of sugarcane was carried out by Copersucar[58], which had the largest program in the world in this area. These works are currently conducted by the Center of Sugarcane Technology – CTC, a private entity maintained by plants and sector supplier associations. It is the largest center for sugarcane technology in Brazil. Besides the CTC, other organizations, both public and private, conduct research in this field. An example of a private sector initiative is "Canavialis", the Agronomy Institute of Campinas - IAC and the Federal University of São Carlos – UFSCAR are examples of public sector initiatives;
- Agricultural technology – the principle of agriculture production management using soil maps, the use of satellite images to identify varieties and general improvements in management deserves special mention;
- Use of stillage (sugarcane fermentation waste) as an organic fertilizer, rich in phosphorus and potassium.

<u>*In the production of ethanol (industrial phase)*</u>

Significant technological progress was reported, resulting in an increase in average productivity of sugarcane conversion into ethanol from 75 liters/t in 1985 to 85 liters/t in 2010, due to various factors:

- Juice extraction – the juice extraction rate during grinding increased from 92% to 97%. Besides that, with small modifications in equipment and in the operating system, it was possible to increase grinding capacity by 45%;
- Treatment and fermentation of juice – first, biological control, and then, continuous fermentation (more than 230% of productivity compared to 1975);
- Distillation – increase in capacity according to the alcohol proof of the mixture, due to improvements in equipment;
- Improvements in the energy field – in the production of sugar and ethanol, from 1980 to 1995, the percentage of electric energy self-sufficiency at plants due to the use of bagasse in the boilers went from 60% to 95%. At present, 100% of the plants are self-sufficient and several units sell surplus energy to the electric generation mix. In 2008, in the state of São Paulo, more than 700 MW of bioelectricity was made available to the electric system (BRASIL, 2009b).

58 Copersucar is the largest Brazilian sugar, ethanol and bioenergy company with important operations in the world's main markets. With 39 associated plants, it has a unique business model, integrating every link in the production, commercialization and logistics chain for sugar, ethanol and bioenergy, from planning operations to delivery of products directly to final clients in Brazil and abroad. The 2009-2010 harvest was responsible for producing 74 million tons of sugarcane, 3.7 million tons of sugar and 3.43 billion liters of ethanol, with a 20 to 25% share in domestic sugarcane agro-industry production (htpp//:www.copersucar.com.br).

Price of Ethanol

Ethanol fuel prices in Brazil are determined by the free market. Given the sector's importance and its nature, fuel production, distribution and commercialization activities are regulated by the National Agency of Petroleum, Natural Gas and Biofuels – ANP.

- From 1980, the percent difference between values attributed to ethanol and gasoline (pure gasoline mixed with anhydrous alcohol is usually called gasoline in Brazil, which is known as 'gasohol' internationally) is an indication of phases in the government's energy policy:

- 1980 to 1983 – strong stimulus for ethanol – driven by a trade balance crisis and by the high prices for imported oil, the price of ethanol during this period was about 40 to 45% less than that of gasoline;

- 1984 to 1988 – moderate stimulus for alcohol fuel – domestic interest in controlling inflation and a drop in imported oil prices starting in 1985 made ethanol prices during the period 35% lower than gasoline on average;

- 1989 to 1996 – weak government stimulus for the program – due to the alcohol supply crisis at the end of the 1980s and the low oil prices in the international market, during the period, the price difference between hydrated alcohol[59] and gasoline for the consumer, fell under 20%, using gasoline prices as a reference;

- 1997 to 2002 – with the oil price increases in the international market, the difference in price between hydrated alcohol and gasoline for the consumer began to rise again, reaching about 50% in 2002. This period saw a lack of any defined policy for hydrated alcohol fuel, although several authorities positioned themselves in the sense of retaking this option. With the enactment of Law no 10,336/2001[60], the return of incentives for ethanol cars and the production of flex fuel cars was debated again, and increasing oil prices in the international market, as well as the exchange rate, made ethanol use feasible;

- 2003 to the present – with the advent of flex-fuel vehicles, the consumer can opt to mix the fuels (ethanol and gasoline) in any proportion. The consumer can make this option based on the advantages and disadvantages of both fuels' production chains, but what is most common is for the consumer to base his decision on the cost-benefit ratio (fuel price/km driven. In order to assist the consumer in this choice, a simple calculation was made that takes into account each fuel's average value and yield. In general, it can be assumed that if the price for a liter of ethanol corresponds to 70% of the price for a liter of gasoline, it is economically more advantageous to fill up with ethanol. Simplified tables that assist the consumer make this calculation have been distributed to service stations. The trade balance for ethanol once again shows net exports[61] and there is a clear tendency that Brazil will be a significant exporter of the product due to the comparative production advantages in the country and the adoption of ethanol fuel use programs in several countries as a strategy to improve the environment and reduce emissions.

The Externalities of Sugarcane Ethanol

Environmental

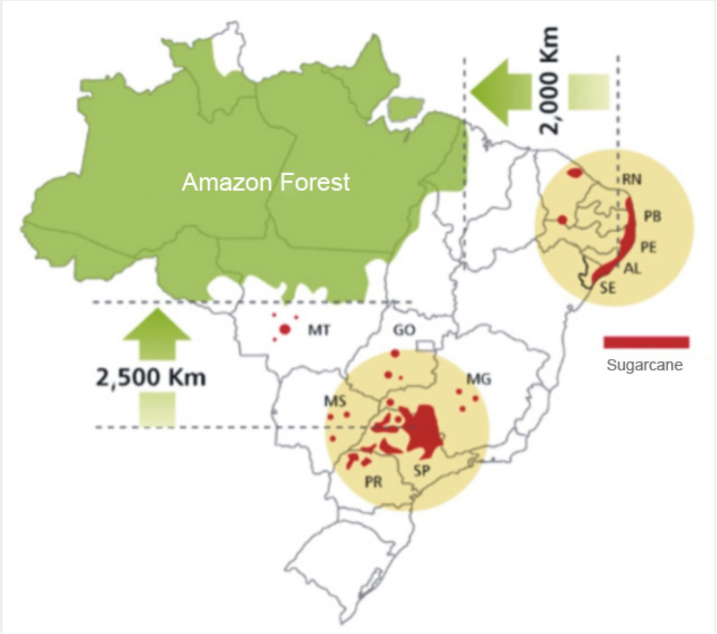
Guarantee of preservation of the Amazon forest and other native forest areas - Brazil's sugarcane production does not occur in the Amazon forest area. Its major producing centers are located at a great distance from such a biome, as shown in Figure 1.5. Brazil's high productivity guarantees there is no need to expand cultivation of the crop to the forest areas.

59 Hydrated alcohol fuel has 96% pure alcohol and 4% water and it is sold directly as fuel, whereas anhydrous alcohol has purity levels of 99.3% and it is mixed to gasoline.

60 Law no 10,336, of December 19, 2001, instituted the Contribution for Intervention in the Economic Domain - Cide, levied on the importation and commercialization of oil and its byproducts, natural gas and its byproduct, and ethylic alcohol fuel. The monies collected through Cide began to be used, in the form of a budgetary law, to pay for subsidies for alcohol fuel, natural gas and its byproducts and oil byproduct prices or transportation; to finance environmental projects related to the oil and gas industry; and to financing for transportation infrastructure programs. This law has already been amended several times, with the final wording given in Law no 12,249, of June 11, 2010.

61 During the 1980s, ethanol favored a reduction in oil and oil byproduct imports while contributing towards Brazil's export mix. However, after 1989, there was a period of net imports of ethanol as a result of the domestic supply crisis.

Figure 1.5 Sugarcane crop areas (in red) in Brazil, showing the distance to the Amazon Forest



Source: UNICA, 2008.

Removal of tetraethyl lead from gasoline – Brazil was the first country in the world to totally eliminate tetraethyl lead from fuels in 1992. Since 1989, nearly 99% of the oil refined in the country has not used this additive. This achievement was possible thanks to the use of ethanol as an additive to gasoline.

Reduction of air pollution in urban centers - a study coordinated by Unica (MEIRA FILHO & MACEDO, 2009) regarding the effects that could stem from total replacement of gasoline and diesel with ethanol in the captive fleet of buses in the city of São Paulo indicated that more than 12 thousand hospital admissions and 875 deaths would be avoided in one year. Therefore, a tragedy would be avoided in face of which its financial cost, of nearly US$ 190 million, would have secondary importance, although highly significant in terms of public and family budgets.

However, it must be underscored that the results of the referred to study are underestimated. This is because the effects on health are measured only in terms of hospital admissions and mortality rates due to the information available in official databases. Nevertheless, it is known that these cases represent only part of the adverse health events. Other diseases, which do not require hospital admission, were not included. Furthermore, only the effects caused by ozone and fine particulate material emissions were studied, disregarding the effects of other toxic agents like sulphur and heavy metals. In other words, the impact is even greater than shown in the simulation numbers.

Greenhouse gas emission reductions - the causes of climate change are strongly related to current production standards and consumption of fossil fuels. Furthermore, greenhouse gas emissions by the transportation sector shall increase drastically in the near future, since every year, a bigger number of people have access to motorized forms of transport. In this sense, there is great potential for reductions in greenhouse gas emissions by biofuels, although it varies significantly, depending on the choice of raw material, form of production, etc.

The International Energy Agency estimated that ethanol derived from sugarcane, like the one produced in Brazil, can reach a reduction of more than 90% in greenhouse gas emissions compared to conventional gasoline and diesel, while ethanol derived from corn reduces emissions about 35% (IEA, 2004; SANTOS ***et. al***., 2004; MACEDO & SEABRA, 2008).

Contrary to Brazilian ethanol produced from sugarcane and using sugarcane bagasse as an energy source in its industrial production process - with negligible net emissions -, alcohol produced from grains (especially corn) consumes large volumes of energy inputs from fossil fuels for its production. This results in reductions of only 30 to 36% in CO_2 emissions in vehicles driven by E85 (85% ethanol and 15% gasoline) fuel and just 2.4 to 2.9% in vehicles driven by E10 (10% ethanol and 90% gasoline) fuels. These are very modest reductions if compared to the reductions achieved by using alcohol produced from sugarcane in Brazil (WANG *et al.*, 1997).

Ethanol's positive impact on mitigating climate change is significant (MEIRA FILHO & MACEDO, 2009). The use of ethanol fuel enabled Brazil to avoid the equivalent of 10% of the greenhouse gas emissions in 2006, excluding the agriculture/livestock and indirect emissions and land-use and forestry changes. For 2020, an 18% cut is estimated. Thus, reduction of direct emissions from ethanol fuel use in Brazil has been approximately 600 million tons of CO_2 since 1975 (PACCA & MOREIRA, 2009).

When we only consider the transportation sector and the generation of electric energy, alcohol's contribution is even more expressive. In 2006, ethanol fuel use provided a 22% reduction in final emissions of two sectors and could reach 43% in 2020 (MEIRA FILHO & MACEDO, 2009).

Although there are greenhouse gas emissions in the agricultural production of sugarcane (due to the use of fertilizers, fuels and inputs) and in its transportation from the field to the plant, the final balance is highly positive, with a net reduction in CO_2 emissions of around 2 t CO_2 equivalent per m^3 of ethanol consumed (MACEDO & SEABRA, 2008). Table 1.2 shows CO_2e flows in the production and consumption of ethanol in Brazil.

Table 1.2 CO_2 equivalent flows in the production and consumption of ethanol in Brazil.

Gases	Flow (tCO_2/m^3 ethanol)
CO_2 reduced*	-2.3
(replacement of gasoline)	-2.1
(replacement of fuel oil)	-0.2
CO_2 released** (production of sugarcane/ ethanol)	0.4
Net Total	-1.9

Source: MACEDO & SEABRA, 2008.
* Average CO_2 reduced by the replacement of gasoline, whether by anhydrous or hydrated alcohol; replacement of fuel oil by sugarcane bagasse; and replacement of electric energy by plant surplus
**CO_2 equivalent of the agriculture and industrial phases of sugarcane and ethanol production. Greenhouse gases like CO_2, CH_4 and N_2O are emitted in these phases, at rates of around 400 kg of CO_2 equivalent per m^3 of ethanol produced.

However, when burning sugarcane leaves for harvest, CO_2 is released. This is not considered a net emission by the specialists because the emitted carbon was previously absorbed by the plant during growth. However, during the combustion process, other gases are produced (N_2O and NO_x during the combustion phase with flame, and CO and CH_4 under burning conditions with predominance of smoke). In the state of São Paulo, there is legislation stipulating the gradual extinction of sugarcane burning for harvest. Additionally, the Environmental Protocol, signed between Unica and the Secretariats of Environment and Agriculture of the state of São Paulo, and which counts with the participation of more than 170 plants, anticipates the deadlines for burning determined by legislation, which implies greater harvesting of raw sugarcane. More than 55% of the sugarcane crop area in the state of São Paulo is currently being harvested without burning (AGUIAR ***et al.***, 2010), and the state is responsible for more than 60 % of Brazilian production (CGEE, 2009).

Water and soil pollution - the disposal of stillage (sugarcane fermentation waste) in rivers, effluents, soils and ground waters was extremely critical in the beginning of the Pro-alcohol Program. Nowadays, this waste from ethanol production has become an economic and environmental advantage for the sugarcane producer and it is now returned to the soil as fertilizer in controlled quantities so as not to contaminate ground waters.

Energy

Positive energy balance – one of Pro-alcohol's great advantages lies in the face that ethanol production is achieved by consuming much less energy than it produces. Studies reveal that the ratio between energy produced (ethanol and surplus bagasse) and energy consumed (fossil fuels and purchased electricity) from the crop in the state of São Paulo varies from 9 to 11.2 times.

Cogeneration potential[62] *using sugarcane byproducts* – the use of bagasse, and eventually sugarcane straw, represents a vast potential for cogeneration of renewable electric energy. At present, more than 90% of the bagasse is consumed as a fuel to provide all the electromechanical and thermal energy required for sugarcane processing. Using high-pressure boilers and thermogenerators, operating only with bagasse during harvest (cogeneration), it is possible to generate surplus electric energy of up to 86 kWh per ton of sugarcane. With the tendency in harvesting sugarcane without burning and using 50 to 80% of available straw, the plant can generate surpluses of more than 100 kWh/ton of sugarcane using conventional technology (high-pressure steam boilers and thermogenerators) or even more than 250 kWh/ton of sugarcane using more advanced technologies, such as biomass gasification and the use of gas turbines. In both these cases, energy would be generated all year long in a hybrid of pure thermal cogeneration and generation.

Estimates indicate that with the continuous use of straw, sales of electric energy by the sugar energy sector could reach 13,158 average MW by the 2020/2021 harvest[63], which would mean an energy reserve for the electric system greater than the amount of energy produced per year at the Itaipu hydroelectric power plant[64]. In August 2010, the bagasse cogeneration project activities carried out under the Clean Development Mechanism - CDM and approved by the Designated National Authority added 1,334 MW in capacity to the electrical sector, and there is significant potential for expansion of this capacity in the future.

62 Energy cogeneration is defined as the combined production process of useful heat and mechanical energy, generally totally or partially converted into electric energy, from the chemical energy provided by one or more fuels.

63 Supposing the use of 50% of straw available in the same harvest year for exporting electric energy and that one ton of sugarcane (bagasse + straw) generates 199.9 kWh for export; lower heating value - LHV of straw = 1.7 LHV of bagasse; Capacity Factor = 0.5 (Koblitz), using a 65 bar boiler (UNICA, 2008).

64 In 2008, the Itaipu power plant generated 94,684,781 MWh, with an installed capacity of 14,000 MW, equivalent to 10,809 average MW. See: <http://www.itaipu.gov.br/energia/geracao>.

Economic

In 2008, it was estimated that the sector's Gross Domestic Product was US$28.15 billion[65], which is equivalent to nearly 2% of the country's GDP. This assessment of the sector GDP, which computed data related to 2008, includes exports of nearly US$ 8 billion (mainly from sugar, US$ 5.5 billion, and ethanol, US$ 2.4 billion). Most of the sector's product is generated in the domestic market, where sales reach US$ 20.2 billion, half of which from hydrated ethanol (NEVES *et. al.*, 2009).

Considering only taxes on earnings — that is, IPI (Tax on Industrialized Products), ICMS (Value Added Tax on Sales and Services), PIS (Social Integration Program Tax) and Cofins (Tax for Social Security Financing) — it is estimated that in 2008, the sector paid the equivalent to US$ 9.86 billion. Of this total, US$ 3 billion refers to sales of agricultural and industrial inputs and US$ 6.86 billion refers to aggregate taxes on the sugar energy sector.

Social

Job generation **-** In 2008, the sugar energy sector employed 1.28 million people with signed working papers, equal to 2.15% of jobs in Brazil. This sum includes jobs generated from growing sugarcane, raw sugar factories, sugar refining and grinding and ethanol production. Most of the jobs were generated by growing sugarcane (481,662 employees), fixed and seasonal, and in sugar factories (561,292 employees). Ethanol production involved 226,513 employees and sugar refining and grinding another 13,791. Data show that the formal job rate in the sugarcane sector has been growing, reaching a national average of 80.9%. This formality rate is higher in the Center-South of the country (90.3%), reaching 95.05% in the state of São Paulo. In the Northeast region, it is 66.5%. Considering that for each direct job two indirect jobs are generated, it is estimated that 4.29 million people work in the sugarcane chain. More than half (55%) of sugarcane workers is illiterate or has little education. However, the increase in mechanization has increased the demand for more qualified professionals (MORAES *et. al.*, 2009).

Keeping labor in the rural zone – besides the high generation of jobs in the sugarcane agro-industry, it is also necessary to underscore the rural nature of those jobs, contributing towards containment of rural-urban migration and avoiding a worsening of growth in large Brazilian cities.

Improvements in health conditions – the reduction in air pollution associated with the use of ethanol also reduces public expenses on health care, especially in large cities.

Strategic

Alternative to oil – the growing consumption of oil in the world, plus the strong concentration of oil reserves in Persian Gulf countries, indicates a growing trend of instability in future carbon fuel prices. In 2008, Brazil produced 99.5% of the domestic supply of crude oil in the country (ANP, 2009). Based on current production levels, sugarcane ethanol could not replace total oil consumption in the country; however, it can be one of the energy options to face situations of instability in oil supply.

Technological

Development of ethanol-powered car technology – Brazil's automotive engineering underwent a great technological effort to adapt Otto cycle vehicles to ethanol use in the diverse climate conditions in the country. New materials and coatings were also used to avoid ethanol-induced corrosion.

A great technological milestone was the creation of automobiles powered by gasoline and ethanol. The first studies on flex-fuel vehicles in Brazil began to be developed in 1990. The cars were launched in the market in 2003, after incorporating important advances, especially in on-board electronics[66] which enable precise control of the main motor functions for each of the fuels used – ethanol or gasoline – and their mixtures. Introduction of this technology in the country was based on the concept of non-modification of the gasoline motor, so that, in the first generation, attention was almost exclusively dedicated to system functionality and meeting emissions requirements, with little concern about ethanol consumption. This technology was gradually improved, but in an unequal manner, by the various car manufacturers that operate in the domestic market. While some car manufacturers, recognizing the consumer's preference for ethanol, have been incorporating innovations that result in a more optimized use of the renewable fuel, others are still in the first generation of flex-fuel motors. Therefore, it can be affirmed that these vehicles are still generally not sufficiently develop to maximize ethanol's benefits, such as greater latent heat of vaporization and higher octane, which offer energy advantages over gasoline. The most recent technological novelty of flex-fuel vehicles, incorporated in 2009 to a single model thus far, was the cold start system

65 The sugarcane industry: ethanol, sugar and bioelectricity. When mapping the sector, an exchange rate of R$ 1.84 per dollar was used, the average for 2008.

66 Onboard Electronics represents any electro-electronic system part of a mobile application, whether an automobile, ship, aircraft or even a tractor. Available at: <http://www.pcs.usp.br/~laa/Grupos /EEM/index.htm>.

with preheating of the ethanol, which forgoes the need for the small auxiliary tank of gasoline and further reduces the emission of pollutants with ethanol.

Technical progress in sugar and alcohol production – the effort by public and private universities and research centers led to notable national scientific and technological evolution in the area. The evolution in sugarcane production led to an intensification in the use of biotechnologies, soil conservation techniques, and improvements in production environments and systems.

Soil quality – in principle, growing sugarcane in the same area, year after year, can create the expectation that productivity will decline over time. However, the opposite proved to be true: after decades of harvests, Brazilian sugarcane productivity has increased continuously. This may be attributed to better preparation of the soil, development of superior varieties of sugarcane and the recycling of nutrients (stillage).

Therefore, the use of sugarcane ethanol as a fuel proves to be a sustainable alternative in relation to fossil fuel use, generating jobs, generating income in the field, developing technology and preserving the environment.

In relation to greenhouse gas emissions, the final balance is highly positive as a result of photosynthesis, where sugarcane absorbs the same quantity of carbon dioxide that is emitted during the burning of alcohol and the bagasse.

1.2 Brazilian Biofuels Program - Pro-Biodiesel

In addition to standing out internationally for sugarcane-based ethanol production, Brazil was the first country to file a biodiesel patent, in 1980.

In 1983, the Brazilian government, motivated by the rise in oil prices, determined implementation of a project entitled "National Program for Vegetable Oil Energy – OVEG Project" in which the use of biodiesel and fuel mixtures was tested in vehicles that ran more than one million kilometers. This initiative, coordinated by the Secretariat of Industrial Technology of the Ministry of Industry, Commerce and Tourism – MICT[67], had the participation of the automobile industry, auto part manufacturers, lubricant and fuel producers, vegetable oil industries and research institutes.

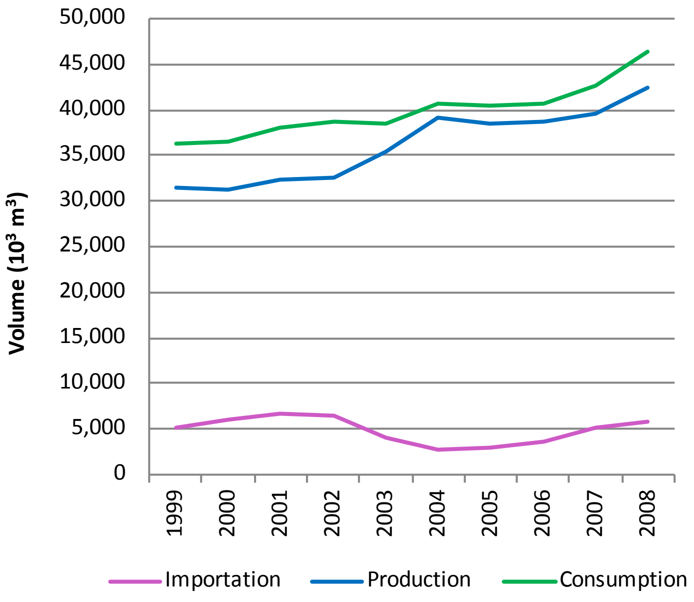
Technical feasibility of the fuel's use was ascertained, making use of existing distribution logistics. However, at the time, biodiesel costs were much higher than those for diesel, and thus biodiesel production on a commercial scale was not implemented.

67 This is currently called Ministry of Development, Industry, and Foreign Trade - MDIC.

The 1990s were characterized by commercial production and the installation of plants on an industrial scale, stimulated by the relative competitiveness of oil and vegetable oil prices and aimed at meeting concerns related to the environment.

In the beginning of the 2000s, the Federal Government started viewing incorporation of biodiesel to Brazil's energy mix as strategic since this fuel was proving to be an alternative for reducing dependence on oil byproducts and as a driving force for a new market for oilseeds. Mainly used for passenger and cargo transportation, diesel is currently the most consumed oil byproduct in Brazil, with annual sales of nearly 38 billion liters (BRASIL, 2009b). Considering the production profile in Brazilian refineries, a growing fraction of this product is being imported, as shown in Figure 1.6. Nowadays, the country imports 12.6% of the diesel consumed in Brazil (BRASIL, 2009b). Thus, development of a biodiesel industry enables the country to reduce expenses. According to the ANP, in 2008, biodiesel use avoided the importation of 1.1 billion liters of diesel oil, resulting in a savings of nearly US$ 976 million, generating foreign reserves for the country.

Figure 1.6 Evolution of production, demand and importation of diesel oil



Source: BRASIL, 2009b.

- Studies indicate that domestic biodiesel production, especially for modern diesel vehicles, presents the following opportunities:
- does not contribute towards an increase in the greenhouse effect (avoiding nearly 2.5 tons of carbon gas emissions per cubic meter of biodiesel used);

- reduces emissions of carbon monoxide pollutants – CO and mutagenicity through the elimination of aromatic composites, big reduction in hydrocarbon emissions – HC and black smoke, as well as a significant reduction in polycyclic aromatic hydrocarbon emissions of the fuel's sulphur content, when compared to diesel, thus contributing towards a reduction in pollution levels in cities, improving the quality of life of their inhabitants;
- it is not toxic;
- current technology enables diesel vehicles to meet EURO III, particulate retention devices – regenerative filters (with B100 they can operate better due to the absence of sulphur and particulate material);
- perspective of exporting biodiesel as an additive with low sulphur content, especially to the European Union, where the sulphur content is being gradually reduced (from 2000 ppm in 1996 to 350 ppm in 2002, and 50 ppm in 2008);
- strengthening of renewable energy sources in the energy mix;
- biodegradable;
- superior performance and use of increasingly smaller motors;
- improves the number of cetane, higher (greater than 50) than diesel's (improved ignition performance), and lubricity (reduced wear, especially of the ignition system);
- appropriate combustion and flash points (safer to handle);
- market in great expansion, especially in Europe, bringing advantages in exporting vehicles, motors and components;
- fuel savings;
- new business opportunities, especially in agro-industry, and generation of jobs and income;
- defined tax burden for fuels;
- growing demand of diesel in Brazil (with implications for import dependence, trade balance and fuel quality);
- diversification of the energy mix; and
- improved transportation logistics.

In July 2003, an Interministerial Work Group – GTI, comprised of representatives from 11 ministries, and coordinated by the President of the Republic, was created to analyze the feasibility of producing and using this fuel in the country.

Taking into account the social, economic, environmental and strategic benefits identified by the GTI, a new presidential decree was published in December 2003 creating an Executive Interministerial Commission on Biodiesel and its executive branch, the Biodiesel Management Group, aimed at promoting and monitoring the measures needed for large-scale introduction of this fuel in Brazil's energy mix.

In December 2004, the Federal Government launched the National Biodiesel Production and Use Program – PNPB, responsible for organizing the production chain, defining lines of credit and structuring the technological base. The PNPB is an interministerial program by the Federal Government aimed at developing production technologies and the biofuels consumption market.

Biodiesel is defined as "biofuel derived from renewable biomass for use in internal combustion motors with compression ignition or, as per the regulation, for generating another type of energy that can partially or totally replace fossil fuels"[68]. Biodiesel must meet the technical specifications as a unique product, without the need for defining the origin of the vegetable oil or type of alcohol to be used in production, but rather as a set of physical-chemical properties for the final product that guarantees its adaptation for use in diesel cycle motors.

Biodiesel can be obtained through different processes, such as cracking, esterification or ethyl or methyl tranesterification[69] . It can be produced from animal fats or vegetable oils. Brazil has several oilseed raw material options, with different energy potentials that can be used, such as castor bean, African oil palm, sunflower, babassu palm, peanut, Barbados nut (*Jatropha curcas* L.) and soy bean, among others (Table 1.3). In this sense, the PNPB tries not to privilege any raw material, leaving the choice up to the producer, who will do so based on an analysis of production costs and opportunity. However, it is worth explaining that *in natura* vegetable oil is much different from biodiesel, which must meet the specification established by the ANP[70].

68 In accordance with Law nº 11,907, of January 13, 2005.

69 Transesterification is currently the most used process for biodiesel production. It consists of a chemical reaction of vegetable oils or animal fats with common alcohol (ethanol) or methanol, stimulated by a catalyzer, from which glycerine is also extracted, a product with various applications in the chemical industry. Besides glycerine, the biodiesel production chain generates a series of other byproducts (pie, meal, etc.) that can add value and become other important sources of income for producers.

70 ANP Resolution nº 07/2008.

Biodiesel totally or partially replaces diesel oil in automotive diesel cycle (trucks, tractors, pick-up trucks, automobiles, etc.) or stationary (electricity and heat generators, etc.) motors. It can be used pure or mixed to diesel in various proportions. The 2% biodiesel mixture to diesel oil is called B2 and so on successively, until reaching pure biodiesel, which is called B100.

Table 1.3 Characteristics of some oilseed vegetables for potential energy use

Species	Origin of Oil	Oil Content (%)	Cycle for Maximum Efficiency	Months for Harvest	Oil Yield (t/ha)
African Palm (*Elaeis guineensis*)	Nut	20	8 years	12	3.0-6.0
Avocado (*Persia americana*)	Fruit	7-35	7 years	12	1.3-5.0
Coconut (*Cocus numifera*)	Fruit	55-60	7 years	12	1.3-1.9
Babassu (*Orbinya martiana*)	Nut	66	7 years	12	0.1-0.3
Sunflower (*Helianthus annus*)	Grain	38-48	Annual	3	0.5-1.9
Rape - Canola (*Brassica campestris*)	Grain	40-48	Annual	3	0.5-0.9
Castor oil (*Ricinus communis*)	Grain	43-45	Annual	3	0.5-0.9
Peanut (*Arachis hypogeae*)	Grain	40-43	Annual	3	0.6-0.8
Soy bean (*Glycine max*)	Grain	17	Annual	3	0.2-0.4
Cotton (*Gossypium hirsutum*)	Grain	15	Annual	3	0.1-0.2

Source: NOGUEIRA & LORA, 2000.

In 2005, it became obligatory to add 2% of biodiesel to diesel oil (B2) sold in any part of the country; after 2008, a gradual increase to 5% was determined by 2013[71]. Considering that the deadlines for meeting the minimum obligatory percentage of biodiesel addition to diesel oil sold to the final consumer, anywhere in the country, can be reduced by the National Committee on Energy Policy - CNPE, in October 2009, the CNPE published a resolution establishing 5% in volume (B5) as the minimum obligatory percentage for biodiesel addition to diesel oil starting January 1, 2010.

The capacity for installed biodiesel production in the country was deemed sufficient to meet such a requirement from January 1, 2009, and it did not require an alteration in the motors or in the fleet of vehicles in circulation, thus guaranteeing greater security for consumers. This modification will generate an additional demand of 740 million liters/year, increasing biodiesel consumption to 2.4 billion liters/year.

This strategy enables the development of the national goods and services industry and contributes towards replacing imported diesel with the national clean and renewable fuel. Furthermore, the production of raw materials and the industrial production of biodiesel, i.e., the biodiesel production chain, has great potential for generating jobs, and, therefore, promoting social inclusion, especially when considering family agriculture's significant production potential. In Brazil's semi-arid and North regions, social inclusion is even more pressing.

In the semi-arid region, for example, a family's net annual income from planting five hectares with castor bean (***Ricinus communis***) and an average production between 700 and 1.2 thousand kilos per hectare can range between R$ 2.5 thousand and R$ 3.5 thousand[72]. Furthermore, the area can be associated with other crops, like beans and corn.

As further incentive for this process, the Federal Government launched the "Social Fuel Seal", a set of specific measures aimed at stimulating social inclusion in agriculture, in this important production chain[73]. In 2005, the Ministry of Agrarian Development – MDA published a regulation[74] for biodiesel projects with perspectives of becoming undertakings that qualify for the social fuel seal. The social framework for biodiesel projects or producers provides access to the best financing conditions with the BNDES and other financial institutions, while providing the right to bid in biodiesel purchase auctions. Producing industries will also have the right to exemption from some taxes, but they must guarantee the purchase of raw materials at pre-established prices, offering security to family farmers. There is also the possibility for family farmers to participate as partners or shareholders in oil extraction or biodiesel production industries either directly or through associations or producer cooperatives.

Family farmers who want to participate in the biodiesel production chain shall also have access to the National Program for the Strengthening of Family Agriculture – Pronaf lines of credit through banks that operate with this program, as well as access to technical assistance provided by companies that have the "Social Fuel Seal" with the support of the

71 Law nº 11,097/2005, Article 2.

72 Biodiesel Industry Yearbook in Brazil 2004-2009. Available at: <http://www.biodieselbr.com/ biodiesel/social/aspectos-sociais.htm>.

73 As per Normative Instruction nº 1, of July 5, 2005.

74 By means of Normative Instruction nº 02/2005.

MDA through public and private partnerships. With that, the producer has an additional chance to generate income, without forgoing the main activity of planting foods. Credit limits and financing conditions follow the same rules as the Pronaf group in which the farmer is placed.

At present in Brazil, Probioamazon, a program managed by the Ministry of Agrarian Development - MDA and the Ministry of Science and Technology - MCT, is the biggest vegetable oil program in existence, with perspectives of producing nearly 500 thousand tons/year[75] of African palm in the North region, from production in National Institute of Colonization and Agrarian Reform – INCRA settlements.

In this maturation process of the biodiesel production chain, one should bear in mind that there are technological issues in pre-commercial stages that need to be resolved in the laboratory, bench and field testing stages, especially the technological route to be developed from biodiesel production using ethanol. The MCT and Petrobras, through the Oil and Natural Gas Sector Fund – CT-Petro, support projects with the participation of universities, such as the Federal Universities of Rio Grande do Sul, in Pelotas and in Alto Uruguay, with the basic aim of adapting and implementing physical-chemical analysis methods, as proposed by ASTM (American Society for Testing Materials) for national biodiesel, and also to assess the properties of the biodiesel mixtures added to diesel in different proportions. Probiodiesel development will make it possible to expand biodiesel's technical and economic competitiveness, increasing environmental gains and generating new business for the agro-industry, auto manufacturers and auto part sectors.

Much is currently discussed about the strategy for using pure biodiesel (B100), with its production being encouraged, considering, among other factors, the industry's idle capacity. B100 has been tested in collective transportation in some cities of Brazil, like Curitiba - PR. There is a Bill in National Congress that seeks authorization for using pure biodiesel (B100) as a fuel for passenger cars and light cargo vehicles (able to transport up to three tons). Tests have also been run on aircraft and ships. Definitive use of the new fuel shall depend on a positive ratio between the energy consumed in the production process and the energy made available by biodiesel, among other factors.

Thanks to this program, Brazil is among the largest producers and consumers of biodiesel in the world, with an annual production in 2009 of 1.6 billion liters and an installed capacity in January 2010, for nearly 4.7 billion liters[76]. The planted area needed to meet the current biodiesel percentage (B5) for mixing with diesel oil is estimated at 3 million hectares, equivalent to 2% of the 150 million hectares planted and available for agriculture in Brazil. This number does not include the regions occupied by pastures and forests.

In 2008, biodiesel use avoided the importation of 1.1 billion liters of oil diesel, resulting in a savings of nearly US$ 976 million, generating foreign reserves for the country.

The objective is to insert biodiesel in the internal offer of fuels, in a sustainable manner (socially, environmentally and economically), in order to make production of this input a vector for development, generating jobs and income, especially in the neediest regions of the country.

H-Bio Process - Petrobras Technology for the Production of Renewable Diesel

Global concern about sustainable development saw the need to define emission limits for automotive technologies. Ever since, researchers have sought the production of less polluting, economically feasible and renewable fuels to achieve the desired environmental improvements. In this sense, the H-BIO process[77] contributes towards the production of diesel oil using a parcel of renewable raw material.

The H-BIO process was developed by the Petrobras Research and Development Center – Cenpes to insert renewable raw material processing in the scheme of oil refining and allow for the use of already existing installations.

In this process, vegetable or animal oil is mixed with fractions of diesel to be hydroconverted at Hydrotreatment Units – HDT used at the refineries mainly to reduce sulphur content and improve diesel quality, adjusting the fuel's characteristics to National Petroleum Agency – ANP specifications.

Different vegetable oils were tested at a pilot plant while developing this technology, such as soy and castor bean, in different operating conditions. They revealed the advantages of the process where high yield of at least 95% v/v stands out in diesel without generating waste and with a small production of propane. For every 100 liters of soy oil processed, 96 liters of diesel and 2.2 Nm^3 of propane are produced. As a result, the Refining and Supply area is conducting industrial tests using up to 10% in volume soy oil in the HDT load, demonstrating the technology's fitness and flexibility.

The process involves a catalytic hydroconversion of a mixture of fractions of diesel and renewable oil in an HDT reac-

75 See: <http://dabdoub-labs.com.br/pdf/probiodiesel.pdf>.

76 See: <http://www.anp.gov.br/?pg=17680&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1281537505937>.

77 See: < http://www2.petrobras.com.br/tecnologia/port/H-BIO.asp>.

tor under controlled high temperature and hydrogen pressure conditions. Vegetable oil is thus transformed into linear paraffinic hydrocarbons similar to those that exist in diesel from petroleum. These composites contribute towards the improved quality of final diesel, underscoring the increase in the number of cetane, which guarantees better quality ignitions and low density and content of sulphur. The benefit in product final quality is proportional to the volume of vegetable oil used in the process.

Petrobras H-BIO technology introduces a new path for the production of biofuels that complements the Brazilian Biodiesel Program, which is in full development. In the future it will expand the use of biomass in the country's energy mix, generating environmental benefits and social inclusion.

Benefits from the H-Bio Process

One of the main benefits of this process is reduced greenhouse gas emission, because the vegetable and animal oils that make up the bulk of the H-BIO raw material are renewable, thus displacing the fossil carbon from oil.

In this sense, the avoided emissions from this process may represent an emission reduction of about 2.0 to 2.6 t CO_2/t of diesel, according to the AM-0089 methodology adopted by the UNFCCC to quantify the greenhouse gas emission reductions for CDM project activities[78].

An additional major benefit provided by H-BIO is to reduce the sulphur content in diesel oil, thus helping to reduce emissions of regulated pollutants. H-BIO also contributes towards the improved quality of final diesel, underscoring the increase in the number of cetane, which guarantees better quality ignitions and reduced density. All of these benefits are commensurate with the volume of renewable oil used in the process.

1.3 Energy Conservation Programs

1.3.1 Government Energy Conservation Programs

Energy conservation measures in Brazil were implemented by the Federal Government as a means to avoid the impacts of foreign crises, notably the rise in oil prices and the increase in interest rates that affected the trade balance.

In response to the 1973 and 1979 oil crises, when Brazil's oil imports supplied nearly 70% of its primary energy consumption, a strategy was set up focusing on the reformulation of the energy supply policy: intensification of oil prospecting, increase of the hydroelectric share in the mix, use of domestic coal and replacement of gasoline with ethanol for the transportation sector.

In the beginning of the 1980s, the Conserve Program was implemented, administered by the Brazilian Development Bank – BNDES, which became the first effort in terms of energy conservation, aimed at promoting energy efficiency in industries; developing more energy-efficient products and processes; and encouraging replacement of imported energy sources.

In the mid 1980s, the National Program of Electric Energy Conservation – Procel, and in the 1990s, the National Program on the Rationalization of the Use of Oil and Natural Gas Products– Conpet, were created, achieving good results.

The ratio between energy savings and greenhouse gas emission reductions is not linear. In other words, a possible reduction in energy consumption does not necessarily entail a reduction of emissions in the same proportion. This is mainly due to the strong water component in electricity generation. However, if there were an increase in energy generation from fossil fuel thermal units, this would entail considerable impact on emissions, which makes energy savings so important.

Annual investments in research and development and in energy efficiency, on the part of energy concessionaires, permissionaires and authorized companies, are currently regulated by law[79], which requires public utility electric energy distribution concessionaires and permissionaires to invest at least 0.75% of net operating revenues per year in research and development in the energy sector, and at least 0.25% in energy efficiency programs for end use. By December 31, 2015, these minimum percentages shall be 0.5% for research and development as well as energy efficiency programs in the supply and final use of energy[80].

Generation concessionaires and companies authorized for independent production, as well as public utility concessionaires for electric energy transmission, are obliged to invest the minimum sum of 1% of net operating revenues in research and development of the electrical sector, annually[81].

In 2001, the National Program for Conservation and Rational Use of Energy was created[82] aimed at the effi-

78 See: <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html?searchmode=advanced&searchon=1&scales=1&scales=2&scales=3&number=&title=&scopeoperation=or&scopes%3Alist=1&button=Search>

79 By means of Law nº 9,991, of July 24, 2000.

80 According to Law nº 12,212, of January 20, 2010.

81 As called for under Law nº 9,991, of July 24, 2000.

82 Law nº 10,295, of October 17, 2001.

cient allocation of energy funds and preservation of the environment. In accordance with this law, the Executive Branch establishes maximum levels of specific energy consumption, or minimum levels of energy efficiency, for energy consuming machines and devices manufacture or sold in the country, based on pertinent technical indicators, which the manufacturers and importers of these machines and devices are obliged to obey. The law also stipulates that the Executive Branch must develop mechanisms that promote energy efficiency in buildings constructed in the country.

Conserve

The Conserve program, created under the Ministry of Industry and Commerce - MIC (the current Ministry of Development, Industry and Foreign Trade - MDIC), in 1981, was the first effort in terms of energy conservation in Brazil, aimed at meeting the objectives of Administrative Rule MIC/GM46, related to promoting energy conservation in industry, developing more energy-efficient products and processes and stimulating the replacement of imported oil with alternative autochthonous sources.

The strategic option being faced at the time was to implement a conservation policy regarding the use of electricity, which ended up being reflected in the creation of Procel in 1985.

Procel

The objective of the National Program of Electric Energy Conservation – Procel is to promote the rationing of electric energy production and consumption with a view to eliminating waste and reducing costs and investments in the sector.

Procel was created in December 1985 by the Ministry of Mines and Energy and by the Ministry of Industry and Commerce, managed by an Executive Secretariat reporting into Brazil's Electrical Utility (*Centrais Elétricas do Brasil S.A.*) – Eletrobras. In 1991, Procel was transformed into a Government Program, broadening its scope and responsibilities.

The Program uses resources from Eletrobras and the Global Reversion Reserve – RGR, a federal fund comprised of concessionaire resources proportional to their investment. It also uses resources from international entities (Table 1.4).

Table 1.4 Procel's annual investments and results

	1986/ 2003	2004	2005	2006	2007
Eletrobras/Procel Investments (R$ million)*	252.01	27.2	37.2	29.24	13.6
RGR investments (R$ 5 million)	412	54	44.6	77.8	39.2
Energy Efficiency Project Investments for Brazil (R$ million)**	2.09	13	16.2	6.2	-
Total Investments Made (R$ million)	666.08	94.2	98	113.2	52.8
Energy Saved (billion of kWh/year)	17.22	2.37	2.16	2.85	3.93
Peak Demand (MW)	4,633	622	585	772	1,357
Plant Equivalent (MW)***	4,033	569	518	682	942
Postponed Investments (R$ billion)	10.65	2.5	1.77	2.23	2.76

Source: Eletrobras/Procel, 1998; Eletrobras/Procel, 2008.
* Only refers to Procel budget resources actually paid each year, not considering Eletrobras/Procel personnel salaries.
** Refers to US$ 11.9 million investment by GEF and Eletrobras' contribution.
*** Obtained from saved energy, considering a typical average capacity factor of 56% for hydroelectric power plants and including 15% of average losses in Transmission and Distribution - T&D for the energy conservation portion.

Procel establishes energy conservation goals that are considered in electrical sector planning, assessing the needs for expanding the supply of transmission energy. Those that stand out are the reduction in technical losses at concessionaires; the rationing of electric energy use; and the increase in energy efficiency in electric devices. Thus, Procel has achieved significant results, as can be seen in Table 1.5.

Table 1.5 Accrued results by Procel

Results	Total
Total Investments Made (R$ billion)*	1.02
Energy Saved and Additional Generation (billion of kWh/year)**	28.5
Peak Demand (MW)	7,969
Plant Equivalent (MW)	6,841
Postponed Investments (R$ billion)	19.9

Source: Eletrobras/Procel, 2008.
* Includes the portion related to RGR and Energy Efficiency Project Resources for Brazil.
** Energy saved and the accumulated additional generation only adding each year's savings, not considering the persistence of implemented measures.

If the current structure of energy use is maintained, the projected supply need for 2015 will be around 780 TWh/year. An estimated annual reduction of up to 130 TWh is believed possible by eliminating waste. This corresponds approximately to the production of two hydroelectric power plants the size of Itaipu. One of Procel's goals has been the reduction from technical losses in concessionaire transmission and distribution to around 10%. With the adoption of the Procel Seal for household appliances, an average increase of 10% is expected in the energy efficiency of equipment participating in the program.

Procel's main objectives are to reduce electric energy waste in the country and to seek energy efficiency in the electrical sector, which aim at achieving some essential goals: technological development; energy security; economic efficiency, new consumer's behavior; and reduction in environmental impacts. Technological development implies scientific research and training of laboratories and technical personnel, for improving quality of life. Energy security aims at guaranteeing energy in the quantity and time needed. Economic efficiency means producing and distributing the economy's goods and services with the best possible use of inputs needed for their production and distribution. Energy is one of the basic inputs for economic activities, thus economic efficiency includes energy efficiency. New parameters can be incorporated to citizenship through actions at every level of formal education in the country, using the "Environmental Education" communications channel[83].

Procel's role is to reduce environmental impacts in Brazil: the various lines of action for each of Procel's Behavior Change and Energy Efficiency Projects make it possible to meet the growing demand for electric energy without expanding supply in the same proportion. One part of the demand for electricity begins to be met by what could be called "virtual" energy, obtained through energy conservation actions.

Such actions permit carrying out more productive activities with the same quantity of energy, increasing the energy efficiency of lamps, motors and household appliances, while also reducing consumption in public buildings and homes. There are also projects to manage energy demand and to reduce transmission and distribution losses, increasing the effectiveness of the supply.

Through projects and actions carried out under Procel – which promote the use of electric energy in a more efficient manner – plants, transmission lines and distribution networks that would need to be constructed to meet the growth in demand, can be avoided, or postponed, thus preventing the release of greenhouse gases into the atmosphere.

83 See Part IV, Section 3.2.1, on Procel at Schools.

Together with COPPE/UFRJ, Procel ran a study that evaluates the quantity of carbon avoided by its programs. The conclusion is that by 2010, energy efficiency will have contributed towards avoiding the emission of nearly 230 million tons of carbon into the atmosphere.

Reluz

The National Program for Efficient Public Lighting – Reluz, coordinated by the Ministry of Mines and Energy and developed by Eletrobras, through Procel, was launched in 2000 and extended until 2010, with projected investments of R$ 2 billion. The Program covers up to 96% of potential energy conservation from the national public lighting grid, currently comprised of 13 million points of lighting, 7.5 million of which can become more efficient. Once this goal has been reached, the Federal Government will be able to cut municipality expenses on public lighting by approximately R$ 183 million per year, with a reduction of 682 thousand kilowatts (kW) and a savings of 1.3 billion kWh/year. Reluz also projects the installation of more than 1 million points of lighting in the country.

Financing of the projects is granted to the electric energy concessionaires – distributors, transmitters and generators – which, in cooperation with local government, carry out the services. The financing value corresponds to up to 75% of the project's total value. The rest is comprised of contributions by concessionaires and local governments, which can be done through their own services such as transportation, labor and other services needed to carry out the projects.

Implementation of the Reluz Program provides improvements for tourism, commerce and night-time leisure; generates new jobs; increases the quality of life of the urban population; reduces demands on the national electric system, especially during peak consumption hours; and contributes towards an increase in reliability and in improved customer service for the electricity consumer market.

Conpet

The National Program on the Rationalization of the Use of Oil and Natural Gas Products – Conpet, instituted by federal decree in 1991, is a Ministry of Mines and Energy program coordinated by representatives of Federal Government entities and private enterprise that comprise Conpet's Coordinator Group. It is up to Petrobras to provide technical, administrative and financial resources for the program. SMS's General Management for Energy Efficiency and Atmospheric Emissions/Support to Conpet is the company entity that exercises the function of Conpet's Executive Secretariat, and is responsible for elaborating projects, operationalizing strategies, promoting institutional coordination and promoting program actions. This Management reports into Petrobras' director for services, which, in accordance with a presidential decree, is Conpet's Executive Secretary.

Conpet's main objective is to encourage the efficient use of oil byproducts and natural gas in transportation, homes, commerce, industry and agriculture.

With Petrobras' support, the program creates technical cooperation agreements and partnerships with government entities, non-governmental organizations and representatives of entities working on the theme and it also organizes and promotes projects. Program actions for rationing the use of oil byproducts and natural gas contribute towards the concertation of economic, environmental and institutional strategies.

Conpet's goal is to obtain energy efficiency gains in the use of oil and natural gas products without affecting the activity level in the diverse sectors of the national economy. Thus, Conpet has been developing projects in the transportation, industrial, residential and commercial sectors, as well as agriculture and the generation of thermoelectric power.

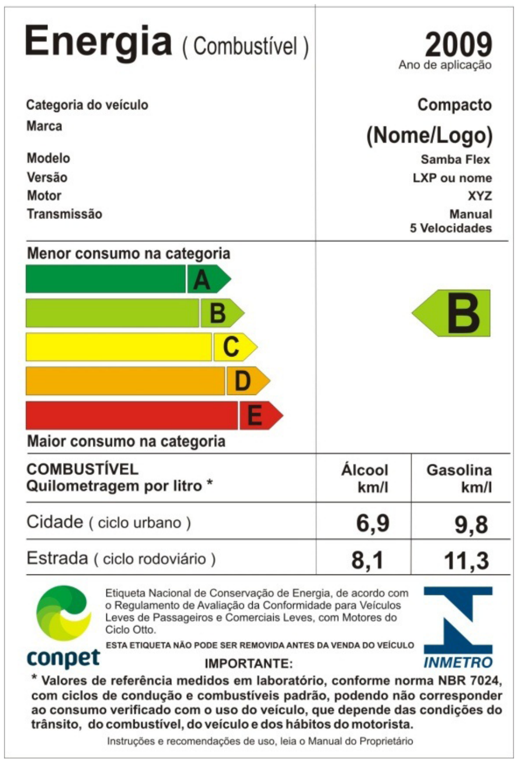
Transportation Sector

Urban passenger transportation – implementation of a methodology for managing diesel use in bus companies, carried out in partnership with the Urban Passenger Transportation Federation of the State of Rio de Janeiro - Fetranspor. About 35 companies in the state of Rio de Janeiro are taking part in the project for the adoption of management practices and technologies geared towards the reduction of fuel consumption.

Economize Project – created in 1996 as an instrument to ration energy use, the priority objective of the MME's energy policy, the project coordinates efforts by public authorities with the private sector, supporting freight and passenger transportation companies in the implementation of measures to improve the management of diesel use and in the professional qualification of drivers and mechanics. The National Transport Confederation – CNT was a partner of the project until 2008. During the partnership, the project operated in 21 states, with the participation of 14 regional entities (federations and unions), and it conducted more than 111 thousand inspections on 67 thousand vehicles. According to these inspections, there were reductions of up to 14% in the specific consumption of diesel in those fleets participating in the project. This resulted in an annual savings in fuel of about 144 million liters and 402 Gg CO_2 not emitted into the atmosphere. Conpet currently has an agreement with the cargo segments in the states of Paraná and Rio de Janeiro, and with the passenger segment in Rio de Janeiro.

Brazil's Vehicle Labeling Program – in order to distinguish the light vehicle that had the best energy performance in its category, Brazil's Vehicle Labeling Program, announced in November 2008 was regulated by the National Institute of Metrology, Standardization and Industrial Quality - Inmetro, an entity that reports into the Ministry of Development, Industry and Foreign Trade – MDIC, and carried out in partnership with Petrobras. This program enables the consumer to compare car energy efficiency characteristics through the National Energy Conservation Label for vehicles. The label is similar to the one used with household appliances, and through them, the cars are classified from A to E, with A being the most economical. (Figure 1.7).

Figure 1.7 National Energy Conservation Label for Vehicles



Vehicle manufacturer and importer adherence to the program is voluntary and renewable every year. When the car manufacturer decides to participate, it shall inform fuel consumption and energy efficiency data for the models in the vehicle owner's manual and at points-of-sale. This information can be consulted on the label, which is optionally affixed to the windows of the manufacturer's cars. The data is also available on the Conpet[84] and Inmetro[85] websites.

The search for energy efficiency in vehicles will bring a technological evolution to Brazilian automobiles, increasing the competitiveness of this industrial segment and augmenting economic, social and environmental gains.

As part of Brazil's Labeling Program, Inmetro, in collaboration with Conpet, is developing a methodology to classify tires according to their performance: a) rolling resistance - the lower it is, the lower is fuel consumption and the lower are amounts of gaseous and solid particles released into the atmosphere; b) wear resistance – the greater it is, the lower are levels of particulate matter released into the atmosphere, smaller is the amount of scrap tires generated and, therefore, natural resources are preserved; and c) adherence to the ground – the greater it is, the higher is the safety index assigned to the tire.

Transport Project – a pioneer initiative created to provide specialized technical support. Fuel transporters that use the supply terminal at the refineries are its target public through instruction and education actions. The objective of the Transport Project is to assist fuel transporters in reducing black smoke emissions through the use of Inmetro certified opacimeters[86], together with methodological processes approved by Petrobras in transportation sector projects; improve air quality; save diesel; contribute towards safety in fuel transportation, always keeping the tank trucks in good condition; and disseminating a culture of social responsibility.

By July 2010, the Transport Project had conducted more than 16,000 inspections on nearly 4,000 vehicles. Nearly 450 companies have already participated in the tests. The efforts and the dedicated work by project members have avoided 45,500 tons/year of CO_2 in emissions (Table 1.6).

Table 1.6 Transport Project Numbers (By July 2010)

Operation time	7 years
Inspections	16,231
Participating Companies	450
Inspections within standards of opacity	12,700
Inspections outside standards of opacity	3,531
Estimated quantity of diesel saved (l/year)	17,000,000
Avoided CO_2 emissions (t/year)	45,500
Avoided particulate emissions (t/year)	1020

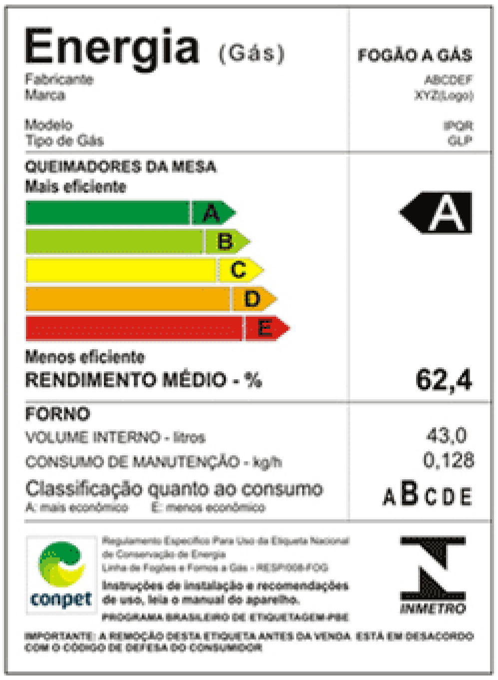
Source: Conpet. Available at <http://www.conpet.gov.br/>.

84 See: <http://www.conpet.gov.br/>.
85 See: <http://www.inmetro.gov.br/>.
86 Portable instrument used to measure the quantity of particulate material (black smoke) emitted by diesel powered vehicles.

Industrial Sector

Brazil's Labeling Program - PBE and Household and Gas Device Labeling - PBE is an energy conservation program that aims at informing the consumer about the energy efficiency of some products sold in the country through the use of informative labels. The program aims at stimulating and rationing energy consumption through the use of more efficient products. Labeling enables the consumer to evaluate the diverse products as to their energy performance and to select those that will bring greater savings during their use. Besides classification of the product as to its energy efficiency, the PBE label contains other information such as brand, model, energy (electricity or gas) consumption value or energy performance (%) and some technical specifications (Figure 1.8).

Figure 1.8 Models of labels for gas stove and heater



Source: MME. Available at: <http://www.mme.gov.br/spe/menu/programas_projetos/programa_brasileiro_ etiquetagem.html>.

Nearly 5 million gas stoves are manufactured in Brazil every year, and approximately 90% of them use Liquefied Petroleum Gas – LPG, also known as cooking or bottled gas. In relation to the consumption of oil byproducts and natural gas in the household, commercial and public sectors, LPG is the main energy used, representing nearly 90% of the total use of this byproduct in this segment.

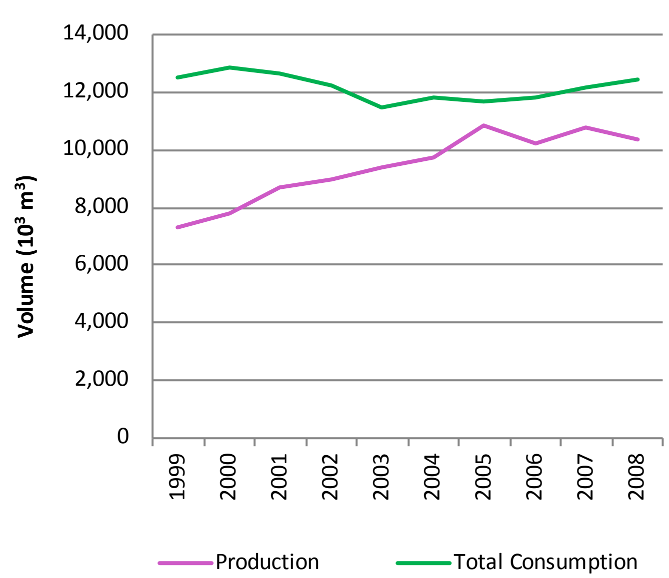
The Conpet Energy Efficiency Seal (Figure 1.9) was established to distinguish the equipment participating in Brazil's Labeling Program with the best performance in its category that complies with the presidential decree establishing the green Energy Efficiency seal.

Figure 1.9 Conpet energy efficiency seal

According to the National Energy Balance – BEN (BRASIL, 2009b), household consumption of LPG, which had been decreasing since 2000, had slight growth in 2004 (2.1%) and remained virtually constant until 2007. Nearly 13% of all households with LPG stoves also have wood-burning stoves, making it possible to return to this energy source at any time. Figure 1.10 shows the evolution of LPG consumption and production in Brazil.

In 2008, LPG production reported a deficit (10.4 million m^3) compared to demand (12.4 million m^3). Considering the household sector on its own, LPG consumption is around 10 million m^3/year or 5.2 million t/year. The program is estimated to have the potential to save around 1.4 million m^3 or 780 thousand tons of LPG annually, reducing the amount of imported LPG needed to supply the domestic market (BRASIL, 2009b).

Figure 1.10 Evolution of LPG Consumption and Production in Brazil: LPG ($10^6 m^3$)



Source: BRASIL, 2009b.

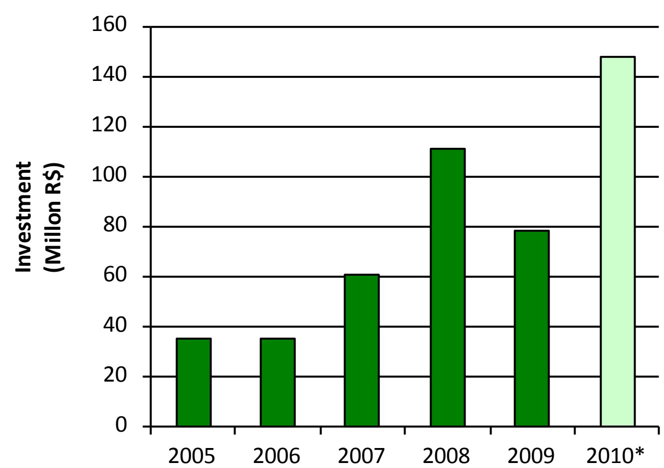
Petrobras Energy Efficiency Program

As a result of the first oil crisis, Petrobras created, from 1974, "energy conservation working groups" in the refineries and developed the Program for Energy Conservation.

An Internal Committee for Energy Conservation - CICE[87] under all bodies and organizations in the direct and indirect federal administration was established, with a mandate to implement energy conservation actions and efficiency improvement projects aimed at reducing electric power and fuel consumption in their units.

Petrobras currently has 48 active CICEs in its operating units and subsidiaries. With the support of these committees, Petrobras has invested in excess of R$ 300 million over the past three years in developing and implementing energy efficiency projects (Figure 1.11).

Figure 1.11 Investments in Petrobras's Energy Efficiency Program



*Planned Hyperion
Source: SAP/BW and Planning - Hyperion

Petrobras currently has a number of energy efficiency projects associated to the following programs:

- energy optimization and integration (enhanced thermal exchange between currents);
- cogeneration and combined cycle units;
- turboexpanders;
- advanced process control;
- existing plant modernization;

87 Decree nº 99,656/1990.

- equipment adaptation: enhanced performance speed variators and motors;
- reduction of losses (steam, condensed, waters, etc.);
- reduction of flare gas;
- project standardization;
- operational procedures standardization; and
- R&D associated to energy efficiency technology.

1.4 Hydroelectric Power's Contribution to Reduce Greenhouse Gas Emissions

Evolution of Electric Power Generation

Brazil is characterized by being a country of continental dimensions, with eight large watersheds: the Amazon River; the Tocantins River; the North and Northeast sections of the South Atlantic; the São Francisco River; the East section of the South Atlantic; the Paraná-Paraguay Rivers; and the Southeast section of the South Atlantic[88].

Water production in Brazil, defined as the average annual flow of rivers that empty into the ocean, is 168,790 m³/s. Taking into account the flow produced in the Amazon watershed, which is in foreign territory, estimated at 89,000 m³/s, total water availability reaches 257,790 m³/s.

Brazil has nearly 20% of the planet's water and 11.1% of the hydroelectric power production in the world, and the tendency is for it to become the largest producer in the next 10 years, if it maintains current annual growth of 4.41%. Brazil's water potential is 260 GW, but only 78.7 GW are currently being used; however, this potential is being further explored, as shown in Table 1.7.

The preference for the hydroelectric option precedes the 1960s, when integrated planning of supply growth at a regional, and then a national level was initiated. Although there are no production statistics for before 1950, data referring to installed generation capacity are sufficient to indicate hydroelectric power's historical predominance in Brazil, as can be seen in the ratio between hydroelectric power generation and total energy generation shown in Table 1.7.

88 See Part I, Section 1.3, Figure 1.3.

Table 1.7 Brazil – Installed Electric Power Generation Capacity

Year	Hydro (MW)	Total (MW)	H / T (%)
1900	5	10	50
1910	124	157	79
1920	301	367	82
1930	630	779	81
1940	1,009	1,244	81
1950	1,536	1,883	82
1960	3,642	4,800	76
1970	8,985	11,239	80
1980	27,651	33,474	83
1990	45,558	53,050	86
2000	61,063	73,712	82
2009	78,700	106,600	74

Source: BRASIL, 2001 and BRASIL, 2010.

In the 1950s, government company action was initiated on a major scale for hydroelectric power generation, with the installation of power plants on the São Francisco and Grande Rivers. The São Francisco River began with the Paulo Afonso I plant (180 MW), in Bahia, followed by the Três Marias plant (306 MW), in Minas Gerais. In the Grande River, the Furnas plant (1,312 MW) stands out for its installed capacity and the capacity of other important undertakings downstream. Then, it is important to highlight the Jupiá (1,414 MW) and Ilha Solteira (3,444 MW) plants on the Paraná River, which began in the 1960s, when exploration of the Paranapanema and Iguaçu watershed was also initiated. Major projects in the 1970s include, besides the increased utilization of the São Francisco and Paraná watersheds (in Brazilian territory), the beginning of construction of the Itaipu power plant (the existing installed capacity is 14,000 MW), in its international section, as well as utilization of the Amazon region's potential with the Tucuruí power plant (4,200 MW, initial) on the Tocantins River.

Planning studies for expanding the electric systems at regional level, considering the coordinated operation of interconnected plants, began in 1962, after contracting the consortium of Canadian, American and Brazilian consultants, called CANAMBRA, which counted on United Nations Development Programme – UNDP and Federal Government resources.

Data obtained from this study identified that the electrical sector's preference for hydroelectric power stemmed from the competitive costs of this modality of electric energy production, even before 1973 (the first oil crisis). This resulted from the favorable natural conditions of several undertakings, their relative proximity to the markets to be served, the consideration of not very high discount rates (around 10%) and, at the business level, access to credits with interest rates that did not exceed 6% per year. These relative advantages presented by several exploitations prevailed even in the 1960s, when oil prices reached their lowest levels, including with a reduction in international transportation prices. The share of fuel and equipment imports (more significant in the case of thermal plants, especially coal-powered) in the trade balance was also important for the option used.

Starting in the 1970s, the share of hydroelectric power in the country's electricity production saw great growth. Several factors contributed to this:

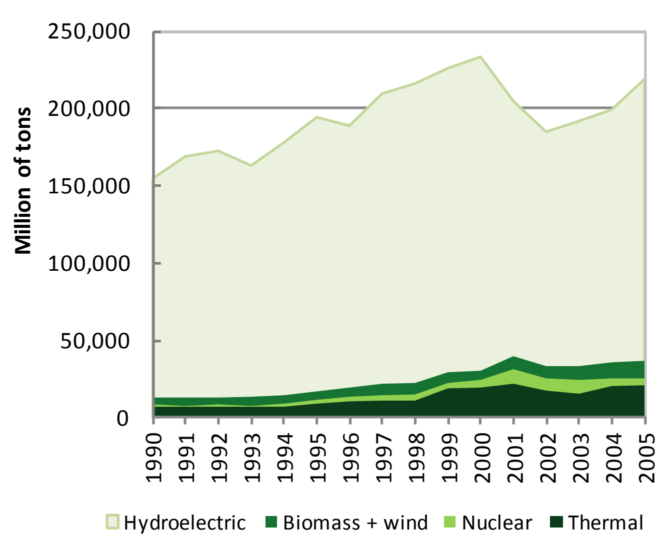
- the rise in fuel prices, with the consequent renewed pressure of imports on the trade balance;
- reduced units costs for transmission, thus enhancing the value of more remote potentials;
- exploitation of hydrological diversities;
- longer service life of the hydroelectric power plants;
- buffering of floods;
- increase in thermal plant costs, especially the coal-powered ones, due to the relatively low quality of domestic coal;
- increase in environmental restrictions that began to be obeyed;
- worsening of the oil crisis, in 1979, when all of the importing countries sought to reduce their dependence on this fuel; and
- geopolitical factors that favorably influenced the decision to implement some projects, such as the Itaipu and Tucuruí plants.

The electric energy industry also developed technologies in the construction field and in the operation of large hydroelectric power plants, as well as in the operation of transmission systems at great distances and in direct current. Its electricity generation grid grew from 11 GW in 1970 to 30.2 GW in 1979, and it exceeded 106 GW in 2009. In hydroelectric power plants alone, installed capacity reached a value of nearly 79 GW in 2009. The result of these measures is clear, whether by the reduction in foreign dependence on energy or the evolution of Brazil's energy mix since the beginning of the 1980s.

In 2009, the Brazilian electric energy market demanded production of 466.2 TWh in public service and self-producing electric power plants. Of this production, 391 TWh, or 84%, was hydroelectric power. As a result of these values, the Brazilian electrical sector takes on special characteristics not only as one of the largest hydroelectric producers in the world, but also the exceptional participation of hydroelectric power in meeting its electric power needs.

If the electricity generated by the non-CO_2 emitting sources were produced by a hypothetical fossil fuel mix, electrical sector emissions would be much higher, as can be observed in Figure 1.12.

Figure 1.12 Avoided CO_2 emissions in the generation of hydroelectric power



Source: BRASIL, 2005.

1.5 Situation and Perspectives for New Renewable Energy Sources in Brazil

The new sources of renewable energy include the "modern use of biomass", small hydroelectric plants – SHPs, wind energy, solar energy (including photovoltaic energy), tidal power and geothermal power. The "modern use of biomass" excludes the traditional uses of biomass, such as wood, and includes the use of agricultural and forest residues, as well as solid waste (garbage) for generating electricity, producing heat and liquid fuels for transportation.

Brazil is characterized by having a primarily renewable energy mix and not necessarily based on traditional energies like wood, but on energies like water power and renewable fuels like ethanol. In remote areas, there is a pent-up demand that will increase the demand for photovoltaic solar energy, small-sized wind energy systems and generation systems using vegetable oils. It is expected that institutional and regulatory incentives introduced in recent years will reduce the space occupied by fossil fuels, benefiting local renewable sources.

This energy mix is expected to also be diversified by including other forms of biomass, wind power and small hydroelectric plants. All these sources have great potential for elaborating CDM project activities.

In August 2010, the biomass, wind energy and small hydroelectric plant project activities developed under the CDM and approved by the Designated National Authority added 4,032 MW in capacity to the electrical sector, and there is significant potential for expansion of this capacity in the future.

One of the main obstacles to technological advances in solar power is its cost. According to the Ministry of Mines and Energy[89], in 2013, the value for the kWh produced by photovoltaic modules for residences will be similar to the kWh generated by other sources, in several states of Brazil.

Recent History of Renewable Energy Sources

In Brazil, the use of new sources of renewable energy gained greater momentum after the United Nations Conference on the Environment and Development - Rio-92 was held. Since then, and until 2008, more than 12 MW[90] of photovoltaic systems and 247.10 MW[91] of wind power systems were installed, which served to demonstrate the technical feasibility of these alternatives, whether in the case of photovoltaic solar power to meet energy needs of certain niches, or for injection in the electric system in prodigal wind resource areas, such as the Northeast coast. The use of energy from small hydroelectric plants and sugarcane bagasse processing, as well as biomass from other regions, already traditional in the country, has been consolidating and expanding since restructuring of the electrical sector and the incentives offered to these sources and to energy cogeneration.

In 1994, the MME and the MCT called a "Meeting to Define Guidelines for Developing Solar and Wind Power in Brazil", where a series of actions were discussed aimed at identifying mechanisms and proposing changes in governmental policies that would enable diffusion of the use of these forms of energy. A Permanent Forum was established to ensure implementation of the guidelines and Reference Centers for the diverse technologies were created, which materialized later, such as the Reference Center on Solar and Wind Energy – CRESESB, the Reference Center on Biomass - CENBIO and the Reference Center on Small Hydroelectric Plants - CERPCH, established in 1994, 1996 and 1997, respectively. The private sector also organized itself, and in November 1994, it created the Brazilian Association of Renewable Energy Companies and Energy Efficiency – ABEER, comprised of company representatives that operate in these segments in the country. Besides the aforementioned sources, solar power also presents potential for the elaboration of CDM project activities.

Legal and Regulatory Framework

The law that created ANEEL[92], stipulates the regime for electric energy public utility concessions and provides other measures, including the reduction of no less than 50% in charges for use of transmission and distribution systems; free commercialization of energy for consumers with loads equal to or greater than 500 kW; and exemption of financial compensation payments for using water resources for small hydroelectric plants - SHPs. A decree[93], also from 1996, defined and regulated independent production and self-production of electric energy, important modalities in electric power generation as alternative and renewable sources.

In 1998, especially important incentives were provided [94] to small hydroelectric plants that became exempt from making royalty payments to states and municipalities. Transmission and distribution tariffs were cut by at least 50% and they were now permitted to sell energy directly to any consumer so long as more than 500 kW and they were exempted from the tender process, requiring only ANEEL authorization.

In 1999, ANEEL[95] stipulated the necessary requirements for obtaining registration or authorization for implementing, expanding or upgrading thermoelectric, wind and photovoltaic power, as well as other alternative energy sources for the commercialization of energy in an independent production, exclusive use or even public utility format. This resolution was created by virtue of the need to update and complement the procedures contained in previous norms aimed at facilitating the entry of new generation sources, simplifying rules and standardizing procedures. Among other pro-

89 See: <http://www.mme.gov.br/see/noticias/destaque1/destaque_0005.html>
90 According to the estimate by the Photovoltaic Systems Laboratory of the University of São Paulo.
91 Cf. ANEEL Generation Information Database. Available at: <http://www.aneel gov.br>.
92 Law nº 9,427, of December 26, 1996.
93 Decree nº 2,003, of September 10, 1996.
94 Law nº 9,648, of May 27, 1998.
95 By means of Resolution nº 112, of May 18, 1999.

visions, it establishes the obligatory registration of plants with generation capacities of up to 5 MW and of authorization (grant) for plants with capacities greater than that.

In 1999, the MME determined that Eletrobras should make an open call for proposals to identify surplus electric energy from cogeneration with the objective of short-term commercialization. It also determined that the same Eletrobras establish the proper mechanisms for purchase, directly or through its affiliates, of surplus electric energy produced by cogenerators duly authorized by ANEEL.

Also in 1999, ANEEL[96] established the conditions and deadlines for subrogation of Fuel Consumption Bill – CCC pro rata benefits to projects to be established in isolated electric systems to replace thermoelectric generation that uses oil byproducts. The resolution permitted the use of CCC resources for total or partial replacement, as well as to meet the new loads due to market expansion. Hydroelectric projects with power greater than 1,000 kW and equal to or greater than 30,000 kW, characterized as small hydroelectric plants, and other electric power generation enterprises using alternative sources from renewable natural resources were explicitly listed. The Reference Energy concept was defined and will be established for each project by ANEEL, based on the market served and existing repressed demand, as well as the availability of long-term energy from the enterprise.

In compliance with the relevant legal provisions[97], and considering the compatibility of SHPs and other alternative sources and technologies of electric power generation with the characteristics of the isolated electric systems, ANEEL seeks to induce forms of electric power generation with the lowest cost and least environmental impact to promote socioeconomic development and reduce regional inequalities[98].

ANEEL[99] also regulated the obligatory application of electric energy concessionaire resources to actions to combat electric energy waste and technological research and development in the electrical sector for 1999-2000, while also stipulating that at least one-tenth of annual operating profits shall be applied to technological research and development projects in the electrical sector. The resolution stipulated that program presentations shall comply with the Manual for Elaborating the Annual Research and Development Program for the Brazilian Electrical Sector, which includes renewable energies among its five lines of research, as well as energy efficiency, electric power generation, environment and strategic research. However, this resolution, especially in relation to annual operating profits, was deeply amended by Law nº 9,991, of July 24, 2000, which obliges concessionaires, permissionaires and authorized electrical sector companies to invest at least 0.75% of the net operating income in energy efficiency and technological development.

In 1999, general conditions were established for contracting access[100], including use and connection, to electric energy transmission and distribution systems. In terms of incentives for alternative sources, the reduction of no less than 50% in transmission and distribution system usage charges for small hydroelectric plants - SHPs deserves special notice.

Another ANEEL resolution[101] established the requirements for energy cogeneration plant qualification. These requirements impose a minimum energy savings percentage in relation to the simple use of heat, and it benefits small units, with less than 5 MW capacity, as well as those with more than 20 MW capacity. Plants that use more than 25% of fossil fuels shall present an electric power generation yield of at least 24%, 27% and 31% for plants producing up to 5 MW, 5 to 20 MW and more than 20 MW, respectively. On the other hand, plants using renewable fuels must present an electric power generation yield of at least 14%, 17% and 21% for the same production brackets, respectively; in other words, 10 percentage points less than in the case of fossil fuels. This regulatory mechanism was established based on incentive policies for the rational use of energy resources, taking into account that energy cogeneration contributes towards energy rationing since it allow for better use of fuels compared to individual generation of heat and electric energy.

The definition of normative values – NV[102] established the formulas to calculate the cost of energy bought to be considered in tariff readjustments for distributors. These formulas contain percentage ranges that progressively limit passing on the price of energy bought to tariffs paid by final consumers. The full amount can be passed on when in the 5% range around the NV. Outside this range, profits or losses resulting from contracted energy values are increasingly assumed by the distributor. An ANEEL measure for July 1999, which establishes normative values in R$/MWh[103], makes new investments possible to expand energy supply (generation), with an incentive for small hydroelectric plants, alternative sources and cogeneration.

According to the text of the resolution, the normative values established by ANEEL are differentiated by type of energy source and are based on the costs for new generation enter-

96 By means of Resolution nº 245.

97 Especially what is stipulated in paragraph 4 of Article 11 of Law nº 9,648, of 1998.

98 This Resolution was amended by the new wording given to Law nº 9,648 by Law nº 10,438 /2002.

99 By means of Resolution nº.261, of September 3, 1999.

100 By means of Resolution nº 281, of October 1, 1999.

101 By means of Resolution nº 21, of January 20, 2000.

102 This is found in ANEEL Resolution nº 266, of August 13, 1998.

103 See: <http://www.aneel.gov.br>.

prises in bilateral purchase contracts for electric energy and in National Energy Policy guidelines. The NV in effect at the time of the contract is associated to each electric energy purchase, as is the respective formula for readjustment. These parameters shall remain constant for the respective contract while it is in effect. ANEEL can decide to review the NVs annually or when there are relevant structural changes in the electric energy production chain, and cease to exist when market conditions so require. Therefore, the transitory nature of the NV is directly related to the contract date and market conditions. Definition of the normative value will not have any impact on current electric energy tariffs authorized by ANEEL for the concessionaires. With competition in the electrical sector, the final consumer will be the most benefited in this process.

With regard to the CCC, some of these ANEEL resolutions[104] have been amended[105]. That law, among other provisions, creates the Program for the Incentive of Alternative Sources of Electric Energy – Proinfa, the Energy Development Bill – CDE, provides for the universalization of electric energy services and amends legal provisions that interfere in the exploitation of alternative sources and the cogeneration of energy, as described below: a) extends those reduction benefits (no less than 50%) involving charges in the use of transmission and distribution systems to enterprises producing up to 30 MW of wind, biomass and qualified cogeneration power; b) extends the benefits from energy commercialization with a consumer or group of consumers of loads equal to or greater than 500 kW in the interconnected electric system to wind, solar and biomass energy producers; c) reduces the minimum load limit for energy commercialization to 50 kW, when the consumer or set of consumers is in an isolated electric system; d) extends CCC's systematic allotment in isolated systems for another 20 years, while obliging the creation of mechanisms that induce economic and energy efficiency, appreciation of the environment and use of local energy resources; e) establishes new procedures and mechanisms for allocating Global Reversion Reserve – RGR resources, including the allocation of resources to enterprises using alternative source generation, particularly small ventures (up to 5 MW) to serve communities in isolated electric systems.

The Proinfa[106] represented a milestone in the regulatory framework for the electrical sector as an organized effort for promoting new sources of alternative energy. The program is coordinated by the Ministry of Mines and Energy – MME, with Eletrobras as its implementing agency.

104 Including Resolution nº 245.

105 From the new wording given to Law nº 9,648 by Law nº 10,438, of April 26, 2002.

106 Created by Law nº 10,438/2002.

It aims at increasing the share of electric energy produced from wind, solar, small hydroelectric plant – SHP and biomass generation. Proinfa[107] inaugurated a new strategy for the sustainable insertion of renewable energies in the Brazilian energy mix and reinforced Brazilian policy for grid diversification and for the incentive to develop renewable energy sources.

In Proinfa's first phase, contracts were signed, ensuring the purchase of all energy to be produced by Eletrobras for a 20-year period. In February 2005, through Eletrobras, the Program contracted 144 generating plants, in 19 states, for a total of 3,299.40 MW of installed capacity. The 3,299.40 MW contracted are divided into1,191.24 MW from 63 small hydroelectric plants - SHPs, 1,422.92 MW from 54 wind plants, and 685.24 MW from 27 biomass plants.

Proinfa has investments, predominantly from the private sector, of R$ 11 billion, and the main financing agents are the Brazilian Development Bank – BNDES; Banco da Amazônia S.A. – BASA; Caixa Econômica Federal – CEF; Banco do Brasil S.A. – BB; and Banco do Nordeste do Brasil S. A. – BNB. Total energy generated from all Proinfa's projects is approximately 12,000 GWh/year, enough to supply nearly 6.9 million homes and equivalent to 3.2% of the country's total annual consumption.

With implementation of the program, it is estimated that greenhouse gas emissions have been reduced by 2.8 million tons of CO_2e/year by including cleaner sources in the production of electric energy in the country. The program also helps distribute of energy production throughout Brazil, resulting in greater distribution of jobs and income among the states, while providing training for technicians and industries in new electric power generation technologies. Besides the production of energy from renewable sources, by the time it is fully implemented Proinfa will generate more than 150 thousand direct and indirect jobs. In the Northeast alone, the expectation is for more than 40 thousand jobs to be generated.

Proinfa's main results registered until 2009 are: 144 projects contracted (in 19 states), with an installed capacity of 3,300 GW, 12,096 GWh/year of energy generated, and investments of more than 11 billion reais. In addition, the program has generated 150,000 direct and indirect jobs[108].

Small Hydroelectric Plants

In relation to SHPs, the country is extremely well-equipped, with great technical knowledge, production capacity and nat-

107 Regulated on March 30, 2004, when its implementation began.

108 See: <http://www.mme.gov.br/programas/proinfa/galerias/arquivos/apresentacao/Situaxo_usinas_PROINFA_ AGO-2009.pdf>.

ural resources. According to the Center of Reference for Small Hydroelectric Plants - CERPCH, the interest in constructing new plants increased considerably in recent years, with a growing number of annual requests. This growth was mainly due to the introduction of regulatory incentives, including the CDM, triggering a massive program in the private sector.

Measures have been taken to attract private sector participation for the development of hydroelectric power plants, as well as a new financing policy, which has already been implemented, with the BNDES now financing up to 80% of the costs.

According to the ANEEL, three are currently 285 SHPs, with a total of 1,728 MW in operation. There are also 64 undertakings under construction (1,137 MW) and another 180 that have been approved (2,700 MW). It is estimated that in 2030, there will be an installed capacity of nearly 7,700 MW, according to the National Energy Plan - PNE 2030[109] (BRASIL, 2008a).

In a ten-year horizon, the expected evolution in installed power is around 1,800 MW by the end of 2015, according to the Expansion Decennial Plan for Electric Power Systems - PDEE 2006-2015, considering 700 MW plus the 1,191.24 MW of SHPs contracted in Proinfa. Large scale adherence by Independent Autonomous Producers – IAP[110] demonstrated adherence of new players to the sector.

Throughout Brazil, an SHP potential of around 15,000 MW has been identified in approximately 3,000 potential projects producing 1 to 30 MW, according to the PDEE 2006/15.

It must also be considered that the SHPs in operation in Brazil are on average 60 years old. Given that at the time of their implementation the current hydrological information was not available for the projects and operation regimes, such plants have reasonable potential for optimization. In the short term, a relatively small investment would expand capacity by 200 MW. SHPs currently not in operation could add another 156 MW of capacity to the system.

There are a total of 1,466 SHPs with 684 MW of power that could be upgraded. There is an estimated 7,000 MW of remaining water potential that could be explored by small hydroelectric plants (BRASIL, 2008a).

The elaboration of CDM project activities by constructing SHPs in Brazil presents considerable results. By the first half of 2010, 63 CDM project activities for SHPs under the CDM had been registered in the country, for a total reduction of 23,366,955 tCO_2e. Implementation of these projects generated an additional installed capacity of 807 MW for the country.

Modern Use of Biomass and Cogeneration

Introduction of some of the aforementioned incentives will reverse the historical tendency of wasting agricultural and forest residues by incorporating already developed technologies, or those in diverse stages of development, for the efficient use of biomass energy. Agricultural residues, not including sugarcane, represents an energy availability of around 37.5 million toe per year, equivalent to 747 thousand barrels of oil per day, practically not being used.

Any organic matter that can be transformed into mechanical, thermal or electrical energy is classified as biomass. According to its origin, it can be: forest (mainly wood), agricultural (soy, rice and sugarcane, among others) and urban and industrial waste (either solid or liquid waste, such as garbage).

Biomass is one of the energy production sources with the greatest potential for growth in coming years. On the international and domestic markets it is considered one of the main alternatives for diversifying the energy mix and consequently reducing dependence on fossil fuels. It is possible to obtain electric energy and biofuels from it, such as biodiesel and ethanol, the consumption of which is growing to replace oil byproducts like diesel and gasoline.

In 2009, in Brazil, biomass had a 32% share of the energy mix, the second most important source of energy, trailing only oil and its byproducts. It occupied the same position among domestic sources of electric energy, responsible for 5.4% of supply. It trailed only hydroelectricity, which was responsible for producing 77.4% of the total supply (BRASIL, 2010).

It is estimated that a large amount of energy could be obtained by planting forests, sugarcane and other sources of biomass. Many studies have shown that the energy generated by biomass gasification can be favorably compared to the energy generated by water resources in Brazil in terms of cost and energy potential. Besides that, the energy generated by biomass can also contribute towards the decentralization of electricity production.

109 The 2030 National Energy Plan - PNE is the first integrated planning study of energy resources conducted by the Brazilian government. Conducted by the Energy Research Company - EPE in close collaboration with the Ministry of Mines and Energy. See: <http://www.epe.gov.br/PNE/Forms/Empreendimento.aspx>.

110 As defined in Law nº 10,438/02. Independent Autonomous Producer – IAP: an independent producer of electric energy is considered autonomous when the company, not being a concessionaire of any sort, is not controlled by or affiliated with a public utility concessionaire or use of a public good for the generation, transmission or distribution of electric energy, nor are its controllers or any other company controlled by or affiliated with the common controller, as per paragraph 1 of Article 3 of Law nº 10,438, of 2002.

The use of biomass as a source for electricity has been growing in Brazil, especially in cogeneration systems (from which it is possible to obtain thermal and electric energy) from the industrial and service sectors. In 2009, it was responsible for supplying 27.4 TWh (terawatts-hour), in accordance with the National Energy Balance (BRASIL, 2010). This volume was 17.5% higher than in 2008, and by corresponding to 5.4% of the total supply of electric energy, it was ranked second in the national electricity generation mix. In relation to domestic sources, biomass was only surpassed by hydroelectricity, with an 84% share (including imports). According to ANEEL's Generation Information Database, in November 2008, there were 302 thermoelectric plants powered by biomass in the country, corresponding to a total of 5.7 thousand installed MW[111].

Sugarcane bagasse and lye are among the most important energy sources in the sugar and alcohol and paper and pulp sectors, respectively, besides various hybrid systems with fossil fuels. The National Energy Plan – PNE 2030 estimated the production of sugarcane bagasse and straw at around 140 million tons (dry matter), in equal parts, in 2010. The Ten-Year Expansion Plan 2000-2009 estimated the technical potential of cogeneration in this sector at 5750 MW, with a market potential of just over 2800 MW in 2009. In the sugar and alcohol sector, current installed capacity is around 1,150[112] MW. In the paper and pulp sector, there are 718 MW in operation, and another 930 MW could be obtained.

By the first half of 2010, 42 CDM project activities based on the use of biomass had been registered in Brazil (not counting those projects that use sugarcane bagasse), potentially avoiding 8,412,774 tCO_2e in emissions, for a total reduction of: 60.223.404 tCO_2e. Furthermore, total installed capacity for approved CDM project activities in the country, in cogeneration with biomass, is 1,211 MW.

Sugarcane Bagasse

In Brazil, due to the great production of sugarcane and the ethanol use related experiences, technical and economic feasibility studies are being conducted for a more expressive use of sugarcane bagasse and straw in energy generation projects.

The plants need little electrical and mechanical energy, in relation to thermal energy, in their processes. Furthermore, until the beginning of this century, legislation practically made it impossible to sell surplus energy. For those reasons, current cogeneration systems only convert nearly 4%[113] of bagasse energy into electric and mechanical energy, using most of the rest as thermal energy. This situation is changing quickly as a result of the possibility to sell surplus energy.

Analyses of conventional (steam) energy generation systems in Brazilian plants and distilleries indicate the possibility of increasing current conversion levels of 4% to 16% or more, including the possibility of cogeneration throughout the year using the waste (leaves and tips). Gasification/gas turbine - BIG/GT technology can raise conversion levels of bagasse into electricity to more than 27% (BRASIL, 2008a). Furthermore, the energy generation potential could become a substantial fraction of total production by Brazilian distilleries.

An evaluation of sugarcane bagasse's cogeneration potential can be seen in Table 1.8. Value for Total Energy and Effective Potential calculated for Brazil were estimated for sugarcane production in 2009 (630 million tons). These potentials can be gradually achieved over the decade, for commercial technologies (cogeneration with steam cycles); advances in cycles with gasification depend on technological developments, and could begin next decade.

Table 1.8 Cogeneration in plants: conventional and with gasification[(a)]

	Consumption in the process		Surplus Energy 80% Brazil (TWh) [(e)]	Effective Power, Brazil (GW)	
	Current 500 (kg of steam /t sugarcane)[f]	Reduced 340 (kg of steam /t sugarcane)		Harvest [(d)]	Annual [(d)]
	Energy, (kWh/t sugarcane)				
Cogeneration, steam 100% from bagasse	57	69	29,9 – 16,6	6,8 – 8,4	
Cogeneration, steam Bagasse + 25% straw [(b)]	88	100	46,4 – 52,8		5,3 – 5,9
Cogeneration, steam Bagasse + 40% straw	115	126	60,7 – 66,4		6,8 – 7,5
BIG/GT (partial) [(a,c)] Bagasse + 40% straw		167	88,0		10,1

Source: Elaborated by MACEDO[114].
(a) Conventional cogeneration: steam cycles, condensation-extraction, 80 bar; using all bagasse and in some cases complemented with straw. Gasification: cycles involving gasification of bagasse and use of gas turbines; technology not available on a commercial basis yet.
(b) Straw: not yet totally available; growing values in coming years.
(c) partial BIG/GT: part of the bagasse is still burned in boilers; not gasified. Systems with total gasification could be more efficient.
(d) Operation only during harvest (4,400 h/year) and annual (8,760 h/year).
(e) 80%: it is believed that 20% of potential will not be used, for several motives.
(f) Thermal energy, at present ~ 500 kg steam/t sugarcane (330 kWh/t sugarcane).

111 See: <http://www.aneel.gov.br/arquivos/PDF/atlas_par2_cap4.pdf>.
112 See: ANEEL Generation Information Database. Available at: <http://www.aneel.gov.br>.
113 Considering 28 kWh/t of sugarcane for generating electricty (where12 kWh/t of sugarcane is for electric energy and 16 kWh/t of sugarcane is for mechanical energy) and 644 kWh/t of sugarcane (thermal energy) using 90% of sugarcane's bagasse (280 kg of bagasse/t sugarcane).

114 MACEDO, I. C., University of Campinas - UNICAMP.

In 2005, the Center of Sugarcane Technology - CTC completed the Biomass Power Generation: Sugarcane Bagasse and Waste project[115], developed under the coordination of the Ministry of Science and Technology and the United Nations Development Programme – UNDP, with the financial support of the Global Environment Facility - GEF. The objective of this project was to develop technology throughout the electric energy production cycle using advanced conversion systems (gasification/gas turbines) with sugarcane biomass. An extensive program was established for this, which intended to assess every phase of the process, from harvesting of the sugarcane and recovery of the straw (quality, availability) to the gasification processes being developed and their integration with plants and their environmental impacts.

The referred to project, identified at the UNDP Brazil as BRA/96/G31, demonstrated significant impact potential, since the surplus from electricity generation in sugar/alcohol plants can be increased fivefold by using BIG/GT (Biomass Integrated Gasification - Gas Turbine) technology[116] and the waste can be used as supplementary fuel to bagasse. The technology can be quickly and broadly replicated, considering the size of the sugarcane industry in the country and the world.

In relation to the assessment of CO_2 emissions, the project considered the burned sugarcane harvest as a basis (scenario of reference: 100% of the burned sugarcane prior to harvest; 10t of dry matter/ha harvested of straw and energy self-sufficiency) and stipulated a future scenario (55% of sugarcane, not burned, recovery of 100% or 50% of straw that refers to this sugarcane, depending on harvest route). Three harvest route hypotheses were established, as seen in Table 1.9.

115 See: <http://www.gefonline.org/projectDetailsSQL.cfm?projID=338>.

116 Gasification technology integrated with a gas turbine, operating in a combined cycle. The gasification process is the transformation of solid waste into a gaseous fuel (gas) similar to natural gas through thermochemical reactions that predict the state of equilibrium of basic reactions involved in gasification by pressure, temperature, fuel moisture and oxygen content parameters in the gasifying agent. The BIG/GT system permit high electricity efficiency (above 40%) with biomass gasification in the high pressure system, as well as a combined cycle that maximizes bagasse use – reducing steam consumption in the plant process. In the conventional medium pressure steam cycle system, electric efficiency is between 15 and 30%.

Table 1.9 Difference in CO^2 emissions between the future and reference scenarios

Routes	Diesel used in agriculture (kg CO_2/t sugarcane)	Replacement of fossil fuel (kg CO_2/t sugarcane)	Difference in total emissions (kg CO_2/t sugarcane)	Brazil: 300 x 10^6t sugarcane/year (10^6 t CO_2/year)
Route 1 *	+2.1	- 139	-137	-41.1
Route 2 **	+7.3	-139	-132	-39.6
Route 3 ***	+2.3	-87.5	-85	-25.5

* whole sugarcane with straw, 100% transported to the plant.
** chopped sugarcane (extractor turned off), 100% of straw transported to the plant.
*** chopped sugarcane (extractor on), 50% of straw transported to the plant.
Source: Biomass Power Generation: Sugarcane Bagasse and Waste Project. Available at <http://www.gefonline.org/ projectDetailsSQL.cfm?projID=338>.

In the last column of Table 1.9, there is a hypothetical reduction in CO_2 emissions that could be achieved in Brazil with implemented BIG-GT technology, according to the scenarios adopted. The scenarios also consider reductions in methane emissions and other gases with the decrease in sugarcane burning. Emission factors for burning straw were measured in wind tunnels specifically for sugarcane[117]; but IPCC values were used to estimate emission reductions in CH_4, CO and N_2O with partial harvest (55%) of sugarcane without burning. The results are for 300 million t sugarcane/year; the current production is around 600 million t/year.

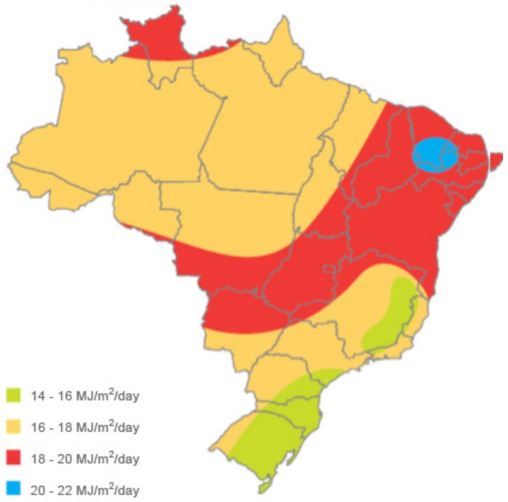
Sugarcane bagasse represents an excellent opportunity for CDM project activities, since it is the main source among types of biomass. Brazil currently has 77 project activities, which correspond to avoided emissions of 2,683,056 tCO_2e/year, which, by the first half of 2010, represented a total reduction of 19,452,342 tCO_2e.

Photovoltaic Solar Energy

As occurs with the winds, Brazil is also privileged in terms of solar radiation. The 2030 National Energy Plan reproduced data from the "Brazilian Solar Metric Atlas" and it reports that this radiation ranges from 8 to 22 MJ/m^2 during the day, with the smallest variations occurring from May to July, ranging from 8 to 18 MJ/m^2. Furthermore, the study continues, the Northeast region has radiation comparable to the best regions in the world, which, however, does not occur in other locations further away from the Equator, such as the South and Southeast regions, where most economic activity is concentrated. Figure 1.13 illustrates this variation.

117 There is only one complete study, conducted with proper methodology, in a wind tunnel (JENKINS, 1994). The IPCC recommends using "general" values for emissions from burning agricultural residues when there are no specific data. These values are higher than those measured for sugarcane as per the study mentioned.

Figure 1.13 Variation of Solar Radiation in Brazil (MJ/m²/day)



Source: BRASIL, 2007.

Despite this potential and the fact that solar heaters are well disseminated in inland cities and rural areas, the share of solar energy in the national energy mix is very small, so much so that it is not mentioned in the list of sources that integrate the 2009 BEN. Only one photovoltaic plant – Araras, in the municipality of Nova Mamoré, state of Rondônia, with installed capacity of 20.48 kW[118] is shown in ANEEL's Generation Information Database – BIG. The BIG does not report any photovoltaic enterprise under construction or already approved. What does exist in the country are pilot projects and research on the technology. One is the Household Photovoltaic Systems project, of the University of São Paulo - USP, which installed 19 photovoltaic systems in the community of São Francisco de Aiuca, located in the Mamiruá Sustainable Development Reserve in the state of Amazonas, producing 13 kWh per month. Growth in the number of solar plants is expected to occur precisely in the rural zone, as part of the service universalization projects focused on poorer communities and located great distances from distribution networks.

The "Electricity for All" Program[119], launched in 2003 by the Ministry of Mines and Energy, installed various photovoltaic systems in the state of Bahia. With the objective of taking electric energy to a population of more than 10 million people who reside in the country, it considers attending to rural demands through three types of initiative: extension of the distribution network, decentralized generation systems with isolated networks and individual generation systems.

Furthermore, initiatives for using photovoltaic solar energy that deserve attention are being coordinated by some energy concessionaires. CEMIG implemented a model in which a tariff is charged to cover part of the costs for serving isolated households, with the other part of investments covered by the obligatory allocation of part of their profits to social programs. COPEL has been incorporating renewable solar systems as an option to its rural electrification program and CESP implemented a pilot project that charges a tariff for the service provided to residential solar systems.

Significant growth is expected for solar energy's participation in electric power generation in coming years, especially in connected systems, with the advances in the technology. It is important to mention that systems connected to the network operate with a capacity factor greater than those in isolated systems. In Brazil, capacity factors between 15 and 19% can be obtained for these systems (annual productivity between 1,300 and 1,700 kWh/kWp).

Thermo-Solar Energy

Thermo-solar technology emerges as one of the potentially most interesting solutions for Brazil since it comes from an abundant, renewable and clean source. In relation to solar energy use for heating water for household (in individual dwellings and in buildings) and commercial (mainly hotels) use, the average annual growth of no less than 30% seen in recent years shall be maintained.

Wind Energy

The dynamics of wind energy production technology in Brazil is spread among university actions, research centers and concessionaires, with scientific and technological production that only gained prominence at the end of the 1970s and during the 1980s. Activities intensified at the end of the 1990s, in an attempt to respond to the improved maturity achieved by the technologies for using wind energy.

Throughout this entire period, various groups and projects were created, the most prominent being Technical Aerospace Center - CTA, Federal University of Paraíba - UFPB, University of Campinas - UNICAMP, Federal University of Minas Gerais - UFMG and CEPEL. At the same time, energy concessionaires initiated wind power inventories.

Most recently in the wind energy sector, several states began wind measurements, such as Minas Gerais, Ceará, Bahia, Paraná and Santa Catarina, which are in different stages of negotiation for implementing wind projects connected to the grid. The most promising projects are found in Ceará, Rio Grande do Norte and Paraná.

118 See: <http://www.aneel.gov.br/arquivos/PDF/atlas_par2_cap5.pdf>.
119 See Part III, Section 1.6, on the National Program for the Universalization of Access to and Use of Electric Energy - "Electricity for All" Program.

The country has good opportunities for integrating large generation blocks with the interconnected system along the North and Northeast coastline. In the south of Brazil, particularly in Rio Grande do Sul, excellent winds were also identified for energy production. When analyzing the energy's application opportunities, it is necessary to take into account the possibility for an integrated operation with the country's hydraulic system.

Brazil is favored in terms of winds, which are characterized by a presence twofold greater than the global average and 5% volatility (wind oscillation), which makes it easier to predict the volume to be produced. Furthermore, since the speed tends to be greater during periods of drought, it is possible to operate wind energy plants in a complementary system with hydroelectric power plants to preserve water in the reservoirs during those periods with little rain. Therefore, the operation would make it possible to "store" electric energy.

Estimates in the 2001 "Wind Energy Potential Atlas"[120] (last study on the subject) point to a wind energy generation potential of 143 thousand MW in Brazil.

Figure 1.14 shows that the regions with the greatest wind potential are the Northeast region, mainly along the coast (75 GW); Southeast region, particularly in Vale do Jequitinhonha (29.7 GW); and South (22.8 GW), the region where the largest wind energy park in the country is located, in Osório, Rio Grande do Sul, with 150 MW. But wind is mainly used in the country to produce mechanical energy for pumping water for irrigation.

Figure 1.14 Brazilian wind energy potential by geographic region (TWh/year)

Source: BRASIL, 2007.

120 See: <http://130.226.17.201/extra/web_docs/windmaps/Brazil_wind_map.pdf>.

In 2008, Brazil had about 247 MW of wind power installed, a very modest sum when compared to estimated potential. Brazil's "Wind Energy Potential Atlas", elaborated by CEPEL and financed by the MME and Eletrobras, shows enormous natural potential of around 143 GW, which can become an important alternative for diversifying the country's electricity generation mix.

Wind energy is one of the fastest growing alternative sources in the world and its technological advances are rapidly entering the market. The country needs to accompany these advances more aggressively[121].

Nine wind energy-based CDM project activities have been registered in Brazil, which account for 3,438,566 tCO_2e in reduced emissions.

Generating Electricity from Vegetable Oils

Supplying electric energy to isolated communities is an important challenge to be faced by Brazilian society towards constructing improvements in living conditions for its neediest populations and suppressing the big regional disparities that exist. Electrification of small isolated communities runs into high costs of transmission lines, transportation of diesel and low purchasing power of the people in these communities.

For the North of the country, which has the rural properties least served by electric energy – fundamentally due to the dispersion of small communities located far from electric power generation centers and where the conventional electric energy transmission lines are economically unfeasible – electricity generation from vegetable oils emerges as a local, feasible and sustainable alternative in socioeconomic and environmental terms. Above all, this region has an enormous diversity of native oilseed plants and favorable edaphoclimatic conditions for growing exotic species that are highly productive in oils, thus enabling the employment of local labor, boosting economic activities and improving housing, health and education conditions. Thus, isolated efforts have been made by Brazilian companies and institutions towards using the energy from vegetable oils.

An example of this was the project aimed at generating and distributing electric energy to the community of Vila Boa Esperança, Municipality of Moju - PA, comprised of 200 homes and a total of 1000 inhabitants, by implementing a micro-plant for extracting African palm oil, produced in the same community, used as a fuel in a "multi-fuel" motor-generator group. The installation allowed for the electrification of the homes and public school and made it possible to

121 See Part IV, Section 1, on Transfer of Technology.

set up public lighting. As a result of these services, significant improvements can be made in the community's socio-economic and cultural life. The electrification of the public school enabled its operation at night with literacy courses for adults and altered some social habits.

African palm oil was opted for due to the fact that the African palm tree is the oilseed plant with the greatest yield per hectare planted, with a productivity of 3 to 5t oil/ha/year, whereas soy bean productivity is around 0.4 to 0.5t oil/ha/year. Furthermore, the Amazon region's edaphoclimatic conditions are conducive to easy adaptation of this oilseed of African origin.

More recently, the national biofuels program has been trying to join these initiatives.

Biogas and Waste Management

Landfills are final disposal sites for urban waste, mainly comprised of household garbage. This garbage, in turn, consists of nearly 50% in weight of wet organic matter, which are primarily remains of foods and food preparations. Therefore, biological decomposition of these wastes is relatively quick. The other 50%, called dry waste, consists of metals, glass and plastics (non-biodegradable waste), papers, cardboard and rags, which are organic products basically comprised of pulp, and therefore, subject to very slow degradation. This composition, when confined in a closed environment, kicks off an aerobic decomposition process – while there is oxygen from the air in the spaces among dumped waste (the lesser or greater the compacting of waste in the landfill) - successively going through stages dominated by facultative and anaerobic bacteria and fungi. Methane appears a few days or weeks after disposing of the waste in the landfill, as soon as the oxygen has been consumed.

In the biomass sector, the use of thermoelectric energy generated from biogas is beginning to become a reality, particularly from the methane generated in landfills and in sludge digestors at urban sewage treatment stations. There is also a still unquantified potential of biogas in sludge from agro-industrial processes.

The main innovation incorporated in the landfill operation was installing horizontal drains that converged towards the drainage wells with the dual function of draining drippings to the bottom drains and gases to be captured on the upper surface of the landfills. These horizontal drains are installed at the surface of each new layer of waste approximately five meters thick. Landfills with ten to twenty layers are commonplace, and they gather fifteen to thirty million tons of waste.

In 1998, São Paulo local government, through the Municipal Secretariat for Ecology and the Environment, began a tender process aimed at the concession of municipal landfill areas (considering the existence of 7 landfills) for exploration of the methane they generate. There were tenders for two landfill projects, currently in operation, with a maximum installed capacity of around 20 MW each, where it is stipulated that half of that potential shall supply 50% of the energy consumed by São Paulo local government.

The anaerobic process that occurs in sludge digestors at urban sewage treatment stations generates the same biogas found in landfills; and its energy potential use utilizes the same technological principles and the same equipment as the potential energy use in landfills. However, capturing gas is simpler because its generation occurs in confined environments, different from landfills, which involves a suction operation inside the landfills with a higher degree of technical complexity. The disadvantage of this potential use is the still low percentage of treated sewers in the country.

The biogas generation potential from agro-industrial waste has yet to be evaluated, such as from the bagasse of barley used in brewing beer, or the many forms of organic sludge. Industries do not necessarily need to invest in constructing digestors. They simply need to pump or transport them to idle sewage digestion units, or they can form a pool of industries to extract the energy fraction from their sludge prior to final disposal of digested sludge, which can be used in animal rations, as is the case with non-digested waste from brewery barley. Organic sludge can also be processed in dryers, resulting in pelletized powder, appropriate for burning in boiler blowpipes for generating steam and thermoelectricity.

As cutting edge technology, the market is offering thermal destruction through plasma, at very high temperatures, with high efficiency for treating sludge and waste (including the biodegradable) and high-energy yield.

Industrial and sanitation companies are also trying to enable the potential use of huge quantities of sludge generated at their effluent and sewer treatment stations for generating energy. Initial studies show the sustainability of this potential use and its environmental and economic attractiveness.

Landfills and the anaerobic treatment of sewers and residual waters are the two biggest sources of this type of methane production. In each case, the organic material contained in the wastes is decomposed by methanogenic bacteria that produce the biogas mainly comprised of methane and carbon gases.

Biogas recovered during the anaerobic digestion process can be burned, reducing greenhouse gas emissions, or can undergo combustion in specific motors for energy generation.

The use of landfill biogas in the country became a reality with the CDM opportunity. By August, 2010, there were 36 CDM project activities at landfills in Brazil, corresponding to 8% of all CDM project activities in the country, with an annual reduction in emissions of 11,327,606 tCO2e and with a reduction in emissions in the first crediting period of 84,210,095 tCO_2e[122]. In addition to the CDM project activities at landfills, 74 CDM project activities and an activity program conducted in the hog-raising area reported a reduction of 39 million tCO_2e and another 17 CDM project activities related to other solid waste and liquid effluent treatments represented a reduction of another 5 million tCO_2e.

Thus, these 127 CDM project activities now total a reduction of 128 million tCO2e and an annual reduction of 16.1 million tCO2e, promoting responsible management of wastes and awareness of the business community for making their businesses sustainable[123].

1.6 National Program for the Universalization of Access to and Use of Electric Energy - "Electricity for All" Program

Accompanying the evolution of programs for the universalization of access to and use of electric energy in Brazil, in November 2003, the Federal Government launched the "Electricity for All" program, with the initial goal of taking electric energy to more than 10 million people in the rural area by 2008. This goal was reached in 2009. During program execution, families without electric energy at home were located and as a result of the emergence of a large number of demands, the National Program for the Universalization of Access and Use of Electric Energy was extended and will now be concluded in 2010[124], and the target has been expanded to 12 million people.

"Electricity for All" was implemented to replace the "Electricity in the Field" Program, which had the objective of taking electric energy to 1 million families in rural areas by 2003. "Electricity for All" also incorporated another program, the Program for State and Municipal Energy Development - PRODEEM, instituted in 1994. It aimed at serving isolated locations not supplied with electric energy by the conventional grid, obtaining energy from local renewable sources, thus promoting social and economic development in these locations[125].

The "Electricity for All" program is coordinated by the Ministry of Mines and Energy, operated by Eletrobras and executed by the electric energy concessionaires and rural electrification cooperatives. Management of "Electricity for All" is shared by all interested entities: state governments, energy distributors, ministries[126], sector agents and communities. Protocols of adherence to the program were signed with the state governments. Besides participating in program management, state governments also enter with funds for community electrification. Community agents are responsible for helping to identify demands and the region's productive vocations, inform about the program, provide assistance and instruct on the use of energy and help inspection.

In order to meet the initial goal, R$ 20 billion were invested. The Federal Government invested R$ 14.3 billion and the rest was shared among state governments and electric energy companies. Federal resources come from sector energy funds, the Energy Development Bill - CDE and the Global Reversion Reserve - RGR.

The map of electricity exclusion in the country reveals that families without access to energy are mainly in locations with the lowest Human Development Index – HDI and low-income families. About 90% of these families make less than three minimum wages and 80% are in rural areas. Thus, the government's objective is to use the energy as a vector for the social and economic development of these communities.

The arrival of electric energy is contributing towards the economic and social development of benefited areas. The program has also facilitated the integration of public initiatives in the rural environment in terms of social programs and actions to meet basic services (education, health and water supply) as well as incentive policies for family farming, small producers and local merchants. The objective of the program is that access to electric energy could contribute towards a reduction in poverty and an increase in income of those families served.

Eletrobras estimates that approximately 300 thousand direct and indirect jobs are generated as a consequence of "Electricity for All", since priority is given to the use of local

122 See: <http://www.mct.gov.br/index.php/content/view/77650.html>.

123 See: <http://www.mct.gov.br/index.php/content/view/4007.html>.

124 See: < http://luzparatodos.mme.gov.br/luzparatodos/Asp/o_programa.asp>.

125 PRODEEM was described in the Initial National Communication of Brazil to the UNFCCC.

126 The Ministry of Mines and Energy has already signed protocols with the Ministries of Agrarian Development; Agriculture, Livestock and Food Supply; Social Development and the Fight Against Hunger; Education; Health; Defense; and Science and Technology so that access to energy can be accompanied by social programs and economic development.

labor and the purchase of domestic materials and equipment manufactured in regions near the locations served.

The reductions in greenhouse gas emissions resulting from this program must also be underscored. Almost half those served by "Electricity for All" stopped using other sources of energy with higher emissions, such as diesel, gasoline, kerosene or coal.

On the international level, the "Electricity for All" program is considered a model to be followed, especially by developing countries, and it is in keeping with the positions defended by Brazil in the most diverse forums in areas of sustainable energy and development.

1.7 Hydrogen

Hydrogen is the simplest and most abundant element in the universe. It has the most energy per unit of mass than any other known fuel: 61,000 BTU/lb (or 33.8 kcal/kg). It normally exists in combination with other elements, like oxygen and carbon. Since it is chemically very active, it rarely remains alone as a single element.

Hydrogen is currently produced and used for non-energetic purposes. The experience of this production and use brings information to the analysis of hydrogen's future possibilities as an energy vector to be used in fuel cells for generating electricity.

Brazil has an R&D program for Fuel Cell systems, which has the production of hydrogen from renewable sources as one of its priority research lines.

1.7.1 Science, Technology and Innovation Program for Hydrogen Economy - ProH2

In 2002, the Ministry of Science and Technology created the Brazilian Hydrogen and Fuel Cell Systems Program – ProCaC, which now is called Science and Technology Program for Hydrogen Economy - ProH_2.

This program was structured in the form of cooperative R&D networks, promoting the coordination of each institution's actions and projects in order to share already established infrastructure, promote the training of human resources, guarantee an exchange of knowledge from information systems and encourage participation by companies.

The Institute of Energy and Nuclear Research – IPEN[127] participates actively in ProH2. Strategic studies are conducted in four research areas at its Fuel Cell and Hydrogen Center:

- Proton Exchange Fuel Cell – PEMFC – In this segment, research involves controlling PEMFC fuel cell technology at a laboratory scale, evaluating the influence of several parameters in unit cell performance. Furthermore, research underway is directed at developing low power prototypes for stationary applications;

- Solid Oxide Fuel Cell - SOFC – In this area, studies are directed at developing materials with optimized properties for SOFC; developing component conformation and manufacturing; and research and development of new materials for SOFC;

- Reformation – This research area is geared towards the reformation of primary fuels to generate hydrogen for use in fuel cells. Three large projects are being carried out: process for obtaining hydrogen from the catalytic decomposition of ammonia for use in fuel cells; obtain hydrogen from the reformation of ethanol steam to be used in fuel cells; and produce biogas from biomass; and

- Development of systems associated with fuel cell technology and their peripherals and accessories.

Seven years after the beginning of research, IPEN currently has more than 50 full or part-time professionals, including researchers, technologists, scientific initiation scholarship holders, Master, PhDs and post-PhDs. Six laboratories are in operation working in R&D in the areas of polymer fuel cells (2) and solid oxide fuel cells (2), fuel cell systems (1) and hydrogen production (1). Eight graduate studies courses are given; 10 Masters and 7 PhDs have already been concluded, and more than 30 academic orientations are underway. Program development has already resulted in 11 deposited patents and more than 50 publications in indexed journals, as well as various participations in national and international events.

1.7.2 Projects for Brazil's Hydrogen Powered Bus

The Brazilian Hydrogen Powered Bus Project was launched in 2006. It consists of acquiring, operating and maintaining up to five buses with hydrogen fuel cells. It also considers the instal-

127 Self-governing para statal agency under the Secretariat of Development of the state of São Paulo. IPEN is technically, administratively and financially managed by the National Nuclear Power Commission - CNEN, a federal entity linked to the Ministry of Science and Technology.

lation of a hydrogen production station by electrolysis of water to supply the buses, as well as monitoring and checking vehicle performance. The buses will be used in the Metropolitan Corridor of the city of São Paulo. Operational testing began in 2009. The next step, in the second semester of 2010, is to test the bus in the Metropolitan Corridor with passengers.

The São Paulo Metropolitan Urban Transport Company – EMTU/SP is the national coordinator of the project, which is directed by the Ministry of Mines and Energy and receives financial support from the GEF, applied through the UNDP, and the Financing Agency for Studies and Projects – Finep[128]. Total value of the project is around US$ 21 million.

The design and manufacturing of the buses were carried out by a consortium comprised of eight renowned national and international companies, coordinated by EMTU/SP. The consortium is comprised of: AES Eletropaulo, Ballard Power Systems, Epri, Hydrogenics, Marcopolo, Nucellsys, Petrobras Distribuidora and Tuttotrasporti.

The characteristics of the Brazilian initiative make it a unique case in the world, since it includes what is best and most advanced in hydrogen use technology on the planet; the transferred technology will establish the foundation for its diffusion in the country to transform Brazil into an exporter of hydrogen-powered buses; the Brazilian bus is a hybrid, that is, it will operate with hydrogen fuel cells and rechargeable batteries, with energy recovery; and it will have the capacity to carry the same number of passengers as other buses, with equal or superior performance.

Besides the manufacturing of bus prototypes, the project foresees a Hydrogen Production and Supply Station that is in its final stages of construction and it considers the installation and interconnection of hydrogen production and supply equipment in the second semester of 2010.

The Brazilian Hydrogen Powered Bus Project was chosen by the UNDP and by GEF as the pilot project in Latin America with the objective of assisting developing countries in adopting projects that seek solutions to mitigate greenhouse gas emissions and their impacts on climate change.

In Rio de Janeiro, the first hydrogen-powered bus with 100% Brazilian technology was launched in May 2010. The vehicle was developed by the Alberto Luiz Coimbra Institute of Graduate Studies and Research in Engineering at the Federal University of Rio de Janeiro – COPPE/UFRJ, in partnership with the State Federation of Passenger Transportation Companies – Fetranspor and the State and Municipal Secretariats of Transportation.

The project had financial support from the Finep, Petrobras, the National Council of Scientific and Technological Development - CNPq and the state of Rio de Janeiro Research Foundation – FAPERJ. There are already plans for industrializing and commercializing the vehicle.

From 2010 to 2011, three hydrogen buses will circulate the city of Rio de Janeiro for comparison purposes with conventional buses. The objective is for the new buses to become a sustainable transportation option and that they may be used to transport passengers during the 2014 FIFA World Cup and the 2016 Olympics.

From a theoretical and commercial perspective, there are world level barriers for the broad scale use of buses powered by hydrogen fuel cells. In general, these factors depend on production costs for the vehicles as well as for the hydrogen. The objective of the UNDP/GEF project on a global scale is precisely to determine and assess these difficulties, including the paths for using the technology in passenger transport systems.

Much has evolved in terms of technology and cost reductions since signing of the protocol that enabled institution of the Brazilian hydrogen bus project, for fuel cell systems as well as for hydrogen production.

In this aspect, the technology developed for construction of the Brazilian bus has much to contribute in technological innovation, as well as in factors related to final costs for the vehicle. These will, if not immediately enable competitive adoption with other propulsion systems, significantly reduce manufacturing costs. With successful construction of the prototype, it can be affirmed that vehicle production cost is already lower in global terms.

1.8 Recycling

Considering the economic, social and environmental advantages, recycling gains increasingly greater importance in Brazil. Furthermore, the government has encouraged these initiatives. These were previously viewed only as some isolated initiatives by local governments, communities and business entities in the sense of promoting selective garbage collection.

The generation of urban solid waste grew as a result of an increase in consumption by Brazilians. In Brazil, the rate of

128 Government-owned company under the Ministry of Science and Technology with the mission of promoting Brazil's economic and social development by public fostering of Science, Technology and Innovation at companies, universities, technological institutes and other public and private institutions.

waste generation per inhabitant ranges from 0.4 to 0.7 kg/inhabitant per day.

According to data from the Brazilian Association of Public Cleaning and Special Waste Companies – Abrelpe, 40% of all urban solid waste collected in Brazil is properly disposed of and 60% is not disposed of correctly. Nevertheless, the volume for recycling grew 4% between 2003 and 2004, growing from 5 million tons in 2003 to 5.2 million tons in 2004[129].

A large number of materials is currently being recycled in Brazil. Some Waste Exchanges[130] recycle industrial wastes, although in a limited manner, without exploiting all of the commercial possibilities. Only materials whose process economicity is clearly feasible (aluminum, paper, glass, plastic, etc.) have aroused interest in terms of recycling. The materials most used for recycling in Brazil are office paper, undulated paper, plastic film, aluminum cans, steel cans, glass, rigid plastic, tires, PET packages, TetraPak carton package, used lubricant oil and steel lead batteries.

In recent years, with great advances in Brazil in terms of recycling, various materials present recycling levels (Table 1.10) similar to those in developed countries. Indicators related to the recycling of aluminum cans in Brazil deserve to be highlighted since the recycling rate jumped from 37% in 1991 to 91.5% in 2008. Brazil's figures exceed those for industrialized countries like Japan and the USA. In 2004, the United States recovered 54.2% of its aluminum cans; Argentina, 90.8%; and Japan, 87.3%.

129 See: < http://www.cempre.org.br/>.

130 Waste Exchanges are information services at the national and international levels designed to identify markets for waste generated in industrial operations and to stimulate their re-use in a rational and economic manner. Waste Exchanges serve as a guide to promote business opportunities to provide new market alternatives and to occupy idle capacity that may exist in some industrial production processes. See: < http://www.abcm.org.br/xi_creem/resumos/SA/CRE04-SA01.pdf>.

Table 1.10 Recycling in Brazil

Material		Level of Recycling (%)
Aluminum Cans		91.5
Glass Packaging		47
Paper	Office	43.7
	Undulated	79.6
	Film	21.2
Plastic	Rigid	21.2
	PET	54.8
Steel Cans		46.5
Tires[1]		58*
TetraPak carton packaging		26.6
Used lubricant oil		26.57*
Urban compost[2]		3
Steel lead battery		99.5

Note: *Data from 2006.
Source: Cempre, 2010[131].

According to the Brazilian Aluminum Association – ABAL[132], in 2008, Brazil recycled more than 12.3 billion aluminum cans, which represents 165.8 thousand tons. The Brazilian scrap market for aluminum cans in 2008 moved nearly R$ 1.6 billion and generated close to 55 thousand direct jobs. The Business Commitment for Recycling – Cempre informs that the material is collected and stored by a network of approximately 130 thousand scrap metal dealers, responsible for 50% of the aluminum scrap supply to industry. The other part is gathered by supermarkets, schools, companies and philanthropic entities.

Recycling is related to reusing materials and waste that in the most part is seen as refuse. Thus, it is of fundamental importance to implement a selective garbage collection system in order to select the material that can be recycled.

In 2006, Cempre raised information on selective collection programs carried out by local governments in 405 munici-

131 See: < http://www.cempre.org.br/>. Technical data sheets.

132 See: <http://www.abal.org.br/reciclagem/latas.asp>.

palities throughout Brazil (although the highest concentration is in locations in the South and Southeast of the country). Nearly 26 million Brazilians were found to have access to selective collection programs and 43% of the programs are directly related to waste picker cooperatives. Despite the unquestionable advantages of recycling, this study revealed that the price for selective collection is still quite high (US$ 221/ton, on average), which is five times more than the cost for conventional collection.

It should be pointed out that the Federal Government instituted the "Urban Solid Waste" program as an integral part of the "Brazil for All" Plan – 2004/2007 Multi-Annual Plan - PPA, which became an interministerial program that shares actions in the solid waste area. This new program unified and replaced the old programs – "Brazil Plays Clean" of the Ministry of Environment, "Urban Solid Waste" of the Ministry of Cities and "Basic Sanitation – Solid Waste Action" of the National Health Foundation – Funasa.

The "Urban Solid Waste" program's action is geared towards supporting development of management and administration processes for urban solid wastes, aimed at guaranteeing solutions for environmental and health problems resulting from improper disposal processes, with an emphasis on socioeconomic components. Its objective is to increase the coverage and efficiency of municipal urban cleaning services from a perspective of universalization and sustainability of the enterprises, focusing on social inclusions, the closing of waste dumps and on environmental quality, that is, encourage the reduction, reuse and recycling of urban solid wastes; expand the coverage and increase the efficiency and effectiveness of public cleaning services, collection, treatment and final disposal; and promote the social insertion of waste pickers and eliminate child labor.

The Ministry of Environment, Ministry of Cities, Ministry of Health – National Health Foundation, Ministry of Labor and Employment, Ministry of Social Development and Fight Against Hunger and the Ministry of Development, Industry and Foreign Trade, through the National Bank of Economic and Social Development, are part of the Program.

All of the funds come from the General Federal Budget (fiscal sphere, parliamentary amendments) or from multilateral credit agencies, such as the CEF and BNDES, through lines of credit.

Program coordination was left up to the Ministry of Environment through the Secretariat of Water Resources and Urban Environment – SRHU, which besides promoting the coordination of actions between the Ministries that are part of it, also develops specific and relevant actions.

Furthermore, the Federal Government instituted[133] the separation of recyclable waste thrown out by direct and indirect federal public administration bodies and entities, at the generating source, and sending it to recyclable material waste picker associations and cooperatives.

According to the decree, in order to receive the collected material, the associations and cooperatives must be formal organizations and exclusively comprised of recyclable material waste pickers who have waste picking as their sole source of income; be non-profit organizations; have infrastructure to screen and classify discarded waste; and use the allotment system among association and cooperative members.

The National Solid Waste Policy[134], which has recently been approved, determined that manufacturers, importers, distributors and merchants will need to invest to put recyclable articles on the market that generate the least amount of solid waste possible. The same applies to packaging. Furthermore, measures must be implemented to receive packaging and products after use by consumers of the following: pesticides, their waste and packaging; batteries; tires; lubricant oils, their wastes and packaging; fluorescent lamps; and electro-electronics products and their components.

The law also provides for selective garbage collection. Other recyclable materials discarded at the end of their service lives shall be reused and the public urban solid waste management and urban cleaning entity shall be responsible for such. Public Authorities shall establish selective collection, implement a composting system (transform organic solid waste into fertilizer) and provide for the environmentally proper final disposal of urban cleaning waste (street sweeping). Urban cleaning companies shall give priority to the work by waste picker cooperatives comprised of low-income workers.

The municipalities that implement collection with the participation of waste picker associations and cooperatives will have priority in receiving Federal lines of credit, under the National Waste Plan. Practices such as discharging waste in beaches, the sea or rivers and lakes; untreated open air discharges, except in the case of mining activities; and open air burning or burning in unlicensed equipment shall all be prohibited. The text also prohibits the importing of hazardous waste or waste that is harmful to the environment and public health.

133 By means of Decree nº 5,940, of October 25, 2006.
134 Law nº 12,305, of August 2, 2010.

1.9 Use of Charcoal in the Industrial Sector

In Brazil, most of the domestic charcoal production is consumed by the iron and steel industries[135] (Table 1.11). Brazil is the only country to still have a significant production of iron and steel using charcoal as the iron ore reducing agent. In the rest of the world, as well as in the greater part of Brazilian steel production, coke derived from coal is used, ever since it was deemed an alternative for the growing industry in the mid 19th Century, with the growing shortages of forest resources in Europe.

Wood and lumber[136] are used for obtaining charcoal through a chemical process known as "pyrolysis", which consists of the thermal decomposition of biomass in the absence of oxygen. Wood carbonization makes it possible to elevate the heat value of the original source, which in wood is approximately 4,320 kcal/kg and in charcoal rises to nearly 6,750 kcal/kg.

The abundance of natural resources found in Brazil since its discovery has favored the development of charcoal production from native forests, which, among others, covered the iron and steel industry needs until the 1940s, when the use of coke derived from coal was introduced by the large integrated steel mills emerging at the time, in response to government incentives to create a national industrial park.

135 In 2006, steel production using charcoal represented 35% of the total, whereas production from coke derived from coal represented 65%. See: <http://www.sindifer.com.br/>.

136 By definition, "wood" is the ligneous part of tree trunks and branches. "Lumber" is the portion from branches or fragments of tree trunks set aside for fuel.

Table 1.11 Charcoal consumption in key industrial sectors

Consumption (1,000 meters of charcoal)								
Segments	1999		2000		2001		2002	
	Consumption	%	Consumption	%	Consumption	%	Consumption	%
Steel Integrated Plants	4,200	15.6	3,750	14.8	3,900	14.9	3,681	13.7
Independent Pig Iron Prod.	18,300	68.0	16,400	64.6	17,580	67	18,032	67.2
Production of Iron Alloys	2,300	8.6	2,250	8.9	2,800	10.7	2,874	10.7
Nodular Cast Iron Pipes	-	-	-	-	365	1.4	233	0.9
Others (*)	2,100	7.8	3,000	11.8	1,575	6.0	2,000	7.5
TOTALS	**26,900**	**100**	**25,400**	**100**	**26,220**	**100**	**26,820**	**100**

Segments	2003		2004		2005		2006	
	Consumption	%	Consumption	%	Consumption	%	Consumption	%
Steel Integrated Plants	3,383	11.6	3,984	10.8	4,499	11.8	4,579	13
Independent Pig Iron Prod.	20,220	69.2	27,590	74.7	27,817	73.1	25,116	71.5
Iron Alloys	3,164	10.8	3,002	8.1	3,191	8.4	3,091	8.8
Nodular Cast Iron Pipes	302	1.0	357,2	1.0	318	0.9	278	0.8
Others (*)	2,133	7.3	1,987	5.4	2,226	5.8	2,061	5.9
TOTALS	**29,202**	**100**	**36,920.2**	**100**	**38,051.5**	**100**	**35,125**	**100**

Charcoal Consumption by Diverse Sectors – Brazil 1000 mdc								
Segments	2007		2008**		2009		2010	
	Consumption	%	Consumption	%	Consumption	%	Consumption	%
Steel Integrated Plants	5,527	15	5,710	17.3	4,850.1	24		
Independent Pig Iron Prod.	25,706	69.9	23,826.5	72.3	12,462.2	61.7		
Iron Alloys	3,097	8.4	3,152.7	9.6	2,574.7	12.7		
Nodular Cast Iron Pipes	288	0.8	280	0.8	319	1.6		
Others (*)	2,160	5.9	-	-	-	-		
TOTALS	**36,778**	**100**	**32,969.2**	**100**	**20.206**	**100**		

Notes:* Charcoal for domestic use, barbeque restaurants, hand forging, calcification, acetylene, etc.
* *After 2008, only charcoal consumed by steel mills and iron alloy mills wa computed.
Source: Silviminas. Available at <http://www.silviminas.com.br/>.

However, over the years, the growing concern with the continued degradation of native forests made it necessary to find means to plant energy forests[137] capable of supplying industry's demand. In the 1960s, coinciding with the creation of fiscal incentives for planting forests[138], national industry was also favored and imports restricted. This increased charcoal's attractiveness as an alternative to the already consolidated practice of using coke derived from coal by the steel giants. However, fiscal incentives for planting forests were extinct at the end of the 1980s[139], decelerating and even paralyzing the creation of new forests.

Furthermore, the opening of the domestic market to imports led to an increase in coke-based production, stimulated by the immediate availability of the input and its advantageous cost, lower when compared to the cost of implementing and maintaining a forest. Also, during the 1990s, privatization of the integrated steel mills led to the deactivation or conversion of their charcoal furnaces to coke furnaces. This scenario led to the closing of various small independent steel mills because of the difficulty in finding sufficient charcoal to keep their blast furnaces in full operation.

At the same time coke use increased, there was also growth in production activities for charcoal derived from native forests. Carried out mostly in precarious conditions by low-income populations from the country's rural areas, this activity uses very rudimentary methods of carbonization. Besides entailing losses in biodiversity and high emissions of greenhouse gases, carbonization activities using native forests frequently involve precarious working conditions, generating social losses. Until the mid 2000s, charcoal production from planted forests remained relatively active using trees planted back in the days of the fiscal incentives, generally obeying the productivity cycle that is divided into 3 seven year rotations, between harvest and resprouting, as in the case of eucalyptus, which is the species most used for energy production. In this context of harvesting wood planted with fiscal incentives, from 1991 to 2006, the use of renewable charcoal helped reduce approximately 249 million tCO_2e (Table 1.12).

The planting of forests can provide the wood needed for producing renewable charcoal, able to supply a large part of industry's demand. It is thus possible to avoid part of the coke derived from coal and use of native forests for this same purpose. Thus, new and additional planted forests are added to the carbon stocks from native areas, increasing carbon removals as a whole.

137 Rapid development trees, such as eucalyptus and pine are generally used.

138 Law nº 5,106, of September 2, 1966.

139 Law nº 7,714, of December 29, 1988.

Furthermore, the adoption of proper regulations and socio-environmental criteria for forestry results in the observance of important parameters, such as the creation of ecological corridors, protection of water springs and sources, and soil protection, among others, guaranteeing preservation of biodiversity, of water resources, and other indicators of sustainability from planted forest regions. Considering crop rotations and the long-term nature of needed investments, the renewable charcoal production activity can be an important vector for rural development integrated with industrial production, in compliance with safety conditions and dignity for field workers.

The development of national sapling production technology practically tripled production capacity per tree. Therefore, currently 1/3 of the area that was once used is needed to obtain the same production result as when energy forest planting began in Brazil. This same technology, applied to degraded lands or with depleted vegetation cover, significantly reduces the need to use new areas for planting forests to supply energy to the industry.

The production of renewable charcoal presents benefits in several phases of the production chain, from planting and maintaining the forest to improving the efficiency of the carbonization process, which generates a reduction in greenhouse gas emissions, and even the consequent mitigation of emissions in the final uses of the product. Therefore, domination of reforestation technology in the country indicates significant potential for mitigation by using the renewable charcoal, so long as stimulation programs and incentives are developed for the country to overcome the current deficit of planted forests for energy use.

The CDM has great potential for assisting the steel sector in overcoming these challenges. Methodologies currently exist, approved by the Executive Board of the CDM, that consider the sector's entire production chain, which stretches from the planting of additional forests (benefit tied to removal of CO_2) to the use of renewable charcoal in iron and steel mills (reductions in CO_2 emissions).

However, sector numbers show there are large scale challenges to be faced. In the iron and steel sector, for example, 49% of all charcoal consumed is still from native forests. However, since applicable legislation has increasingly restricted the use of native forest charcoal, the tendency being observed in the absence of newly planted forests and additional incentives is the use of coke derived from coal, a more competitive input with lower transaction costs, as per a tendency already consolidated at global level.

The numbers shown in Table 1.12 indicate the relevance of renewable charcoal in the past, based on fiscal incentives. In this context, it is important to highlight the environmental gain resulting from mitigation of greenhouse gas emissions through emission reductions and net removals (during the 2001-2006 period, emission reductions of approximately 100 thousand tons of CO_2e were reported), as it creates a buffer that prevents pressure to deforest native forests.

Table 1.12 Charcoal consumption, charcoal share from reforestation, consumption of renewable charcoal and emission reductions from the sector in Brazil[140]

Year	Charcoal Consumption (10^3 t)	Reforestation share	Renewable Charcoal	Reduced Emissions (tCO_2)
1991	7,745	42.3	3,276	12,174
1992	7,294	38.9	2,838	10,547
1993	7,925	43.5	3,444	12,802
1994	8,250	54.0	4,455	16,558
1995	7,771	52.0	4,041	15,020
1996	6,500	70.0	4,550	16,911
1997	5,900	75.4	4,450	16,540
1998	6,600	67.4	4,450	16,540
1999	6,725	70.0	4,708	17,497
2000	6,350	70.5	4,475	16,633
2001	6,555	65.2	4,276	15,894
2002	6,705	63.5	4,257	15,821
2003	7,301	58.2	4,247	15,783
2004	9,230	47.2	4,358	16,196
2005	9,513	50.4	4,797	17,830
2006	8,781	51.1	4.484	16,666

Note: Emission factors used are 0.63 toe/t CV and 1.609 tC/toe. Source: Silviminas. Available at <http://www.silviminas.com.br/>.

140 These numbers only consider emission reductions associated with the use of renewable charcoal by the sector. See: <http://www.silviminas.com.br/>.


Missão

Chapter 2

Programs And Actions That Contain Measures That Contribute Towards Climate Change And Its Adverse Effects

2 Programs And Actions That Contain Measures That Contribute Towards Climate Change And Its Adverse Effects

This section aims at analyzing Brazil's replacement of fossil energy sources with high carbon content per unit of generated energy, with others with lower content. The programs and actions presented have the objective of helping to mitigate climate change and contribute towards achieving the final objective of the United Nations Framework Convention on Climate Change, that is, achieve stability in greenhouse gas concentrations in the atmosphere at a level that impedes any dangerous anthropogenic interference in the climate system.

It is worth underscoring that CH_4 generated when treating waste can be used as an energy source or it can be burned when it cannot be used, thus avoiding its release into the atmosphere and the generation of carbon gas emissions, with less potential for global warming than methane. Given the predominantly organic nature of waste in Brazil, this reduction was dealt with in section 1.5, on Biogas and Waste Management.

That section also presents the development of nuclear energy in Brazil, which due to its characteristic of being energy from mineral resources, and therefore depletable, it cannot be characterized as sustainable over the long term. Furthermore, the environmental impact of thermonuclear plants has also been greatly emphasized over recent decades, becoming a major concern for environmentalist movements. On the other hand, nuclear plants do not emit greenhouse gases and therefore can contribute towards mitigating climate change and its adverse effects.

2.1 The Role of Natural Gas in Reducing Greenhouse Gas Emissions in Brazil

2.1.1 History and Participation of Natural Gas in Brazil's Energy Mix

Besides being a basic input in the petrochemical industry, natural gas has proven to be increasingly more competitive compared to several other fuels in the industrial and transport sectors and in electric power generation. In the latter case, inclusion of natural gas in the national energy mix plus the need to expand the electric generation network and the search for alternatives in relation to the country's hydraulic potential has aroused interest in analysts and entrepreneurs to expand its use for thermoelectric generation.

Versatility is the main characteristic of natural gas. This energy can be used to generate electric energy as well as in combustion engines in the transport sector, in the production of flames (as a substitute for liquefied petroleum gas, LPG), heat and steam. Thus, application is possible in every sector of the economy: industry, commerce, services and homes. Other positive elements include dispersion capacity in cases of leaks and low emissions of pollutants throughout the production chain when compared to other fossil fuels.

The interest in natural gas is directly related to a search for alternatives to oil and less aggressive sources to the environment. The exploration of natural gas in the country began timidly in the 1940s with discoveries of gas associated with oil in Bahia. Production initially only met the needs of industries in the Bahia Bay. After a few years, exploration and production also extended to the Sergipe and Alagoas basins. The great leap in reserves occurred in the 1980s, with the discovery of the Campos Basin. Finally, the beginning of operations for the Bolivia/Brazil pipeline, in 1999, with capacity to transport 30 million m^3 per day, significantly increased the country's natural gas supply in relation to the country's gross domestic supply, which jumped from 2.4% in 1990 to 8.1% in 2005.

In the 1990s, continuous development of exploration activities made it possible to expand total proven reserves of natural gas at a rate of 4.36% per year during the 1990-2005 period, until reaching 326,084 million m^3 in 2005, as shown in Table 2.1.

Table 2.1 Evolution of proven reserves and natural gas production in Brazil

Year	Proven Reserves (10^6 m^3)	Annual Production (10^6 m^3)*	Reserve/Production (years)
1990	172,019	6,279	27.4
1991	181,724	6,597	27.5
1992	192,534	6,976	27.6
1993	191,051	7,355	26.0
1994	198,760	7,756	25.6
1995	207,964	7,955	26.1
1996	223,562	9,156	24.4
1997	227,650	9,865	23.1
1998	225,944	10,788	20.9
1999	231,233	11,898	19.4
2000	220,999	13,283	16.6
2001	219,841	13,998	15.7
2002	244,547	15,525	15.8
2003	245,340	15,792	15.5
2004	306,395	16,971	19.2
2005	326,084	17,699	18.1

Notes: *Total production volume includes volumes of reinjected gas, burnings and losses.
Source: BRASIL, 2007; ANP, 2010a; ANP, 2010b.

According to BEN, in 2005 a share of 8.1% in gross domestic supply places natural gas in fourth place in the national energy mix, exceeded by oil and natural gas liquids (41.1%), biomass and other renewable sources (30.4%); and hydraulic energy (13.4%).

In 2005, the country consumed 24.0 billion m^3, local production was 17.7 million m^3, and imports stood at 9.0 billion m^3. Thus, the country had a total supply of 26.7 billion m^3 (the difference between total supply and consumption corresponds to process losses), mostly to the industrial sector (8.2 billion m^3) and thermoelectric power plants (4.5 billion m^3), although consumption in the residential and highway transport sector has also increased, the latter being the most prominent, with a 971.3% variation compared to 1990, as shown in Table 2.2.

Table 2.2 Natural Gas consumption by industry in Brazil in 1990 and 2005

Natural Gas Identification	Million of m^3	
	1990	2005
Production	6,279	17,699
Imports	0	8,998
Est. Var. Losses and Adjustments (*)	-2,030	-5,729
Total consumption	4,607	24,006
Transformation	1,193	6,720
Oil Byproduct Production	1,107	2,215
Electricity Generation	86	4,505
Final consumption	3,414	15,044
Non-energy final consumption	1,010	849
Energy final consumption	2,404	14,195
Energy Sector	859	3,500
Residential	5	217
Commercial/public	3	321
Transport	2	1,945
Highway	2	1,945
Industrial	1,310	8,209

Source: BRASIL, 2008a.
(*) Including not used and reinjection.

In Brazil, the only company to operate in natural gas exploration and transportation is Petrobras, alone or in partnership with private enterprise (as in the gas of the Bolivia/Brazil pipeline). For distribution, the country has 27 companies, most of which with participation in Petrobras as shareholders. These companies have a monopoly for operation in their concession regions. According to Petrobras' current balance sheet for 2007, the country had a total grid of 6,511 kilometers of pipeline.

2.1.2 Perspectives for Natural Gas Use

The perspectives for natural gas use in thermoelectric generation are promising and attract an increasing number of entrepreneurs interested in exploring this energy niche. The availability of large reserves in the country and creating conditions for importing natural gas by private enterprises - result of the current liberalization process of the hydrocarbon sector - increase the possibility of natural gas supplies for the domestic market in the mid-term, which decisively contributes towards investments in natural gas thermoelectric power plants.

In 2008, Brazil was dependent on imports from Bolivia. The discovery of the Jupiter field, rich in natural gas and located in the Santos Basin pre-salt layer, could make the country self-sufficient in the mid-term. Reserve estimates are still in the study phase, but according to Petrobras, the size of the Jupiter field is similar to the Tupi field, discovered in 2007 and also in the Santos Basin. Its reserves are estimated between 176 billion and 256 billion m^3. The Mexilhão field, Petrobras' first initiative in natural gas not associated with oil, should also start up in 2010. Discovered in 2003 in the Santos Basin, the field has an estimated capacity for producing 15 million m^3 per day. Brazil also has important reserves in the state of Amazonas. In the Urucu Basin, they are estimated at 52.8 billion m^3. Petrobras is constructing the Urucu-Coari-Manaus pipeline at the site with the objective of transporting natural gas for electricity generation in Manaus, which was served by fuel oil and diesel driven thermoelectric power plants in 2008.

Besides its proven natural gas reserves, Brazil also has a vast supplier market in Latin America, especially from bordering countries like Bolivia, Argentina and Venezuela. Another option for reinforcing gas supply in the country is to import liquefied natural gas - LNG, by sea, from exporting countries like Algeria (with reserves of 4,520 billion m^3), Nigeria (3,510 billion m^3), Australia (1,260 billion m^3) and Trinidad and Tobago (600 billion m^3).

Through thermoelectric generation, natural gas acts as a promoting agent for decentralizing the electric system operation as well as an energy integration factor for Brazil with neighbouring countries. An example of this is the importation of natural gas to supply thermoelectric plants in the South and Southeast regions, such as the 600 MW Uruguaiana Thermoelectric Power Plant, supplied with gas from Argentina. Furthermore, supplying natural gas to thermoelectric plants is important to make pipeline operations under construction in the country financially feasible, ensuring minimum consumption levels and consequently serving potential natural gas consumer centers.

The strategic role played by natural gas in the expansion of self-producer, independent producer and even private public utility concessionaire generation capacity also results in most of the comparative advantages over fuel oil and other fossil fuels used to generate thermoelectricity, such as less corrosion, reduction in equipment maintenance frequency, greater control over burning in the production process and elimination of fuel stocks.

Natural gas thermoelectric plants and energy co-generation systems also bring major benefits to stability in the future supply of electric energy due to greater capacity in adapting supply to demand. This is due to their modularity characteristic and the speed in constructing these undertakings as well as better management of the electric system load curve, which reduces peak demand, thus avoiding the installation of additional generation capacity. Another advantage to underscore is the possibility of installing them near large load centers, generating savings transmission costs and contributing towards reductions in electricity loss levels and increases in operation reliability.

On the demand side, natural gas shows great versatility, adapting to a broad range of applications which include LPG and natural gasoline production; replacement of LNG and manufactured gas in residential, commercial, industrial and other uses; use as a raw material in the petrochemical and fertilizer industry; replacement of diesel in bus fleets and public utility vans; replacement of oil byproducts in industry; and generation of industrial heat.

However, one of the main trends for gas penetration is its use as a fuel for thermoelectric generation, a determining factor for reducing the risk of possible restrictions in the supply of electricity during unfavorable hydrological periods.

In relation to global sustainability, the replacement of oil byproducts and other fossil fuels with natural gas is positive since there are fewer emissions of greenhouse gases from using natural gas. This change is mainly expected in the transport and industrial sectors. However, in the generation of electricity, where the high participation of hydraulic power grants the country favorable conditions in relation to the emission of greenhouse gases, the increase in thermoelectric generation projected for coming years will add new elements to the debate on environmental issues related to an expansion of electricity supply, considering a probable increase in greenhouse gas emissions by considering this element in isolation.

2.1.3 Comparison between Greenhouse Gas Emissions from Natural Gas Thermoelectric Plants and Other Plants Fuels

With the expanded number of thermoelectric power plants, attention has increasingly shifted to the issue of controlling air quality, due to pollutant emissions, such as sulphur oxides (SO_2 and SO_3), nitrogen oxide and dioxide (NO and NO_2), carbon dioxide (CO_2), carbon particles (C), carbon monoxide (CO) and heavy metals, all stemming from the incomplete combustion (except for CO_2) of fossil fuels and their impurities, as well as other byproducts from secondary reactions that occur in the atmosphere, such as sulphuric acid (H_2SO_4) and nitric acid (HNO_3).

The impacts resulting from global climate change are the ones that impose the greatest obstacles to the growth of thermoelectricity in the country, in terms of costs and technical/economic feasibility of implementing conventional thermoelectric power plants. However, it is necessary to consider that the use of natural gas to replace other fossil sources traditionally used in thermoelectric generation is, among fossil fuels, the most appropriate alternative for full development of thermoelectricity in the country, because it allows increasing energy efficiency in generation and, most importantly, mitigating a major part of the adverse effects caused by other fossil sources to the environment.

Indeed, the comparison of carbon emissions contained in CO_2, based only on the fuels' chemical characteristics and their energy contents, shows that the burning of natural gas emits 218 mg C/kcal, with a reduction of 44.5% compared to emissions from burning European coal, which corresponds to 393 mg C/kcal. In relation to heavy fuel oil, which emits 307 mg C/kcal, the burning of emissions from adopting natural gas is around 29.0%. Compared to the use of light fuel oil (290 mg C/kcal), the burning of natural gas provides a reduction of 24.8% in total carbon emissions.

These results differ a little from emissions calculated based on electricity generated, which also depend on the efficiency of technological standards employed at the thermoelectric plants. However, natural gas is a real alternative for reducing the growth rate of greenhouse gas emissions, presenting coefficients of carbon gas emissions per kWh generated less than those for fuel oil and coal in thermoelectric generation in the main technologies used, which are the conventional steam cycle, gas turbines and the combined cycle.

Compared to the burning of fuel oil, the option for natural gas allows a 27% reduction[141] in total projected carbon gas emissions designed with generation technology based on the conventional steam cycle. In undertakings with gas turbines, CO_2 emissions obtained from using natural gas in replacement of fuel oil reached 31%. For thermoelectric generation from the combined cycle, replacement of the energy sources proposed above would imply a 28% reduction in CO_2 emissions (ROSA & SCHECHTMAN, 1996).

2.1.4 Petrobras's programs to improve natural gas use in the Campos Basin

The Campos Basin is the main oil-producing region in Brazil, and accounts for about 80% of the domestic oil. It covers the coast of the state of Espírito Santo, the entire state of Rio de Janeiro and a portion of the state of São Paulo. Its leadership in the development of deep-water production technology in these oil fields has earned it several awards and international recognition.

Due to increased production in this region and the prospective growth in the natural gas market, the Zero Burning Project – PQZ was created in 1997, with actions to improve use of gas in the Campos Basin. The purpose of the project was to increase availability of gas in the market, improve the use of energy resources and reduce greenhouse gas emissions.

In 2000, in view of the potential crisis in the energy sector in Brazil, the control over gas flaring in the Campos Basin was stepped up by Petrobras and ANP, which prompted additional actions for PQZ. As a result, in 2001 the Plan for the Optimization of Natural Gas Use in the Campos Basin – POAG was established.

The POAG covered installation and rescaling of compressors, and construction of new gas pipelines in the sea, thus freeing compression capacity for gas transfers to the mainland. POAG also includes actions associated to a review of procedures, stock control and personnel training. With the completion of 94 planned actions on 24 platforms, there was a significant reduction in gas flaring in the Campos Basin and a better use of the gas produced, which allowed Petrobras to increase the supply of fuel in the market. Investments in this project have exceeded US$200 million, with potential gains in gas use of 4.2 million cubic meters per day. Over R$180 million will be invested to further reduce gas flaring, with an expected gain of 800 thousand cubic meters per day.

In addition to this program, US$ 98 million have been invested in two gas injection projects in the Campos Basin, which make it possible to store up to 2.4 million cubic meters of associated gas per day in the reservoir rock itself. This gas can be used on an as-needed basis. Coupled with the storage facility, the reduction in gas flaring has contributed significantly to meeting the market demand for gas.

POAG played an important role in mitigating greenhouse gas emissions, considering that between 2002 and 2005 the program prevented about 15 million tons of CO_2 from being released into the atmosphere.

2.1.5 Reduction in Fugitive Emissions of Methane in Natural Gas Distribution in São Paulo

Fugitive emissions of natural gas conveyed through distribution systems mainly occur as the result of leaks in the joints and parts of pipeworks. These also occur because of accidents and at the consumer end, both in the residential and commercial or industrial sectors.

In 2005, Brazil had an estimated natural gas market of 90 million m^3/day, and a loss equivalent to the use of a thermal power plant of 1,000 MW was reported. This meant not only an economic loss, but also a considerable environmental cost due to the methane released and its impact on global warming.

Comgas, the gas utility for São Paulo, took measures to reduce emissions of methane gas in the piped natural gas distribution system, focusing on curbing wastage in the system, both at the network and at the consumer end, whether residential or non-residential.

Comgas prepared an inventory of fugitive emissions of methane in the distribution systems of piped natural gas in Brazil. This was in 1997, and the inventory followed IPCC's methodology, as recommended by the MCT. This inventory guided Comgas's actions for reducing leaks in the system, thus helping reduce methane emissions into the atmosphere.

There are no measurements for the monitoring of fugitive emissions of piped gas. To be able to assess progress on emission reduction actions, it is essential to have monitoring continuously and consistently in place. Thus, the inventory preparation is, in fact, a fundamental step for inception of a long-term process.

141 Efficiencies were considered based on higher calorie power - PCS. In the conventional steam cycle, an efficiency of 38.1% was considered for natural gas, 39.2% for heavy oil, 38.8% for European and Colombian coal and 33% for domestic coal. In the gas turbine and combined cycle, efficiencies of 30.1% and 42.7% were adopted, respectively, for natural gas, and 27.7% and 41.1% for light oil.

Since it was privatized in 1999, the company has managed to reduce the share of unaccounted gas from 5.2% to 2.1%, mainly by renovating networks, replacing cast iron pipes – which stemmed from the early activities of the utility, in the late 19th Century – with polyethylene pipes, which, in addition to being easier to install, minimize losses in the system and allow for enhanced sealing and durability.

For steel- or polyethylene-based systems, periodic maintenance is effective to prevent leakage, with special attention to special fixtures (valves, pressure regulating stations, measuring systems, etc.).

In addition, minor leaks cannot be detected by smell. In this case, a device consisting of a vehicle to which air collectors are coupled is used in an online analysis to check the amount of gas in the air. Once the leak has been detected, a bypass is applied to scheduled maintenance activities, i.e., whenever it is technically possible, the gas contained in a given section is transferred to another section and no gas is purged into the atmosphere.

Based on research results for the inventory of fugitive emissions of piped natural gas from the distribution system, the value for Brazil is virtually negligible in the balance of total annual anthropogenic methane emissions at global level. However, additional measures to control emissions of this nature are desirable, including the following:

- implementation and operation of risk management systems in order to reduce accidental leaks or, if these do occur, ensure that they may be contained promptly;
- performance of maintenance operations or manoeuvres in the network that require a section of the pipework to be emptied to prevent gas from being purged into the atmosphere;
- program for continued maintenance of network equipment;
- educational campaigns targeted at residential, industrial and commercial consumers;
- technical support to consumers for the regulation of burning equipment and maintenance of the internal network; and
- program for the rehabilitation of cast iron networks.

2.2 Programs in the State of São Paulo for Reducing Vehicle Emissions from Urban Transport

Air pollution is one of the environmental impacts felt the most by the population in the state of São Paulo. In the 1970s and 1980s, industrial sources were the target for most control actions. Rigor in controlling industrial emissions plus the growing fleet of vehicles in circulation resulted in the need for more effective control of emissions from automotive vehicles, especially since the 1990s, since they began to represent the greatest sour of air pollution in the most densely urbanized regions.

Some of the actions by the government of São Paulo, through the Environmental Sanitation Technology Company of the state of São Paulo – Cetesb[142], occur as contributions to federal programs, such as the cases of Proconve and Promot[143], participating as a technical agent reporting into Ibama.

Other important complementary actions carried out by Cetesb are the implementation of environmental management programs in freight and passenger transport fleets; training of garages – aimed at improving service quality in the Otto and Diesel cycle vehicle repair network; the incentive for continuous improvement in automotive fuel quality and energy alternatives for transport; and the intensification of inspections for excess black smoke emissions by diesel vehicles in circulation in the state of São Paulo.

Within the legal scope, the most prominent are contributions towards elaborating the Sustainable Transport Bill; the Vehicle Pollution Control Plan in the state of São Paulo – PCPV; and the State Policy on Climate Change, which involves other sectors of the government and civil society - especially transport, traffic, energy and planning sectors – in issues related to the impact of motorized mobility in environmental quality.

In 2007, the São Paulo Breathes Project was created under the São Paulo State Secretariat of Environment, with the objective of implementing new air pollution control programs, especially in metropolitan regions; establishing goals for reducing the most polluting sources and for assessing results; intensifying inspection of pollutant emissions with the support of the environmental police; improving the diagnosis of air quality and air emissions in the state of São Paulo, including those that cause global warming.

142 See: <http://www.cetesb.sp.gov.br>.
143 See Part III, Section A.3.7, on Proconve.

From a strategic perspective, the Breathe São Paulo Project was conceived to provide structural tools for improving air quality management and to promote direct and indirect actions to control air pollution sources. In the first case, we can underscore: improvements in the emissions inventory, expansion of the air quality monitoring network, elaboration of scenarios with estimates of emissions reductions stemming from control actions, introduction of new legal mechanisms, among others.

2.2.1 Winter Operation

The Winter Operation was incorporated to the Breathe São Paulo Project in 2007, which enabled an expansion of activities. Major activities include the huge inspection roadblocks for black smoke emissions conducted simultaneously on several highways in the state by Cetesb agents, in partnership with the Military Highway and Environmental Police. Millions of leaflets were distributed at toll booths, malls, parking garages and repair shops instructing drivers and encouraging them to regulate engines and consequently reduce emissions of pollutants. The leaflets also encouraged the population to report vehicles emitting excess black smoke. In order to meet a demand that grew nearly tenfold, a new call center system was set up (Dial Black Smoke) as well as a system to receive reports over the Internet. Another innovation was the implementation of an incentive program for vehicle maintenance, which provided a 90% discount on a fine written up on the vehicle. The main results obtained in the most recent Winter Operations are shown in Table 2.3.

Table 2.3 Main activities carried out as part of the Winter Operation in the state of São Paulo, 2005-2009

Action	2005	2006	2007	2008	2009
Fines at Roadblocks	145	320	2,322	1,628	2,965
Inspection roadblocks	3	7	13	18	4
Mega roadblocks	0	0	3	3	2
Inspected vehicles	84	300	438	461	NA

NA: Not available.

Source: Elaborated by Cetesb[144].

144 Data provided by the Environmental Sanitation Technology Company of the state of São Paulo - Cetesb as an input for the Second National Communication of Brazil to the UNFCCC.

2.2.2 Air Quality Monitoring

Cetesb's air quality monitoring network generates information that is made available to the population in real time. It also subsidizes environmental licensing, emission source control programs, planning and managing air quality and epidemiological studies. In 2008, twelve new automatic stations were installed, about a 30% increase in the monitoring network, which allowed for a better evaluation of air quality in other areas of the state, especially the west and northwest, accompanying the expansion of the sugar and alcohol sector. Stations were also installed where previous data indicated the need for a more systematic monitoring on the part of Cetesb.

In 2009, a new web environment system was launched (*qualar* system) to provide air quality information measured by Cetesb monitoring networks.

2.2.3 Peak Hour "Rodízio" (Rotation) Program

São Paulo's Peak Hour "Rodízio" (Rotation) Program, conducted by the Traffic Engineering Company – CET, is a restriction of motor vehicle circulation in the city of São Paulo. It began in 1997 with the objective of improving environmental conditions by reducing the pollutant load in the atmosphere, and it consequently reduced traffic jams on major routes in the city during peak traffic hours. However, these traffic jams continue to get worse, reaching a historical 266 km traffic slowdown record in April 2008. The situation is worsened by the accelerated and continuous growth of the vehicle fleet, a result of the city's economic dynamism. In order to mitigate its effects on city traffic and air quality, São Paulo local government extended the rotation (restriction) program to truck circulation starting June 30, 2008. The rotation system does not apply to the entire city, and is limited to a region called *"Centro Expandido"* (expanded center), which is delimited by a series of roadways[145].

Circulation restriction affects private and company vehicles from any city, except for those conducting essential functions, urban and school transportation, medical care, transporting perishable products and transporting the physically handicapped or being driven by them. It is applied according to a scale and two ranges of time: from 7am to 10am and from 5pm to 8pm.

145 Roadways are: Marginal do Rio Tietê, Marginal do Rio Pinheiros, Avenida dos Bandeirantes, Avenida Afonso D' Escragnole Taunay, Complexo Viário Maria Maluf, Avenida Presidente Tancredo Neves, Avenida das Juntas Provisórias, Viaduto Grande São Paulo, Avenida Professor Luís Inácio de Anhaia Melo, and Avenida Salim Farah Maluf.

The scale determines which days of the week certain vehicles cannot circulate. This scale is governed by the last digit of the vehicle's license plate. Drivers caught violating this circulation restriction are fined and lose points on their driver's license.

2.3 The Role of Nuclear Energy in Reducing Greenhouse Gases in Brazil

2.3.1 Brazil's Energy Sector and Nuclear Energy

At the end of the 1960s, it was decided to install nuclear plants in national territory. With these plants, the Federal Government intended to acquire knowledge on the new technology that was rapidly expanding around the world, while also solving a local problem: the need for thermal energy to complement the supply of electricity to Rio de Janeiro.

Construction of Angra 1 began in 1972, using American technology from Westinghouse, acquired in a turn-key system (no transfer of technology). Three years later, in 1975, the country signed a Cooperation Agreement Related to Peaceful Uses of Nuclear Energy with the Federal Republic of Germany. In July of the same year, it acquired Angra 2 and Angra 3 from ***Kraftwerk Union A.G.*** - ***KWU***, a subsidiary of ***Siemens***, also from Germany. The contracts provide for partial transfer of technology.

Angra 1, with installed power of 640 MW, started commercial operations in 1985. Angra 2, with installed power of 1,350 MW, started up in 2000. Construction of Angra 3, with another 1,350 MW, has been on hold for many years for a number of reasons. Considering the need to diversify primary sources of energy in the country, the National Energy Policy Council – CNPE approved the proposal to resume and conclude the Angra 3 nuclear plant. Its construction is currently included in the 2019 Ten-Year Plan for Expanding Electric Energy, taking into account that in 2008 Ibama granted a prior license authorizing the resumption of works. It is estimated the Angra 3 should start up in 2015 with a price projected by the MME for MWh to be produced by the plant that will be competitive with the average price of MWh produced by the thermoelectric plants.

In 2009, nuclear generation of 13 TWh was responsible for 2.6% of Brazil's total electric energy supply (505.8 TWh). Although with a modest participation in generating electric energy, and considering the country's circumstances, nuclear plants currently in operation are responsible for more than 50% of the energy consumed in the state of Rio de Janeiro, an important state of the country in terms of GDP. In 2019, with the projected increase, nuclear power will maintain its 1.9% share in installed national energy, estimated to reach 178 GW.

2.3.2 Institutional Aspect of the Nuclear Sector

In 1997, the Furnas nuclear area, the company responsible for most of the electricity supply in the most developed region of Brazil, merged with government-owned Nuclebras Engenharia – Nuclen, responsible for the design, construction management and tenders involving nuclear power plant equipment. The new company, called Eletrobras Termonuclear S.A. - Eletronuclear is responsible for the design, tender, follow-up on national and foreign equipment, management of construction, assembly and commissioning of nuclear power plants, while also being the only owner and operator of nuclear power plants in the country. It is also responsible for acquiring the needed know-how and for promoting private industry.

Other players in the nuclear sector include Eletrobras, responsible for coordinating and financing the electricity program in the country; the National Nuclear Power Commission - CNEN, the licensing authority; Nuclear Industries of Brazil - INB, fuel supplier; Nuclebras Equipamentos Pesados S.A. - NUCLEP, Brazilian manufacturer of heavy components; private Brazilian engineering companies and private Brazilian suppliers of mechanical and electrical equipment.

2.3.3 Nuclear Energy's Contribution towards Reducing Greenhouse Gas Emissions

Nuclear power is the only energy technology that treats, manages, contains and isolates its waste to completely protect human health and the environment. Solutions for the final disposal of low-, medium- and high-level radioactive waste exist and are in use in several countries.

Furthermore, waste management and disposal technologies are continuously advancing, including recycling of the fuel. Implementation of these improved technologies could help increase public acceptance of nuclear energy. Furthermore, due to the fact that nuclear power is a highly concentrated form of energy, nuclear power plants and fuel cycle installations do not need large areas. Thus, the environmental impact of nuclear power on the earth, forests and water is minimal and does not require re-settlement of large populations.

By virtue of the increase in greenhouse gas concentrations in the atmosphere, governments and companies around the world are increasingly considering the possibility of constructing a substantial number of new nuclear power plants.

An evaluation of the impact from introducing nuclear power in Brazil on greenhouse gas emissions must be conducted comparing it with the situation that would exist if the energy source were not available. Thus, this evaluation, like any other replacement evaluation, adopts a hypothesis of what the existing scenario would be like in the absence of the implemented alternative (usually called "baseline").

Despite the strong predominance of hydroelectric power in Brazil's electric generation mix, starting the second half of the 1990s an increase was seen in thermoelectric participation in absolute and relative terms. It was in this growth scenario of thermal energy's participation in the generation of electricity that nuclear power took on a more important role in this generation. This justifies the use of existing thermoelectric plants to estimate the impact on CO_2 emission reductions due to the use of nuclear energy, since the probable alternative in its absence would be an increase in thermal plant share to supply the needed electricity. Thus, a hypothesis was adopted whereby nuclear energy, if it were not an existing option, would be replaced by other fossil fuels used in thermal generation at public utility plants every year.

From 1984 (the year Angra 1 began to generate electricity) to 2009, 152 TWh were generated from nuclear plants in Brazil, which is equivalent to 32.7 million toe, with a thermal efficiency of 40%. Considering the hypothesis that this energy would be generated by coal, the use of nuclear energy in Brazil would have avoided the emission of 127 million tons of CO_2, a sum that corresponds to 37% of total emissions for 2009 from using the energy.

From the above, the use of nuclear power should be viewed as an option to be considered for producing energy with low greenhouse gas emissions.

Chapter 3

Integration of Climate Change Issues to Mid- and Long-Term Planning

3 Integration of Climate Change Issues to Mid- and Long-Term Planning

The majority of the programs described in this section do not directly intend to reduce greenhouse gas emissions, but they may have effects on emissions from various sources.

3.1 Brazilian Environmental Legislation

The Federal Constitution enacted in 1988 represented significant progress for the environmental areas by dedicating, in an unprecedented manner, a special chapter to the environment, including its advocacy among principles of an economic order, seeking to reconcile socioeconomic growth with the necessary environmental protection and preservation.

Thus, Article 225 of the Federal Constitution, which makes provisions on the environment, establishes that: "All have the right to an ecologically balanced environment. which is an asset of common use and essential to a healthy quality of life, and both the Government and the community shall have the duty to defend and preserve it for present and future generations." Thus, the environment is characterized as an inherent right for individuals and for society as a whole, with Public Authorities and community equally held responsible for preserving and ensuring environmental balance.

Besides the measures and provisions assigned to the Public Authorities, the Federal Constitution imposes a set of rules on those who may direct or indirectly harm the environment. Furthermore, the Constitution[146] stipulates that the Brazilian Amazon Forest, Atlantic Forest, Serra do Mar, Pantanal Wetlands in Mato Grosso and coastal zone are national heritages, and they shall be used as per the law, under conditions that ensure the preservation of the environment.

Although the Constitution gives special attention to preventive activities, it also makes reference to repressive measures. Paragraph 3 of Article 225 stipulates criminal and administrative sanctions for violating individuals or organizations whose conduct or activities are considered harmful to the environment, regardless of the obligation to repair damage caused.

In 1996, a major change was made to the Forest Code[147]. This amendment provides for the prohibition of any increases in forest areas converted into farmland in the North region and northern Central-West region. The new wording in Article 44 of the Forest Code establishes that clear cutting exploitation in these areas can only be conducted if a forest cover of at least 50% of the area of an individual property is maintained. Furthermore, according to the Provisional Measure, in those properties where the tree cover is made up of forest vegetation profile, clear cutting is not allowed in at least 80% of these forest types. This Provisional Measure has been re-enacted ever since[148].

In 2000, The National Protected Area System - SNUC[149,150] updated the concept of protected area by introducing the issue of social dimension and use for other purposes. The importance of establishing a National Protected Area System is in that it standardizes and consolidates criteria for the creation and management of these areas, thus making it possible to enhance management of Brazil's environmental heritage.

Priority was given to aspects related to forest concessions and allocation of public forests to communities[151], thus creating the legal basis for the preparation of concessions in the shortest timeframe possible. The regulation includes the National Registry of Public Forests, managed by the Forest Service, and linked with the National Rural Registry System. The National Registry includes records from the public forests in states and municipalities, the Registry of Indigenous Lands, and the National Registry of Protected Areas. The forests located in areas pertaining to the Federal Government, self-governing public agencies, foundations, public enterprises, and semi-public corporations already registered or going through the process of collection are also included in the Registry. The military areas are included upon authorization by the Ministry of Defence. The Registry contains sufficient information about these forests to facilitate their management, including its geographical boundaries, forest type, existence of conflicts, and also any recommendations already made through Ecological and Economic Zoning - ZEE.

146 Paragraph 4 of Article 225.

147 Provisional Measure no 1,511, of July 26, 1996 changed the wording of Article 44 of Law nº 4,771, of September 15, 1965.

148 A Provisional Measure also amends Articles 1, 4, 14, 16, and 44 significantly, and adds provisions to Law no 4,771, of September 15, 1965, which institutes the Forest Code, and amends Article 10 of Law no 9,393, of December 19, 1996, which establishes the Rural Property Tax - ITR, and other measures. This Provisional Measure stipulates that forests and other forms of native vegetation, except for those located in permanent preservation areas, as well as those not subject to a limited use regime or object of specific legislation, could be cut, so long as a minimum of 80% of the rural property located in forest area in the Legal Amazon is maintained as a legal reserve (the percentage to be maintained for other regions is also determined). Vegetation of the legal reserve cannot be cut. It can only be used under a sustainable forest management regime, in accordance with the technical and scientific principles and criteria established in current legislation. The provisional measure also regulates the conduct of a owner or holder of a rural property with native, natural, primitive, or regenerated forest cover in it.

149 See Part III, Section 3.11 on the National System of Protected Areas - SNUC.

150 Law nº 9,985, of July 18, 2000.

151 Decree nº 6,063, of March 20, 2007.

The Brazilian legislation concerning the protection of the environment is comprised of numerous other laws. In other sections of this document, various legal instruments are discussed in relation to specific issues. This phenomenon – as in almost all areas of law – is due, among other reasons, to the different political and institutional circumstances that have marked the country's recent history.

In summary, it is recognized that the Brazilian environmental legislation is one of the most advanced in the world, with clear legal guidelines in pursuit of sustainable development, although there are institutional and administrative difficulties for their wider implementation.

It must be recognized, however, that in many cases such legislation is not properly enforced. There are, to some extent, difficulties in such a continent-sized country to control factors that drive economic development and are inconsistent with sustainable development.

3.2 Brazil's Agenda 21

The United Nations Conference on Environment and Development - Rio-92 - was a milestone, considering that it was a planetary effort to establish new development guidelines which are based on environmental protection, social justice and economic efficiency. This conference produced five documents: the Rio Declaration on Environment and Development; Agenda 21; the Declaration of Principles on the Use of Forests; the United Nations Framework Convention on Biological Diversity; and the United Nations Framework Convention on Climate Change.

The Rio Declaration brings together a set of guidelines adopted by consensus by leaders of the world, to ensure development on a sustainable basis for the next century. Sustainable development is defined as "development that meets present needs without compromising the ability of future generations to meet their own needs"[152].

Hence, Agenda 21 indicates the strategies to promote sustainable development, recommending the actions, actors, partnerships, methodologies, and institutional mechanisms necessary for its implementation and monitoring.

The emphasis of the debates on the development of the Agenda was based not only on global strategies, but sought an approach that was both global and local. The strategies outlined in Agenda 21 for the solution of problems combine decentralized cooperation and local action through the implementation of policies and programs that engage local, national, regional and international institutions at once.

Considering the need to establish specific priorities for development, the countries signing the agreements resulting from the United Nations Conference on Environment and Development made a commitment to develop and implement their respective national Agenda 21.

The national Agendas 21 are intended to develop the parameters of a strategy for sustainable development by setting national priorities and enabling sustainable use of natural resources. They should take into consideration the comparative advantages of the relevant country to produce goods and services to society more efficiently, as well as the specific environmental fragility.

In Brazil, in early 1997, a committee on sustainable development was established, and it reported into the Council of Government's Natural Resources Policy Chamber. This new institutional arrangement was meant to place under the Presidency the coordination of various governmental organizations and entities engaged directly with development of the National Agenda 21.

As a result, the Commission on Sustainable Development Policies and the National Agenda 21 - CPDS were created[153] under the Natural Resources Policy Chamber in order to propose strategies for sustainable development and to coordinate, develop and implement the agenda.

The first phase of the national Agenda 21 was the preparation of the Brazilian Agenda 21 document. This process, which lasted from 1996 to 2002, was coordinated by the CPDS and had the involvement of about 40,000 people throughout Brazil.

Brazil's Agenda 21 was completed in 2002. From 2003, the Brazilian Agenda 21 not only launched the implementation phase, assisted by the CPDS, but it was also promoted to the status of the 2004-2007 Multi-Annual Plan - PPA[154], by the government. The Agenda 21, under the PPA, was comprised of three strategic actions undertaken with civil society: implementation of Brazil's Agenda 21; development and implementation of Local Agendas 21; and ongoing training

152 Definition used in the Our Common Future document, 1987, known as the Brutland Report, elaborated by the Commission on Environment and Development, created by the United Nations and chaired by then Prime Minister of Norway, Gro-Brutland.

153 Decree of February 26, 1997.

154 In Brazil, the Multi-Annual Plan ¾ projected in Article 165 of the Federal Constitution, and regulated by Decree 2,829, of October 29, 1998 ¾ establishes the measures, expenses and objectives to be followed by the Federal Government over a four year period. It is approved by a quadrennial law, subject to differentiated terms and rites for proceedings. It is in effect from the second year of a President's term to the end of the first year of the following term. It also stipulates government action during the aforementioned period in programs of continuous duration already instituted or to be instituted in the mid-term.

in Agenda 21. The priority was to guide preparation and implementation of Local Agendas 21 based on the principles of the Brazilian Agenda 21 which, in line with the global Agenda, recognized the importance of local level actors in achieving sustainable public policies.

Agenda 21 was also included in the 2008-2011 PPA, based on the performance of three purposive actions: development and implementation of Local Agendas 21; continuing education in Local Agenda 21; and the promotion of Local Agenda 21 projects (through FNMA).

3.3 National Plan on Climate Change

Although Brazil does not have any quantified commitments on greenhouse gas emission limitation or reduction, according to the multilateral climate change regime, the country has not been neglectful and is playing a critical role in fighting against climate change. As reported in this National Communication, various government programs and initiatives in Brazil are bringing about major reductions in greenhouse gas emissions, some of which are responsible for the fact that Brazil has a clean energy mix, compared to other countries, with low greenhouse gas emissions per unit of energy produced or consumed. Increasingly, Brazil is moving towards undertaking voluntary commitments that represent a significant reduction in the emission of greenhouse gases and protection to sinks.

Hence, in order to do things in a planned manner, in 2007 the President of the Republic included in the agenda of government activities the development of a plan, initially called "National Action Plan to Combat Climate Change," aimed at structuring and coordinating government actions concerning the effects of global warming arising from anthropogenic activities.

As a means of meeting this demand, the Executive Secretariat of the Brazilian Forum on Climate Change - FBMC[155] held several meetings that resulted in the elaboration of a reference document entitled "Proposal of FBMC for the National Action Plan to Combat Climate Change", and this was submitted to the President of the Republic.

In 2007, the government created the Interministerial Committee on Climate Change – CIM[156], coordinated by the Executive Office of the Presidency of the Republic ("Casa Civil da Presidência da República"), with a mandate to develop the National Plan on Climate Change and the National Policy on Climate Change.

155 See Part IV, Section 3.3, on the Brazilian Climate Change Forum.
156 Presidential Decree nº 6,263, of November 21, 2007.

The Executive Group on Climate Change - GEx, which is coordinated by the Ministry of Environment and reports into CIM, is responsible for elaborating, implementing, monitoring and evaluating the National Plan on Climate Change. As a result of Gex's work, a bill for the National Policy on Climate Change was submitted to the Legislative Branch[157].

Another practical result of GEx's work was the draft National Plan on Climate Change. In its initial phase of drafting, consultation questionnaires were forwarded to the ministries that comprise the CIM in order to bring together the actions already in place for each of them and their related bodies, such as programs and projects that contribute to preventing climate change.

This process included public consultations of the utmost importance: the III National Conference on the Environment[158] and the meetings held by the Brazilian Climate Change Forum, the so-called "Sector Dialogues"[159].

The overall objective of the National Plan on Climate Change is to identify, plan and coordinate actions and measures that can be undertaken to mitigate greenhouse gas emissions generated in Brazil, as well as those necessary for the adaptation of society to the impacts of climate change. The plan must be guided by the National Policy on Climate Change on an ongoing basis.

3.4 National Policy on Climate Change - PNMC

In 2009, the National Policy on Climate Change – PNMC was put in place[160], and it established its own principles, objectives, guidelines, and instruments.

The National Policy on Climate Change - PNMC aims, among other things, at the harmonization of social and economic development while protecting the climate system; reduction of anthropogenic greenhouse gas emissions in relation to their various sources; strengthening of anthropogenic removals by sinks of greenhouse gases in the country; and implementation of measures to promote adaptation to climate change by the three (3) levels of government, with

157 Bill nº 3,535, of June 10, 2008. This bill became the basis for negotiations in the National Congress that resulted in Law nº 12,187, which was sanctioned by the President of the Republic on December 29, 2009, as discussed in the next section.
158 The National Conferences on the Environment are part of the Federal Government's policy for social mobilization in decision-making processes. They have been held since 2003, with the I National Conference on the Environment, becoming a source of social legitimization and democratic stability.
159 In the sector dialogues held in this first phase of the Plan, several sectors of society were heard, such as industry, forestry, finance, agriculture, forest and changes in land use, municipal movements, civil society and NGOs.
160 By means of Law nº 12,187, of December 29, 2009, sanctioned by the President of the Republic.

the participation and collaboration of the economic and social stakeholders, particularly those especially vulnerable to its adverse effects.

The objectives of the National Policy on Climate Change should be in line with sustainable development in order to pursue economic growth, poverty eradication and reduction of social inequalities.

The following are considered to be instruments of the National Policy on Climate Change: the National Plan on Climate Change, the National Fund for Climate Change[161]; the Action Plans for the prevention and control of deforestation in the biomes; Brazil's National Communication to the United Nations Framework Convention on Climate Change, according to the criteria established by the Convention and by the Conference of the Parties; the resolutions of the Interministerial Commission on Global Climate Change[162]; the fiscal and tax measures to encourage emission reductions and removal of greenhouse gases, including differentiated tax rates, exemptions, compensations and incentives, to be established by specific legislation; the lines of credit and financing of specific public and private financial agents; the development of research programs by funding agencies; the specific allocations for actions on climate change in the federal budget; the financial and economic mechanisms related to climate change mitigation and adaptation to the effects of climate change that exist under the United Nations Framework Convention on Climate Change and the Kyoto Protocol; and the financial and economic mechanisms, at national level, pertaining to mitigation and adaptation to climate change[163].

Furthermore, instruments of the PNMC also include existing or future measures that encourage the development of processes and technologies that contribute to the reduction of greenhouse gas emissions and removals, as well as to adaptation, among which the establishment of eligibility criteria in tenders and bids, including public-private partnerships, and the authorizations, permits, grants and concessions of public services and natural resources; to proposals that provide greater savings of energy, water and other natural resources; and to reduction of greenhouse gas emissions and waste.

The institutional instruments for the implementation of the National Policy on Climate Change include:

I – the Interministerial Committee on Climate Change[164];

II - the Interministerial Commission on Global Climate Change;

161 See Part III, Section 3.14.3, on the FNMC.
162 See Part I, Section 3.1.3, on the Interministerial Commission on Global Climate Change.
163 See Part III, Section 3.14, on Financial and Tax Measures.
164 See Part I, Section 3.1.4, on the Interministerial Committee on Climate Change.

III - the Brazilian Climate Change Forum;

IV – the Brazilian Research Network on Global Climate Change – Climate Network[165];

V - the Commission for the Coordination of Meteorology, Climatology and Hydrology Activities.

The official financial institutions will provide specific lines of credit and financing for the development of actions and activities that meet the objectives of the Law on Climate Change that are aimed at encouraging private players to act in compliance with and enforce the PNMC as part of their social responsibilities and actions.

The principles, objectives, guidelines and instruments of public policies and government programs should be made compatible with the principles, objectives, guidelines and instruments of the National Policy on Climate Change.

As announced by the President of the Republic during the High Level Segment of the 15th Conference of the Parties to the Convention (COP-15) and the 5th Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP-5), held in Copenhagen, the text of the law provides that, in order to achieve the goals of the PNMC, the country will adopt, as a voluntary commitment at national level, actions to mitigate greenhouse gas emissions with a view to reducing its projected emissions by 36.1%-38.9% by 2020.

Accordingly, in January 2010 the Government of Brazil informed the Secretariat of the Convention of the nationally appropriate mitigation actions that it intends to undertake, for the information of the Parties to this international instrument. These actions are as follows:

- Reduction in Amazon deforestation (range of estimated reduction: 564 million tons of CO_2 eq. in 2020);
- Reduction in Cerrado deforestation (range of estimated reduction: 104 million tons of CO_2 eq. in 2020);
- Restoration of grazing land (range of estimated reduction: 83 to 104 million tons of CO_2 eq. in 2020);
- Integrated crop-livestock system (range of estimated red uction: 18 to 22 million tons of CO_2 eq. in 2020);
- No-till farming (range of estimated reduction: 16 to 20 million tons of CO_2 eq. in 2020);

165 See Part IV, Section 4.4, on the Brazilian Research Network on Global Climate Change - Climate Network.

- Biological N_2 fixation (range of estimated reduction: 16 to 20 million tons of CO_2 eq. in 2020);
- Energy efficiency (range of estimated reduction: 12 to 15 million tons of CO_2 eq. in 2020);
- Increase the use of bio-fuels (range of estimated reduction: 48 to 60 million tons of CO_2 eq. in 2020);
- Increase in energy supply by hydroelectric power plants (range of estimated reduction: 79 to 99 million tons of CO_2 eq. in 2020);
- Alternative energy sources (range of estimated reduction: 26 to 33 million tons of CO_2 eq. in 2020);
- Iron & steel (replace coal from deforestation with coal from planted forests) (range of estimated reduction: 8 to 10 million tons of CO_2 eq in 2020).

It should be emphasized that these are voluntary actions, and that they will be implemented in accordance with the principles and provisions of the Convention, particularly Article 4, paragraph 1; Article 4, paragraph 7; Article 12, paragraph 1(b); Article 12, paragraph 4; and Article 10, paragraph 2(a). Use of the Kyoto Protocol's CDM is not excluded.

The PNMC provides that the projected emissions for 2020, as well as the detailed actions to achieve the reduction goal above will be established by Decree, based on the Second Brazilian Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol[166].

In 2010, work on the measures to implement the PNMC started, with a view to establishing the following sector plans to achieve the goal expressed in the PNMC regarding mitigation actions:

- Action Plan to Prevent and Control Deforestation in the Legal Amazon;
- Action Plan to Prevent and Control Deforestation in the Cerrado;
- Energy;
- Agriculture and Livestock;
- Replace coal from deforestation with coal from planted forests in the iron and steel industry.

166 See Part II.

3.5 Science, Technology and Innovation - ST&I Policy and Climate Change

3.5.1 Action Plan for 2007-2010: Science, Technology and Innovation for National Development and Climate Change

The MCT, in line with the Federal Government, prepared and presented to the scientific, technological and business community, as well as the Brazilian society as a whole, its Action Plan for 2007-2010, called "Science, Technology and Innovation for Development".

The main objective of the plan is to develop a wide range of initiatives, actions and programs to help make the role of science, technology and innovation - ST&I more critical in the country's sustainable development. Many of the planned initiatives are intented to encourage companies to incorporate research, development and innovation - RD&I activities into their businesses.

The Action Plan was divided into priorities that are directly related to the four strategic axes that guide the current National Policy on ST&I, namely:

- Axis I: Expansion and Consolidation of the National ST&I System;
- Axis II: Promotion of Technological Innovation in Enterprises;
- Axis III: Research, Development and Innovation in Strategic Areas;
- Axis IV: ST&I for Social Development.

Axis III: Research, Development and Innovation in Strategic Areas includes a program on climate change called the "National Climate Change Program", which aims to expand Brazil's scientific, technological and institutional capacity in the area of global climate change so as to increase knowledge on the issue, identify the impacts on the country, and support public policies to cope with the problem both at national and international level. Thus, specific implementation actions during the 2007-2010 period have been defined, and one of these actions focused on directly supporting the preparation of the Second National Communication of Brazil.

The 2007-2010 Action Plan included funds worth R$ 179 million from the government and the private sector to the area of climate change under the National Climate Change Program, which is an indication of the importance of this topic for the Brazilian government. Most of these funds were earmarked for purchasing the latest supercomputer at the INPE[167], as well as for the expansion of Brazil's scientific, technological and institutional capacity in the area of climate change.

3.5.2 Meteorology and Climate Change Program under the Federal Government's Multi-Annual Plan (2008-2011)

Science, Technology and Innovation - ST&I are State-level issues that go beyond the reach of individual governments, and should be treated as commitments that are carried across administrations. By its very nature, the relevant public policies are developed at various ministries. To coordinate and make these activities mutually coherent, the government takes advantage of plans that reconcile the various lines of activity and that provide the instruments for their implementation and the guidelines to be followed.

Development with income distribution and quality education are key priorities for the Federal Government, which have an impact on the Growth Acceleration Program - PAC[168], the Education Development Plan - PDE and other priorities in the social domain. As a result, this is the foundation of the Government's Strategic Guidelines - OEG[169] and, therefore, of the Executive branch's, established under the 2008-2011 Multi-Annual Plan (MCT, 2008).

Under the Federal Government's 2008-2011 Multi-Annual Plan, the program called Meteorology and Climate Change aims to provide insight into the mechanisms of global climate change and to improve weather, climate, hydrological, and environmental forecasting capacities. In this program, specific actions in the area of climate change have been planned, such as the National Inventory of Greenhouse Gas Emissions, operationalization of the Clean Development Mechanism and the Research and Development on Global Climate Change.

167 The new supercomputer (Cray Inc.), whose peak speed is 244 Teraflops per second, will make it possible to run models with a higer spatial resolution. The purchase of the new supercomputer takes place precisely when the CPTEC/INPE receives from the World Meteorological Organization - WMO a recommendation to become a Global Producing Centre - GPC for long-term forecasts, in recognition of the world-class quality of its seasonal climate forecasts. The new supercomputer, in turn, makes it possible to follow up on a number of activities that earned the CPTEC this distinction as per WMO's experts opinions.

168 The PAC is more than a program for expanding growth. It is a new concept of investment in infrastructure that, together with economic measures, aims at stimulating the production sectors while also taking social benefits to every region in the country. For more information, see: <http://www.brasil.gov.br/pac/>.

169 In this context, the OEG represent a long-term development and investment strategy, another step towards a national development project inspired by a vision of the future, of the values and objectives extolled by the National Development Agenda, defined by the Economic and Social Development Council.

The strategic guidelines for the 2008-2011 PPA in the area of Climate Change are as follows:

- strengthening Brazil's leading role in tackling global climate change;
- fostering studies and research on climate change with a view to diffusing scientific and technological knowledge and supporting public policies to mitigate greenhouse gas emissions;
- implementing the Brazilian Research Network on Global Climate Change – Climate Network, to conduct studies and research on the causes and effects of global climate change with a view to disseminating knowledge to enable the country to rise to the challenges associated to this change, especially with regard to aspects associated to national development; and
- promoting development of technologies that involve lower net emissions (emissions less removals) of anthropogenic greenhouse gases (MCT, 2008).

3.6 National Air Quality Control Program - Pronar

Industrial and urban development, growth of the automobile fleet, current consumption patterns, deforestation and fires, etc. have resulted in increased emissions of air pollutants. The increasing concentrations of contaminant substances in the air and its disposal on the soil, vegetables and other materials is responsible for damages to health, significant reductions in agricultural production and, in overall terms, for imbalances in ecosystems.

Management actions needed to prevent or reduce emissions of air pollutants and the effects of degradation of the environment have proven to be compatible with economic and social development. Thus, management of air quality involves mitigation measures that are based on the definition of acceptable limits of pollutant concentrations in the atmosphere, restrictions on emissions and a better performance in the application of enforcement and control instruments, including licensing and monitoring. The importance of devising a national policy oriented towards normative and institutional strengthening actions aimed at preventing and controlling air quality in the country has been recognized in order to harmonize the country's economic growth and preservation of environmental quality.

In this context of institutional and normative demands, Conama established the National Air Quality Control Program - Pronar[170] in order to "allow the economic and social development in an environmentally safe way by restricting the levels of pollutant emissions by sources of air pollution, with a view to improving air quality, meeting the established standards and not compromising air quality in those areas considered to be not degraded".

To achieve Pronar's objectives, national limits on emissions by type of sources and priority pollutants have been defined as the basic strategy, the use of standards for air quality control being reserved as a complementary control action. Measures for the following have also been planned: classification of areas according to the desired level of air quality; monitoring; environmental licensing; preparation of the national inventory of sources and air pollutants; interface with other management and training measures by environmental bodies.

Pronar also set goals for the improvement of quality management to be met in the short, medium and long terms, without, however, establishing time limits for each category. So the short-term goals would be: (i) definition of emission limits for priority pollution sources and air quality standards; (ii) inclusion of areas in the classification of intended uses; (iii) supporting the development of similar programs in the states; and (iv) laboratory training and human resource training.

The medium-term measures would include: (i) definition of all other emission limits for sources of pollution; (ii) implementation of the National Air Quality Monitoring Network; (iii) creation of the National Inventory of Sources and Emissions; and (iv) continued laboratory training of human resources, the latter also being a long-term goal.

The first legal provision arising from Pronar[171] established national standards for air quality, and it is still in force. Another achievement afforded by that resolution was the establishment of national criteria for drafting an emergency plan for acute air pollution events, which were only in place for the state of São Paulo in the past.

From a management-oriented perspective and as a means to enable its measures, other programs have been incorporated into Pronar, such as the following: (i) Motor Vehicle Air Pollution Control Program – Proconve; (ii) National Industrial Pollution Control Program - Pronacop; (iii) the National Air Quality Assessment Program; (iv) National Program for the Inventory of Air Polluting Sources; and (v) State Programs for Air Pollution Control.

170 Resolution no 05, of June 15, 1989.
171 Conama Resolution nº 03, of June 28, 1990.

3.7 Motor Vehicle Air Pollution Control Program - Proconve

The Motor Vehicle Air Pollution Control Program – Proconve was established in 1986. The program was coordinated by Ibama; it set the first emission limits for light motor vehicles and contributed towards meeting the air quality standards instituted by Pronar. In 1993, Law nº 8,723 endorsed the mandatory reduction in pollutant emission levels from motor vehicles, contributing towards encouraging technological development by fuel, motor and auto part manufacturers, and enabling domestic and imported vehicles to meet the established limits.

Compliance with these requirements is verified by standardized dynamometer testing and with "reference fuels". Furthermore, Proconve also requires the certification of prototypes and statistical monitoring of vehicles in production phases (production testing); Ibama's authorization for use of alternative fuels; removal or repair of vehicles and motors found in noncompliance with production or design; as well as a ban on the sale of non-certified motor vehicle models.

The certification of prototypes is indeed the backbone of Proconve, and it forces auto manufacturers to apply design concepts that ensure low polluting potential in new vehicles and an emission deterioration rate throughout its service life that is as low as possible.

Another important point to be highlighted is that control by the program takes place from the classification of vehicles according to their Total Gross Weight – TGW (Table 3.1), where the phases denoted by "L" for light vehicles (Table 3.2) and "H" for heavy vehicles (Table 3.5) have been implemented according to differentiated timetables.

Table 3.1 Classification of vehicles adopted by Proconve, according to Total Gross Weight

Light passenger vehicles (automobiles)	With total mass up to 3,856 Kg
Light commercial vehicles (pick-ups and vans)	Category subdivided into vehicles with mass for testing up to 1,700 kg and above 1,700kg
Heavy vehicles (buses and trucks)	With total mass greater than 3,856 Kg

Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

Timetable for Proconve Implementation

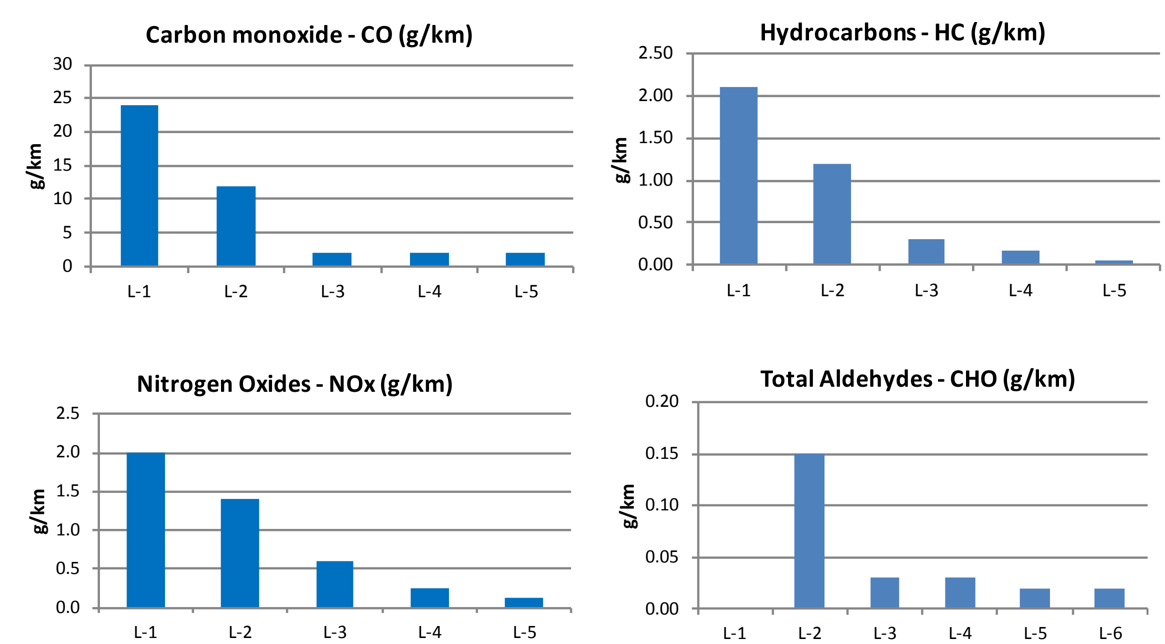
Because the unfolding of this program depends on projects and investments in technology and production lines, implementation of its phases involves negotiations between regulatory bodies and the sectors involved. In relation to emission limits for light vehicles, Figure 3.1 summarizes their evolution in each phase already implemented or in progress.

Table 3.2 Proconve implementation strategy for light vehicles ("L" Phases)

Phase	Implementation	Characteristic / Innovation
Phase L-1	1988-1991	Involves the elimination of more polluting models and improvement of model designs already in production. This phase also kicked off control of evaporative emissions. The main technological innovations in this phase were: recycling of exhaust gases to control NO_x emissions; secondary injection of air in the exhaust collector to control CO and HC; installation of a shock absorber in the carburetor butterfly valve to control HC; and optimize ignition advance.
Phase L-2	1992-1996	Based on the limits set under Conama Resolution nº 18, of 1986, in this phase investments were made in adapting catalyzers and electronic injection systems for use with ethanol mixtures in a unique proportion in the world. The main innovations in vehicles were electronic injection, electronically assisted carburetors and catalytic converters. Vehicle noise control began in 1994.
Phase L-3	1997-2004	Given the demands to meet the limits established on January 1, 1997 (Conama Resolution nº 15, of 1995), there were significant reductions compared to previous limits, and the manufacturer/importer jointly employed the best technologies available for preparing the mixture and the electronic control of the motor, such as the oxygen sensor (called the "lambda probe").
Phase L-4	2005-2008	With Conama Resolution nº 315, of 2002, as a reference, the priority in this phase, which began in 2005, was to reduce HC and NO_x emissions, (ozone precursor substances). In order to meet this phase, motors were developed with new technologies, such as optimization of combustion chamber geometry and injection nozzles, increase in injector pump pressure and electronic injection.
Phase L-5	2009-2013	With emission limits from Conama Resolution nº 315, of 2002, matching those in Phase L-4, the priority in Phase L-5 is to reduce HC and NO emissions. Similarly to Phase L-4, technological innovations involved optimization of combustion chamber geometry and nozzles, increase in injector pump pressure and electronic injection. Thus far in this phase, there has been a 31% reduction in non-methane hydrocarbon emissions for Otto cycle light vehicles and 48% to 42% in NO_x emissions for light Otto and Diesel cycle vehicles, respectively. Furthermore, aldehyde emissions were reduced approximately 67% for Otto cycle vehicles.

Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

Figure 3.1 Evolution of CO, HC, NO_x and CHO limits for light vehicles (Proconve Phases – L)



Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

Light Commercial Vehicles

With the significant increase in the fleet of light commercial vehicles, Proconve also turned to this segment. Conama Resolution nº 15, of December 13, 1995, set maximum emission limits for vans and pick-ups (Table 3.3).

Table 3.3 Emission limits for light commercial vehicles, in effect as of 01/01/1998

Pollutants	Limits	
	Vehicles with specific mass up to 1,700 kg	Vehicles with specific mass greater than 1,700 kg
Carbon monoxide (CO g/km)	2.0	6.2
Hydrocarbons (HC g/km)	0.3	0.5
Nitrogen oxides (NO_x g/km)	0.6	1.4
Particulate matter (PM** g/km)	0.128	0.16
Aldehydes (CHO* g/km)	0.03	0.06

* except for vehicles with diesel cycle motors.

** except for vehicles with Otto cycle motors.

Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

In 2009, Conama approved Resolution no 415, introducing Phase L6, which will enter into force in 2013. Phase L6 basically sets new maximum limits for new, light, passenger motor vehicle exhaust emissions with masses less than or equal to 1,700 kilograms and light commercial vehicles with masses greater than 1,700 kilograms (Table 3.4). Both categories are for highway use and consider Otto and Diesel cycle vehicles. The introduction of oxidation catalyzers, a particulate filter and gas recirculation are projected for the future.

Heavy Vehicles

There is an ongoing concern in relation to vehicles with total maximum mass greater than 3,856 kg, or vehicle mass kerb weight greater than 2,720 kg (heavy passenger and/or freight transport vehicles), since they are the main emitters of particulate matter and nitrogen oxides. To this end, Conama Resolution nº 18/1986 and Conama Resolution nº 8/1993 provided the initial guidelines for controlling diesel vehicle emissions. Table 3.5 shows the strategies adopted by Proconve in each phase for heavy vehicles, and Table 3.6 shows the respective emission limits.

The reduction in sulphur concentration contained in the fuel was a ***sine qua non*** condition for meeting the limits established in Phase P-6, since the formation of sulphured composites in combustion contributes towards the so-called "poisoning" of the catalyzer, leading to its poor operation in reducing NO_x and HC emissions. Thus, 2005 proceeded with the diesel specification at 2,000 ppm (parts per million) of sulphur as a maximum limit for this fuel to be sold in rural areas (called "diesel S 2000"), and 500 ppm of sulphur for diesel sold in metropolitan regions (called "diesel S 500"). This provided for a significant reduction in sulphur emissions in recent years, with sulphur concentrations in diesel jumping from 13,000 ppm to 500 ppm.

Table 3.4 Summary of Proconve Phase – L6 requirements and comparison with Phase – L5

Category	Comb.[7]	Model	Classification	Phase	Application Date	CO (g/km)	HC (g/km)	NMHC (g/km)	NO_x (g/km)	CHO[2] (g/km)	M.P.[3] (g/km)	EVAP[2] (g/km)	CO^2 (%)	Durab. Emissions[6] (km)
						NBR-6601 Cycle						SHED	Slow M.	AMA Cycle
Light vehicles TGW M 3.856 kg and CW M 2.720 kg)	Gasoline (E22), Ethanol (E100), Diesel[4] or NGV			L5	1/12009	2	0.3[1]	0.05	0.12[2] / 0.25[3]	0.02	0.05	2	0.5	80000
		Automobiles		L6	Diesel vehicles: 1/1/2014 Otto Vehicles: 1/1/2014 NM: 1/1/2014 TM: 1/1/2014	1.3	0.3[1]	0.05	0.08	0.02	0.025	1.5[5]	0.2	80000
		Light Commercial Vehicles & Off-Road	MVE < 1,700 kg	L5	1/1/2009	2	0.3[1]	0.05	0.12[2] / 0.25[3]	0.02	0.05	2	0.5	80000
				L6	Diesel vehicles: 1/1/2014 Otto Vehicles: 1/1/2014 NM: 1/1/2014 TM: 1/1/2014	1.3	0.3[1]	0.05	0.08	0.02	0.03	1.5[5]	0.2	80000
			MVE > 1,700 kg	L5	1/12009	2.7	0.5[1]	0.06	0.25[2] / 0.43[3]	0.04	0.06	2	0.5	80000
				L6	Diesel vehicles: 1/1/2014 Otto Vehicles: 1/1/2014 NM: 1/1/2014 TM: 1/1/2014	2	0.5[1]	0.06	0.25[2] / 0.43[3]	0.03	0.04	1.5[5]	0.2	80000

Notes:
(1) – Only for vehicles running on NGV
(2) – Only for vehicles running on gasoline or ethanol
(3) – Only for vehicles running on diesel
(4) - Currently, diesel automobiles are not allowed in Brazil
(5) – As of 1/1/2012, these limits are required for new models (new homologations)
(6) – For fewer than 15,000 units per year, 10% of DF is accepted for all pollutants
(7) - For flex-fuel vehicles, tests with E22, E100, and 50% E22 + 50% E100 must be performed
LVW = Loaded Vehicle Weight (= CW + 136 kg)
CW = Curb Weight
TGW = Total Gross Weight
Gasoline E22 = Gasoline mixed with 22% of ethanol
Ethanol E100 = 100% Hydrated Ethanol
NGV = Natural Gas Vehicle
Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

Table 3.5 Proconve implementation strategy for heavy vehicles ("H" Phases)

Phase	Implementation	Characteristic / Innovation
P-1 and P-2	1990-1993	In 1990, motors were already being produced with emission levels lower than those that would be required in 1993 (year when emission controls for such vehicles began with the introduction of phases P-1 and P-2). In this period, gaseous (phase P-1) and particulate material (phase P-2) emission limits were not legally required.
P-3	1994-1997	Development of new motor models aimed at reducing fuel consumption, increasing power and reducing nitrogen oxide emissions (NO_x) by adopting intercoolers and turbo motors. This phase saw a drastic reduction in CO (43%) and HC (50%) emissions.
P-4	1998-2002	Further reduced the limits created by phase P-3.
P-5	2003-2008	The objective was to reduce particulate material (PM), NO_x and HC emissions.
P-6	2009-2011	In January 2009, phase P-6 was launched[3], pursuant to Conama Resolution nº 315/2002. Its primary objective, as in phase five, was to reduce emissions of particulate materials, NO_x and HC. This was replaced by phase P-7, through Conama Resolution nº 403, of November 2008; it will come into force on January 1, 2012.

Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

Table 3.6 Evolution of emission limits for heavy vehicles (Proconve's phases "H")

	Pollutants / emission limits			
Phase	CO	HC	NO_x	PM
P-1	14.00*	3.50*	18.00*	xxx*
P-2	11.20	2.45	14.40	0.60*
P-3	4.90	1.23	9.00	0.40
P-4	4.00	1.10	7.00	0.15
P-5	2.1	0.66	5.00	0.10
P-6	1.5	0.46	3.5	0.02

Note: *Gaseous (Phase P-1) and PM (Phase P-2) emissions were not legally mandatory.

Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

By force of Resolution 315, which was not brought to pass, on January 1, 2009, phase P-6 should begin with "diesel S 500" being distributed in rural areas, and "diesel S 50" in metropolitan regions.

In view of this deadlock, in November 2008 Conama approved a new phase (P-7) for heavy vehicles, with even stricter emission limits, through Resolution nº 403, which will enter into force on January 1, 2012 (Table 3.8). This phase implies making diesel with an approximate sulphur content of 10 ppm available on the market.

According to the timetable in effect, the automobile and fuel industries have until 2016 to adapt to the new technical norms, providing diesel and motors to the Brazilian market that meet the standards already adopted in Europe, where diesel-powered vehicles emit a quantity of sulphur up to 200 times less than is discharged by Brazilian buses and trucks. With the change that creates phase P-7, further reductions in emissions are expected.

Proconve was established twenty-three years ago, and the result achieved by the program show that the strategy for implementation was correct, and its success is due to the adoption of increasingly more restrictive phases, accrediting it as one of the most successful programs in terms of policies for the environmental sector.

Table 3.7 Emission limits in g/kWh for Phase P-7[172]

	Pollutants / emission limits						
	NOx	HC	CO	CH_4 (2)	PM	NMHC	Opacity (m-1)
Test ESC(4)/ ELR(5)	2.00	0.46	1.50	N.A.	0.02	N.A.	0.50
Test ETC(1)	2.00	N.A.	4.00	1.10	0.03(3)	0.55	N.A.

Notes:
(1) E.T.C. Cycle - called the European Transient Cycle – test cycle that consists of one thousand, eight hundred transient modes, second by second, simulating conditions of real use. Gas motors are tested only in this cycle.
(2) Only gas motors have to comply with this limit.
(3) Gas motors do not have to comply with to this limit.
(4) E. S. C Cycle - called the European Stationary Cycle – consists of a testing cycle with 13 modes of operation in a stationary regime;
(5) E.L.R. Cycle - called the European Load Response Cycle – testing cycle that consists of a four-level sequence at constant rotations and increasing loads from ten to one hundred percent, to determine exhaust emission opacity.
Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

3.7.1 Vehicle Inspection and Maintenance

The aforementioned benefits provided by Proconve tend to not hold up if correct procedures for fleet maintenance are not adopted in the country. Once in use, and under proper conditions, manufacturers must ensure that pollutant emissions from vehicles shall remain below the limits required by Proconve for at least 80,000 km for Otto cycle vehicles[173] and 160,000 km for diesel cycle vehicles.

The reality of vehicle conservation and maintenance in the country, especially in areas of greater concentration, call for the adoption of inspection programs to ensure the technical revisions stipulated by the manufacturer and in the periods defined by regulatory bodies.

Although there have been prior attempts in this sense, in 2009 Conama approved Resolution nº 418, which established criteria for developing Vehicle Pollution Control Plans - PCPV and the implementation of Inspection and Maintenance Programs for Vehicles in Use - I/M by state and municipal environment entities.

Article 104 of the Brazilian Traffic Code - CTB[174] also contributes in this sense, by determining that "vehicles in circulation shall have their safety conditions, pollutant gas emission and noise controls evaluated by inspection, which will now be mandatory, in the form and frequency established by the National Traffic Council - Contran, for safety items, and by Conama for pollutant gas emissions and noise."

At the national level, Rio de Janeiro is the only state with a significant history of implementation of programs of this nature. Instituted in 1997, the state program encompassed, in its initial phase, only the Rio de Janeiro Metropolitan Region. It was then expanded to the entire state thanks to the adoption of a technical cooperation model between the State Environmental Engineering Foundation – FEEMA, currently the State Institute for the Environment – INEA and Detran-RJ.

In terms of fleet coverage, at first it involved vehicles with more intensive use, like buses, trucks and service utility vehicles (taxis and vans). In a second phase, initiated in January 2008, this annual inspection was expanded to passenger cars, motorcycles and other vehicles manufactured after 1998.

In 2008, The Vehicle Environmental Inspection Program of the city of São Paulo expanded its inspection scope. It was once geared towards the entire diesel fleet registered in the city. In 2009, all diesel vehicles underwent inspection, as did all motorcycles (except 2-stroke motorcycles) and cars powered by alcohol, gas or gasoline registered in the city between 2003 and 2008. It is estimated that in 2010, the program shall reach 100% of the fleet (6.5 million vehicles).

3.7.2 Program for Controlling Air Pollution from Motorcycles and Similar Vehicles - Promot

The rapid growth of the motorcycle and similar vehicle segment in recent years in the country and their usage profile – notably in the delivery service economic sector in urban regions – made it necessary to establish a specific program to control the category's emissions.

Thus, in 2002, the Program for Controlling Air Pollution from Motorcycles and Similar Vehicles – Promot was created, with the objective of complementing Proconve's controls and contributing towards reducing air pollution by mobile sources in Brazil.

The legislation that created Promot was based on legislation in effect in Europe, mainly in European Community Directive nº 97/24/EC, where the first limits proposed for taking effect in 2003 (equivalents to EURO I limits) took into account the technological stage in which the domestic motorcycle and similar vehicle industry stood. Subsequent phases followed with significant reductions in emissions, equivalent to those established by the European Economic Community (EURO II and EURO III limits). Subsequently, Ib-

172 Conama Resolution nº 403, of November 11, 2008.
173 For which Emission Deterioration Factors must be determined through highway travel accumulation tests, as per Conama Resolution nº 14, of December 13, 1995.
174 Law nº 9,503, of September 23, 1997.

ama Normative Instruction nº 17/2002 and Conama Resolution nº 342/2003, complementing Resolution nº 297/2002, were issued, establishing EURO III limits for motorcycles, which entered into force in 2009.

These milestones positioned Brazil just one control phase behind the European Community and resulted in a reduction of 2/3 of carbon monoxide emissions compared to previous models without emission controls.

In an analogous manner to Proconve, Promot "phases" consist of the time between a specific emission limit given by legislation takes effect and when new and more restrictive limits enter into force (Phases "M") (Table 3.8). The phases consider technological innovations in motorcycles and similar vehicles that enable reducing emissions. In terms of the adopted emission limits, Table 3.9 shows the achievements afforded by Promot.

Table 3.8 Promot implementation strategy ("M" Phases)

Phase	Implementation	Characteristic / Innovation
M-1	2003-2005	Established the maximum initial limits for exhaust gas emissions for new mopeds (two-wheeled and similar vehicles equipped with an internal combustion motor, whose engine size does not exceed 50 cc).
M-2	2006-2008	The second phase began with drastic reductions in limits set in the 1st phase (CO = 83% reduction in emissions; Hydrocarbons + NO_x = 60% reduction).
M-3	2009 on	Considered all models of new mopeds, motorcycles and similar vehicles and vehicles in production. There was also a significant reduction in pollutant emission in this phase, sometimes greater than 50% better than the limits stipulated in the previous phase.

Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

Table 3.9 Emission limits for Mopeds, Motorcycles and Similar Vehicles according to Promot phases

Vehicles	Phase	Engine Size	CO (g/km)	HC + NO_x (g/km)	HC (g/km)	NO_x (g/km)	COr* (% vol)
Mopeds	Phase 1 - 2003	-	6.00	3.00	-	-	-
	Phase 2 - 2005	-	1.00	1.20	-	-	-
Motorcycles and Similar	Phase 1 - 2003	<= 250 cc	13.00	-	3.00	0.30	6.00%
		> 250 cc		-			4.50%
	Phase 2 - 2005	< 150 cc	5.50	-	1.20	0.30	-
		>= 150 cc		-	1.00		-
	Phase 3 - 2009	< 150 cc	2.00	-	0.80	0.15	-
		>= 150 cc		-	0.20		-

*COr = revised carbon monoxide.

Source: Elaborated by ZAMBONI, A.; SILVA, L. A.; DIAS, J. B.

Promot Results

The main results by Promot show clear achievements in pollutant emissions controls in these vehicles. In 2000, a new motorcycle emitted 16 times more carbon monoxide than a light vehicle (12 g/Km compared to 0.73 g/Km for an automobile). In 2006, this rate fell to 2.3 g/km in motorcycles compared to 0.33 g/km for cars (data refer to motorcycles with 150 cc or less). With the implementation of the program, there was a reduction in emissions of around 80% for carbon monoxide and 70% for hydrocarbons. For 2009, emission limits for pollutant gases from motorcycles and automobiles will be very similar.

3.8 National Logistics and Transportation Plan - PNLT

The transportation sector is a major contributor to greenhouse gas emissions in the world. Every day it consumes more energy to move the growing population and globalized production.

Although Brazil is less dependent on oil in the transportation sector than other nations in the world due to its use of alternative fuels, such as bioethanol and natural gas vehicle - NGV, the sector's greenhouse gas emissions are still considerable.

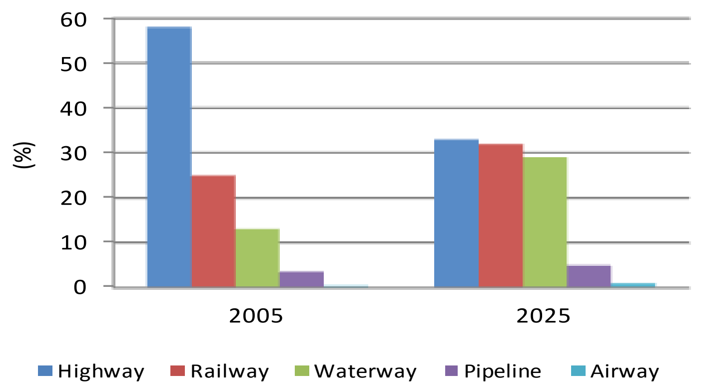
It must be pointed out that, more than half a century ago, the country's transportation mix was primarily based on highways, for freight and passengers. Since a good part of this transport, especially trucks and buses, is still powered by diesel, this results in higher greenhouse gas emissions.

Although not directly developed to reduce sector greenhouse gas emissions, but rather to try and correct distortions in the country's transportation mix, mainly seeking a more balanced freight transportation mix, the National Plan for Logistics and Transportation - PNLT (PNLT, 2007) can also result in importation emission mitigation measures.

The PNLT is a government plan developed to be a State plan, that is, a proposal for the country that will subsidize elaboration of the next four Multi-Annual Plans - PPA. The plan marks the resumption of transportation planning in the country, being the product of a partnership between the Ministry of Transportation and the Ministry of Defense.

With the progressive implementation of projects planned under PNLT, the intention is to balance the Brazilian transportation mix as indicated in Figure 3.2.

Figure 3.2 Freight Transportation Mix in Brazil



Source: PNLT - 2007. Available at: <http://www.transportes.gov.br/pnlt/index.htm>.

3.9 Measures Against Deforestation in the Amazon

3.9.1 Main Causes of Deforestation

Large Development Projects

Social, economic and political inequalities among the different regions of Brazil, as well as the stratification of Brazilian society, led to the implementation of development projects in border areas, especially between 1960 and 1980.

Low land prices and the consequent expectation for future gains, easy access to natural resources, a lack of awareness of resource depletion, and the concession of fiscal and credit incentives by the government were factors that attracted the private sector, without any interest in improving technologies that would provide competitiveness and sustainability to resource exploitation.

Deforestation in the Amazon[175] caused by the aforementioned factors began in the 1970s, when agricultural settlement programs were launched in the North region, promoted by the Military Government at the time. The movement began along the southern and eastern borders, extending to the west in the 1980s.

The region's settlement programs at the time were supported by the Program for National Integration - PIN, the Program for Land Redistribution and Incentives for Agroindustry in the North and Northeast regions - Proterra[176] and

175 The Brazilian Legal Amazon encompasses the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Tocantins and a part of the states of Mato Grosso and Maranhão, corresponding to approximately 4.2 million km^2. Of this total, the forest profile classes extend over nearly 3.4 million km^2.

176 PIN and Proterra were part of the national integration policy for the North and Northeast regions, established in the I National Development Plan (1972-1974). The PIN mainly encompassed construction of the Transamazonia (a transversal axis running east-west to connect with the Northeast and a north-south longitudinal axis to connect with the central south of the country). It also encompassed settlement of the surrounding region in association with private enterprise, installing housing clusters. Proterra, in turn, through a land review of these regions, aimed at splitting large properties and expanding properties with insufficient size for economic exploitation, with a view to stimulating the mid-sized rural company and alter traditional production systems by proper use of the land, credit and application of modern technologies to increase sector productivity.

the Programs for Agriculture and Livestock and Agromineral Hubs in the Amazon - Polamazônia[177].

In general, the objectives of large development projects in the Amazon focused on an increase in the intense production/extraction of natural resources, especially minerals and wood; on the creation of an industrial pole for assembling electro-electronic equipment and gem-cutting and polishing; on support for agriculture and livestock activities; and on occupation of distant regions to ensure territorial sovereignty. In three decades, little has been invested in the sense of attracting private companies capable of implementing competitive production structures and innovative technologies in the North region.

Large cattle ranches, agricultural settlement projects and most of the mega projects for development funded by the Federal Government in the region proved to be unsustainable over the mid-term and provided very low social return and high environmental impact.

The following had an influence on deforestation in the Amazon, among other factors: credit policies that offered lower real interest rates on loans for agricultural activities than for non-agricultural sectors; the policy that guaranteed minimum prices for rural producers; flexible "right to ownership" rules for squatters; low property taxes; and fiscal incentives for investing in approved undertakings in the region.

Between 1960 and 1990, centralized decisions – with the participation of the Superintendency of Amazon Development - Sudam – on infrastructure works and development projects fostered by the Federal Government as "actions for developing and integrating the North region," did not fully take into account the environmental, cultural and socioeconomic realities of the region. This can be seen in the deforestation rates in 1995, of 29,059 km^2, the highest rate since the beginning of satellite monitoring in 1988.

This period represented little in terms of regional development due to the low technological standard of the Amazon's main activities and its low social development index.

A study released in 2009 assessed how human development varies along the deforestation border to determine whether deforestation is associated with an improvement in the population's well-being (RODRIGUES et al., 2009). This study was based on HDI data from 286 municipalities in the Brazilian Amazon (UNDP, or PNUD in Portuguese, 2000). The municipalities were grouped into seven categories describing their position in relation to the deforestation border in 2000, defined in relation to deforestation activity as well as the extension of deforestation. The categories vary from municipalities with virtually no deforestation, progressively moving on to deforested categories, with an increase and subsequent decline in deforestation activity, to highly deforested municipalities.

The results show that those living in municipalities that cut down the entire forest do not have a better quality of life than those living in municipalities that preserved the forest. The deforestation process promotes a slight improvement in the population's quality of life rates in the initial stages, but this tapers off as deforestation begins to affect larger areas of the municipality. Thus, deforestation does not generate wealth, and it actually compromises the possibility of future generation of wealth and opportunities. This theory (tested by RODRIGUES ***et al.***, 2009) is known as the boom-collapse (SCHNEIDER ***et al.***, 2000).

Characteristics of Economic Activities in the Amazon

The relations between primary activities and the forest in the Amazon are in competition because they need space for production. Great growth in agriculture and cattle-raising are reported in the Amazon after 1970, which can be related to deforestation rates. This expansion was driven by growing population pressure in the region, stimulated by government programs and lines of credit. In recent decades, the Amazon has shown a strong growth in resident population, especially in big cities. In the North region, the population jumped from approximately 5.9 million inhabitants in 1980 to nearly 10 million in 1991, and reaching close to 12.9 million in 2000 and more than 15 million in 2007. This population pressure is also one of the factors that cause changes in land use in the region.

In addition to being a factor for deforestation in the region, agriculture and livestock growth in the Amazon can result in degradation and abandonment of areas used.

In recent decades, a great number of roads have been built for the circulation of people and products. This is directly correlated to population density, agriculture establishments, economic activity and, consequently, deforestation.

The direct effects of mining in the Amazon on deforestation have been limited, but major investments in mineral hubs led to a development boom with more encompassing impacts in the region. However, gold mining caused enormous environmental damage to the region and to the local population, especially pregnant women, children and the elderly (HACON et al., 1997; HACON, 2000). It is estimated that

177 Polamazônia aimed at promoting the integrated use of agriculture and livestock, forest and mineral potential in projects located in 15 selected areas and spatially distributed over the Legal Amazon.

for each kilo of gold extracted from the Amazon, 1.2 kg of mercury has been released into the atmosphere (LACERDA et al., 2001).

Another important economic activity in the Amazon is logging, which is not a recent activity, since it has been carried out for more than 300 years. However, it was conducted in a rudimentary manner, with the extraction of few species, without causing any significant damage to the forest ecosystem. Wood was a byproduct from clearing the land for agriculture. However, in the past three decades, a much more intense and predatory logging system has been reported, clear cutting, with the use of machines that make it possible to extract a large number of plant species in a short period of time, in an unsustainable manner, disturbing the entire forest ecosystem.

Brazil is considered as a major tropical wood producer in the world, as well as a large consumer. It also has an considerable participation in the international wood market and it is the second biggest exporter of sawn tropical wood.

Another factor that must be considered when evaluating economic activities in the Amazon is that the wood, as well as other extractive products from the forest (nuts, rubber, etc.) has a relatively low market value. Thus, its predatory extraction, besides reducing the region's natural resources, has not contributed towards improvement in the local population's income, creating a vicious cycle between poverty and environmental degradation. On the other hand, its sustainable extraction is a livelihood for indigenous peoples and traditional communities in the region, whose sustenance is threatened by the uncontrolled exploitation of these resources for commercial purposes.

Forest sustainability, encompassing its environmental, legal, economic, and social aspects is viewed as imperative for the region. Therefore, criteria and methods must be established that enable the exploitation of forest resources, taking into account balance between regrowth and production. Sustainable forest management can be a feasible alternative for achieving this goal and national legislation has sought to reinforce and encourage this option.

The inefficient use of forest resources in the Brazilian Amazon stems primarily from two causes: (i) market failures related to a lack of property rights that, combined with the abundance of lands, forests and mineral resources, among others, leads to their overutilization; (ii) institutional failures and difficulties in regulating property rights, making it necessary to strengthen the region's institutional structure, that is, increase the technical and administrative capacity of research, regulation and monitoring, and enforce compliance with the law at the local and national levels. The Federal Government has strived to solve these issues since 2006, seeking to encourage sustainable forest management in public lands in the Amazon by instituting a legal (Public Forest Management Law and its regulations) and institutional (creation of the Brazilian Forest Service and definition of state and municipal competences) framework.

Sustainable forest management is defined under the Public Forest Management Law as "administration of the forest to achieve economic, social and environmental benefits while respecting the mechanisms that support the ecosystem, which is the object of management, and cumulatively or alternatively considering the use of multiple wood species, multiple non-wood products and byproducts, as well as the use of other forest goods and services"[178,179].

Thus, forest management plans must be guided by concern in relation to the conservation of natural resources, forest structure and its functions; and maintenance of biological diversity and socioeconomic development in the region. This law also creates a forest concession modality, called onerous delegation, made by the granting power, of the right to practice sustainable forest management to exploit products and services at a management unit, through a tender, to the organization, in a consortium or not, which meets the demands of the respective public tender announcement and demonstrates the capacity for performing such, assuming all costs and risk for a certain period of time. Thus, sustainability and State control are sought over commercial logging.

It therefore attempted to regulate the exploitation of forests and other forms of tree vegetation for alternative land use in the Amazon. Brazilian forest legislation also makes mandatory to replace forest stocks. This is replacing the volume of raw material extracted from natural vegetation with the volume of raw material resulting from afforestation for generating a stock or recovery of forest cover. The individual or organization who uses forest raw materials from the cut of natural vegetation and that is authorized to cut this natural vegetation is obliged to replace the forest stocks[180].

178 Article 3, clause VI, of Law nº 11,284/06.

179 This Article is in conformity with Article 4.1(d) of the UNFCCC, which states that all Parties, in accordance with their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall "promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs for all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and maritime ecosystems."

180 Decree nº 5,975, of November 30, 2006.

The main obstacles to sustainable forest management are economic, social, technical and institutional. Major problems identified are management's low profitability, in some cases, mainly due to competition from predatory logging, and the tendency for conversion of natural forest areas into areas for agriculture and livestock production.

Furthermore, although the country has gained broad experience in forest growing and biotechnology techniques from sub-tropical planting, these innovative management techniques are restricted to the South and Southeast regions, and have yet to be extended to the Amazon's forest resources. It is also necessary to point out that there are few centers for technical training and few skilled workers for this activity in the region.

One of the factors of complexity and high cost for implementing forest management in tropical areas is the high diversity of tree species - ssp. While management plans in temperate areas are carried out to support 30 ssp/ha, in wet tropical forests they must be conceived to support nearly 400 ssp/ha. This diversity of species implies lower density of individual of a same species, making forest management less productive than when it is conceived for few species.

Land Distribution and Macroeconomic Issues

According to IBGE data, the land status for this region reveals that 24% of the territory is claimed as private area; 29% is covered by legally protected area, including Protected Areas and Indigenous Land; and 47% is public and/or unoccupied land on which Public Authority supervision is still incipient.

The lack of land use planning and land regulation in this large volume of public lands, combined with the fragile presence of the State, encourages "land grabbing"[181] and other forms of improper land occupation, and stimulates predatory exploitation of natural resources and impunity for environmental crimes. This state-of-affairs has important social consequences, since it decisively contributes towards stirring up conflicts resulting from land disputes in which, historically, the better capitalized sectors have had advantages, favoring land concentration in the region (BRASIL, 2004).

The land distribution problem is directly related to the primary activity problem in the Amazon. Brazil has a serious land distribution problem, where most of the properties with more than 10 thousand hectares represent more than 40% of productive lands. Due to this unequal distribution, thousands of families have no access to land, which in recent decades has led to a situation of enormous political pressure for pushing through agrarian reform and, consequently, search for new frontiers for agriculture expansion.

The relative weight of properties equal to or greater than 10,000 hectares is very pronounced in the North region. In 1966, 35.9% of the rural properties in the North had 10,000 hectares or more, reaching 56.3% in 1978, and 47.4% in 1992[182].

The 1988 Federal Constitution sought to establish the bases for changing this pattern. The Constitution stipulates that property shall serve its social function[183], and also provides that "the Federal Government is responsible for expropriating on account of social interest, for purposes of agrarian reform, the rural property that is not meeting its social function"[184]. Although the norm that contains the social function principle regarding property entered into force immediately, that is, has immediate applicability, as is the case with all constitutional principles, it is still a topic that raises doubts. The Constitution also provides that "the destination given to public and unoccupied lands shall be made compatible with the agricultural policy and the national agrarian reform plan" [185].

Thus, in the Amazon, especially in the 1980s and beginning of the 1990s, there was a titling and privatization policy for forest covered public lands was pursued. Also, having a large tract of forest on a property made it easier for it to qualify as unproductive for agrarian reform purposes. Although this distortion has been under review in recent years, 80% of the lands allocated for agrarian reform are located in the Legal Amazon.

Over the past few decades, the Amazon has been given priority by the Federal Government for the establishment of rural settlements. The lack of adequate land use planning by the National Institute of Colonization and Agrarian Reform - INCRA and state land bodies has led to the creation of settlements in improper locations. Many family farmers, in precarious conditions of survival, end up abandoning their areas in search of employment or lands in new settlement fronts in the Amazon. Those who buy these areas (generally local merchants, lumber dealers and ranchers, including successful settlers) purchase them through informal transactions. As a result of this land (re)concentration process in agrarian reform settlements, tendencies for increased deforestation are reported, associated with the expansion of extensive cattle-raising (BRASIL, 2004).

181 "Land grabbing" (*grilagem de terra*) is the improper appropriation of public lands by falsifying documents. There are several interests for this criminal practice: real estate speculation, sale of the site's natural resources (especially wood), money laundering and even fund raising.

182 INCRA, Brazilian Land Atlas, 1996.

183 Article 5, clause XXIII.

184 Article 184.

185 Article 188.

This evaluation is needed to understand the relation between deforestation rates in the region, land structure and macroeconomic issues. In Brazil, variations in the deforestation rate may be influenced by diverse factors, including population pressure, economic crises and social conflicts, political instability, and the legal insecurity in specific areas of the region. The mix of these factors in Brazil resulted in a historical increase in deforestation rates in 1994-1995: 29,059 km^2 of Amazon Forest[186]. This represents a 38% increase in relation to the average annual gross deforestation rate reported in 1978-89, of 21,130 km^2.

Additionally, illegal hardwood logging in the Amazon through illegal foreign and national sawmill[187] operations, is still an indication of the need for the institutional strengthening of law enforcement, management and land use planning bodies in the Amazon.

3.9.2 Measures Against Deforestation

Legal Measures

Data raised for a report produced by the then Secretariat of Strategic Affairs - SAE and the annual gross deforestation rate published by INPE[188] provided data that stimulated the government and led it to adopt actions to reverse this scenario[189]. From July 1996, the government created the "Amazon Package", which included two emergency measures.

The first emergency measure[190] provides for the suspension of new authorizations for forest exploitation and a two-year moratorium on granting licenses for the exploitation of two species: mahogany (***Swietenia macrophylla***) and baboon wood (***Virola surinamensis).*** In June 1998, the government renewed the moratorium for another two years[191]. This theme is also being discussed under the Amazon Cooperation Treaty – TCA, in the regional policy objectives for mahogany. Mahogany later obtained international protection through the Convention on International Trade in Endangered Species of Wild Fauna and Flora – CITES.

The second measure[192] restricted clear cutting in the Amazon, thus increasing the legal reserve in the Amazon from 50% to 80%. This measure has been re-issued 67 times[193], which has made it valid until it is revoked by another Provisional Measure or final deliberation by the National Congress.

Another important legal aspect for controlling deforestation is the Environmental Crimes Law[194]. This law consolidates environmental legislation, specifying the environmental crimes and violations and their respective penalties. Thus, compliance with the Forest Code will not be restricted to the economic aspect. It will have more serious consequences for individuals and companies.

In 2000, the National System of Protected Areas - SNUC was created[195]. Implementation and consolidation of protected areas had taken place prior to this law; however, it intensified after this legal measure was adopted and ended proving to be effective in combating deforestation by establishing the use for areas subject to "land grabbing" practices.

In 2002, the Federal Government launched the program Amazon Region Protected Areas – ARPA, with a projected duration of 10 years, to expand, consolidate and maintain part of the SNUC in the Amazon Biome, protecting at least 50 million hectares and promoting the region's sustainable development.

ARPA tries to identify those areas that would be most important to represent samples of the Amazon's ecological diversity; creates and consolidates protected areas for full protection and for sustainable use, organized as groups (mosaics) of protected areas; develops strategies for the long-term financial sustainability of protected areas; considers support for local community development; evaluates the effectiveness of protected areas; and monitors the conservation of biological diversity.

The second phase of the Amazon Region Protected Areas Program (2009-2012) has the goal of creating new areas that will cover 20 million hectares (10 million hectares for full protection and 10 million hectares for sustainable use), reaching 60 million hectares for protected areas in the Amazon by 2012. Financial execution is the responsibility of the Brazilian Biodiversity Fund - Funbio, with funds donated by

186 See: <http://www.obt.inpe.br/prodes/prodes_1988_2009.htm>.

187 The illegal operation of foreign sawmills was identified because 22 of these sawmills declared having 508,000 hectares and were only exploiting 186,000 hectares. However, with these data, ecologists calculated they could extract only 6 million cubic meters of hardwood, while in reality they were declaring production of 30 million cubic meters. A more careful inspection conducted by SAE (see previous footnote) revealed that only 8 sawmills had 1.9 million hectares of forest, fourfold more than the total declared area by the 22 companies together.

188 See Part III, Section 3.10.1, on the Prodes.

189 The report elaborated by the Secretariat of Strategic Affairs was published in 1997, but the previously raised studies serve as subsidy for legal measures in 1996.

190 Established by means of Presidential Decree no 1,963/1996.

191 This moratorium was extended until 2001 for mahogany exploitation.

192 Provisional Measure no 1,511, of July 25, 1996, which, among other measures, gives new wording to Article 44 of Law no 4,771, of September 15, 1995. Provisional Measure nº 2,166, of August 24, 2001, also makes significant modification in Articles 1, 4, 14, 16, and 44, and adds provisions to Law no 4,771, of September 15, 1965.

193 Under nº 2166/01, it was embraced by Constitutional Amendment nº 32/2001.

194 Law nº 9,605/1998.

195 See Part III, Section 3.11, on the National System of Protected Areas.

the GEF, managed by the World Bank; the German Bank for Reconstruction and Development - KfW and the WWF Network, through WWF-Brazil, and the technical cooperation of the German Agency for Technical Cooperation - GTZ.

Major results from Development of Production Activities actions in 2004-2008 include approval of the law[196] that establishes the management of Public Forests, implementation of the forest concession system, increasing the area covered by managed forests with independent certification in the Amazon from 300 thousand to 3 million hectares, and creation of the BR-163 Sustainable Forest District.

Another important instrument instituted by the Public Forest Management Law for sustainable production was the National Registry of Public Forests – CNFP. The CNFP is comprised of the registry of the Federation's public forests, the registries of state, Federal District and municipal public forests, and it will be interconnected to the National Rural Registration System. Its objective is to gather georeferenced data on Brazil's public forests to offer public managers and the population in general a reliable database of maps, images and data with important information for forest management, conditioning community allocation processes on the creation of protected areas, the future holding of forest concessions and contributing towards the transparency of forest information and participation of society in management processes.

This law establishes Public Forest Management for sustainable production; institutes the Brazilian Forest Service - SFB, within the structure of the Ministry of Environment; creates the National Fund for Forest Development - FNDF; and amends other laws[197].

It is also important to emphasize the Law[198] that establishes land title compliance of settlements in Federal areas within the Legal Amazon. Although this law needs adjustments, it is an important step towards solving the land issue in the Amazon, which is one of the main structural problems of deforestation.

Another important measure is the Federal Program to Support Environmental Compliance of Rural Properties, called the "More Environment Program"[199]. The decree creating the Program aims at implementing the Forest Code in the national territory, using georeferenced information on legal reserves and permanent preservation areas, with the subsequent commitment by the owners of rural properties to make these areas compliant with the legislation.

Administrative Measures

Despite the importance of these measures, their effectiveness depends on an improved scheme for surveillance, training and monitoring the Amazon (audits, decentralization, human and institutional training, computerization, education, etc.).

Development of a more effective system for the surveillance of deforestation in the Amazon is fundamental. It must involve actions that seek to direct natural resource exploitation and use towards legality, by enforcing legal instruments. In this regard, surveillance is an important tool for preservation, aimed at coordinating, implementing and enforcing public authority determinations.

Furthermore, a new surveillance plan focusing on audits at large sawmills has been implemented by Ibama, which intends to be more effective than increasing the number of onsite Ibama officials. The previous plan proved inefficient over the long term. Isolation of government officials working in the middle of the forest has been an obstacle for effective action.

Another important element for combating environmental degradation is the country's growing technological training. The INPE's monitoring of the Amazon Forest enables Ibama to implement an identification system and to accompany deforestation dynamics, expanding the effectiveness in using the different legal instruments available to control anthropogenic action in the region.

Ibama's surveillance gained in quality by using new technologies such as remote sensing, satellite images, georeferenced location and aerotransported sensors. Now actions are planned beforehand and they are more targeted.

The annual release of data on deforestation is a fundamental measure to guide the planning of political actions and is an important tool available to the Federal Government and Brazilian society.

Economic Measures

It is necessary to understand that the purpose of all these legal norms, surveillance measures, programs and technological innovations is to seek a change in paradigm of the economic exploitation model in the Amazon Forest.

196 Law nº 11,284/2006

197 Laws nº 10,683/2003; 5,868/1972; 9,605/1998; 4,771/1965; 6,938/1981; and 6,015/1973.

198 Law nº 952, of June 26, 2009. This Law amends Laws nº 8,666, of June 21, 1993, and nº 6,015, of December 31, 1973; and makes other provisions.

199 Decree n 7,029/2009.

The Green Protocol[200] and the incentives for sustainable management in special indirect-use protected areas, known as National Forests - Flonas are among those economic actions that can improve implementation of the "Amazon Package".

The Green Protocol is a declaration of principles signed by Brazil's state-owned banks to guarantee that development projects financed through public investments are environmentally sustainable and in accordance with environmental legislation.

The National Environment Policy[201] states that, without prejudice to the penalties defined under federal, state and municipal legislation, non-compliance with the measures needed for preserving or correcting disruptions and damage caused by degradation of environmental quality will make violators liable to loss or restriction of fiscal incentives and benefits granted by Public Authorities, and the loss or suspension of participation in lines of credit at official credit institutions.

The public financing system has been one of those responsible for environmental degradation and for the non-sustainable conversion of natural habitats. Thus, adjusting financial policies and practices is a fundamental step towards promoting development and conservation of the environment. The impacts of the Green Protocol still need to be clearly evaluated, but if the environmental concerns have been truly institutionalized in financial practices, as called for in the Green Protocol, national financial institutions can be an effective instrument for complying with legislation and environmental programs. This strategy has achieved relative success at international financial institutions.

One of the most effective measures for reducing deforestation was the introduction of environmental criteria for rural credit in the Amazon Biome[202]. Financial operations now require a valid Rural Property Registry Certificate – CCIR; as well as a valid license, certificate or similar document that proves conformity with environmental regulations related to the property where the project to be financed will be implemented, issued by the relevant authority at state level; or, at least, a certificate of receipt for the required documentation for the property's environmental compliance, issued by the relevant state authority.

It is also worth mentioning initiatives by the private sector, such as the "Soy Bean Moratorium" and the "Sustainable Livestock Group", which seek sustainability and production traceability when faced with market pressures.

200 See Part III, Section 3.14, on Financial and Tax Measures.
201 Article 14 of Law nº 6,938/1981, in its chapeau and clauses II and III.
202 By means of Central Bank Resolution nº 3,545.

The Flona projects are another action that embody concerns related to economic incentives and improved surveillance. National Forests are areas of public domain with a status of inalienability and non-availability, in part or in whole, constituting a Federal property, with native or planted vegetation cover, established with the following objectives: 1) promote the management of natural resources, focusing on production of wood and other plant products; 2) guarantee the protection of water resources, scenic beauty and historical and archaeological sites; 3) develop basic and applied scientific research, environmental education and recreation, leisure and tourism activities. The basic intention is to increase the area in the Amazon under State control (21% of the Amazon area in Brazilian territory belongs to the Federal Government), reserving it for afforestation purposes and promoting its sustainable use[203].

On one hand, the Flona project represents an attraction for lumber dealers who now have the chance to exploit resources that are not on their private properties, where they can now postpone hardwood logging. On the other hand, Flona can become areas for promoting research of new techniques for forest management that research institutes and NGOs, such as WWF, have developed. However, these may not be easily disseminated or implemented by entrepreneurs who resist changing their traditional methods, unless they are obliged to do so or receive economic benefits for such.

The revocation of forest concessions that Ibama had already granted, together with provisions ensuring that only sustainable forest activities are permitted in the future[204], and an enhanced establishment of Flonas should represent a preliminary initiative for effectively implementing the "Amazon Package". Its long-term effectiveness depends on three basic measures: a broad review of the land acquisition system, which still allows private companies (national and international) to own huge extensions of land in Brazil; conducting a study to assess whether legal reserves on those properties have been officially ensured, taking into account that actual implementation of legal reserves in the region resulted in a significant contribution for conservation of vegetation cover in Brazil; implementing a broad-based campaign to raise awareness of international consumers about the existence of more than 100 species of tropical trees for commercial use – besides mahogany – so changes in forest project management can be driven by the international market.

In 2002, there were 59 National Forests covering an area of more than 16 million hectares. This number increased to

203 In accordance with Decree nº 1,289/1994.
204 In accordance with Article 3, of Provisional Measure nº 1,511-16/1997.

77 Flona in 2009, reaching almost 23 million hectares[205]. In these areas, the government may be capable of conducting better surveillance, and may allow development of forest activities and sustainable extractive activities.

Another important step taken in developing and reviewing forest management norms and instruments, and which has an economic basis, is the law[206] that regulates Rural Property Tax - ITR, and which favors forest management and replacement, including forest policy mechanisms, when calculating land taxes[207].

The ITR is due annually and it applies to property, useful ownership or possession of a continuous area, comprised of one or more parcels of land located outside a municipality's urban zone, and therefore, in the rural zone. According to this law, for purposes of determining the taxes owed, the value of the property shall be considered, minus those sums related to constructions, fixtures and improvements; permanent and temporary crops; cultivated and improved pastures; and planted forests.

The area to which the tax shall apply is considered the property's total area, minus the following[208]:

a) permanent preservation[209] and legal reserve[210,211] areas;

b) areas of ecological interest for protecting ecosystems, so declared by a competent federal or state body, and which expand those use restrictions stipulated in the above item;

c) areas proven to have no agriculture, livestock, chicken-raising, aquiculture or forest exploitation value, declared to be of ecological interest through a competent federal or state body.

This decision encourages important initiatives, such as the creation of legal reserves and permanent preservation areas, adoption of forest management and expansion of areas in the specific programming of Private Natural Heritage Reserves - RPPNs.

It is also worth noting that a line of credit – called Pro-Recovery – has also been established based on a 4% reduction in interest rates per year[212], for financing under "Constitutional Funds" earmarked for the compliance and recovery of legal reserve and degraded permanent preservation areas. Another measure, as part of this Provisional Measure, which is fundamental in the context of transition to sustainability and legality of rural establishments, is the possibility of using the forest as a collateral for financing sustainable forest management and reforestation, which will also have an impact on other regions in the country.

Another important financial measure that raised great expectation was the creation of the Amazon Fund[213].

Political Action Strategy

The development and execution of an action strategy with national reach and social range requires an innovative position by the Federal Government: listen to all segments involved with the problem; identify proposals and negotiate solutions in search of consensus by elaborating positive agendas with Brazilian states that are part of the Amazon.

Elaboration of a positive agenda assumes that problems such as deforestation and burnings will not be solved by surveillance alone, but rather through a concerted effort by diverse of society, presenting alternatives that generate jobs and income in a sustainable manner, contributing towards the solution of economic and environmental crises based on policy guidelines.

The Presidential Decree of July 3, 2003 instituted the Interministerial Permanent Work Group for the Reduction of Deforestation Rates in Legal Amazon aimed at proposing

205 See Part III, Section 3.11, on the National System of Protected Areas - SNUC.

206 Law nº 9,393/1996.

207 See Part III, Section 3.14, on Financial and Tax Measures.

208 Provisional Measure nº 2.166-67, of August 24, 2001, gives new wording to Article 10 of Law no 9,393/96, stipulates that areas under forest stewardship must also be excluded from the total area of the property for calculating ITR. In accordance with the same provisional measure, which adds a provision to Article 44 of Law nº 4,771/65, "the rural landowner can institute forest stewardship by voluntarily renouncing, permanently or temporarily, the rights to suppression or exploitation of native vegetation located outside the legal reserve and of the area with permanent preservation vegetation". The limitation on use of vegetation in the forest stewardship area must be, at least, the same as established for the legal reserve.

209 Provisional Measure nº 2,166-67 also defines the permanent preservation areas as the "area protected as per the terms of Articles 2 and 3 of the Forest Code, covered or not by native vegetation, with the environmental function of preserving water resources, landscape, geological stability, biodiversity, fauna and flora gene flow, protecting the soil and ensuring the well-being of human populations."

210 Provisional Measure no 2,166-67, of August 24, 2001, gives new wording to Article 1 of Law no 4,771/1965, which defines the legal reserve area as the "area located in a rural property or possession, except the permanent preservation area, needed for the sustainable use of natural resources, conservation and rehabilitation of ecological processes, conservation of biodiversity and sheltering and protection of native fauna and flora."

211 Stipulated under Law nº 4,771, of September 15, 1965, with the wording given by Law nº 7,803, of July 18, 1989; the wording in Provisional Measure nº 2,166-67, of August 24, 2001, should be considered.

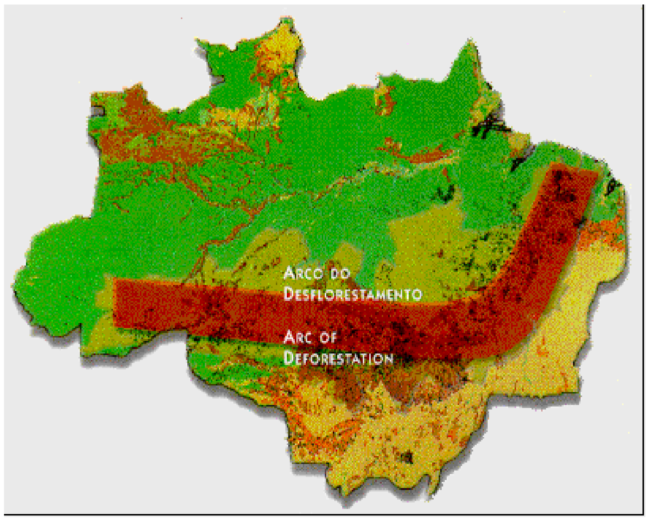
212 By means of Provisional Measure nº 432/2008 (transformed into Law nº 11,775, of September 17, 2008).

213 Created by means of Decree nº 6,527 of August 1, 2008. See Part III, Section 3.14.4, on the Amazon Fund.

measures and coordinating actions to reduce deforestation rates in Legal Amazon through the following instruments:

- land restructuring in municipalities that comprise the so-called Arc of Deforestation ("Arco do Desmatamento"). See Figure 3.3[214];
- fiscal and credit incentives with the objective of increasing economic efficiency and sustainability of already deforested areas;
- procedures for implementing environmentally sustainable infrastructure works;
- generation of jobs and income in activities to recover altered areas;
- incorporation of open and abandoned areas to the production process and management of forest areas;
- integrated action by federal bodies responsible for monitoring and inspecting illegal activities in the Arc of Deforestation; and
- other instruments deemed pertinent.

Figure 3.3 Municipalities with the highest rates of deforestation in the Amazon that make up the "Arc of Deforestation"



Source: IBAMA, 1998.

214 See Part III, Section 3.12.1, on the Program for the Prevention and Control of Burning and Forest Fires in the Arc of Deforestation – Proarco.

This team is coordinated by the Executive Office of the Presidency of the Republic ("Casa Civil da Presidência da República") and it is comprised of 13 Ministries. It established the Action Plan for the Prevention and Control of Deforestation in Legal Amazon - PPCDAM as one of its main goals.

The general objective of this plan is to promote a reduction in deforestation rates in Brazilian Amazon through a set of integrated actions of territory and land restructuring, monitoring and control, promotion of sustainable production activities and infrastructure, involving partnerships between federal bodies, state governments, local governments, civil society organizations and the private sector. Creation of the PPCDAM in 2003 resulted in a gradual and significant reduction in deforestation from 2004.

The PPCDAM is divided into 3 main axes of activity:

Land and Territorial Restructuring Axis – The policies related to this axis in Brazilian Amazon, which define norms for land access rights and guidelines for using and exploiting natural resources, have a strong influence on deforestation dynamics, burnings and illegal logging in the region. The specific objectives of strategic territorial restructuring actions in Brazilian Amazon are:

- Provide the Brazilian State with legal, technical and political instruments aimed at guaranteeing territorial restructuring on sustainable bases;
- Combat land grabbing and other forms of improper appropriation of public lands and promote land compliance actions, with priority to critical Arc of Deforestation areas;
- Implement the National Agrarian Reform Program, taking into consideration the region's social, cultural and environmental characteristics;
- Revise public land use and allocation policies in light of sustainable development principles;
- Promote the expansion and consolidation of Protected Areas and Indigenous Lands, with priority to critical deforestation areas;
- Implement territorial restructuring actions and local sustainable development, with priority to critical Arc of Deforestation areas;

Major results achieved through Land and Territorial Restructuring actions in 2004-2008 include creation of a green belt of PAs (about 26 million hectares) along the deforestation border in areas of intense deforestation and land conflict. Additionally, nearly 10 million hectares of Indigenous Lands were certified; new criteria were adopted for the utilization of public lands and thousands of squatters had their Rural Property Registration Certificates cancelled.

Monitoring and Environmental Control Axis – The Plan proposes a set of integrated actions that can establish an effective and definitive presence of the State in the Amazon in the short, medium and long terms. Besides improvement of the entire environmental norm system, the integration of works is essential and must consider the institutional competence of each of the participants and the needs to face problems in an integrated manner, through partnerships. Another proposal is to develop a series of awareness and social mobilization initiatives geared towards the prevention of environmental damage related to deforestation and burnings, integrated to those actions proposed by the Sub-Group to Foster Sustainable Production Activities.

Thus, the following specific objectives were defined in relation to Monitoring and Control:

- reduce illegal deforestation and other illicit environmental activities in critical areas, through the presence of the State by means of monitoring, licensing and surveillance actions, considering the needs for strengthening partnerships between the Federal Government, states and municipalities, and active participation of society;
- improve the systematization and diffusion of updated information from the monitoring of deforestation, burnings and logging, as a subsidy for licensing and surveillance actions and society's participation in the follow-up;
- contribute towards improvement of environmental licensing procedures, overcoming obstacles identified in legal and operational terms; and
- combat environmental crime together with other illicit acts associated to it, creating a culture of "integrated environmental surveillance".

Among the main results of strategic Monitoring and Control actions in 2004-2008, development and consolidation of deforestation monitoring systems (Prodes, Deter and Detex) and improvement of Ibama's surveillance actions based on a methodology for identifying priority areas for surveillance deserve special notice, resulting in an expressive apprehension of volumes of wood in logs and of equipment.

Promotion of Sustainable Production Activities Axis – The proposals defined for this axis consider the following recommendations: the Federal Government, in collaboration with state and municipal governments, should focus its agricultural stimulus policy on increasing productivity in already deforested lands and on incorporating abandoned areas to the production process; it should promote economical options that can coexist with the forest and biodiversity, or those that need the latter to exist; and it should promote the recovery of permanent preservation and legal reserve areas, as called for in the Forest Code.

The following general objectives were established from these considerations:

- contribute towards the region's sustainable development;
- promote sustainable family agriculture;
- promote the recovery of degraded areas;
- promote sustainable community and business forest production (wood and non-wood);
- promote the intensification of agriculture and livestock in already deforested areas in sustainable manners.

In 2008, the PPCDAM (BRASIL, 2004) launched a new level of relationship with state governments in the Amazon region, supporting the elaboration of State Plans for Preventing and Controlling Deforestation. These Plans follow the same principles and guidelines as the federal Plan and will establish goals for reducing deforestation, constituting fundamental instruments for tackling climate change problems. States with state plans will have a seat on the Steering Committee for the Amazon Fund. The new phase of the PPCDAM (2008-2012) is characterized by a strategy that can be summarized as the shared responsibility for controlling deforestation, involving states, municipalities, the private sector and civil society. In this sense, there are measures related to the sustainability of agriculture and livestock financing and monitoring of production chain links. One of the major measures is rural environmental registration, which will enable states and municipalities to conduct more effective monitoring of their vegetation cover, the chance to make the perpetrators of offenses related to non-compliance with the Forest Code liable, and to constitute a basis for a transition strategy for the sustainability of production activities.

Starting in 2008, a list of municipalities with the highest deforestation rates in the Amazon began to be released, with 36 municipalities that year, and 42 in 2009. In order to be removed from the list, the municipalities must have at least 80% of their properties registered in a georeferenced Rural Environmental Registry – CAR system and demonstrate deforestation reductions.

Besides the PPCDAM at national level, some states have already created or are creating their own state plans to combat deforestation, such as Mato Grosso, Pará, Amazonas, and Acre, which launched their Action Plans for Preventing and Controlling Deforestation and Burnings in 2009.

At the international level, it is necessary to point out Brazil's participation in initiatives aimed at promoting a reduction in deforestation at global level, such as the Paris-Oslo Partnership for Financing REDD - Reduction of Emissions from Degradation and Deforestation.

3.10 Amazon Monitoring Program by Remote Sensing

INPE's Program for the Monitoring of the Amazon by Remote Sensing has four operational and complementary systems: Prodes, Queimadas, Deter, and Degrad. Prodes has been operated by INPE since 1988 to estimate the annual rate of deforestation for clear cutting, when forest cover is completely removed. Prodes identifies clear cutting areas greater than 6.25 ha. It does not capture partial clearing of forests resulting from burning and selective logging.

Prodes data are not sufficient for prevention and surveillance actions due to the time they take to be produced and because it only includes clear cutting areas. So, in 2004, INPE implemented the Real Time Deforestation Detection System – Deter – for the continuous monitoring of deforestation and forest degradation. Deter provides the location and approximate size of new changes in vegetation to assist surveillance actions and deforestation controls. The system was created to support the PPCDAM.

Furthermore, since 1985, INPE has maintained a satellite operational system for monitoring deforestation. For such, it developed methodologies and programs to identify points of heat in low resolution satellite images, such as NOAA, GOES, TERRA, AQUA, and METEOSAT.

In 2008, INPE developed the Degrad system as a result of indications of growing forest degradation in the Amazon obtained from Deter data. It is a new system for mapping areas undergoing deforestation in LANDSAT and China-Brazil Earth Resources Satellite - CBERS images, where forest cover has yet to be fully removed. The objective of this system is to map details of forest areas that tend to be converted to clear cutting. These areas are not considered by Prodes.

3.10.1 Project for Estimating Gross Deforestation of the Brazilian Amazon - Prodes

Technical Aspects

The Project for Estimating Gross Deforestation of the Brazilian Amazon - Prodes is the largest forest monitoring project in the world using satellite remote sensing techniques. Since 1988, INPE has been producing annual estimates of deforestation rates in the Legal Amazon. Starting in 2003, Prodes began to adopt the computer assisted interpretation process to calculate the deforestation rate in the Amazon. It is called Prodes Digital to distinguish it from the previous process. The procedure's main advantage is in its georeferencing precision of deforestation polygons to produce a multitemporal geographic database. Disclosure of the data shows the Federal Government's continuous commitment to handle this information with transparency.

The methodology for calculating the rate of Amazon deforestation is based on the following assumptions:

- the images used are from the LANDSAT satellite and they form a grid that covers the entire Amazon, comprised of set of orbits and points. Each image is identified univocally by an orbit-point ordered pair;
- a part of the images cannot be analyzed due to cloud cover problems or conflict between the time needed to process all images and the projected date for releasing the rate. In this case, images are selected to cover the largest deforested area possible the year before;
- starting in 2005, in cases with great cloud cover, images from other satellites (or dates) began to be used to comprise the scene;
- areas not observed due to cloud cover problems shall be taken into account when calculating the estimated increase for each image;

- deforestation only occurs during the dry season. Thus, for each orbit-point, the dry season was established based on climatological parameters. In order to provide an annual deforestation rate on the image, the increases in deforestation shown in each image need to be projected to a reference date.

The image interpretation methodology consists of the following steps: selection of images with the least cloud cover and dated as close as possible to the reference data for calculating the deforestation rate (August 1); georeferencing of the images; transformation of image radiometric data into scene component images (vegetation, soil and shadow) applying the spectral mixture algorithm to concentrate information on deforestation in one or two images; segmentation into homogenous fields of soil and shadow components; non-supervised classification and fields of soil and shadow images; mapping of non-supervised classes into informative classes (annual deforestation, forest, etc.); editing of the class mapping result and development of thematic chart mosaics for each Brazilian state.

Prodes uses images from TM (NASA LANDSAT satellite), DMC (Disaster Monitoring Constellation satellites) and CCD (INPE CBERS satellites) sensors, which cover the Amazon with low time frequency (16 and 26 days) and have spatial resolution of 30 and 20 meters, respectively. These sensors make it possible to map deforestation when the area exceeds 6.25 hectares.

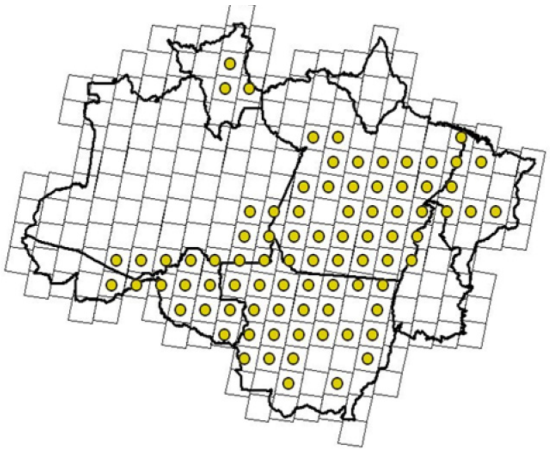
By virtue of the number of LANDSAT and/or CBERS shots needed to map the entire Amazon - approximately 215 images -, INPE calculates the annual rate of deforestation in two steps:

- Priority scenes: These are 85 scenes in which nearly 90% of total deforestation was recorded in 2006-2007 (Figure 3.4). These scenes were given priority for processing so the 2008 rate could be disclosed before the end of the year.

- Non-priority scenes: correspond to the remaining scenes (approximately 130) where less than 10% of the deforestation for 2007 was detected. These scenes are being processed and the final rate was released in the first semester of 2009.

This two-step approach to releasing the rate has been used for several years. From prior year experience, the margin of error for the first deforestation rate estimate is 5%.

Figure 3.4 Location of the 85 LANDSAT scenes used to calculate the deforestation rate for 2007-2008



Data Use

Information provided by INPE enables Ibama and other state environmental entities to conduct a study of the causes, the dynamics and the consequences of deforestation in the Amazon. The integrated surveillance strategy employed by Ibama is based on the following points:

- intense use of aerotransported sensors for identifying selective cutting of wood;

- adoption of satellite communication systems installed in Ibama's surveillance vehicles for consulting registrations, enabling the verification of documents and existence of irregularities; and

- identification, diffusion and application of technologies for the sustainable use of the forest, aimed at replacing environmentally-unfriendly agriculture and forest practices.

As a result, it is possible to control the issuance of notices of violation, authorizations for transporting forest products and surveillance reports, while also enabling a follow-up of the inspectors' work, since each vehicle is monitored.

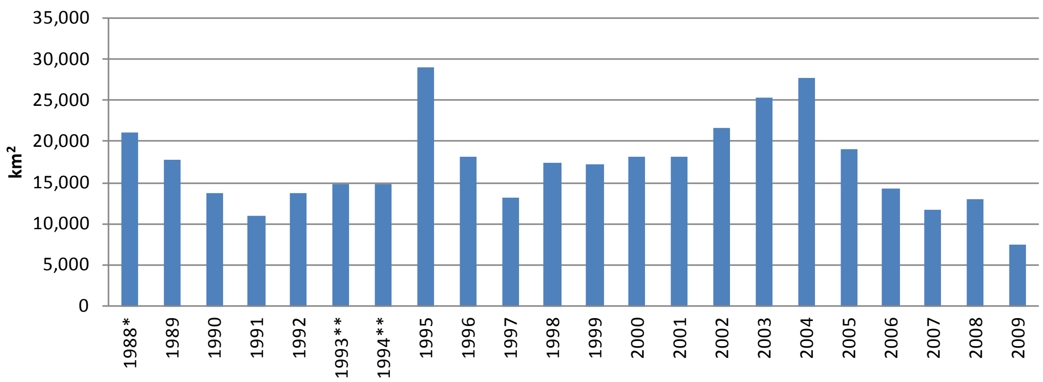
Data Gathered by Prodes

For the purposes of this study, deforestation is defined the conversion of primary forest areas by anthropogenic actions to carry out activities of crop-livestock-forestry integrated system, detected from orbiting platforms. The term gross deforestation indicates that areas in the process of secondary succession or revegetation are not deducted from extension and rate calculations.

From 1995 to 1997, deforestation increased and then decreased. In 1995, deforestation reached its peak, with 29,059 km², compared to the lowest record for the decade, in 1991, of 11,130 km². In 1997, deforestation was reported at 13,227 km², confirming the tendency towards decreasing that began in 1996, when it fell nearly 40%. However, the deforestation rate began to grow again in the period related to 1998, remaining more or less stable between 1998 and 2001. The deforestation rate saw considerable growth between 2002 and 2004, when it reached 27,772 km², near the peak of 1995. Since then, with a series of measures that have been adopted, the deforestation rate has been falling significantly, as proven by the figures for 2009, of 7,464 km² (Figure 3.5 and Table 3.10).

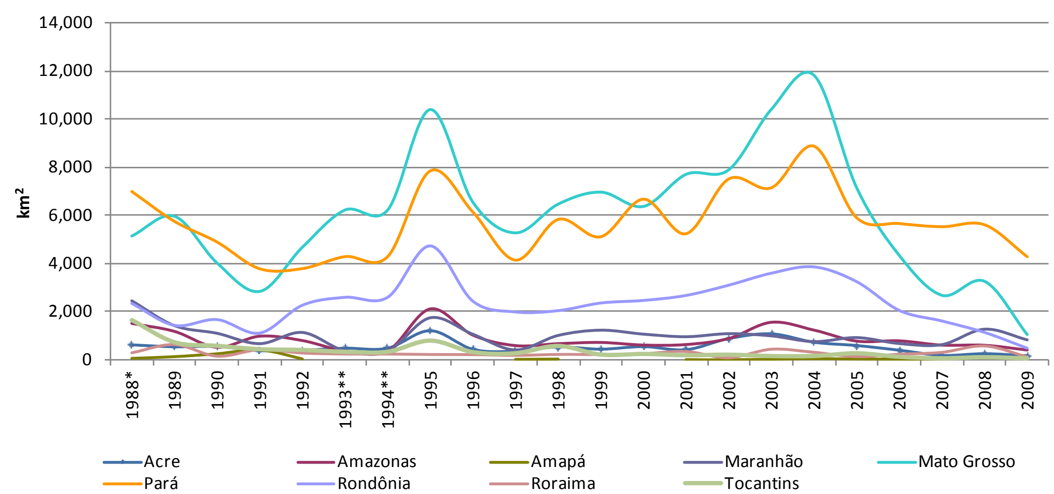
A better view of the change in deforestation figures in each state of the Amazon is provided by Figure 3.6.

Figure 3.5 Annual Deforestation Rate in the Legal Amazon (km²/year)



Notes:
* Average for 1977-1988.
** Average for 1993-1994.
Source: INPE, 2010. Data available at: < http://www.obt.inpe.br/prodes/prodes_1988_2009.htm>

Figure 3.6 Deforestation by area (km²), by state in the Amazon, 1988-2009



Notes:
* Average for 1977-1988.
** Average for 1993-1994.
Source: INPE, 2010. Data available at: < http://www.obt.inpe.br/prodes/prodes_1988_2009.htm>

Table 3.10 Average gross deforestation rate (km²/year) from 1978 to 2009

states\ year	1988*	1989	1990	1991	1992	1993**	1994**	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Acre	620	540	550	380	400	482	482	1208	433	358	536	441	547	419	883	1078	728	592	398	184	254	167
Amazonas	1510	1180	520	980	799	370	370	2114	1023	589	670	720	612	634	885	1558	1232	775	788	610	604	405
Amapá	60	130	250	410	36			9		18	30			7	0	25	46	33	30	39	100	70
Maranhão	2450	1420	1100	670	1135	372	372	1745	1061	409	1012	1230	1065	958	1085	993	755	922	674	631	1271	828
Mato Grosso	5140	5960	4020	2840	4674	6220	6220	10391	6543	5271	6466	6963	6369	7703	7892	10405	11814	7145	4333	2678	3258	1049
Pará	6990	5750	4890	3780	3787	4284	4284	7845	6135	4139	5829	5111	6671	5237	7510	7145	8870	5899	5659	5526	5607	4281
Rondônia	2340	1430	1670	1110	2265	2595	2595	4730	2432	1986	2041	2358	2465	2673	3099	3597	3858	3244	2049	1611	1136	482
Roraima	290	630	150	420	281	240	240	220	214	184	223	220	253	345	84	439	311	133	231	309	574	121
Tocantins	1650	730	580	440	409	333	333	797	320	273	576	216	244	189	212	156	158	271	124	63	107	61
Legal Amazon	**21050**	**17770**	**13730**	**11030**	**13786**	**14896**	**14896**	**29059**	**18161**	**13227**	**17383**	**17259**	**18226**	**18165**	**21651**	**25396**	**27772**	**19014**	**14286**	**11651**	**12911**	**7464**

Notes:
* Average for 1977-1988.
** Average for 1993-1994.
Source: INPE, 2010. Data available at: < http://www.obt.inpe.br/prodes/prodes_1988_2009.htm>

3.10.2 Real Time Deforestation Detection System - Deter

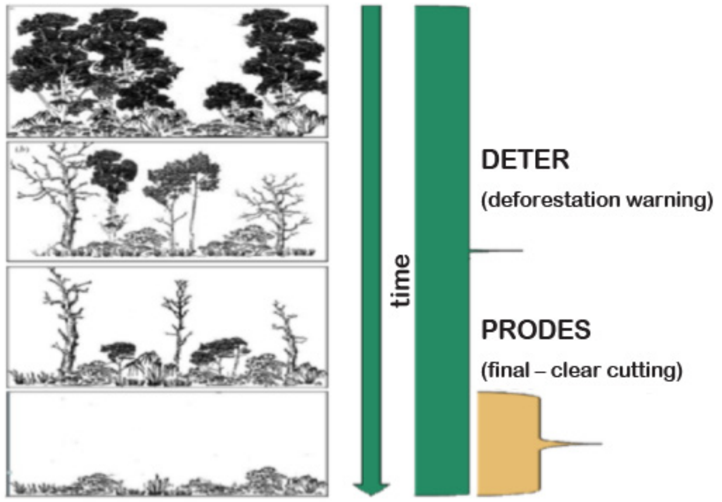
The Real Time Deforestation Detection System - Deter uses images from MODIS sensors on board NASA's TERRA satellite and WFI on board INPE's CBERS-2B Brazilian satellite. These sensors cover the Amazon with high time frequency, every two to five days, respectively, but with moderate spatial resolution of 250 meters. With this spatial resolution, sensor images only make it possible to detect deforestation in areas greater than 25 hectares. Deter's measurements are thus less precise than Prodes, but made with greater frequency.

In assisting in the surveillance and control of illegal forest use, Deter uses a more comprehensive concept of deforestation than Prodes. Prodes only identifies and accounts for the areas that reveal clear cutting, that is, the final stage of deforestation. With Deter, every change in forest cover identified during the period of analysis is indicated as a warning area and liable to inspection, without discriminating the stage of deforestation. Thus, Deter seeks to identify intermediate stages of deforestation. Every 15 days, when observation conditions are favorable, Deter produces a digital map with all deforestation occurrences in the previous two weeks. It thus enables those entities responsible for surveillance (Ibama, SEMAs, Attorney General's Office, etc.) to plan their field actions and combat operations for illegal deforestation.

All data generated by the Prodes and Deter systems, in the form of maps, images or tables, are available at their respective websites[215]. The two systems work in an integrated manner, as shown in Figure 3.7, to improve the deforestation detection system in the Amazon.

215 See: <http://www.obt.inpe.br/prodes> and <http://www.obt.inpe.br/deter>.

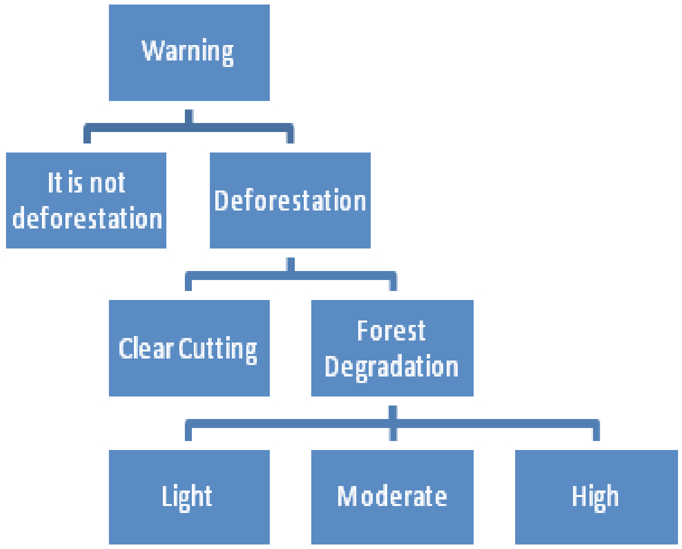
Figure 3.7 Comparison of Prodes and Deter systems in terms of detection time and deforestation process



Starting May 2008, INPE began to classify the deforestation warnings issued monthly by Deter. This classification is carried out by analyzing a sample of Deter polygons in images with better resolution (LANDSAT and/or CBERS).

The warnings are overlaid on the images with best spatial resolution and then classified as Clear Cutting or Light, Moderate or High Intensity Forest Degradation. Warnings not confirmed as deforestation are also accounted for. The classification scheme is shown in Figure 3.8.

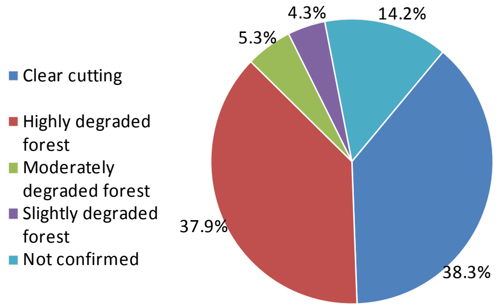
Figure 3.8 Classification Scheme for Deter warning data*



* Final classes are represented by the boxes: 1) Not confirmed as deforestation; 2) Clear Cutting; 3) Light, Moderate or High Intensity Forest Degradation.

Deter's warning system has been showing a good deforestation event confirmation average, as shown in Figure 3.9 for 2007-2008.

Figure 3.9 Proportion of Deter warning area qualified as clear cutting deforestation; high, moderate and light forest degradation; and not confirmed

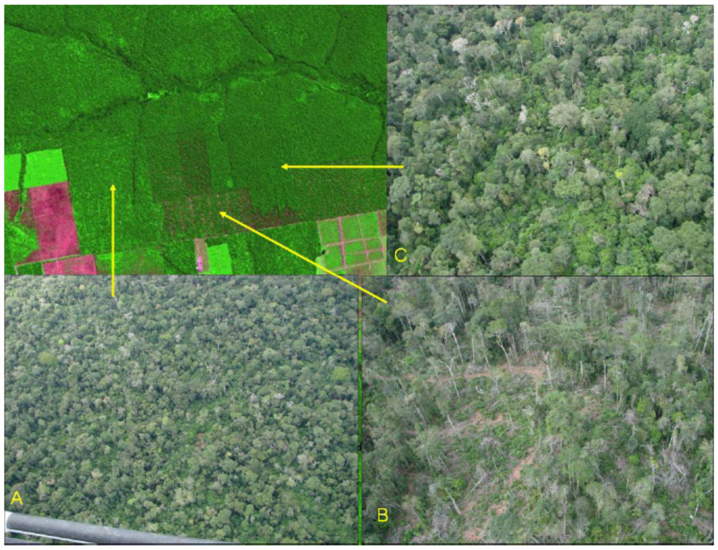


3.10.3 Mapping of forest degradation in the Brazilian Amazon - Degrad

In 2008, INPE developed the Degrad system as a result of indications of growing forest degradation in the Amazon obtained from Deter data. It is a new system for mapping areas undergoing deforestation where forest cover has yet to be fully removed. The system uses satellite images from LANDSAT and CBERS and its objective is to annually map degraded forest areas that tend to be converted into clear cutting areas. Like Prodes, the minimum area mapped by Degrad is 6.25 hectares. In order to better understand the forest degradation process, INPE has developed specific techniques for processing images.

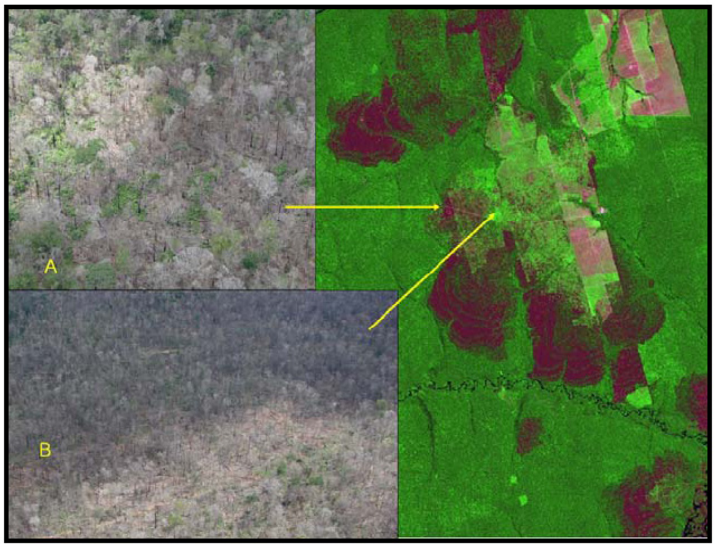
The process consists of preparing the satellite images, applying contrast highlights to underscore evidence of degradation. Degraded areas are then mapped individually. Figure 3.10 illustrates the degradation patterns by wood cutting activity in highlighted images. In Figure 3.11, the patterns resulting from forest fires that occur in logging areas are shown.

Figure 3.10 Patterns of forest degradation due to wood extraction, in highlighted images



A) Moderate intensity degradation, area in regeneration after logging, yards can still be detected;
B) High intensity degradation, active logging, great proportion of soil exposed;
C) Light intensity degradation, evidence of installation of access roads.
(Field photos available at www.obt.inpe.br/fototeca; coordinate for point C: W 54º 27' 14'', S 11º 55' 25'').

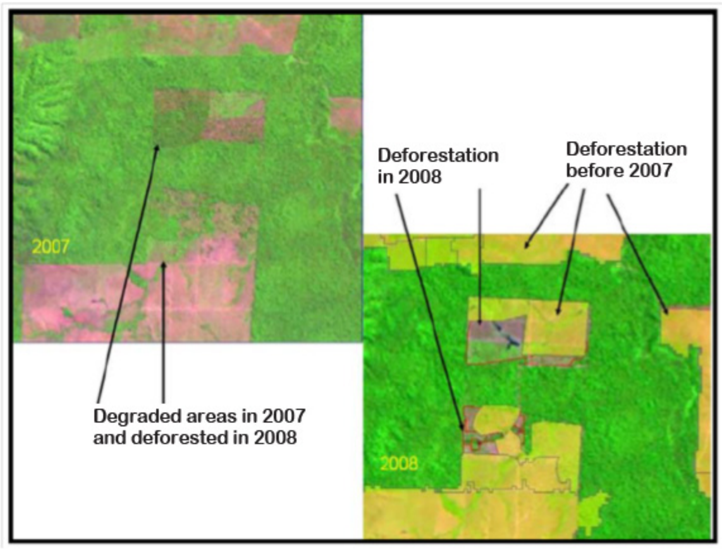
Figure 3.11 Patterns of forest degradation caused by logging and recurring fires



A) Area burned in 2007;
B) Area burned recurrently, considered deforestation;
(Field photos available at www.obt.inpe.br/fototeca; coordinate for point B: W 53º 54' 20'', S 11º 09' 27'').

In 2007-2008, the preliminary study of degraded areas in these images reported 14,915 km^2 in 2007 and 24,932 km^2 in 2008. These values indicate a considerable quantity of areas in degradation, which, as illustrated in Figure 3.12, could become clear cutting if the process is not interrupted.

Figure 3.12 Sample of LANDSAT images from 2007 and 2008*



* Demonstrating the evolution of degraded areas to clear cutting. Approximate location: 51º 52'W, S 06º 09'S.

The mapping of degraded areas and the evaluation of this degradation's intensity advanced greatly with the use of CBERS' HRC images. On board the CBERS-2B satellite, the High Resolution Camera - HRC is a panchromatic sensor that acquires data in the 0.5 – 0.8 ×m spectral band, with 2.7 m of spatial resolution in an imaging band of 27 km, and a 130-day revisit rate.

This 2.7 m resolution allows for detailed identification of features in the areas undergoing selective cut logging, such as wagon trails and log storage yards. Figure 16 compares a LANDSAT image with an HRC image. This figure shows the improved definition of stock yards and trails in a logging area in the HRC image (Figure 3.13 A) compared to the image where only LANDSAT was used (Figure 3.13 B). The areas where forest fires occurred are also clearer in the HRC image in Figure 3.13A.

HRC data began to be processed and made available by INPE in June 2008 and a reasonable quantity of images is already available.

Figure 3.13 Comparison of the image obtained and image using a merger of LANDSAT and HRC/CBERS data (A) and image with LANDSAT data (B)

A) Merger of LANDSAT and HRC/CBERS data.

B) Color composition of LANDSAT data (TM3-Blue, TM4-Green, TM5-Red).

3.10.4 Monitoring Burnings

For more than 20 years, INPE has maintained a satellite-based operating system for monitoring burnings for all of Brazil and a good portion of South America. Various methodologies and computer systems have been developed over these years that make it possible to identify heat spots (hot pixels) in low resolution satellite images, such as the NOAA, GOES, TERRA, AQUA, and METEOSAT satellites.

The splash page for the INPE website on burnings[216] features a map of South America showing the burnings detected on all images received from various satellites over the past two days. Burning spots are indicated by small crosses, and their color indicates the satellite that detected them. The data are updated every three hours. Access to all the information is free and does not require additional programs or equipment.

216 See: <http://sigma.cptec.inpe.br/queimadas/>

The graphs in Figure 3.14 and Figure 3.15 show the comparison of heat spots (burnings) in 2006/2007 and -2007/-2008 using two different satellites, TERRA/MODIS and AQUA/MODIS, which allow for daily detection of burnings by processing their 1 km bands of resolution.

Figure 3.14 Distribution of heat spots observed in 2006-2007 and 2007-2008 by state

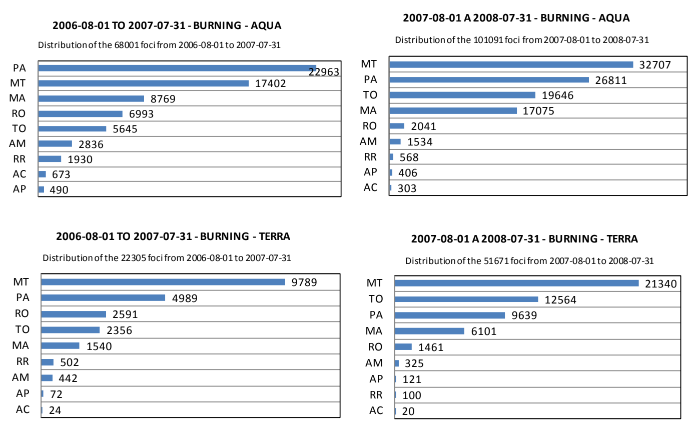


Figure 3.15 Distribution of heat spots observed in 2006-2007 and 2007-2008 by month

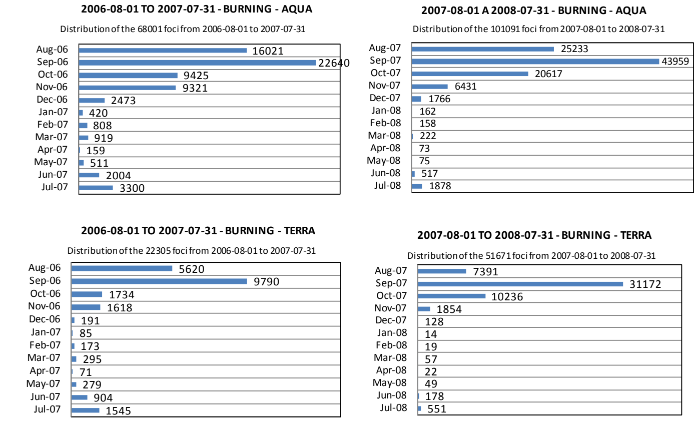
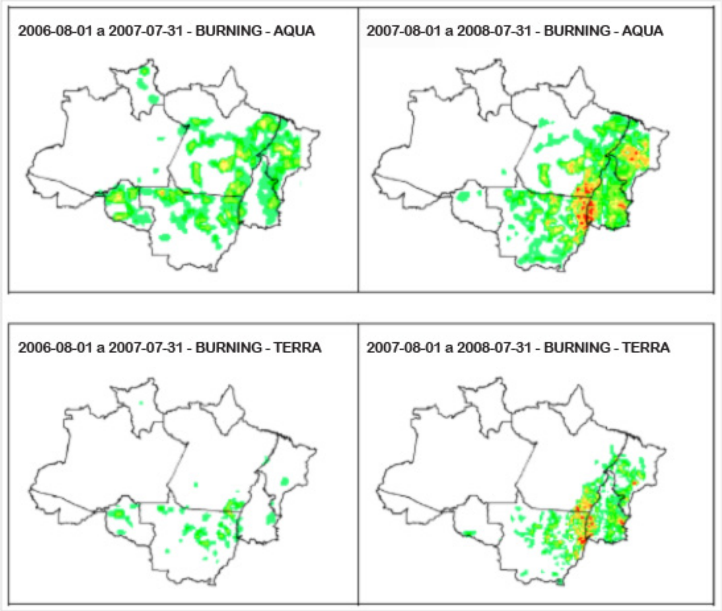


Figure 3.16 shows the spatial distribution of burnings for 2006-2007 and 2007-2008. Each map shows the intensity of the heat spots (hot pixels) in the period, grouped in 20 x 20 km cells. The gradient of green, yellow and red hues represents an increase in the number of spots per cell. There was a large increase in the number of burnings in 2007-2008 in comparison with 2006-2007.

As mentioned, fire is widely used in some stages of the deforestation process. The increase in the number of burnings in 2007-2008, as shown in the graphs, is consistent with the increase in forest degradation areas detected by Deter in the same period.

Figure 3.16 Spatial distribution of heat spots in 2006-2007 and 2007-2008



3.11 The National System of Protected Areas - SNUC

Current Situation

Brazil is one of the wealthiest countries in the world as fas as environment is concerned: its territory contains approximately 1/3 of the remaining tropical forests in the world and the largest fluvial system on the planet. Furthermore, it is home to the largest portion of the biggest area of floodable lands – the Pantanal wetlands; the savannah that is home to the richest biological diversity – the Cerrado; and more mangroves than any other country.

Although Brazil has one of the most advanced environmental legislations in the world[217], there are many difficulties in combating the destruction of Brazilian flora and fauna in many areas. For this reason, protected areas have been created. These spaces are specifically set aside to protect and conserve Brazilian flora and fauna species. Legislation on protected areas was fragmented and sparse. In 2000, the law was approved[218] that consolidates and institutes the SNUC, which is comprised of all federal, state and municipal protected areas. A protected area can be defined as the "territorial space and its environmental resources, including jurisdictional waters, with important natural characteristics, legally instituted by Public Authorities, with the objectives of conservation and limits defined, under a special administration regime to which appropriate guarantees of protection apply."

217 See Part III, Section 3.1, on Environmental Legislation.
218 Law nº 9,985/2000.

The SNUC has the following objectives:

- contribute towards the maintenance of biological diversity and genetic resources in national territory and jurisdictional waters;
- protect endangered species at the regional and national levels;
- contribute towards the preservation and restoration of natural ecosystem diversity;
- promote sustainable development starting with natural resources;
- promote the use of nature conservation principles and practices in the development process;
- protect natural and slightly changed landscapes of notable scenic beauty;
- protect the relevant characteristics of geological, geomorphological, speleological, archaeological, paleontological and cultural nature;
- protect and recover water resources and those related to the soil;
- recover or restore degraded ecosystems;
- provide means and incentives for scientific research activities, studies and environmental monitoring;
- enhance the economic and social value of biological diversity;
- favor conditions and promote education and environmental interpretation, recreation in contact with nature and ecological tourism; and
- protect the natural resources needed for the subsistence of traditional populations, respecting and showing appreciation of their knowledge and their culture, and promoting them socially and economically.

Brazil has an extensive set of protected areas, which has been broadly increased in recent years. The framework for the policy of creating, appreciating and using protected areas is drawn up by the National Council for the Environment – Conama. The implementing bodies are the Chico Mendes Institute on Biodiversity Conservation – ICMBio[219], as well as state and municipal entities.

Protected areas belonging to the SNUC are divided into two groups, with specific characteristics: full protection areas and sustainable use areas. The basic objective of full protection areas is to preserve nature. Only the indirect use of their natural resources is allowed, with those exceptions stipulated by law. The group of full protection areas is comprised of Ecological Stations – EsEc, Biological Reserves – Rebio, National Parks – Parna, Natural Monuments – MN and Wildlife Refuges – ReViS. Sustainable use areas aim at harmonizing nature conservation with the sustainable use of a portion of their natural resources. Environmental Protection Areas - APA, Areas of Relevant Ecological Interest - Arie, National Forests - Flona, Extractive Reserves - Resex, Fauna Reserves, Sustainable Development Reserves and Private Natural Heritage Reserves - RPPNs make up the group of sustainable use areas.

Without counting indigenous reserves and RPPNs, the 311 federally protected areas in the country represented a total area of 79,783,581 hectares, in 2009, which corresponds to 9.35% of Brazil's territory (Table 3.11).

Also, many protected areas are managed by the states (662 PAs in 2005), protecting a total area of 53,171,684 hectares, as shown in Table 3.12. Some of these areas are very large, like the Amanã Sustained Development Reserve – AM, with 2.35 million hectares. This reserve connects to the Mamirauá Sustainable Development Reserve, the Jaú National Park, the Anavilhanas Ecological Reserve and the Rio Negro State Park, all together comprising a continuous corridor in the state of Amazonas of more than 8,567,908 ha, one of the largest protected forest areas on the planet.

219 Law nº 11,516, of August 28, 2007, established the Instituto Chico Mendes on Biodiversity Conservation - ICMBio, whose mandate covers the proposition, implementation, management, protection, surveillance, and monitoring of Protected Areas established by the Federal Government.

Table 3.11 Federally Protected Areas by category

Category		2002			2009		
		Nº	Total Area* (ha)	% country**	Nº	Total Area* (ha)	% country**
FULL PROTECTION	National Parks	47	11,669,883	1.37	64	23,718,701	2.78
	Biological Reserves	24	2,984,401	0.35	29	4,310,906	0.51
	Ecological Stations	28	3,694,311	0.43	32	7,054,300	0.82
	Natural Monuments	-	-		2	44,211	0.005
	Wildlife Refuge	1	152	0.00	5	169,543	0.02
Subtotal	Full Protection	99	18,348,596	2.15	132	35,297,661	4.14
SUSTAINABLE USE	Environmental Protection Areas	28	6,473,193	0.76	32	9,730,516	1.14
	National Forests	59	16,075,244	1.88	77	22,603,405	2.64
	Areas of Relevant Ecological Interest	16	32,371	0.004	16	34,585	0.004
	Extractive Reserves	23	3,906,555	0.46	60	12,052,679	1.42
	Sustainable Development Reserves				1	64,735	0.007
Subtotal	Sustainable Use	127	26,487,364	3.10	185	44,485,920	5.21
Total	**Federally Protected Areas**	**226**	**44,835,960**	**5.25**	**311**	**79,783,581**	**9.35**

* overlays between protected areas were processed including them in the category with the greatest restriction.
** based on Brazil's municipal digital grid of 1996, provided by IBGE; continental area of the country, not including oceanic islands.
Source: Ibama, 2002; ICMBio, 2010.

Table 3.12 State Protected Areas in Brazil

Category		2005		
		Nº	Total Area (ha)	% country
FULL PROTECTION	State Parks	180	7,697,662	0.90
	Biological Reserves	46	217,453	0.03
	Ecological Stations	136	724,127	0.09
	Natural Monuments	2	32,192	0.01
	Wildlife Refuge	3	102,543	0.004
Subtotal	Full Protection	367	8,773,977	1.03
SUSTAINABLE USE	Environmental Protection Areas	181	30,711,192	3.59
	State Forests	58	2,515,950	0.29
	Areas of Relevant Ecological Interest	19	12,612	0.001
	Extractive Reserves	28	2,880,921	0.34
	Sustainable Development Reserves	9	8,277,032	0.97
Subtotal	Sustainable Use	295	44,397,707	5.19
Total	**State Protected Areas**	**662**	**53,171,684**	**6.22**

Source: RYLANDS & BRANDON, 2005.

Thus, adding up all Protected Areas in Brazil – federal and state, full protection and sustainable use PAs, and excluding only the RPPNs –, the total covers 132,955,265 ha, or 15.57% of the country's territory.

As shown in Figure 3.17, Brazil is divided into 6 major biomes.

Figure 3.17 Brazilian biomes

Source: IBGE, 2004.

Table 3.13 shows the current overview of Federally Protected Areas in the country, divided by biomes, in relation to the total area of Brazil and the area of each biome. The Amazon biome is the largest and best preserved biome in the country, with the largest percentage of Protected Areas. Adding only Full Protection and Federal Sustainable Use Protected Areas gives a total preserved area close to 64 million hectares, which accounts for 15.22% of the biome's total area. The Cerrado has Federally Protected Areas that cover over 6 million hectares. The Atlantic Forest, in turn, is in an area experiencing high pressure in terms of the real-estate market and urban growth, because it is located along the entire coast of the country, where some of Brazil's largest cities are located, such as São Paulo and Rio de Janeiro. Perhaps, for these reasons, the creation and maintenance of Protected Areas in areas with Atlantic Forest cover are more important than in any other region of the country. Despite all the pressures, over 4 million hectares of the Atlantic Forest are preserved through Federally Protected Areas. The coastal ecosystems make up the region with the highest percentage of protected areas in the country. Its Federally Protected Areas represent approximately 32% of the biome's total area.

Table 3.13 Federally Protected Areas by Biome

Brazilian Biomes	Area of Biome* (ha)	% of total	Full protection** (ha)	% of Biome	Sustainable Use** (ha)	% of Biome
Amazon	419,694,300	49.00	28,006,927	6.67	35,871,417	8.55
Caatinga	84,445,300	9.86	844,905	1.00	2,718,640	3.22
Southern Fields	17,649,600	2.06	104,886	0.59	318,000	1.80
Cerrado	203,644,800	23.76	4,552,724	2.24	1,498,749	0.74
Coastline	5,056,768	0.59	358,140	7.08	1,253,075	24.78
Atlantic Forest	111,018,200	12.96	1,283,877	1.16	2,825,868	2.55
Pantanal Wetlands	15,035,500	1.76	146,200	0.97		
Total (2009)	**856,544,468**	**100**	**35,297,661**	**4.14**	**44,485,920**	**5.21**

* according to mapping elaborated by IBAMA/WWF on a scale of 1:5,000,000, only considering the continental area.
** overlays between PAs were processed including them in the category with the greatest restriction.
Source: IBAMA, 2002, ICMBio, 2010.

The municipalities also have organized systems of protected areas, generally subordinated to the respective Secretariats of Environment, with grants in their budgets. Additionally, many universities and research institutes establish and protect significant ecological/forest reserve areas for scientific/experimental purposes, beyond conservation. Examples include the Adolfo Ducke Forest Reserve, with 10,000 ha in Manaus, AM, administered by INPA and the IBGE Ecological Reserve, with 1,260 ha, in Brasília, DF, administered by the IBGE.

Some private organizations administer protected areas aimed at conservation, many of which working in the field of ecological tourism. Mining, energy and forestry companies, especially in the pulp business, have equally important reserves created as environmental compensation or geared towards the development of management techniques. For example, paper and pulp companies maintain more than 1,000,000 protected hectares in the Atlantic Forest region. An example of this type of protected area is the Companhia Vale do Rio Doce's Linhares Forest Reserve, with 21,787 ha, a large and important area of Atlantic Forest.

Various conservationist NGOs maintain important private reserves or ecological sanctuaries. Examples include the Caratinga Biological Station, with 880 ha in eastern Minas Gerais, administered by the Biodiversitas Foundation; the Salto Morato Natural Reserve, with 1,716 ha in eastern Paraná, administered by the "O Boticário" Nature Protection Foundation - FBPN and the Wildlife Sanctuaries Network, established by the Pro–Nature Foundation - Funatura.

Another achievement in recent years was the creation of marine Extractive Reserves – Resex along the Brazilian coast. These reserves only encompass the aquatic part and do not demand solutions to land problems on the coast (protected by ordinary legislation). Besides these Resex, there are federal protected areas comprised of oceanic or coastal islands, as well as others that protect beaches, dunes, coral reefs, marine pastures, bays, estuaries, lagoons with marine influence, bathed areas, mangroves, sand banks and salt marshes. These Protected Areas contributed broadly towards an increase in preservation areas in coastal ecosystems in recent years.

Difficulties in Administering Protected Areas

Although the number of protected areas may be expressive, it is necessary to consider the fact that their simple creation, with the objective of protecting biodiversity, does not guarantee this will indeed happen. In Brazil, many of these areas have implementation problems that make their operation unfeasible. This fact results from a lack of funds provided by the Federal Government to maintain these areas, making it necessary to form international cooperation programs and co-managements with non-governmental organizations.

The main problem faced by the protected area strategy for full protection has been the small number of ICMBio employees by area. Other limiting factors have been lack of access to areas and the lack of means of transport and of equipment. The Army, state and federal police, local governments and non-governmental organizations have been mobilized at strategic points. When involving the Resex and sustainable development reserves, "surveillance helpers" have been mobilized, as have community leaderships trained and accredited by ICMBio. The surveillance of coastal and marine areas has been hampered by the lack of a coast guard operating in the environmental area in Brazil. However, Brazil's Navy frequently collaborates with the ICMBio in this sense.

Another problem identified is that deforestation and occupation of land around the parks for real estate development and agricultural activities convert a large part of this areas in "green islands" under constant external pressure, despite the legislation the projects the existence of these surrounding areas, a 10 km strip around the protected areas. In this "buffer zone", defined in a Conama resolution, human settlement and economic activities must be compatible with the area's role of preservation, not offering risk to its integrity.

However, the situation of Protected Areas in the country has been improving significantly in recent years. The National System of Protected Areas updated and consolidated the principles and guidelines that are the foundation for applying public policies related to on-site conservation of biological diversity, replacing the set of previous laws on the matter and it has been promoting improvements in protected area administration.

In accordance with this law, the entities responsible for protected area administration can receive resources, including visitation fees, or donations of any nature, national and international, with or without charges, from private or public organizations or individuals who wish to contribute. Furthermore, the administration of resources obtained is up to the area's managing entity, and they are used exclusively for their implementation, management and maintenance.

Private Natural Heritage Reserves - RPPNs

Another important step forward in the conservation of biological diversity in Brazil was the implementation of the RPPNs, private areas, created in perpetuity, with the objective of conserving biological diversity[220].

The current model was reached in 1990, where areas considered RPPNs are not deforested and there is no removal of extractive products so the area can maintain the characteristics of a genetic bank, with full and perennial protection[221]. By 2009, 429 RPPNs had been created, distributed in the regions as follows: 46 in the Central-West region, 74 in the Northeast region, 30 in the North region, 102 in the Southeast region and 177 in the South region; although data on the exact area for each area is not yet available.

The landowner can transform the entire area into RPPNs, or just a part of it. For an area to be recognized as RPPNs, it must be significant for the protection of biological diversity, contain landscapes of great beauty or gather conditions that justify environmental recovery actions capable of conserving fragile or threatened ecosystems. Individual or organization owners of RPPNs enjoy some advantages: they do not pay ITR on the part of the property allocated for such; they have priority in obtaining resources from the National Environment Fund – FNMA and they have protection against burnings, hunting and deforestation.

Indigenous Lands

In Brazil, indigenous areas are set aside by the Federal Government for the exclusive use of those indigenous communities that inhabit them. According to the Indigenous People Statute[222], indigenous lands are regarded as reserved areas (indigenous reserve, indigenous park and ingenous agricultural settlement) and lands under the control of indigenous communities. Concomitantly, the National Indian Foundation - Funai[223] stipulated the name "indigenous land" for any territory occupied by the indigenous people.

At the end of the 1970s, the indigenous issue became an important theme for civil society. Indigenous people in Brazil simultaneously began the first movements towards their own organization, in defense of their interests and rights.

Several indigenous organizations and advocacy entities promoted broad-based debates aimed at ensuring the de-

220 The RPPNs were created by Federal Decree nº 98,914/1990, and consolidated by Law nº 9,985/2000.

221 Decree nº 1,922/1996 established rules for the recognition of the RPPNs.

222 Law nº 6,001/1973.

223 By means of Administrative Rule nº 1,060/1994.

limitation of indigenous lands and a critical reflection on integration policy. While they were organizing themselves politically, in the sense of defending rights to ownership of indigenous lands, a debate began on the bases for a new indigenous policy founded on respect for the sociocultural organization of the indigenous peoples.

The significant changes in how to consider and deal with indigenous societies, established in the Federal Constitution, were thus the result of the country's redemocratization process, where the indigenous issue was advocated by the movement that aimed at ensuring the right to ownership of indigenous lands and by criticism of the integration policy.

These were the recent facts that enabled an acceleration of the delimitation work of indigenous lands and made it possible to make them compliant with the law in Brazil. The specific and explicit legal framework, well-defined technical procedures and partnership in the delimitation process - whether with national and international government entities, non-governmental organizations or representatives of the interested indigenous communities - have guaranteed greater legitimacy, consistency and speed in demarcating indigenous lands.

At present, the surface area of the 488 indigenous lands, whose delimitation processes are minimally in the "DELIMITED" phase, total 105,672,003 hectares, or 12.41% of Brazil's total territory. Another 123 are still in the process of identification so it has been possible to add their surface areas to the above total. It must also be reported that there are several references to lands presumably occupied by indigenous people and have yet to be researched to define whether they are indigenous or not. Table 3.14 shows details of the situation for the 611 indigenous lands in the country in terms of their administrative compliance procedure.

Table 3.14 Situation of Indigenous Lands in Brazil

	Nº of Indigenous Lands	%	Area (in hectares)
Under consideration	123	-	0
Delimited	33	1.66	1,751,576
Declared	30	7.67	8,101,306
Certified	27	3.40	3,599,200
Regularized	398	87.27	92,219,200
Total	611	100	105,672,003

Source: Funai, 2010. Available at <http://www.funai.gov.br/indios/terras/conteudo.htm#atual>.

These areas are not considered protected areas since their primary management objective is not the protection of biological diversity. However, due to their extension, they are very important in protecting the country's biological wealth.

Thus, adding up all Protected Areas in Brazil – federal and state PAs, full protection and sustainable use - and indigenous lands -, the total is 238,627,268 ha, or 27.98% of the country's territory. It must be beared in mind that to reach the total number of preserved areas in the country, the Municipal Protected Areas must be included; Permanent Preservation Areas; Private Reserves of Natural Heritage and military areas, plus a large area of native forest (mainly in the Amazon) are not within protected areas.

3.12 Prevention of Fires and Burnings

3.12.1 Program for the Prevention and Control of Burning and Forest Fires in the Arc of Deforestation - Proarco

Throughout the 1980s, deforestation rates in the Amazon consumed more than 21 thousand km^2/year of forest. In the wake of this deforestation, the largest burnings and fires were identified in the region. In this context, the combination of an excessive number of burnings in deforested areas of the Amazon with the adverse effects of ***El Niño*** could increase the susceptibility of the region's vegetation cover to fire, especially in the most southerly portion, which corresponds to the "arc of deforestation".

After the forest fires in the state of Roraima, the Federal Government recognized its limitations in dealing with these problems in an isolated manner, without cooperation with other government and non-governmental bodies. In general, the episode revealed that government institutions that operated in controlling burnings and forest fires were not sufficiently equipped and trained to exercise effective monitoring and control of these processes. Existing programs, at the federal and state levels, did not prove effective in solving the problem, resulting in punctual, uncoordinated and discontinuous actions, with little optimization of infrastructure and financial, material and human resources.

The answer in the search for alternatives was embodied in the Program for the Prevention and Control of Burnings and Forest Fires in the Arc of Deforestation - Proarco, launched in May 1998 by Ibama.

Proarco's general scope[224] is to prevent and combat large scale forest fires in the Legal Amazon, especially in the "arc of deforestation", identified as an area much altered by agricultural activity, forest exploitation and other interventions and subject to damage of great proportions.

For such, the program promoted the integration of bodies from different spheres of government and society in executing prevention actions, surveillance and control of burnings and combating forest fires in the region, decentralizing the execution of actions and defining the responsibilities of the federal, state and municipal governments.

Proarco concluded its activities in 2006, transferring its activities to PREVFOGO.

3.12.2 National System for Preventing and Combating Forest Fires - PREVFOGO

In 1989, the Federal Government created the National System for Preventing and Combating Forest Fires - PREVFOGO[225], as part of Ibama. Its objectives include developing programs to organize, monitor, prevent and combat forest fires and developing and disseminating techniques for the managed control of fires.

PREVFOGO's mission is to "promote, support, coordinate and carry out activities for education, research, monitoring, control of burnings, prevention and combating forest fires in Brazil, evaluating its effects on ecosystems, public health and the atmosphere". Among these activities attributed to PREVFOGO, training and empowering rural producers and fire brigades, as well as combating forest fires and monitoring heat spot from satellite images have stood out.

Since 2001, PREVFOGO, as a specialized center, seeks to establish control over forest fires by contracting Prevention and Combat Brigades. At first, contracting was restricted to Federal Protected Areas, taking into account the size of Brazilian territory and the consequent impossibility to encompass it as a whole, thus prioritizing areas of known biological importance. In these areas, the brigades achieved important objectives for local biodiversity conservation by setting up prevention routines, involving the population surrounding the Protected Areas – PAs, responding to frequent occurrences and forming a field team for combating fires of great magnitude. The number of contracted brigades grew continuously until reaching a peak of 82 PAs served in 2008.

Starting January 2009, contracting of PA brigades became the responsibility of ICMBio, and since then PREVFOGO/Ibama has worked in Protected Areas exclusively in cooperation with that institution, supporting training activities for brigade members and supporting expanded combat events, when requested. Thus, PREVFOGO/Ibama began to play a secondary role at the Federal Protected Areas in issues involving forest fires at a time when there was latent demand for more effective action in several critical municipalities hit by forest fires every year.

The year of 2008 was marked by an extension of this line of action in municipalities notably threatened by forest fires. The main motivation was the fact that a state of environmental emergency was announced in 14 states as a result of climatic conditions that favor the occurrence of forest fires and burnings.[226] That same year, the Ministry of Planning, Budget and Management[227], authorized Ibama to contract brigade members for working in environmental emergencies.

Supported by this instrument[228], Ibama authorized the implementation of prevention and combat brigades with actions in those municipalities most exposed to forest fires, and it determined its operating structure.

With this new direction for PREVFOGO actions, it was necessary to establish objective criteria to choose the municipalities that would be served by the Forest Fire Prevention and Combat Brigades. Thus, 31 municipalities located in 5 states of the Legal Amazon were chosen. The municipal brigade project finished 2008 with 894 fire fighters trained in preventing and combating forest fires (IBAMA, 2009). In 2009, brigade service was expanded, contemplating 64 municipalities, spread over 10 states.

With the definition of these municipalities, continuity was sought in the Forest Fire Prevention and Combat Brigade program, as well as the delimitation of a more direct area of action for PREVFOGO. This may also enable learning about fire behavior in these locations and improve the institution's action. The National System for Information on Fires – SisFogo was created in consonance with the evolution of PREVFOGO's action. The system gathers information on burnings, especially information obtained by the brigades that work in critical municipalities.

The PREVFOGO structure is comprised of teams at the Headquarters and state and regional coordinations, which bring together professionals in specific attributions. The teams are divided as follows:

224 See: < http://www2.ibama.gov.br/proarco/index0.htm>

225 PREVFOGO was created by means of Decree nº 97,635/1989 and it is currently governed by Decree nº 6,099/2007.

226 As per Directive nº 163/2008, of the Ministry of the Environment.

227 By means of Administrative Rule nº 155/08.

228 By means of Administrative Rule no 23/2008.

- Team for Empowerment and Training: has the objective of setting up a human resource empowerment structure to act in forest fires and burnings in the managerial and operational context, in order to offer all agencies that are part of the system opportunities to increase the technicians' level of knowledge and skill. Since this is a pioneer initiative in Brazil, program structuring has been concerned about everything from training trainers to defining program content, elaborating didactic material and the physical structuring of some regional training centers;

- Team for Communication and Environmental Education: its objective is to develop institutional resources (hard copy, electronic and media), promoting training activities (mini-courses on fire), promoting and participating in events and producing and systematizing internal information.

- Team for Inter-Agencies and Control of Burnings and Forest Fires: its mission is to develop actions to prevent and control burnings and forest fires, with the premise that forest fire management has prevention as its basic principle.

- Team for Research and Monitoring: its objective is to develop routines to monitor heat spots (hot pixels) using geospatial information, as well as promoting, supporting and participating in research related to forest fires and burnings;

- Team for Planning and Administration: has the objective of providing administrative, financial and logistics support for PREVFOGO;

- Team for Preparation and Combat: includes actions that will make it possible to anticipate decision-making about a risk of fire as well as act directly in combating fires. It also works at elaborating and implementing operational plans that serve to plan local actions for combat, elaborated based on a diagnosis.

3.12.3 Prohibition of Sugarcane Harvest Burnings in the state of São Paulo

In recent years, the state of São Paulo has recorded rapid growth in sugarcane production, mainly as a consequence of the increase in demand for ethanol to meet the flex fuel vehicle market in the country. From 2008 to 2009, total sugarcane crop area in the state grew nearly 70% (RUDORFF *et al*., 2010).

The most meaningful item of data, from an environmental perspective, is that for the first time more than half of the harvest was made without burning. The report on the 2009-2010 harvest shows that 56% of the harvest was made without burning, compared to 44% that used that technique. Nearly 34% of the 2006-2007 harvest was gathered without burning.

The practice of dehusking sugarcane by burning was common in the state, following the example of other states in the country and other countries in the world. However, this practice began to be contested by members of the state Attorney General's Office through lawsuits and community actions concerned about the effects of this agricultural practice on health, safety, environment and quality of life in urban centers near the fields. Government technicians also began to question sugarcane burning due to environmental damage, especially air pollution, fire risks and greenhouse gas emissions.

From another perspective, harvesting and transporting burned sugarcane is claimed to be cheaper than green sugarcane related costs. Besides, the productivity of manual cutters with burned sugarcane is twofold more than with green sugarcane, so they prefer cutting burned sugarcane even though they are exposed to higher levels of dust and soot.

The government of the state of São Paulo has adopted measures since the mid 1990s in an attempt to contain problems resulting from burning straw, one of the most serious environmental issues in the state, without jeopardizing agriculture production and jobs generated in the sector. There has been notable pressure by plant owners who allege economic difficulties in adopting less impacting methods for cutting sugarcane, which has generated permanent discussions and negotiations for new deadlines for the gradual elimination of dehusking by burning. There is also another complicating factor in the gradual elimination of dehusking by burning and replacing it with mechanized agriculture, i.e., the increase in rural unemployment, with the eventual laying off of labor employed in the sugarcane harvest.

In 1998, joint resolution was published[229] between the State Secretariats of Agriculture and Food Supply and of Environment. It regulates the gradual elimination of sugarcane straw burning, making it obligatory to present plans, criteria, deadlines and reports on the elimination of burnings, among other measures.

Later, in 1999, discussions resumed under the Sugar and Alcohol Chamber of the State of São Paulo, aimed at a new negotiation of the terms of legislation[230] which was unable to meet a series of demands.

229 Resolution no 01/1998.
230 State Decree nº 42,056/1997.

In 2000, the Legislative Assembly of the State of São Paulo approved a law that defined procedures, prohibitions, rules for execution and measures of precaution to be obeyed when using fire in agricultural, pastoral and forest practices, known as the "Burning Law" [231]. This law did not establish a clear timetable for eliminating burnings, nor did it define clear sanctions for those who did not comply.

In 2002, the state of São Paulo passed the law[232] that stipulates the elimination of sugarcane straw burning and sets a timetable for 2002-2031, with the percentages of planted areas where burning must be eliminated. They range from 20% the first year to 100% in 2021, for mechanizable areas, and until 2031 for non-mechanizable areas. Furthermore, the law prohibits burning within a one kilometer perimeter of urban areas and indigenous reserves, and it demands an annual plan from farmers to be delivered to Environmental Sanitation Technology Company of the state of São Paulo – Cetesb, adapting the production areas to the plan for eliminating burnings.

In 2007, the state government and the Sugarcane Industry Union - Unica signed a protocol of intentions (Agro-environmental Protocol for the Sugar and Alcohol Sector), setting new goals for adopting mechanization, in which, in areas that can be mechanized burning shall be abandoned in 2014 and in those with declivities greater than 12% it will be eliminated by 2017[233]. For sugarcane suppliers, the proposal is for total elimination by 2021.

In February 2008, 141 sugar and ethanol industries had already adhered to the Protocol, receiving the respective "Certificate of Agro-environmental Conformity". These adherences correspond to more than 90% of all sugarcane produced in the state of São Paulo. Anyone can accompany the progress of the protocol and the list of industries that adhered to it on the "Green Ethanol Program" website.

Gradual elimination of sugarcane straw burning is regulated[234], and a series of procedures has been determined, such as the prohibition of sugarcane burning from 6:00am to 8:00pm between June 1 and November 30, 2010 (during this period, droughts are common, and uncontrolled fires may become widespread).

The Secretariat of Environment of the state of São Paulo currently uses the burning protocol conditioned on determinations that refer to relative humidity, available on the Gradual Elimination of Sugarcane Straw Burning portal[235].

Since 2007, implementation of the Agro-environmental Protocol of the Sugar and Alcohol Sector avoided the burning of 2.6 million hectares of sugarcane in the state of São Paulo, with the consequent reduction in pollutant emissions, as shown in the data in Table 3.15.

Table 3.15 Reduction in pollutant emissions due to a reduction in sugarcane burning in the state of São Paulo, 2006-2007 to 2009-2010 harvest

Avoided emissions (millions of tons)	Harvest 06/07	Harvest 07/08	Harvest 08/09	Harvest 09/10	Total avoided
CO	413,763	1,896,206	2,250,167	3,368,190	7,928,326
Hydrocarbons	59,109	270,886	321,452	481,170	1,132,617
Particulate Material	35,465	162,532	192,871	288,702	679,570

Source: Secretariat of Environment of the state of São Paulo, 2010. Available at <http://www.ambiente.sp.gov.br/ projetos18.php>.

3.13 Cities for Climate Protection

The Cities for Climate Protection - CCP campaign is an initiative by the International Council for Local Environmental Initiatives - ICLEI, launched in June 1991. It is an international campaign to mobilize local government actions towards reducing greenhouse gas emissions and to raise the international profile of municipal governments ***vis-à-vis*** national governments and the UNFCCC.

The Cities for Climate Protection Campaign provides assistance to cities in relation to adopting policies and imple-

231 Law nº 10,547, of 2000, by means of its Regulatory Decree nº 45,869, of June 22, 2001, stipulates: "the use of fire as a dehusking method and facilitator for cutting sugarcane shall be gradually eliminated, and this reduction can be less than 25% of the area of each agroindustrial unit or property not tied to an agroindustrial unit, (...)". The decree also establishes that after 2001, the burning of sugarcane straw shall not be used at a percentage of 25% of mechanizable areas and 13.35% of non-mechanizable areas."

232 State Law nº 11,241.

233 See: < http://www.ambiente.sp.gov.br/etanolverde/>

234 As per Resolution nº 35/2010 of the Secretariat of Environment of the state of São Paulo, which stipulates the procedures related to the suspension of sugarcane straw burning dictated by State Law nº 11,241, of September 19, 2002, and regulated by State Decree nº 47.700, of March 11, 2003 (available at: http://www.sigam.ambiente.sp.gov.br/Sigam2/Repositorio /24/Documentos/Resolu%c3%a7%c3% a3o% 20SMA%20-%2035,%20de%2011-5-2010.pdf).

235 See: < http://www.sigam.ambiente.sp.gov.br>.

menting quantifiable measures to reduce local emissions of greenhouse gases as a means to improve air quality and life in urban centers.

The campaign is based on an innovative performance structure through five milestones with which local governments are committed. These milestones help local governments to understand how municipal decisions affect energy use and how these decisions can be useful for mitigating climate change while they improve the quality of life in the community. The CCP methodology is in compliance with international standards and it offers a simple way to act on behalf of reducing emissions and of monitoring, measuring and producing performance reports.

One of the campaign's objectives is to coordinate initiatives and provide technical assistance and educational material to municipalities for developing local capacity to understand the problem and implement "Local Action Plans" that can reduce greenhouse gas emissions. To this end, the campaign aims at developing and maintaining a structure that encourages its participants to monitor, qualify and report their results to the ICLEI and to their national governments.

Although developing countries have not signed commitments in the sense of establishing quantified obligations for reducing greenhouse gas emissions, in accordance with the Kyoto Protocol, the cities of these countries can be and are encouraged to adhere to this campaign and take initiatives to reduce their emissions.

The ICLEI promotes this campaign regionally and nationally in Brazil, Australia, Canada, Europe, Japan, Latin America, Mexico, New Zealand, South Africa, south and southeast Asia, and United States. More than 800 local governments participate in the CCP, integrating measures to mitigate global climate change in their decision processes.

Seven cities adhered to this campaign in Brazil: Betim - MG, Goiânia - GO, Palmas - TO, Porto Alegre - RS, Rio de Janeiro - RJ, São Paulo - SP and Volta Redonda - RJ, reaching nearly 20 million inhabitants. Each formalized their adherence to the campaign by signing a municipal or state government resolution agreeing to follow the basic guidelines defined by the ICLEI for their participation, aimed at reducing greenhouse gas emissions, where many of them are already taking local measures for such.

By the end of the pilot project phase in March 2005, Brazilian cities participating in the project had conducted their greenhouse gas emissions inventories, established goals for emission reductions, developed action plans focused on mitigation and implemented at least two of the proposed measures.

The activities in which these cities engaged in 2001 to 2005 focused on promoting awareness of the theme, diffusion among the community and training of municipal technicians. Among the training activities, those that stood out were opportunities for learning among peers; the exchange of experiences with cities from other countries in South America and the Caribbean, members of the ICLEI; participation in international events, including the 10th and 11th Conference of Parties of the Convention, held in Buenos Aires and Montreal, respectively; as well as various thematic seminars held in partnership with the cities concerning the relationship between climate change and solid waste, sustainable transport and energy.

The first test version of the application for calculating greenhouse gas emissions and local pollutants (Harmonized Emissions Assessment Tool - HEAT) was presented in the thematic seminars. It included spreadsheets for entering energy and cost data, especially developed for local governments using the IPCC methodology.

The Cities for Climate Protection Campaign also opened the way for other initiatives that contribute towards reductions in greenhouse gas emissions. Besides a project on sustainable public tenders geared towards climate friendly products, with the participation of the city of São Paulo and the state governments of São Paulo and Minas Gerais, it also created the Local Renewables Model Communities Network in Brazil (Local Renewables), called "Rede Elo" (Network Elo), with two model cities: Betim - MG and Porto Alegre - RS.

3.14 Financial and Tax Measures

3.14.1 Banks' Environmental Responsibility

The Federal Constitution provides that "(a)ll have the right to an ecologically balanced environment, which is an asset of common use and essential to a healthy quality of life, and both the Government and the community shall have the duty to defend and preserve it for present and future generations [236]." Public and private banks cannot be excluded from the concept of "community". In this regard, Brazil has various legal instruments that seek to determine guidelines for public and private banks in their actions regarding the environment.

236 Article 225 of the 1998 Federal Constitution.

The National Environmental Policy Law[237] includes mechanisms that, when applied to financial institutions, in a broad sense, increases financing and credit at the level of instruments for environmental control. Financing, especially through government incentives, should incorporate the environmental component when granted, through the conducting of environmental impact studies prior to analysis of projects and granting of credit, as has been occurring within the World Bank.

Financing organizations are viewed as traditional banks, but also cooperatives, public entities, mixed economy companies, multiple and investment banks and pension funds, in short, all those institutions that may, in a broad sense, fit in the expression "entities or bodies for financing and government incentives".

The Environmental Crimes Law provided various mechanisms with a direct impact on consideration of banks' environmental responsibility. This law stipulates that organizations shall be held administratively, civilly and criminally responsible in cases where the violation is committed by decision of its legal or contractual representative, or its collegiate body, in the interest or on behalf of the entity. The responsibility of organizations does not exclude physical persons, authors, co-authors or participants in the fact.

By granting credit without observance of environmental licensing or Conama standards, the financial institution could be condemned to reimburse for eventual financial losses in face of degradation of the environment. Furthermore, the administrator is placing itself on equal footing with those who commit the pollution-related crimes and can expose the lives of others to danger.

Another aspect must be underscored in the case of fiscal incentives, since these incentives are part of taxes that are being reduced, which society is renouncing, in order to develop a given activity at a certain site. Thus, the very tax would be used to damage the environment.

It must also be pointed out that holding international credit institutions responsible is an achievable measure through sources of International Public Law, while being strengthened by domestic legal mechanisms. Damage caused by international creditors can most certainly not be beyond the reach of the country's jurisdiction, nor can the acts by its employees.

237 In its Articles 3, 12 and 14

Green Protocol

In 1995, the Federal Government launched the Green Protocol progam aimed at incorporating the environmental variable as an indispensable criterion to sustainable development in the analysis process for granting official credit and fiscal benefits.

The Protocol's two original objectives are: give priority to allocating public resources through credit operations or fiscal benefits in projects that present the best capacity for socio-environmental self-sustenance; and avoid using these resources in projects that contribute towards increasing negative impacts on the environment.

In 1995, the "Charter of Principles for Sustainable Development" was signed[238] by the five federal banks (Brazilian Development Bank - BNDES, Banco do Brasil, Caixa Econômica Federal, Banco do Nordeste do Brasil and Banco da Amazônia).

Some priorities were identified among the guidelines of the initial Green Protocol document to be carried out jointly or individually in accordance with the mandate of each institution involved. Three basic groups of themes stood out in these priorities to:

- define criteria and prepare instruments for analyzing the environmental variable in allocating credit;
- identify needs for improving the environmental licensing system and eventual changes in the framework for legislation and environmental regulations; and
- seek new sources and mechanisms to increment the availability of funds for environmental projects.

The Green Protocol achieved results mainly in what concerns awareness and equipping the involved federal financial institutions; the institutional adjustment of licensing mechanisms; the effort to identify external private resources directed towards the environment; designing projects and programs together with the banks, geared towards sustainable development and for discounting environmental liabilities; and most especially, rationing the use of pesticides.

238 By listing the General Principles of Sustainable Development, the aforementioned "Charter" stipulates, among other things, that the banking sector shall increasingly privilege financing projects that are not aggressive to the environment or those that present characteristics of sustainability; that the environmental risks shall be considered in their analyses and financing conditions; and that environmental management requires the adoption of practices that anticipate and prevent degradation of the environment.

In 2008, the Brazilian Central Bank became a signatory of the Green Protocol. Brazil's Federation of Banks – Febraban joined in 2009. Other private banks that also adhered to the Green Protocol include Banco Itaú Unibanco, Santander Brasil, Bradesco and HSBC.

The commitments of the signatory institutions are:

- offer lines of credit and programs that promote the population's quality of life and the sustainable use of the environment;
- consider the socio-environmental impacts and costs on managing their assets and in analyzing project risks, based on the National Environmental Policy;
- promote the conscious consumption of natural resources and of materials derived from them in internal processes;
- inform, make aware and continuously engage interested parties in the institution's sustainability policies and practices;
- promote the cooperation and integration of efforts among those organizations that signed the Protocol.

Furthermore, the Institutions that are part of the Protocol must require environmental licensing in industrial financing, including a differentiated sector analysis by sector (fishing, wood and other extractive products). For granting rural credit, agreements must be made with technical assistance companies, which shall recommend appropriate conservationist production technologies for defending the soil and the environment. In agrarian reform projects, the debtor shall undertake a commitment to conserve the environment, obeying technical and legal criteria for preservation (riparian forests, hillsides, etc.). In cases of rural sector financing, it shall be required to preserve 50% of the Amazon Forest and 20% of the Cerrado areas, with the respective entries at a notary public, a certificate of good standing with Ibama, as well as other licenses stipulated by law.

Other lines of credit also projected include industrial credit, for processing and recycling solid wastes, and financing for sawmills, restricted to those that develop forest management projects, reforestation or whose production line is verticalized.

Table 3.16 shows the banking policies and practices geared towards socio-environmental responsibility adopted by financial institutions in Brazil.

Table 3.16 Banking policies and practices geared towards socio-environmental responsibility adopted by financial institutions in Brazil

2010
BM&F-Bovespa adheres to the Principles for Responsible Investment - PRI.
2009
The BNDES and BM&F-Bovespa announce the creation of stock index focused on global climate change.
Serasa Experian[4] launches "Environmental Conformity", enabling financial institutions to assess compliance with environmental legislation on the part of companies.
Caixa Econômica Federal adheres to the Equator Principles[5].
Banco Itaú Unibanco launches the Itaú Carbon Index Investment Fund, the first Brazilian bank to launch a fund tied to a carbon credit index.
Banco Itaú Unibanco launches its sustainability policy.
Banco Santander adheres to the Equator Principles.
Febraban launches the Green Protocol for private banks, with the initial adherence of Bradesco, Cacique, Citibank, HSBC, Itaú Unibanco, Safra and Santander Brasil – Real.
Brazil's Central Bank creates the Working Group on socio-environmental responsibility.
2008
Brazil's federal public banks launch a revised version of the Green Protocol.
Serasa launches the Social Responsibility Report that incorporates social issues when evaluating credit risk.
Unibanco Asset Management - UAM and Banco Real Asset Management adhere to the PRI.
Banco Real launches the Sustainable CDB, a fixed income security with a socio-environmental focus.
Banco do Brasil, Banco da Amazônia, Banco do Nordeste do Brasil, Caixa Econômica Federal and BNDES re-publish the Green Protocol.
HSBC launches lines of credit with a socio-environmental focus.
Banco Unibanco obtains a line of credit from the IFC to finance projects in renewable energy, energy efficiency and sustainable construction.

BNDES creates the Brazil Sustainability Fund, the country's first investment fund geared towards the development of environmental projects.
Banco Itaú launches a credit policy with a socio-environmental risk classification for corporate clients.
2007
Banco Rabobank launches a carbon credit program to stimulate the reforestation of illegally deforested areas in the Amazon.
Banco Bradesco announces the launch of products with a socio-environmental focus that will generate resources for the Sustainable Amazon Foundation.
Banco Bradesco launches the Banco do Planeta, an area dedicated to centralize and expand all its socio-environmental projects and initiatives.
The Brazilian Mercantile & Futures Exchange - BM&F (*Bolsa de Mercadorias & Futuros*) holds the first public auction of carbon credits in the world.
Unibanco, in an agreement with the Japan Bank for International Cooperation - JBIC, creates a line of financing for projects to sell carbon credits.
Serasa launches the Social Responsibility Report that incorporates environmental issues when evaluating credit risk.
The IFC and the Center of Studies on Sustainability - FGV/SP launch the Latin-American Forum on Sustainable Finances.
Nearly 50 global financial institutions sign the Equator Principles, representing nearly 90% of the project finance market in the world.
Caixa Econômica Federal and Banco Banif launch the Environmental Savings fund, the first fund with a focus on projects in the basic sanitation and environment sector.
Banco Unibanco and Caixa Econômica Federal launch funds tied to the Business Sustainability Index – ISE.
2006
Banco Bradesco is included in the Dow Jones Sustainability Index.
IFC approves its new socio-environmental policies.
Private banks launch a new version of the Equator Principles, ratified by Brazilian banks.
Rabobank launches a socio-environmental policy with criteria for the rural sector.
Banco Bradesco initiates a dialogue with its suppliers on socio-environmental responsibility.
Bancos Itaú, Bradesco and Abn Amro Real launch products with a socio-environmental focus.
Banco Bradesco creates a socio-environmental responsibility area.
Bancos HSBC, Bradesco and Safra launch funds tied to the ISE.
The BankTrack Network launches the "What to Do and not to Do at a Sustainable Bank" manual.
HSBC launches a specific policy for the energy sector.
Abn Amro Real launches an investment in infrastructure fund with an environmental management system - the InfraBrasil Fund.
Pioneer adherence by the Caixa's Previ pension fund to the PRI.
The BankTrack Network launches specific campaigns to monitor banks in developing countries and human rights in financial institutions.
2005
Banco Bradesco creates the corporate socio-environmental policy and committee.
Banco do Brasil adheres to the Equator Principles and adopts socio-environmental criteria in financing projects not included in the Equator Principles.
Banco Itaú improves its socio-environmental policies, creates the Socio-environmental Responsibility Commission and adopts socio-environmental criteria in financing projects not included in the Equator Principles.
HSBC launches specific policies for freshwater and chemical infrastructure sectors.
Abn Amro initiates the launch of specific policies for sectors more sensitive to socio-environmental impacts.
Abn Amro Real expands its line of products with a socio-environmental focus.
Abn Amro Real initiates business with carbon credits.
Banco do Brasil launches a fund linked to the ISE.
Bovespa launches the Business Sustainability Index – ISE.
Petros pension fund adopts socio-environmental criteria for selecting stock portfolios.
Banco Itaú launches products with a socio-environmental focus.
CEBDS creates the Technical Chamber of Sustainable Finances, whose members are Banco do Brasil, Abn Amro Real, Itaú, Bradesco, Caixa Econômica Federal and the Brazilian Mercantile & Futures Exchange - BM&F (*Bolsa de Mercadorias & Futuros*).

Source: Sustainable Finance[239].

239 See Sustainable Finance. Available at <http://www.financassustentaveis.com.br/contexto.asp>.

3.14.2 Ecological ICMS

The Value-Added Tax on Sales and Services – ICMS is a significant part of revenue for Brazilian states and it is also an important source of resources of the municipalities. The Federal Constitution[240] stipulates that 25% of the recourses stemming from ICMS in each state must be passed on to their municipalities; of that 25%, 75% shall be distributed according to the added value generated by each municipality, and the remaining 25% following criteria established by the states themselves.

In recent years, distribution of that final 25% in some states led to a new category that stimulates municipalities to maintain conservation areas and develop correct environmental practices, such as waste and sewage treatment.

This category is called "Ecological ICMS" and it is used to compensate those municipalities that forgo generating products and services so society can enjoy environmental resources and services in their territory. It is an excellent incentive for municipalities not to abandon these environmentally correct activities, since they are not duly compensated by ICMS resources (which in the past almost only privileged economic activity), and for others, especially those not graced by nature with natural preservation areas, to create reserves and carry out ecological activities.

Over time, this experience evolved and the law shifted from a concept of compensation to the spirit of a real "economic incentive", awarding those municipalities with good management of their natural areas. Thus, this mechanism created an opportunity for the state to influence the process of sustainable development in municipalities by awarding some environmentally desirable activities, making the Ecological ICMS a public policy instrument that represents the operationalization of a set of innovative principles for improving Brazil's environmental management, especially the provider-receiver principle.

Some Brazilian states already successfully apply Ecological ICMS (Table 3.17), whereas others are still developing the legal instruments for its application.

In addition to Paraná, the states of São Paulo, Mato Grosso do Sul, Minas Gerais, Rondônia, and Rio Grande do Sul are major pioneers in the use of the Ecological ICMS. However, the individual states set their own distribution criteria according to their region's profile, which helps legitimate the enforcement of Ecological ICMS in areas with a distinctive environmental profile.

240 Article 158.

Table 3.17 Ecological ICMS in the states

state	Year Ecological ICMS law was approved	Percent of Municipality ICMS distributed according to environmental criteria	Distribution criteria
Paraná	1991 (Complementary State Law nº 59/1991)	5%	Based on two criteria: protected areas and water sources for supply, each with 2.5%, totalling 5% of the ecological criteria contained in the law.
São Paulo	1993 (Complementary State Law nº 8,510/1993)	0,5%	Municipalities with areas set aside for environmental protection, created by and the responsibility of the state.
Mato Grosso do Sul	1994 (Complementary Law nº 077 of 12/7/1994)	5%	Municipalities with Protected Areas, Indigenous Lands and Water Sources for Public Supply.
Minas Gerais	1995, with legislation amended in 2009 (Complementary State Law nº 18,030/2009)*	1% of the constitutional ¼ and after 2011, it will be 1.10%.	Divided into three indexes: 1. Environmental Sanitation Index, which refers to Sanitary Landfills, Sewage Treatment Plants and Composting Plants; 2. Conservation Index, geared towards Protected Areas and other similar sites, and; 3. The last one is based on ratio between the area with dry forest in each municipality and its total area.
Rondônia	1996 (Complementary State Law nº 147/1996	5%	Protected Areas and other especially protected spaces.
Rio Grande do Sul	1997 (State Law nº 11.038/1997)	7%	Municipalities with Protected Areas
Pernambuco	2000 (Law nº 11.899/2000) Socio-environmental ICMS	3%	1% to municipalities that have Protected Areas and 2% to those municipalities with treatment or final disposal systems for Solid Waste.

Goiás	2007 (Approved Constitutional Amendment nº 40 – lacks state regulation)	5%	This state has no information on transferring Ecological ICMS to municipalities, since it has yet to legislate on the matter.
Ceará	2007 (Approved Law nº 14.023/2007) Socio-environmental ICMS	2%	Ceará adopted the Socio-environmental ICMS considering not only the environment, but also education and health among its tax transfer criteria. It is divided as follows: 18% for the Municipal Index on Educational Quality – IQE; 5% for the Municipal Index on Health Quality – IQS; and 2% for the Municipal Index on Environmental Quality – IQM...
Rio de Janeiro	2007 (Approved Law nº 5,100/2007)**	2,5%	The application will be carried out progressively: 1% in 2009; 1.8% in 2010; and 2.5% for fiscal year 2011 and on. The Ecological ICMS transfer index will be comprised of the following: 45% for Protected Areas; 30% for water quality; and 25% for administration of solid waste. local governments that created their own Protected Areas will have the right to 20% of the 45% set aside for maintaining protected areas, that is, an additional in the score for municipalities that assume the responsibility for creating, implementing and managing Nature Protected Areas (municipal) in their respective territories.
Piauí	2008 (Law nº 5,813/2008)	5%	The application will be carried out progressively: 1.5 % in the first year of distribution, 3% in the second, and 5% from the third year on.

*This Law replaces Complementary State Law nº 12,040/1995, upon approval of the Ecological ICMS in the state of Minas Gerais

**This Law amends Law no 2,664, of December 27, 1996, which deals with the transfer of 25% (twenty-five percent) of the product of ICMS collections to municipalities, including the environmental conservation criteria, and it provides other measures

3.14.3 National Fund for Climate Change - FNMC

The National Fund for Climate Change - FNMC [241] is an accounting-based fund under the Ministry of the Environment - MMA, aimed at ensuring resources to support projects and studies and to finance undertakings that aim at mitigating climate change and adapting to climate change and its effects.

FNMC resources are constituted as follows:

- up to 60% (sixty percent) of the proceedings from the special share in the oil production volume[242];
- donations appropriated in the Federal Government's Annual Budget Law and in its additional credits;
- resources stemming from agreements, adjustments, contracts and agreements signed with federal, state, district or municipal public administration bodies and entities;
- donations made by public or private, domestic and international entities;
- loans for domestic and international financial institutions;
- reversal of unused annual balances;
- resources from loan interest and amortization.

241 Established by means of Law nº 12,114, of December 9, 2009.

242 Law nº 9,478, of August 6, 1997, stipulates national energy policy; the activities related to the oil monopoly; establishes the National Energy Policy Council and the National Petroleum Agency and provides other measures. In Article 50, paragraph 2, clause II, it stipulates that 10% of the proceedings from the special participation of oil production volume will be allocated to the MMA for developing environmental management activities.

The FNMC is administered by a Managing Committee that reports into the MMA, which coordinates it. Its competence and composition are established in regulations, and the participation of six Federal Executive branch representatives and five non-governmental representatives is ensured.

FNMC funds are used to provide reimbursable financial support through the granting of loans by the operator agent; and to non-reimbursable financial support for projects related to the mitigation of climate change or adaptation to climate change and its effects, approved by the FNMC Managing Committee, as per the guidelines previously established by the Committee. The definition of resources to be invested in each of the modalities is up to the FNMC Managing Committee, and this application may be used in the following activities:

- education, empowerment, training and mobilization in the global climate change area;
- climate science, impact and vulnerability analyses;
- adaptation of society and of ecosystems to impacts from global climate change;
- greenhouse gas emission reduction projects;
- projects for the reduction of carbon emissions from deforestation and forest degradation, with priority to natural areas threatened of destruction and important for biodiversity conservation strategies;

- development and diffusion of technology for mitigating greenhouse gas emissions;
- development of public policies for solving problems related to the emission and mitigation of greenhouse gases;
- research and creation of project and inventory systems and methodologies that contribute towards the reduction of net emissions of greenhouse gases and the reduction of emissions from deforestation and changes in land use;
- development of products and services that contribute towards the environmental conservation dynamics and the stabilization of greenhouse gas concentrations;
- support for sustainable production chains;
- payments for environmental services to communities and individuals whose activities demonstratedly contribute towards carbon storage, dependent on other environmental services;
- agro-forest systems that contribute towards a reduction in deforestation and the absorption of carbon by sinks and towards income generation; and
- recovery of degraded areas and forest restoration, with priority to Legal Reserve areas and Permanent Preservation Areas and priority areas for the generation and guarantee of quality in environmental services.

The FNMC's financial agent is the BNDES, which can also enable Banco do Brasil, Caixa Econômica Federal and other public finance agents to conduct finance operations using FNMC resources.

3.14.4 The Amazon Fund

The Amazon Fund stems from a proposal presented by the Brazilian government during the 13th Conference of Parties to the Convention held in Bali in December 2007 aimed at creating a mechanism to support deforestation reduction efforts in the Amazon.

In 2008, the Brazilian Development Bank - BNDES took over management and administration of the Amazon Fund[243]. The fund aims at capturing donation for non-reimbursable investments in actions that can contribute towards preventing, monitoring and combating deforestation, as well as initiatives that promote the conservation and sustainable use of the Amazon biome, as per the terms of the decree.

The BNDES took on responsibility for operating, informing and monitoring the Fund, agreeing to ensure the highest standards of ethics to be observed during selection and contracting of projects to be carried out with Fund resources. The Bank also agrees to maintain the resources from donations separated from those provided by the BNDES, and thus duly accounting for them.

The Amazon Fund has a Steering Committee – COFA ("Comitê Orientador"), comprised of 24 representatives – from the Federal Government, states in the Amazon and civil society – who must determine the guidelines and accompany results obtained. It also has a Technical Committee - CTFA ("Comitê Técnico") comprised of six specialists with renowned technical-scientific knowledge appointed by the Ministry of Environment, after consulting the Brazilian Forum on Climate Change, with three year terms, which may be renewed for an equal period. The Technical Committee is responsible for attesting the calculations presented by the Ministry of Environment as to the actual reductions in carbon emissions stemming from deforestation, evaluating the methodologies for calculating the area of deforestation and the quantity of carbon per hectare used to calculate emissions.

The resources that integrate the Amazon Fund heritage come from donations. The Amazon Fund already receives donations from foreign governments and it is structuring itself to receive donations from multi-lateral institutions, non-governmental organizations and individuals. All donors will receive a diploma recognizing the contribution towards emission reductions stemming from Amazon deforestation in terms of tons of CO_2. The diploma specifies the quantity of carbon corresponding to the sum of the donation and that this quantity is not negotiable.

The Amazon Fund supports projects in the following areas:

- management of public forests and protected areas;
- environmental control, monitoring and surveillance;
- sustainable forest management;
- economic activities carried out from sustainable use of the forest;
- ecological and economic zoning, land planning and land compliance;

243 Created by means of Decree no 6,527, of August 1, 2008.

- conservation and sustainable use of biodiversity; and
- recovery of degraded areas.

The Amazon Fund can also support development of deforestation monitoring and control systems in other Brazilian biomes, and even in other tropical countries.

Besides a reduction in greenhouse gas emissions, the thematic areas proposed for support by the Amazon Fund can be coordinated to contribute towards obtaining significant results in implementing objectives for preventing, monitoring and combating deforestation and promoting the conservation and sustainable use of forests in the Amazon biome.

By June 2010, five projects had already been approved by the Amazon Fund, for a total investment of R$ 70.3 million. They are:

1 – Funbio - R$ 20 million for the program Amazon Region Protected Areas - ARPA.

2 – Sustainable Amazonas Foundation - R$ 19.2 million for the Forest Grant program in the state of Amazonas.

3 - TNC - R$ 1 6 million for Rural Environmental Registration in 12 municipalities in the state of Pará and Mato Grosso.

4 - IMAZON - R$ 9.2 million for mobilizing Rural Environmental Registration in 11 municipalities in the state of Pará.

5 - Ouro Verde Institute - R$ 5.4 million for recovering 1.2 million hectares of forest in 6 municipalities in the state of Mato Grosso.

Chapter 4

Clean Development Mechanism - CDM Project Activities in Brazil

4 Clean Development Mechanism - CDM Project Activities In Brazil

One of the main elements of the Kyoto Protocol is the possibility of using market mechanisms by developed countries to meet their quantified greenhouse gas emission limitation and reduction commitments. Brazil can participation in this market through the Clean Development Mechanism – CDM, taking into account that it is the only mechanism under the Kyoto Protocol that allows for voluntary participation of developing countries. Under the CDM developing countries can benefit from project activities resulting in Certified Emission Reductions – CERs, which can be sold to developed countries, which may use the CERs accruing from such project activities to contribute to compliance with part of their quantified greenhouse gas emission limitation and reduction commitments. Emission reductions resulting from each project activity shall be certified on the bases of reductions in emissions that are additional to those that would occur in the absence of the certified project activity, thus ensuring real, measurable and long-term benefits related to the mitigation of climate change.

The statistics of CDM project activities in Brazil and in the world are presented below. They are updated by August 17, 2010.

4.1 Number of Project Activities

The current status of project activities undergoing the validation, approval and registration stage is showed in Figure 4.1. A total of 6,567 project activities were in some phase of the CDM project cycle. From this total, 2,323 were already registered by the CDM Executive Board and 4,244 were undergoing different phases in the cycle. As can be seen, Brazil is ranked third in terms of the number of project activities, with 460 projects (7%). China is ranked first, with 2,487 projects (38%), with India coming second, with 1,769 projects (27%).

4.2 Expected Emission Reduction for the First Crediting

In terms of expected emission reductions associated with CDM project activities, Brazil is ranked third, being responsible for a reduction of 393,527,792 tCO_2e, which accounts for 5% of the worldwide total for the first crediting period, which can be a maximum of 10 years for fixed-term projects, or seven years for renewable period projects.

The distribution of expected emission reductions for the first crediting period is showed in Figure 4.2.

Figure 4.1 Share of total CDM project activities in the world

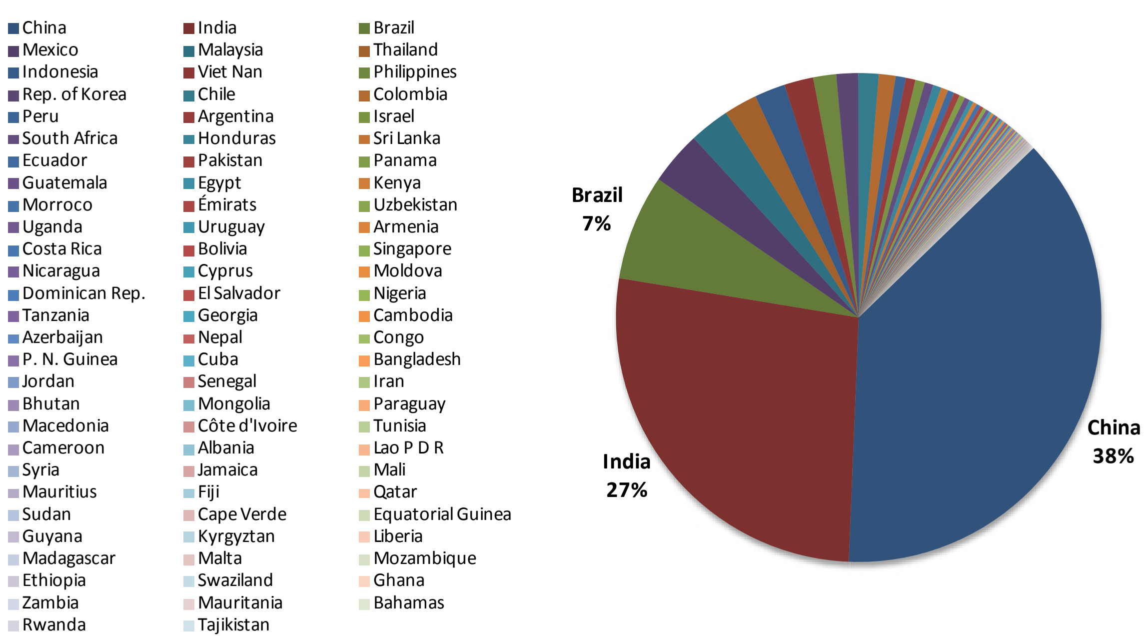
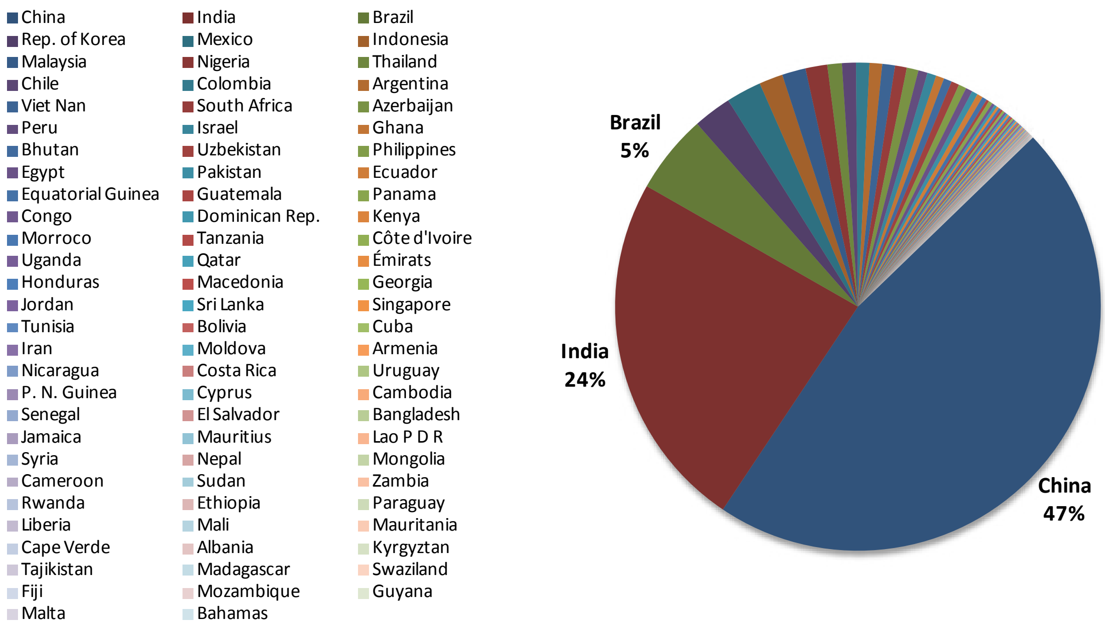


Figure 4.2 Share in the expected emission reductions for the first crediting period



4.3 Expected Annual Emission Reductions for the First Crediting Period

An annual estimation of the expected emission reduction for the first crediting period related to CDM project activities is showed in Figure 4.3. At global level, Brazil is ranked third among those countries with the largest annual greenhouse gas emission reductions, with a reduction of 49,768,483 tCO_2e/year, corresponding to 6% of the worldwide total.

4.4 Distribution of Project Activities in Brazil by Type of Greenhouse Gas

The share of CDM project activities undertaken in Brazil, in relation to greenhouse gas emission reductions, by type of gas, is presented in Figure 4.4. In terms of the number of project activities, it can be noted that those activities related to CO_2 emission reduction are currently the most significant, followed by those project activities related to CH_4 and N_2O emission reduction. According to Figure 4.5, the majority of project activities undertaken in Brazil is in the energy sector, which explains the predominance of CO_2 in the balance of emission reductions in Brazil related to CDM project activities.

Figure 4.3 Share in the expected annual emission reduction for the first crediting period

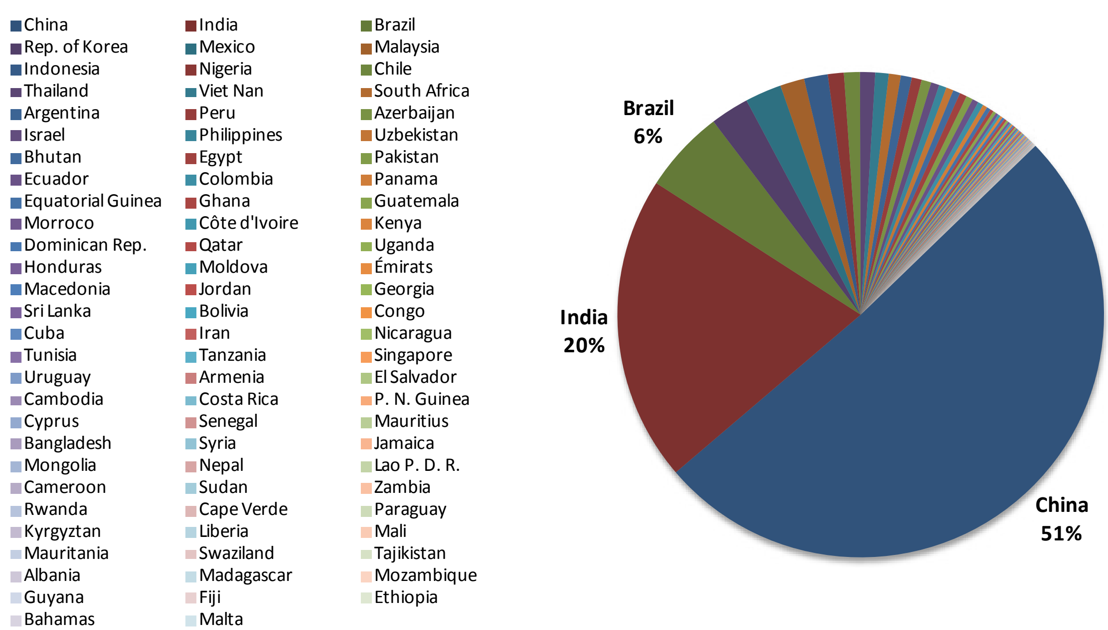
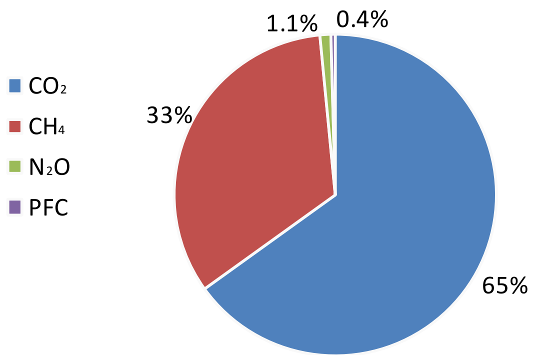


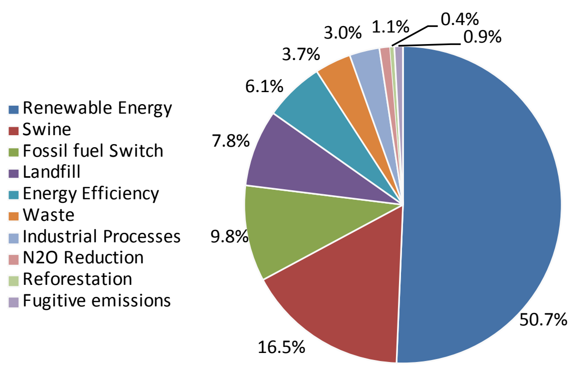
Figure 4.4 Distribution of project activities in Brazil by type of reduced greenhouse gas



4.5 Distribution of Project Activities in Brazil by Scope

This indicator shows the scopes that are more attractive to project participants. The energy sector is preponderant, as can be verified in Figure 4.5.

Figure 4.5 Distribution of project activities in Brazil by scope



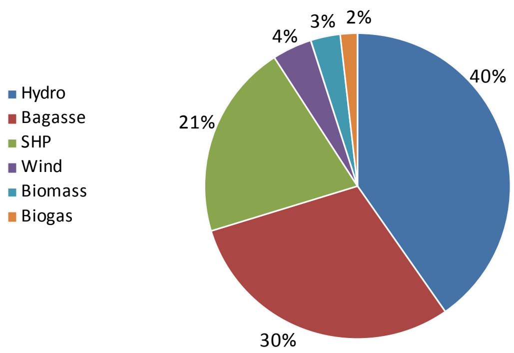
4.6 Distribution of Registered Project Activities in the CDM Executive Board

Considering the total of 2,323 registered project activities in the CDM Executive Board, Brazil shares 175 project activities and the country ranks third in number of registered project activities, as well as in expected emission reductions during the first crediting period, with 172,993,311 tCO_2e.

4.7 Installed Capacity (MW) of CDM Project Activities Approved by the DNA

The Figure 4.6 is based on the total installed capacity of 4,032 MW related to approved CDM project activities by the Designated National Authority - Brazilian DNA in electricity generation sector. It also shows the distribution of the main types of generation: hydroelectric power plants (1,625 MW); biomass-based cogeneration (1,334 MW); and small hydroelectric plants - SHPs (831 MW).

Figure 4.6 Distribution of CDM project activities approved by the Brazilian DNA based on Installed Capacity (MW)



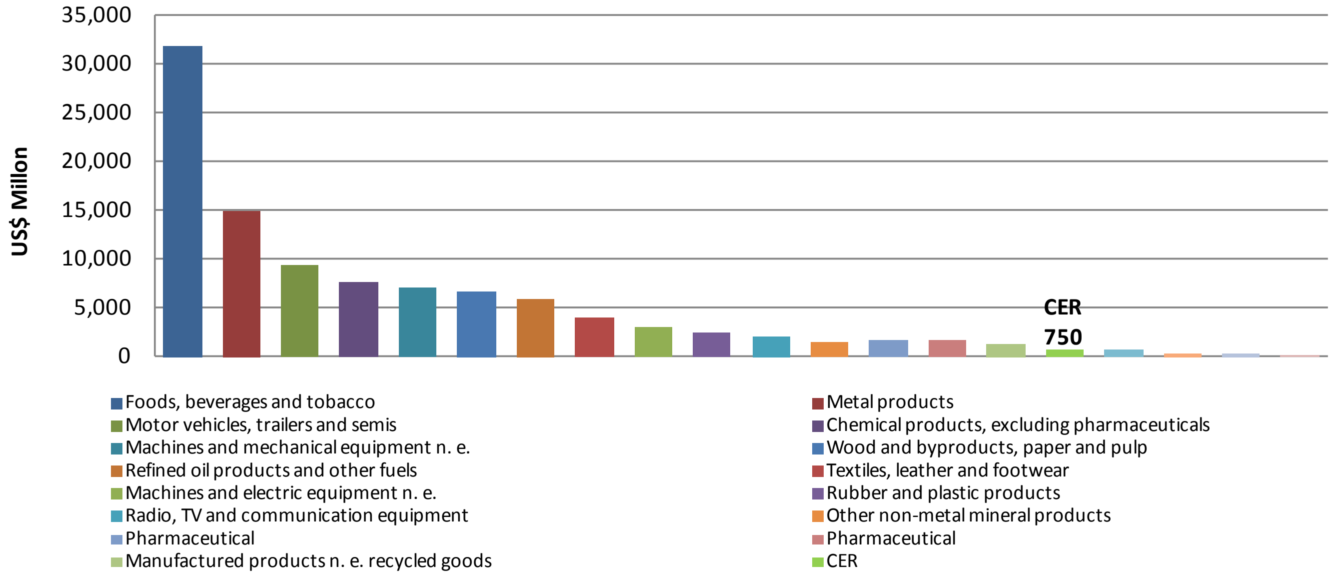
The success of CDM in Brazil is unquestionable and it has undoubtedly contributed to mitigating greenhouse gas emissions in the country. In August 2010, the potential of annual greenhouse gas emission reduction from 460 CDM project activities in Brazil under validation or in a subsequent phase in the CDM pipleline represented 8% of emissions from sectors other than land use, land use change and forestry – LULUCF (only afforestation and reforestation are eligible for CDM as LULUCF activities). Emissions from this sectors accounted for 59% of Brazil's emissions in 1994.

Two relevant examples of significant results from CDM in terms of reducing greenhouse gas emissions in Brazil are the following: five CDM project activities related to the production of adipic acid and nitric acid alone have reduced N_2O emissions virtually to zero in the Brazilian industrial sector, and 25 registered CDM project activities accounted for a reduction of approximately 47% of methane emissions in landfills in 1994.

Regarding CDM Program of Activities – PoA, the first Brazilian PoA is another relevant example in terms of greenhouse gas emission reduction. This programme promotes CH_4 capture and combustion from Aninal Waste Management System in swine farms. 961 small-scale CDM program activities have been included in the registerd PoA by the coordinating/managing entity (Sadia Institute). The inclusion of these small swine farms in this PoA clearly indicates the relevance of the CDM to make feasible initiatives that would not occur in the absence of the Kyoto Protocol.

Another relevant example of the importance of CDM in Brazil is estimating the amount of external financial resources to flow into the country during the first crediting period. Considering US$ 15/tCO_2e, it is approximately US$ 5.8 billion or US$ 750 million per year. In 2009, Certified Emission Reductions – CERs from CDM project activities would be ranked 16th if considered as part of the Brazilian export portfolio, as can be seen in Figure 4.7.

Figure 4.7 Brazilian industrial sectors exports - 2009 (US$ million FOB)



SECTION B

PROGRAMS CONTAINING MEASURES TO FACILITATE ADEQUATE ADAPTATION TO CLIMATE CHANGE

B PROGRAMS CONTAINING MEASURES TO FACILITATE ADEQUATE ADAPTATION TO CLIMATE CHANGE

Because of the limited financial resources available, in the early stages of the implementation of the Convention in the country, the Brazilian government adopted the strategy of placing emphasis on the studies for the prepation of the Brazilian Inventory of Net Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases Not Controlled by the Montreal Protocol. Hence, emphasis was given to the Inventory at the Initial Communication of Brazil to the Convention. In 2000, with the inclusion of the climate change theme in the Multi-Annual Plan – PPA, 2000-2003, studies were initiated on vulnerability to climate change, with and emphasis on health, agriculture and coral bleaching.

In elaborating the Second National Communication of Brazil to the Convention, in addition to the Inventory, special attention was also given to studies on vulnerability to the effects of climate change in strategic areas, according to Brazil's national circumstances.

One of the main objectives of the Second National Communication was to elaborate a methodological approach related to evaluating vulnerability and measures for adaptation, which has two results: elaboration of regional modeling of the climate and climate change scenarios; and conducting research and studies on vulnerability and adaptation related to strategic sectors that are vulnerable to the effects associated with climate change in Brazil.

The first result is related to the need for downscaling methods (reduced scale with increased resolution) to develop more detailed climate projections for Brazil in the long term, i.e., with spatial resolution that is better than that provided by a global climate model, with a view to applying this to studies on the impacts of global climate change. The first item in this section addresses the efforts made by Brazil in this regard.

The second result provides a preliminary analysis of the impacts associated with climate change in the main areas according to Brazil's national circumstances, especially in those areas where vulnerability is influenced by physical, social and economic factors. This result depends on the development of regional climate models that provide more reliable scenarios for South America in relation to the impacts of climate change both on the average surface temperature and on rainfall patterns.

Thus, studies were conducted on the semi-arid region, urban areas, coastal zones, human health, energy and water resources, forests, agriculture and livestock and prevention of disasters, elaborated under the 2007 management contract signed by the Center for Strategic Studies and Management in Science, Technology and Innovation – CGEE, under the supervision of the Ministry of Science and Technology – MCT. To this end, ten renowned Brazilian scientists in the field were mobilized[244,245].

Additionally, the regional model runs and the availability of regionalized climate change scenarios until 2100, made it possible to conduct in-depth studies in the areas of health, energy, water resources, agriculture, and coral bleaching areas[246].

1 Program for Modeling Future Climate Change Scenarios

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007b), in its Technical Summary for Group II, which deals with "Impacts, Adaptation and Vulnerability", the main adverse impacts that could affect Brazil in the future as a result of global climate change, and that therefore could require adaptation measures in Brazil, are as follows:

(i) Very high probability of arid and semi-arid areas in northeastern Brazil being especially vulnerable to global climate change impacts on water sources, with a reduction in water supply. This scenario is even more important if the expected increase in demand for water as a result of population growth is considered.

(ii) High probability that the increase in rainfall in southeastern Brazil will affect crops and other types of land use, as well as increase the frequency and intensity of flooding. A 0.5 °C increase in temperature was reported in Brazil.

244 Carlos A. Nobre (climate change scenarios for South America for the end of the 21st Century); Thelma Krug (Forests); Magda Aparecida de Lima (livestock and farmland); Vanderlei P. Canhos (biodiversity); José A. Marengo (semi-arid region); Marcos Aurélio Vasconcelos de Freitas (water and energy resources); Carlos Freitas Neves and Dieter Muehe (coastal zones); Wagner Costa Ribeiro (urban zones); and Ulisses E.C. Confalonieiri (human health). The studies were coordinated by Marcelo Poppe, of the CGEE.

245 The complete articles derived from these studies can be found in the "Revista Parcerias Estratégicas" (Strategic Partners Journal) nº 27, December 2008, CGEE, Brasília, 2008. This study is also available on the Internet at: <http://www.cgee.org.br/parcerias/p27.php>.

246 This study is also available from the MCT website: <http://www.mct.gov.br/clima>.

(iii) High probability that in the next few decades a considerable number of species in the tropical region of Latin America will become extinct. Gradual replacement of tropical forests with savannahs in the eastern region of the Amazon and some semi-arid areas with arid areas in northeastern Brazil as a result of rising temperatures and dwindling water in the soil. Risk of losses in biodiversity. By 2050, there is a high probability that 50% of farmable lands will be subject to desertification or salinization. The dry season in the Amazon region in 2005 deserves special mention here.

(iv) There is a high probability that the expected increase in sea level will affect Brazil's coastal areas, with adverse impacts on the mangroves as well. Studies indicate great water flow towards the South region of Brazil as a result of the expected increase in sea level.

(v) Global climate change could raise rainfall rates, thus exacerbating the impacts caused by erosion. Brazil's Northeast region is vulnerable because erosion in that region has already caused the sedimentation of reservoirs, and has consequently reduced water storage and supply capacity. Developing countries are especially vulnerable to erosion, especially with regard to the mountain slopes of illegal settlements in metropolitan areas.

(vi) In regions that face water shortages, like the Northeast region of Brazil, the population and ecosystems are vulnerable to less frequent and more variable rainfall as a result of global climate change, which could actually jeopardize the population's supply and the agricultural potential of this region (difficulties in irrigation).

(vii) In the analysis made, groundwater recharge diminishes drastically, by 70%, in Brazil's Northeast region.

(viii) There may be global climate change impacts on public health, with diseases related to flooding, such as diarrhea, having been reported in Brazil. There is also an impact on public health as a result of smoke from burning fields. Global climate change can also have an effect on the increase in cases of schistosomiasis (of the *Schistosoma* genre).

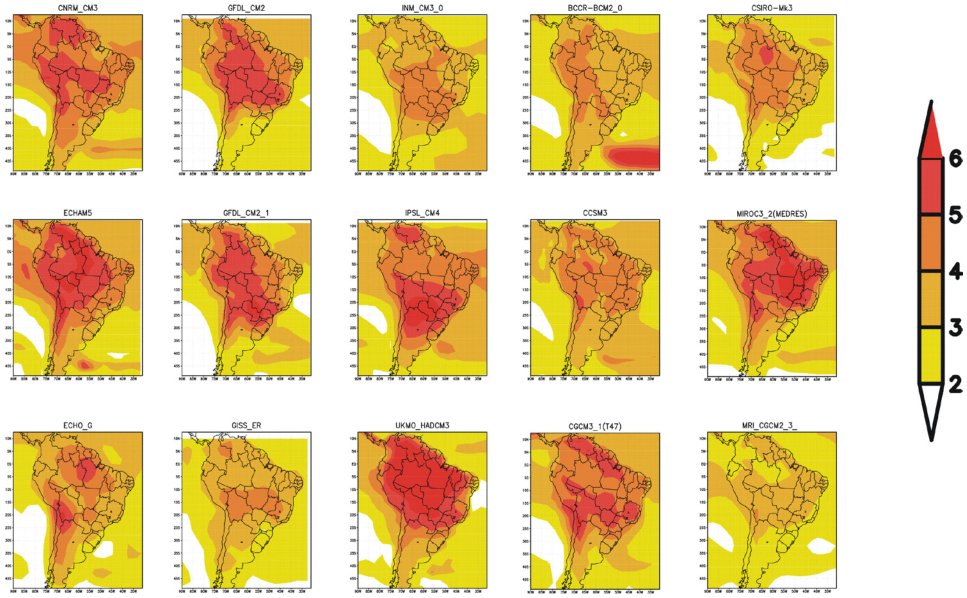
However, it is important to underscore that the analyses of future impacts are based on different scenarios of greenhouse gas emissions until 2100. These scenarios do not assume additional measures to combat climate change or greater adaptive capacity of the systems, sectors and regions under analysis. The most severe impacts projected would only occur in a future scenario (2100) where greenhouse gas emissions have not been mitigated, especially in the case of a significant increase in population and world economic growth with the intensive use of fossil fuels. Thus, the most pessimistic scenarios and their projected impacts may not occur[247] if the international community adopts measures to combat climate change by reducing greenhouse gas emissions.

It must be pointed out that scenarios are not predictions, especially when considering the current state of development of global climate system models, which still pose countless uncertainties. Figures 1.1 and 1.2 illustrate these uncertainties, with an emphasis on the discrepancy of results that exists among the different scenarios. The figures also show the climate scenarios for 2071-2100 for 15 different global climate models based on scenario A2[248] of greenhouse gas emissions by the IPCC.

247 Many of the studies generally conducted on vulnerability and adaptation were based on the scenario with the greatest emissions, and generally using the Hadley Centre model, from England, which presents the most worrisome results. However, it is important to underscore that this choice is often justified by the fact that Hadley Centre model data are available to all, whereas most data from other models is not made available.

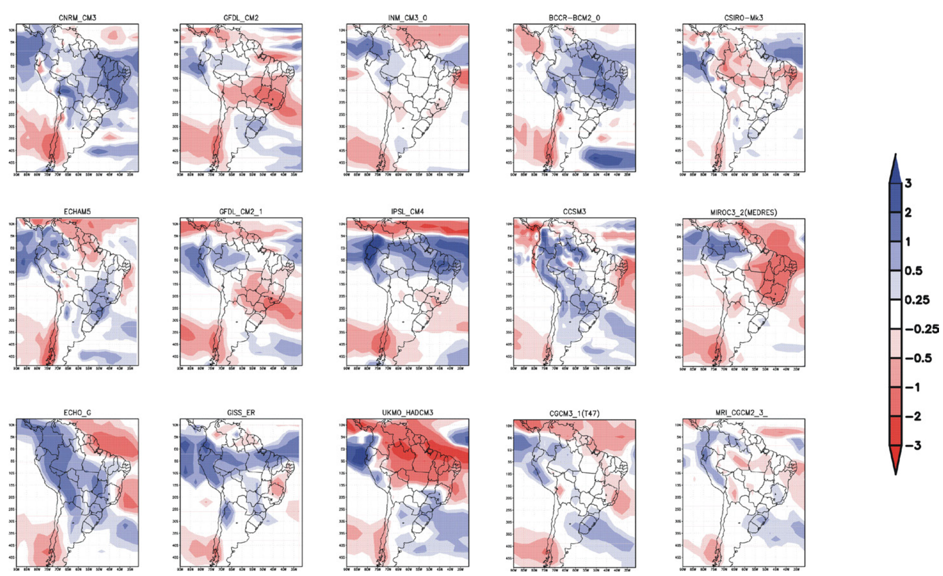
248 Maintenance of greenhouse gas emission standards observed in recent decades; this scenario would imply reaching 2100 with CO_2 concentrations that have nearly 850 parts per million in volume (ppmv).

Figure 1.1 Projected temperature (°C) anomalies for South America for the period 2071-2099 (Scenario A2) in relation to the base period 1961-1990 for 15 different global climate models available from the IPCC



Source: NOBRE *et al*., 2008.

Figure 1.2 Projected rainfall (mm/day) anomalies for South America for the period 2071-2099 (Scenario A2) in relation to the base period 1961-1990 for 15 different global climate models available from the IPCC



Source: NOBRE et al., 2008.

It is also clear that there is much variability in the temperature and rainfall anomalies projected under the different models in magnitude and sign of the anomaly until the end of the 21st Century. The difference between the anomalies for the different models suggests that a considerable degree of uncertainty in future climate projection scenarios is still the case. This indicates the need to improve representation of physical processes. The state of current science does not make it possible to establish unequivocal scenarios (NOBRE *et al*., 2008).

Again, regarding the issue of deficiencies in identifying risks stemming from climate change in Brazil, it is necessary to seek increased reliability associated with the possible future climate scenarios in the country. Current knowledge of regional dimensions of global climate change is still very fragmented, and requires further study. However, in order to elaborate these studies it is necessary to develop long-term climate change models with appropriate spatial resolution for regional analysis. This will provide the enabling conditions for elaborating possible future scenarios of climate change with different concentrations of CO_2 in the atmosphere and for analyzing the impacts of global climate change on Brazil.

Most of the uncertainties in the model's projections for climate change scenarios can be related to the problem of spatial scale and the representation of extreme climate events in higher spatial scales than those produced by most global climate models.

Climate change scenario projections for the 21st Century were derived from the various global climate models used by the IPCC. The fact that global climate models use different physical representations of processes, at a relatively low degree of resolution, introduces a specific amount of uncertainty to these future climate change scenarios. This uncertainty is extremely significant when assessing vulnerability and the impacts of climate change, as well as when implementing measures for adaptation and mitigation. For example, for the Amazon Basin some models produced climates with heavier rainfall and other climates relatively drier. For the Northeast region of Brazil, some models suggest an increase in rainfall rates.

The time scale problem is also crucial, since extreme events (waves of low humidity, cold or heat and storms) can only be identified with daily data, and not with the monthly or seasonal data produced by most global IPCC models. There is also the problem of representation of the physical process using sets of parameters from different models and the correct representation of current climate by climate models.

Thus, there is a need for downscaling methods[249] that can be applied to climate change scenarios from global models in order to obtain more detailed projections for states, valleys or regions, with higher spatial resolution than what is provided by a global climate model. This would be greatly useful for studies of the climate change impacts on the management and operation of water resources, on natural ecosystems, on agriculture activities and even on health and the spreading of disease.

Therefore, it is of fundamental importance to develop climate modeling capacity in Brazil by analyzing global and regional models for current and future climate change scenarios.

In this sense, the MCT recognized it is of fundamental importance to develop climate modeling capacity in Brazil by analyzing global and regional models for current and future climate change scenarios, and it sought to invest in this.

The National Institute on Space Research – INPE, which is attached to the MCT, has been responsible for coordinating regional climate modeling and climate change scenarios for the future. It also coordinates the relationship between these results and the vulnerability and adaptation research and studies related to strategic sectors that are vulnerable to impacts associated with climate change in Brazil.

1.1 The Eta-CPTEC Model

The INPE has been evaluating the different climate change scenarios proposed by the global coupled models of the IPCC Fourth Assessment Report and has been developing downscaling methods for Brazil, which are applied to climate change projections from regional climate change models to

249 The downscaling technique is used to make an "interpolation" from a sub-grade scale with less resolution to one with greater resolution, adjusted to meso scale processes, such as those at the watershed level. The downscaling technique consists of projecting large scale information onto a regional scale. This "translation" of a global scale to a regional one and of annual time scales to daily ones, would also increase the degree of uncertainty regarding climate change projections. For example, although a climate model may be capable of reproducing the field of observed precipitation with some success, it is probable that it will be less successful in reproducing daily variability, especially in relation to high order statistics, such as standard deviation and extreme values. Thus, although it may seem reasonable to adopt a scenario of interpolated temperature starting with the points of a global climate model grade for a specific location, the interpolated time series can be considered inappropriate for current climates, and therefore generate uncertainty in climate change scenarios.

obtain more detailed climate projections, with improved spatial resolution from regional models. These projections may be used in studies of climate change impacts on several socioeconomic sectors (agriculture, energy, health, water resources, etc.), indicating vulnerability to risks in the form of probabilities.

To this end, the INPE has developed the Eta-CPTEC regional model for South America, which is run on supercomputers, given the need for great processing in real time. Numerical models generally need great computation and data storage capacity. The Eta model was run on INPE's NEC-SX6 super computer, which can run 768 billion arithmetic operations per floating point per second, with the capacity to use numerical models for simulating weather and climate, integrating atmospheric and oceanic information with capacity for regional modeling**.**

Eta is a complete regional atmospheric model that has been used by the CPTEC since 1997 for operational and seasonal weather forecasting. The model was adapted to be used as a Regional Climate Model – MCR, and it was validated as such (PESQUERO *et al*., 2009). The MCR Eta-CPTEC was used to produce regionalized scenarios for future climate change for the Second National Communication of Brazil to the Convention**.**

The initial results of regional climate models derived from the global climate model by the Hadley Centre (UK) were made available in 2007, which came to comprise INPE's "Climate Report"[250] (MARENGO *et al.*, 2007), using 3 regional models: RegCM3, Eta CCS and HadRM3P, with the lateral condition of the atmospheric model HadAM3P, for extreme emission scenarios A2 (high emissions) and B2 (low emissions), with a resolution of 50 km.

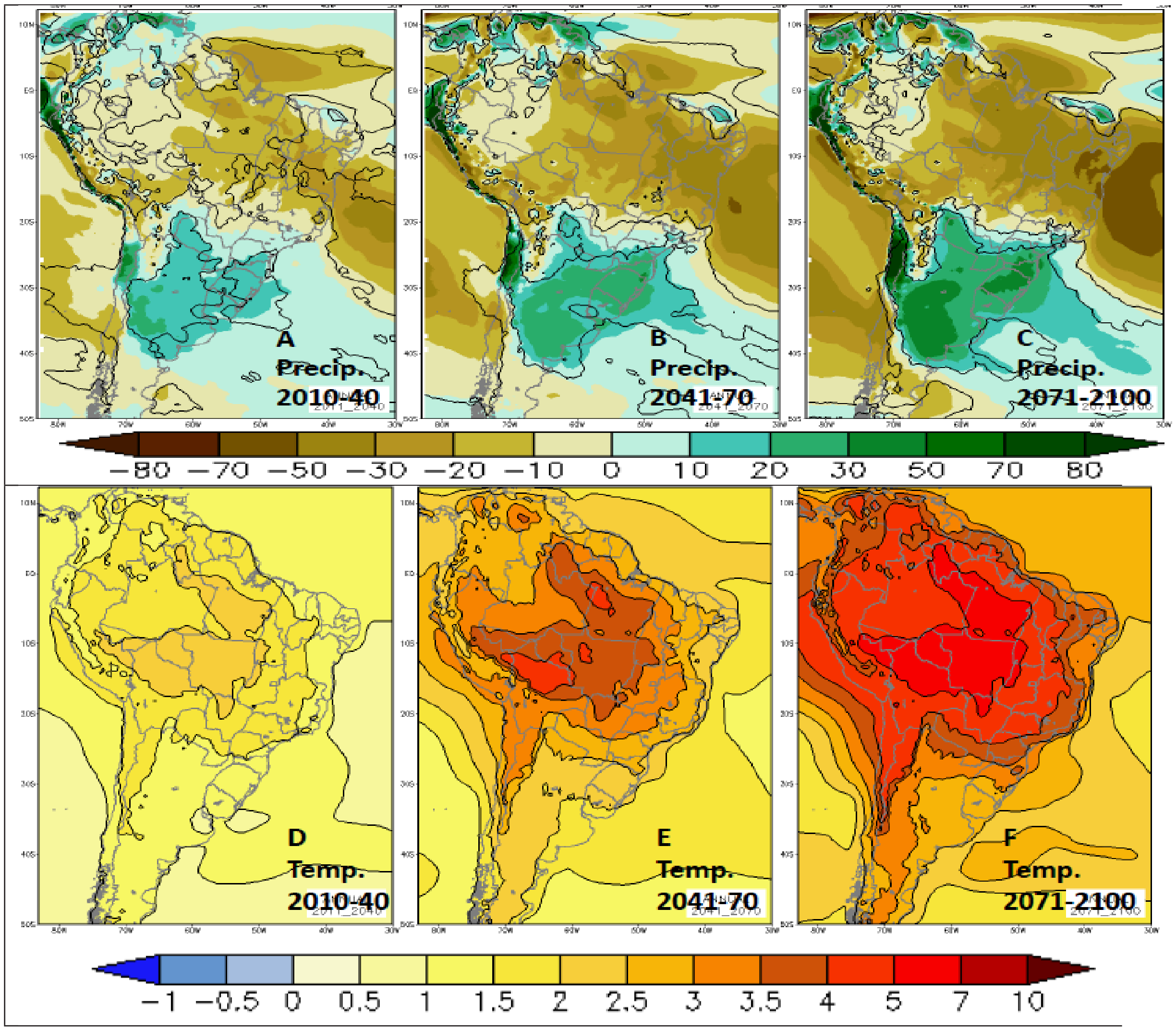
The various impact studies and vulnerability analyses that have used the projections provided by the three regional models include the report "Climate Change and Energy Security in Brazil," published in May 2008 by COPPE/UFRJ (SCHAEFFER *et al.*, 2008); the report "Global Warming and the New Geography in Agricultural Production in Brazil," published in August 2008 by EMBRAPA-UNICAMP (ASSAD & PINTO, 2008); and the study "Climate Change, Migration and Health: Scenarios for the Northeast region of Brazil" (CEDEPLAR & FIOCRUZ, 2008). Moreover, the reports on the economic impacts of climate change in Brazil (MARCOVITCH *et al.*, 2010) and Latin America (CEPAL, 2009) deserve attention as well.

The Eta-CPTEC regional model recently featured new lateral conditions of the coupled ocean-atmosphere global model HadCM3 provided by the Hadley Centre. This study, related to downscaling methods for Brazil was applied to climate change scenarios from the global model HadCM3 to obtain more detailed climate projections (2010-2040, 2040-2070, 2070-2100) with improved spatial resolution under scenario A1B. To include a measure of uncertainty in the projections, the HadCM3 model underwent slight changes, or disturbances, generating three new realizations or members. These members provided the projections for the end of the 21st Century, with different sensitivities to temperature. A member had strong warming, another member showed an average warming, and yet another member displayed slight warming, all maintaining the same rate of increase of CO_2 corresponding to the A1B scenario. Including the results of the HadCM3 model without disruption, a total of four members of HadCM3 were used.

These conditions were provided to the Eta-CPTEC model to generate the current climate, 1961-1990, and projections for the period 2011-2100 in detail in the grid for 40km. The evaluation of the results for the present climate showed that the model generally represents it accurately in relation to winds, temperature and rainfall. The results also show an improvement in the simulation of rainfall and temperature using the Eta-CPTEC Regional Model in relation to the HadCM3 global model. In general, HadCM3 conditions underestimate the frequency of *El Niño* events (warming of Pacific Ocean waters) and *La Niña* events (cooling of Pacific Ocean waters), and the anomalies represented by the downscaling show patterns that are similar to those reported (CHOU *et al.*, 2010). Figure 1.3 shows the annual projections for 2010-2100 for temperature and rainfall derived from the Eta-CPTEC model for South America, showing increases in rainfall in Brazil's South region, and reductions in rainfall in the Northeast region and the Amazon, while temperatures rise throughout Brazil, and they are higher in the mainland area (MARENGO *et al.*, 2010a).

250 The results of works conducted by the INPE's Climate Change Research Group - GPMC is called "Climate Report". The objective of this group is to develop research related to climate change. Its members include researchers who work in climate change areas, vulnerability analyses, impact and adaptation studies, from top institutions such as the University of São Paulo-IAG (see http://www.iag.usp.br); the University of Campinas (see http://www.unicamp.br); the Brazilian Foundation for Sustainable Development (see http://www.fbds.org.br), with collaborations from Federal Government institutions such as Embrapa, INMET, Fiocruz, ANA, Aneel, ONS, COPPE-UFRJ among others, as well as state centers of meteorology, universities, FBMC and organized civil society. The group also works together with Brazil's National Program of Climate Change of the MCT, with the Secretariat of Climate Change and Air Quality of the MMA, with the Climate Network and Fapesp's Global Climate Change Program, as well as national programs from some South American countries. More information is available online at: < http://www.cptec.inpe.br/mudancas_climaticas>.

Figure 1.3 Projected rainfall (%) and temperature (°C) changes for South America for 2010-2100 (Scenario A1B) in relation to the base period 1961-1990 generated by the Eta-CPTEC model, 40 km from HadCM3's projections



Source: MARENGO *et al.*, 2010a.

It is worth pointing out that regional climate projections were provided to groups of Latin American countries so the scenarios could be developed in national centers by specialists from each country.

The INPE, with the support of the MCT, coordinated the preliminary results related to elaboration of the regional climate model and climate change scenarios and the research and studies on vulnerability and adaptation related to strategic sectors that are vulnerable to the impacts associated with climate change in Brazil. Reports were generated with climate scenarios to serve as inputs for studies on vulnerability in the health sector; energy sector; water resource, flooding and desertification sector; agricultural sector; biodiversity sector (including coral bleaching); and coastal zones.

The reports contain the results from models used in digital form (specialized results in an appropriate resolution for analysis, tables, graphs, diagrams, as appropriate), and were widely made available.

Although this is an initial effort for regionalizing future climate change scenarios and for conducting vulnerability studies based on them, with these results, the country should be better equipped to identify more vulnerable regions and sectors with a greater degree of reliability than offered by global models. Thus, in the future, specific adaptation projects can be developed with the proper scientific foundation, enabling a more rational allocation of public resources.

However, much still needs to be done. The planned improvements of this version of the MCR Eta include dynamic vegetation and changes in land use. Atmospheric models assume a type of vegetation that is not affected by climate change. However, the type and density of vegetation can suffer changes[251] capable of exerting considerable influence on local climate modeling. Dynamic modeling makes it possible to include these effects. The Eta model has also been run thus far only using a few boundary conditions for the global climate model. Consequently, detailed and quantified information about projection uncertainties are limited.

Operation of an improved version of the Eta model is projected, forced with at least four global climate models from world centers in the Americas, Europe and Asia, including the Brazilian Global Climate System Model – MBSCG (see item 1.2 below). These results are expected to fill in the gaps from existing scenarios, reduce margins of error and increase spatial resolution from 40x40 km^2 to 20x20 km^2, which will improve the level of detail in the projections for mountainous regions and valleys. This level is needed for evaluating impacts.

1.2 The Brazilian Global Climate System Model - MBSCG

The Brazilian Global Climate System Model – MBSCG is in its elaboration phase at INPE, in collaboration with the climate centers in South America, South Africa, India and Europe. The objective of the MBSCG project is to establish a global climate model adapted to long-term climate change projections. The MBSCG is based on the main structure of CPTEC's current climate model (which is used for seasonal climate predictions), but includes more realistic representations of phenomena that act in a broader scale of time: sea-ice transitions, aerosols and atmospheric chemistry, dynamic vegetation, CO_2 variability and other improvements. The advances in the MBSCG would enable INPE to participate in IPCC's Fifth Assessment Report and the conducting of climate change projections.

The work surrounding the MBSCG began with financial resources from Brazil's government and several Brazilian financing agencies[252]. This model will have great potential for generating detailed assessments of climate change effects, vulnerability and adaptation for Brazil. The regional climate change scenarios will enable a careful analysis of uncertainties using the assembly model technique. Climate change scenarios are generated by the supercomputers in operation at CPTEC/INPE.

The efforts in developing the Brazilian Global Climate System Model – MBSCG will be shown in the vulnerability, impact and adaptation studies included in the Third National Communication of Brazil to the Convention.

251 Vegetation can be affected when climate threshold conditions are exceeded; or due to adaptation measures that entail changes in land use.

252 One part of the Brazilian Global Climate System Model (4 years) was financed by the São Paulo Research Foundation - Fapesp.

2 Effects of Global Climate Change in Marine and Land Ecosystems

2.1 Semi-arid Region

Brazil's Northeast region covers 1,600,000 km^2 of the national territory and 59% of its area is covered by the so-called "Drought Polygon" (*Polígono das Secas*), 940 thousand km^2 of semi-arid land that encompasses nine states of the Northeast and faces a chronic water shortage problem and rainfalls of less than 800 mm per year (MARENGO, 2008). More than 20 million people live in the semi-arid region, making it the most densely populated dry region in the world. The region is an enclave of scarce rainfall that encompasses the coastlines of the states of Ceará and Rio Grande do Norte until the middle of the São Francisco River, with *Caatinga* vegetation. The semi-arid region is heterogeneous, comprised of many micro climates with different species of vegetation, which also include micro climates with remaining Atlantic Forest areas. These regions are threatened by anthropogenic pressure, with growing environmental degradation.

Historically, Brazil's semi-arid region has always been affected by great droughts or great flooding. Years of drought and abundant rains alternate erratically, with intense droughts in 1710-11, 1723-27, 1736-57, 1744-45, 1777-78, 1808-09, 1824-25, 1835-37, 1844-45, 1877-79, 1982-83 and 1997-98, and rains in 1924, 1974, 2004-2005, and 2009.

The droughts are associated with the region's climatic characteristics and variabilities in the Pacific and Tropical Atlantic Ocean (MARENGO & SILVA DIAS, 2007; NOBRE et al., 2006). Statistically, there are 18 to 20 years of drought every 100 years. The most serious droughts are shown in historical records since the beginning of colonization in the 16th Century, and they are commonplace. The 20th Century was one of the most arid thus far, with 27 years of drought.

Rainfall alone is not a guarantee that dry farming subsistence crops will be successful. The semi-arid region frequently has dry periods during the rainy season, which, depending on the intensity and duration, cause heavy damage to subsistence crops (NAE, 2005), and consequently, adverse impacts on the region's agriculture. Impacts on the population can increase with heavier rainfall. For example, in the first semester of 2009, intense rains jeopardized 664 thousand people in six states of Brazil's Northeast and North regions.

INPE's "Climate Report" indicated a tendency for draught and extreme rain event scenarios in large areas of Brazil. The semi-arid region is considered to be Brazil's most vulnerable region to potential climate change since water availability per capita in a significant portion of the area is already insufficient, with a growing process of degradation and desertification and with more than 50% of the population living in poverty conditions.

According to the aforementioned INPE report, in a pessimistic scenario - based on regional models RegCM3, Eta CCS, and HadRM3P - temperatures would increase 2 °C to 4 °C and rainfall would drop off 15 to 20% (2-4 mm/day) in the Northeast region by the end of the 21st Century. In an optimistic scenario, warming would be between 1 °C and 3 °C and rainfall would decrease 10 to 15% (1-2 mm/day). The increase in Amazon deforestation could also generate adverse in the semi-arid region, making it drier.

With the possible consequence of a more arid semi-arid region, and with greater frequency in droughts and intense or excessive rainfall, the impacts could be very negative to the economy and society. The basis for sustaining human activities - such as agriculture and livestock, mining, industry, hydroenergy and tourism - would reduce, probably increasing displacement of the population to cities or areas where it would be possible to develop irrigated agriculture. The poorest population and subsistence farmers would be the most strongly affected.

As an example of climate extremes with great impact on the region, in November 2007, the Sobradinho reservoir reached only 15% of its volume when full. In the state of Paraíba, 158 municipalities were in states of emergency motivated by this drought. This situation could occur with greater frequency, since, according to the Water Atlas of the Northeast region (ANA, 2006), more than 70% of cities with populations of more than 5,000 inhabitants will face crises in water supply for human consumption by 2025, regardless of integration of the São Francisco watershed to the Northeast region's northern watershed[253]. Therefore, supply problems could hit a large part of the Northeast region's population.

The region has low social and health indicators. Indeed, among the ten lowest Human Development Indexes – HDI in the country, eight are from states in the Northeast region (MARENGO, 2008). The population's vulnerability increases when you add the semi-arid climate to this. The region also has the highest child mortality rates and the lowest life expectancy in Brazil. This scenario can worsen with rising temperatures and decreasing rainfall.

In the 1960s, the agriculture sector was responsible for nearly 30% of the Northeast region's GDP. This percentage is currently around 7%. However, those who depend on agricultural activities still represent nearly 30% of the region's workforce. In other words, a large part of the workforce still has very low productivity, which explains the rural poverty in the region.

253 See box "Transposition of the São Francisco River".

Box 1 - Transposition of the São Francisco River (MI, 2010)

The Project for the Integration of the São Francisco River with Watersheds of the Northern Northeast is a Federal Government project under the responsibility of the Ministry of National Integration - MI, to ensure water supply, in 2025, to nearly 12 million inhabitants of small, medium and large cities of the semi-arid region in the states of Pernambuco, Ceará, Paraíba, and Rio Grande do Norte.

Integration of the São Francisco River to the temporary river watersheds of the Semi-Arid will be possible with the continuous removal of 26.4 m^2/s of water, equivalent to 1.4% of the flow guaranteed by the Sobradinho dam (1850 m^2/s) in the river section where this capture will take place. This sum of water will be used for consumption by the urban population of 390 municipalities in Brazil's *Agreste* and *Sertão* regions of four states in the northern Northeast region. In years when the Sobradinho reservoir is overflowing, the captured volume can be expanded up to 127 m^2/s, contributing towards an increase in guaranteed water supply for multiple uses.

The Northeast region, which has only 3% of Brazil's water availability and 28% of its population, has great internal irregularity in the distribution of its water resources, since the São Francisco River represents 70% of the region's entire offer.

This irregularity in the internal distribution of water resources, associated with a discrepancy in demographic densities (nearly 10 inhabitants/km^2 in the largest part of the São Francisco River watershed and approximately 50 inhabitants/km^2 in the northern Northeast) divides Brazil's Semi-Arid region in two, from a water supply perspective: the São Francisco watershed's Semi-Arid, with 2,000 to 10,000 m^3/inhabitant/year of water available from a permanent river, and the Northern Northeast's Semi-Arid, encompassing part of the state of Pernambuco and the states of Paraíba, Rio Grande do Norte and Ceará, with little more than 400m^3/inhabitants/year made available from dams built on intermittent rivers and from aquifers with limitations as to quantity and/or quantity.

In view of this reality, based on water availability of 1500 m^3/inhabitant/year established by the UN as the minimum needed to guarantee water supply to a society for its diverse uses, the Integration Project establishes the interconnection of the São Francisco River watershed, which has a relative abundance of water (flow of 1850 m^2/s guaranteed by the Sobradinho reservoir), with basins in the Northern Northeast with water availability that establishes limitations to the region's socioeconomic development.

The basins that will receive water from the São Francisco River are: Brígida, Terra Nova, Pajeú, Moxotó and Basins in Pernambuco's Agreste; Jaguaribe and Metropolitanas in Ceará; Apodi and Piranhas-Açu in Rio Grande do Norte; Paraíba and Piranhas in Paraíba.

Benefits

The Project for the Integration of the São Francisco River with watersheds of the Northern Northeast is the most important structuring action, under the National Water Resource Policy, with the objective of guaranteeing water for the socioeconomic development of the states most vulnerable to droughts. In this sense, while guaranteeing long-term supply to large urban centers in the region (Fortaleza, Juazeiro do Norte, Crato, Mossoró, Campina Grande, Caruaru, João Pessoa) and to hundreds of small and medium sized cities in the Semi-Arid, the project benefits inland Northeastern areas with reasonable economic potential, strategic under a development deconcentration policy, until now almost exclusively polarized by the state's capitals.

The Integration Project will also have great reach in supplying the rural population, either through hundreds of kilometers of perpetuated channels and river beds or through water mains to serve a set of locations.

In relation to the impacts on biodiversity in the semi-arid region, it should be borne in mind that the *Caatinga* is the only exclusively Brazilian biome, which is home to unique fauna and flora, with many endemic species not found anywhere else on the planet. This is one of the most endangered biomes in Brazil, with a great part of its area already greatly altered by the extreme climate conditions reported in recent years, and it is potentially very vulnerable to global climate change. Results from vegetation modeling experiments associated with climate change scenarios involving high emissions of greenhouse gases (SALAZAR *et al.*, 2007) suggest that the *Caatinga* could be replaced with a vegetation more typical of arid zones, with a predominance of cactuses by the end of the 21st Century.

Concerted action is needed to cope with the possible adverse effects of climate change in the semi-arid region. Some of the initiatives implemented include the Brazilian Early Warning System for Droughts and Desertification (INPE/MCT and MMA), the Real Time Climatic Monitoring Program in the Northeast - Proclima, of the Northeast Development Superintendence - Sudene and the Ministry of Integration – MI, and the National Action Program to Combat Desertification and Mitigate the Effects of Drought - PAN-Brasil, of the MMA.

The Northeast semi-arid region has a long history of policies for adapting to climatic variability, especially droughts. This experience involved the creation and development of institutions, construction of water and transportation infrastructure, conducting emergency actions in periods of drought, research and rural extension in agriculture and reduction in participation in the economy (economic diversification) related to activities dependent on rains, such as dry farming.

Examples of adaptation include the creation of emergency jobs in times of drought (in 1983, 3 million "work front" jobs were created); accumulation of water in dams and cisterns; public and private irrigation; management of water resources; rehabilitation of watersheds, including micro basins; development of activities less dependent on climate resources.

In order to cope with the challenges in Brazil's semi-arid region, studies on vulnerability to climatic events, changes in land use, population increases and conflicts involving the use of natural resources are needed (MARENGO, 2008). Efforts must focus on helping to plan and implement actions that lead to the region's sustainable development, strengthening society's, the economy's and the environment's capacity to adapt, while also contributing towards mitigation initiatives geared towards reducing the causes of global climate change.

Long-term environmental policies are also needed, as are environmental education programs. Knowledge about the *Caatinga*'s ecosystem must be improved. In this sense, elaboration of a map of risks and possible vulnerabilities of the semi-arid region to global climate change is recommended, which integrates the different vulnerabilities in various sectors and their causes, including an instruction guide for planning strategies to adapt to these vulnerabilities. It is necessary to establish water supply and basic sanitation policies, especially in small communities. There is also a need to evaluate food security in the Northeast and develop crops and agricultural systems adapted to the semi-arid region, within the context of climatic variability as well as climate change.

However, just as the semi-arid region is vulnerable to climate change, it is also a region with potential that needs to be better known and incorporated to plans for adaptation and regional sustainable development.

2.2 Urban Areas

According to IPCC's Fourth Assessment Report, Working Group II's Report, "Impacts, Adaptation and Vulnerability", more frequent heat waves in urban areas are predicted, with greater intensity and duration, as well as an increase in minimum temperatures (IPCC, 2007b), with possible impacts on health, especially among the elderly and children up to 5 years of age. Deterioration in air quality and an increase in risk areas can also be projected, especially in tropical cities, which are subject to increasingly more intense rainfall that can cause landslides and flooding.

The Brazil's population is concentrated in megacities and in large and mid-sized cities. Brazil's urbanization is a recent phenomenon when compared to other industrialized countries (RIBEIRO, 2008). Real estate speculation and rural exodus are some of the aspects that generated areas with high concentrations of low-income populations, which ended up choosing to live in risky areas, such as bottoms of valleys, low grasslands bordering bodies of water and steep cliffs, or in slums or degraded properties due to lack of maintenance. Each of these situations exposes its inhabitants to dangers caused by adverse and extreme climatic events.

The recent study "Vulnerability of Brazilian Megacities to Climate Change: the metropolitan region of São Paulo" (NOBRE *et al.*, 2010) shows that, if the historical pattern of expansion is followed, in 2030 the urban sprawl in the metropolitan region of São Paulo will be twice as big in comparison with the current sprawl, thus increasing risks of floods and landslides in the area, increasingly affecting the population as a whole, and especially the poorest. This is because this expansion should occur mainly at the outskirts, illegal lots and buildings, and in fragile areas, such as floodplains and unstable soils, with great pressure on natural resources. The risks will be magnified by the increasing number of days with heavy rains due to global climate change. Preliminary studies suggest that, between 2070 and 2100, an average rise in temperature in the area from 2 °C a 3 °C could double the number of days with heavy rainfall (above 10 mm) in the capital of São Paulo.

Rising temperatures in Brazilian cities can be the result of natural factors, such as the heating of the South Atlantic, which has been observed since 1950 (MARENGO, 2006), or due to anthropogenic factors (ex: heat islands, the effect of verticalization and the intense use of automobiles in large cities), or a combination of both. The highest rates of heating can be detected in the megacities in the Southeast region of Brazil (mainly in São Paulo and Rio de Janeiro), but this is also perceptible in cities like Manaus - AM, Cuiabá - MT, Campinas - SP and Pelotas - RS. The "heat island" (LOMBARDO, 1985), frequently found in megacities and large cities, results in thermal discomfort and an increase in energy consumption to cool buildings. The increase in global temperature could also have significant impacts on human health, especially in large cities, with a worsening in the health of those with high blood pressure, which increase the number of deaths[254].

The Earth's atmosphere has been constantly contaminated by substance emitted by industries, automobiles, thermoelectric plants and other sources. This impact is more evident in large urban centers, such as the city of São Paulo, where air pollution is treated as a public health problem (SALDIVA, 1992). Air pollution generates an increase in hospital admissions (especially those with respiratory problems and heart disease), neonatal deaths, hematological, ophthalmological, neurological and dermatological problems (COELHO-ZANOTTI, 2007). This mainly occurs in periods of dry weather, especially in the winter, in cities in the Southeast and South regions, when there is greater frequency of the so-called thermal inversion, a phenomenon that could intensify with an increase in global temperatures.

Climate change could also result in more frequent urban pests. Higher temperatures will facilitate appearance of insects on a larger scale. It will be necessary to create campaigns to cope with urban pests to avoid their spread to the point of generating difficulties for residents of Brazilian cities or to avoid their becoming vectors for the propagation of disease.

Another possible consequence of global climate change will be the greater frequency of very intense rains. Extreme events result in very intense local problems, such as flooding of roads, traffic jams, losses of housing, especially among the low-income population, material losses and even death, generally among inhabitants of risky areas (RIBEIRO, 2008).

Along the entire eastern coast of the Northeast region, in the "Forest Zone" (*Zona da Mata*)[255] (from a portion of the state of Rio Grande do Norte, as well as the state of Pernambuco, especially the cities of Recife and Olinda, to the state of Bahia, in the Bay [*Recôncavo*] region[256]), strong rains brought by eastern waves certainly accompanied by powerful breakers that, driven by the wind, can cause destruction and even greater damage to buildings and road structures along the coast (XAVIER *et al.*, 2008).

Since the rains should be more intense in some regions, the water will have greater speed and strength to create wakes and transport sediment, causing and/or accelerating erosion processes. Erosion can put homes at risk. Furthermore, more intense erosion further contributes towards the silting of bodies of water, which increases the possibility of flooding in bottoms of valleys. In many cities of the country, bodies of water were made water resistant and low grasslands were occupied by road systems. Heavy rains will worsen the already known flooding of public roads, which generates property and human losses every year in the country.

Landslides on cliffs and flooding caused by severe storms are two types of natural disaster responsible for a great number of victims in the country, especially the metropolitan regions of Rio de Janeiro, São Paulo, Recife, Salvador, and Belo Horizonte, and the *Serra do Mar* and *Mantiqueira*[257] mountain ranges.

Construction assets can also be affected by climate change. Intense rains and higher temperatures will demand even more attention and resources to maintain the architectural

254 It is important to underscore the concentration of pollutants irritates the eyes, accelerates development of coughs, influenza and colds. These are serious problems because they affect those at the extremes of the population pyramid: children up to 5 years of age and the elderly (RIBEIRO, 2008).

255 Formed by a narrow strip of land (about 200 kilometers wide) located on the Northeast coast. The original vegetation in the "Forest Zone" (Zona da Mata) was predominantly Atlantic Forest. It is an area with a high level of urbanization, concentrating the Northeast's main regional centers. Large tobacco, sugarcane and cocoa properties stand out in the agriculture sector. There is large scale agriculture production due to the fertile soil.

256 Bahia's Bay (*Recôncavo Baiano*) is the geographic region around "Todos os Santos" Bay, encompassing the Metropolitan Region of Salvador, where the capital of the state of Bahia, Salvador, is located. The region is very rich in oil and sugarcane.

257 The "Serra da Mantiqueira" is a mountain range that extends through three states of Brazil: São Paulo, Minas Gerais and Rio de Janeiro.

heritage of cities and megacities in Brazil, as has already occurred, for example, in Ouro Preto - MG and Paraty - RJ (ZANIRATO, 2004).

The rising sea level can lead to the abandonment of buildings located in low urban areas and to the displacement of the population living along the coast and of service centers installed on beaches (RIBEIRO, 2008). Another difficulty in coastal cities will be sewage disposal, which is collected and transported to the sea through underwater emissaries without any prior treatment. Calculations of the flow of this material were made for sea levels much lower than those projected by global climate change.

Some cities of the country are already taking measures to mitigate and adapt to global climate change, as in the case of Rio de Janeiro, where warning systems for undertows and risks of landslides have already been developed (CIM, 2008). São Paulo has also already implemented its Climate Change Plan, which should help in mitigation and adaptation. At the state level, the State Plan on Climate Change has also been approved in São Paulo, Minas Gerais and Pernambuco. The cities of São Paulo and Curitiba are members of the C40, which comprise the group of large cities in the world committed to combat climate change. Another initiative is the Cities for Climate Protection - CCP, launched in June 1991, by the International Council for Local Environmental Initiatives - ICLEI, with the objective of mobilizing local government actions to reduce greenhouse gas emissions and to strengthen collective international expression of municipal governments in face of national governments and the Convention[258].

Among the measures for adapting to climate change for urban areas, the following stand out:

- offer housing alternatives to low-income population that are currently living in areas of risk;
- greater rigor in compliance with laws of land use and occupation;
- development and implementation of urban design plans with a focus on urban and environmental comfort, which are not determined by decisions made in the real-estate sector;
- implementation of measures to mitigate rising temperatures (planting trees in cities, adaptation of buildings to tropical conditions);
- reformulation of the road system and sewage collection, especially in coastal cities;
- renaturalization (restoration of micro climates, revegetation, revitalization of watercourses) of urban areas.
- development of knowledge and technical alternatives to mitigate and adapt the population and cities to climate change;
- regulation of constructions through the Works Code and Director Plan, adapting to the effects of climate change; and
- implementation of mechanisms and policies to stimulate public transportation, subway/railway transport and modal integration.

2.3 Coastal Zone

Based on the different scenarios of greenhouse gas emissions, IPCC's Fourth Assessment Report (IPCC, 2007b) predicts that the combination of water's thermal expansion and the melting of glaciers located on the continents would result in an average increase in sea level of 18 cm to 59 cm between 2090-2099, compared to 1980-1990. Climate change and rising sea levels (variations in the relative level of the sea, that is, variations between the continent and sea) could increase erosion of coastal areas, the risk of coral bleaching and coral mortality and the negative impacts on mangroves and wet coastal areas. In Latin America, rising sea levels would increase the risk of flooding in lower coastal areas, mainly affecting river deltas and coastal urban areas.

Brazil's coast extends from the equatorial region of the Northern Hemisphere to the subtropical latitudes of the Southern Hemisphere, along more or less 8,000 km washed by the Western Atlantic Ocean. When considering the extension of the coastline, including the outline of the main estuaries and islands, that extension is approximately 12,600 km. As a consequence, along its entire extension, the Coastal Zone crosses different climate environments that vary from the equatorial and tropical humid to the semi-arid in the Northeast region, and the subtropical climate of the South region, and different geological and geomorphological environments (NEVES & MUEHE, 2008). For legal purposes, the Coastal Zone is comprised of a maritime band, 12 nautical miles wide, and a land band, 50 km wide from the coastline, corresponding to a total territorial surface of 535,000 km^2 (VIDIGAL, 2006). Nearly 20% of Brazil's population inhabits the municipalities bathed by the sea and along the banks

258 See Part III, Section 3.13, on Cities for Climate Protection.

of estuaries, that is, more than 38 million people, mainly concentrated near the state capitals. Ports, exploration of mineral resources, tourism, aquaculture, and environmental conservation or environmental protection areas, as well as housing, are the main economic activities or types of settlement in the coastal zone.

A method to analyze coastal municipality vulnerability to climate change consists of identifying the percentage of GDP generated there in comparison to state GDP. Wealth generation in the states of Amapá, Piauí, São Paulo, Paraná, Santa Catarina, and Rio Grande do Sul is comparable to the population that resides in the coastal zone. The state of Rio de Janeiro, where just over 80% of the wealth and 70% of the population are in the coastal zone, it is the combined result of the oil industry and various maritime activities (shipyards, tourism, etc.). In the other states, there is a stark discrepancy between population percentages (30% to 50%) and GDP (40% to 70%) percentages, with the extreme cases being Pernambuco (65% of GDP for 40% of the population), Alagoas (58% to 40%), Paraíba (45% to 28%), and Espírito Santo (72% to 48%). However, upon analyzing GDP *per capita* figures for all Brazilian municipalities, it is clear that, out of the 50 highest figures, only 14 municipalities were in the coastal zone, which is generally home to activities associated with ports or the oil industry, and out of the 100 highest figures, just 22 were in the coastal zone. Curiously enough, out of the 100 lowest figures for GDP per capita in Brazil, 12 were in the coastal zone.

In order to check the capacity of coastal municipalities to respond to emergency health events related natural disasters, it was found that along 6,000 km of coastline the number of hospital beds is under 1.5/1,000 inhabitants; along 4,100 km, the supply is somewhere between 1.5 and 2.5 beds/1,000 inhabitants; at 1,500 km, the supply is less than 3.5 beds/1,000 inhabitants; and, in just 800 km, the supply exceeds 3.5 beds/1,000 inhabitants, a rate that is considered desirable by Brazil's health authorities. However, the weakness of the port municipalities to tackle diseases brought by the crews of foreign vessels or other diseases caused by polluted water ballast is also a reality.

Therefore, all of this makes up a socioeconomic and physical-geographic picture that is quite complex for the Brazilian coastal zone, thus stressing the poor distribution of wealth in the municipalities, their inability to solve social and environmental problems associated with climate change, and the difficulty of states to perform coastal management.

The geomorphological areas most prone to erosion are in the Northeast region, partly due to the lack of rivers capable of supplying the sea with sediment, but also the retention of marine sands in the dune fields and the small declivity of the continental shelf, which amplifies the coast's adjustment to rising sea levels. The widespread depletion of internal continental shelf sediment, along with other factors — such as natural or induced changes of the sediment balance — has caused erosion of various degrees of intensity, along Brazil's coast (MMA, 2006).

On the other hand, the coasts in Brazil's South and Southeast regions are subject to extratropical cyclones, which in a unique situation reached hurricane force, Catarina, which hit the coast of the state of Santa Catarina, in February 2004 (NEVES & MUEHE, 2008).

It is estimated that the material values at risk in the coastal zone, considering the scenario with the highest rise in sea levels and extreme weather events, range between R$ 136.5 billion and R$ 207.5 billion (ROSMAN *et al.,* 2010). It is estimated that due to the estimated value of the property at risk, there must be a minimal investment of R$ 4 billion by 2050 to guarantee a sustainable base for decision-making and the safe assessment of infrastructure needed to tackle the expected changes. However, this appraisal of impacts and responses to climate change in Brazil's coastal zone is very uncertain, since little is known about some of the most important events, such as the generation of waves and meteorological tide, the region's relief and the morphology of the inner continental shelf.

The wind regime associated with dune deforestation has been a worrisome factor for urban occupation in several spots of Brazil's seashore (such as Itaúna-BA, Grussaí-RJ, Cabo Frio-RJ e Arraial do Cabo-RJ and several locations in the Northeast), due to wind transportation of sediment. Climate change that affects the local wind regime or dune-fixing vegetation, in the presence of sediment availability along the coastal strip, can cause adverse impacts. It is also important to be aware of variations in the reach of sea breezes in terms of sea spray on materials and structures.

As air circulation affects rainfall, the water balance in coastal regions (including rivers and lagoons, as well as sand banks and dunes, where rainwater is stored, and mangroves) will be very sensitive to global climate change. Since this areas has great economic value and population attraction, greater pressure may appear on the use of water resources in these regions, whether as sources of freshwater, or as areas of waste discharge.

Other factors can increase vulnerability, such as uncontrolled land occupation, the unsustainable exploitation of sand mines in estuaries and branches of the sea, as well as construction of coastal protection works with improper technical engineering criteria, which often trigger rapid erosion processes (such as Fortaleza - CE, Olinda - PE, Conceição da Barra - ES, Matinhos - PR).

In summary, the projected impacts on the Brazil's coastal zone as a consequence of global climate change, excluding those that would be common to continental areas (agriculture, climate, etc.), could be the following (NEVES & MUEHE, 2008):

- coastal erosion;
- damage to coastal protection works;
- effects of salt spray on concrete structure (buildings and maritime works) and historical monuments;
- structural or operational damage to ports and terminals;
- damage to urbanization works in coastal cities;
- structural damage or operational losses to sanitation works;
- exposure of buried ducts or structural damage to exposed ducts;
- landslides on coasts (or sea cliffs) in the coastal zone;
- saline intrusion in estuaries and aquifers that can affect the capturing of freshwater;
- alteration of the mangrove occupation area, which can result in impacts on birds, including migratory birds, such as local ichthyofauna[259];
- damage to ecosystems due to lack of freshwater caused by effects related to salt disequilibrium;
- damage to coral reefs.

Besides these effects, climate change associated with ocean-atmosphere interaction and its possible consequences on various types of settlement of the coastal zone and the Exclusive Economical Zone, including mineral exploration activities in the continental shelf and slope[260], and on the navigation routes in the South Atlantic must also be considered in view of the intensity and frequency of storms.

259 In ecology and fish sciences, ichthyofauna is the set of fish species that live in a specific biogeographical region.

260 In oceanography, the continental slope is the ocean floor with an accentuated slope that lies between the continental shelf and the continental margin, where the abyssal plains begin.

For management and policy decision purposes related to the best response to climate changes that affect the coastal zone, it is necessary to consider a multi- and interdisciplinary staff that considers fifteen "dimensions": (1) integrated cartographic base for the coastal zone (emerged and underwater regions); (2) continental contour and its vulnerability to various dynamic agents; (3) climate in the coastal zone and proper monitoring programs for diverse uses, including for engineering projects; (4) economic dependence in relation to the sea and coastal activities; (5) urbanization of the coastal band and the political arrangement of human occupation; (6) planning and control of collections and wealth generated in the coastal zone; (7) integrated analysis of environmental information; (8) education for the future, at every formal level and as part of informal education (scientific diffusion); (9) health in the coastal zone, including current infrastructure and political aspects of national migrations and health aspects of international maritime borders (port health); (10) coastal zone water, including those aspects related to capturing, treating and distributing drinking water, as well as the collection, treatment and return of wastewater; (11) final disposal of solid wastes; (12) energy generation and distribution; (13) food production and distribution; (14) geopolitical foreign relations at a regional, national and international level; (15) legislation at the federal, state and municipal levels that needs to be updated and foresees a specific budget for monitoring and adapting to climate change.

At the moment, the most recommendable response to the effects of climate change is establishing a strategy of actions for Integrated Coastal Management, which includes:

- conducting permanent environmental monitoring (long-term);
- proposing municipal legislations for urban land use and stricter enforcement of these;
- implementing effective state policies for coastal management;
- land use planning;
- integrating programs and policies for managing water resources and for coastal management;
- directing federal action efforts: legislation, education, monitoring, early warning system;
- planning and prioritizing studies for the classic forms of response (back off, accommodation and protection).

- elaborating guidelines and technical norms for coastal and maritime works that incorporate possible global climate change impacts on works and constructions;

- developing techniques for biological improvement of mangroves, aimed at reforestation;

2.4 Human Health

In terms of future effects of global climate change on human health, IPCC's Fourth Assessment Report, Working Group II's Report, "Impacts, Adaptation and Vulnerability" recognized the following possible impacts (IPCC, 2007b):

- changes in spatial distribution and intensity of endemic infectious disease transmission, especially those transmitted by vectors, such as malaria, dengue fever, leishmaniasis, etc.;

- greater risk of diarrhea, especially in children, as a result of worse access to good quality water, especially in dry tropical regions;

- worsening in the nutritional state of children, hampering their development, in areas already affected by food insecurity, and who suffer from prolonged periods of drought, in developing countries;

- increase in the risk of cardiorespiratory diseases due to the increase in the concentration of troposphere pollutants (especially ozone) influenced by higher temperatures;

- increased risk of problems in population groups considered most vulnerable, such as children and the elderly, indigenous populations and traditional communities, poor communities in urban zones, coastal populations and populations that depend directly on natural resources affected by climate variation.

Due to Brazil's geographic location and continental size, it can be the target of important climate changes that can have socio-environmental impacts, which, in turn, help increase in climate-sensitive endemic infectious diseases, such as malaria, dengue fever, cholera, leishmaniasis and leptospirosis, among others (MCT, 2007). Climate change action mechanisms can be direct, such as persistent humidity and temperatures that lead to the development and dissemination of infectious agents and vectors, and indirect, such as the human population migration processes triggered by drought, causing spatial redistribution of endemics and increased vulnerability of communities.

The important outbreaks of leptospirosis that have occurred in Rio de Janeiro are an example. From 1975-2006, 4,643 cases were reported, and in 1996 there was a great epidemic in Jacarepaguá - RJ, with 1,797 confirmed cases (CONFALONIERI & MARINHO, 2007). This was one of the greatest epidemics of the disease ever reported in the world. Similar problems are found in other great cities of the country, as a result of the precarious sanitation infrastructure and improper urban land use. The endemic infectious diseases of greatest importance in Brazil, related to climate change, are malaria and dengue fever, and their incidence can either increase or decrease at the regional level. The greatest importance of these problems is mainly related to their incidence and difficulty to control, as well as the known sensitivity to climate factors.

States in the Northeast region are the most vulnerable to climate impacts on health (MCT, 2007), which include water shortages, capable of affecting the epidemiological scenario of diseases associated to poor hygiene (for example, infectious diarrhea in children), as well as worsen food security situations that cause malnutrition. In years of severe drought associated with the *El Niño* phenomenon, a significant increase in children mortality rates caused by diarrheic diseases was ascertained.

In Brazil's semi-arid region, in the absence of seasonal rains — as occurs in periods of drought — the population has historically migrated from rural to urban areas in search of government assistance. Thus, the demographic change factor can become one of the major mediating elements among extreme climate phenomena (in this case, drought) and their effects on the economy and health. Intra- or interregional displacement of drought migrants entails changes in the regional economy and an increase in public security at destination points, as a result of the increase in demand for public services in general, including those from the Single Health System - SUS[261]. Triggering of

261 The Single Health System - SUS was created by the Federal Constitution of 1988 and regulated by Law nº 8,080/1990 and nº 8,142/1990, Organic Health Laws, with the purpose of changing the situation of health care inequity for the population, making it obligatory for the public system to care for any citizen and where monetary charges of any sort are prohibited. For more information, see <http://portal.saude.gov.br/portal/saude/visualizar_texto.cfm?idtxt=24627>.

migratory flows can also spatially redistribute chronic as well as infectious diseases such as dengue fever, chalazion, schistosomiasis and Chagas' disease.

A regional study that quantifies the vulnerability of Brazil's Northeast region, in relation to impacts inferred by regional climate scenarios, helped develop a composite index of vulnerability. The rational behind this study of the Northeast were the following:

- projected increase of aridity in the region according to INPE scenarios;
- worst health vulnerability rates, according to the MCT/Fiocruz project, at national level (CONFALONIERI *et al.*, 2009);
- possibly the region most affected by climate change in Brazil, in accordance with the "Climate Change Index" (BAETTIG *et al.,* 2007);
- region historically affected by droughts, with serious social impacts, and with low socioeconomic indicators.

The General Vulnerability Index was obtained by state for the region through the association of health problem data (Health Vulnerability Index – HVI) capable of being directly or indirectly influenced by climate factors, with environmental data (Desertification Vulnerability Index – DVI) and demographic and economic projections obtained from regional climate change scenarios, as a consequence of global climate change (Socioeconomic Vulnerability Index – SEVI and Climatic Vulnerability Index – CVI). The main assumption was that based on projections of an increase in future aridity, water and food shortages will worsen the health scenario and lead to migrations capable of redistributing endemic diseases in the geographic space and increase pressure on health care services in migrant destination areas. The analysis instrument was to obtain metrics, ranging from 0.0 to 1.0 capable of reflecting important causal relations in the context of "drought/agricultural losses/food insecurity/migrations/health".

Inclusion of data on desertification was considered important due to the relation this form of soil degradation has with climate (and land use), as well as its impact on subsistence farming productivity, and therefore, on the permanence of the population in affected areas.

Indexes for both climate change scenarios (A2 and B2) were analyzed by state. As a result, those with the greatest vulnerability in both scenarios were determined to be Ceará and Pernambuco. High values for partial Health Vulnerability Index – HVI, Desertification Vulnerability Index – DVI, Socioeconomic Vulnerability Index – SEVI and, to a lesser degree, Climatic Vulnerability Index – CVI indicators contributed to this. In the scenario of higher carbon emissions (A2), the state of Bahia also revealed a high degree of vulnerability (0.75), an index that fell to 0.37 in the lower emission scenario (B2).

For the Second National Communication, based on the Eta-CPTEC runs, a General Vulnerability Index - IVGp was built (it was prepared by Fiocruz and UFMG's Department of Demography); with a composite indicator for each Brazilian state, made up of health sub-indicators (trends of climate-sensitive endemic infectious diseases); demographic (population growth in general and population growth for those older than 60, until 2040); and projected climate anomalies, according to the Eta-CPTEC model, with lateral conditions for the global coupled HadCM3 model. For the A1FI scenario (2011-2040), which assumes the continuation of intensive use of fossil fuels, the following values were obtained for each state. These values are arranged in ascending order, from lowest to highest vulnerability (an IVGp value = 1.0 denotes the highest vulnerability):

IVGp Values	**states**
0.0 < IVGp<= 0.2	DF, PR, PE, RJ, RS, SE
0.2 < IVGp<= 0.3	AL, PB, SC, SP
0.3 < IVGp<= 0.4	AP, RN
0.4 < IVGp<= 0.5	CE, ES, RR
0.5 < IVGp<= 0.7	AM, BA, MS, MG, PI, RO, TO
0.7 < IVGp<= 1.0	AC, GO, MA, MT, PA

The computation of IVGp shows a predominance of states in the Central-West, North and Northeast regions in the worst category (values from 0.5 to 1.0), comprising 12 states. Regarding the group of states with the lowest IVGp values, it is clear that those with values up to 0.3 include two states in the Southeast region, the three states in the South region and the Federal District, in addition to four Northeastern states. The overall vulnerability of states, as noted in this assessment, if compared with the previous study (MCT, 2005), shows the following:

- There is a general agreement between the two studies in the sense of indicating the Federal District and all Southern states as among the least vulnerable.

- There is less agreement as regards the lowest IVGp values. This is so because while in the first study (MCT, 2007) all the worst situations were represented by the Northeastern states, in the current assessment this distribution was more heterogeneous, since this group has states that are in the North, Central-West and even Southeast regions, in addition to the Northeast region.

In relation to the importance of these studies, it is necessary to consider the use of these types of composite indexes, in a comparative manner, in public policies and regional strategies to cope with climate change. Taking into account the relative contribution of each factor and the cross-cutting nature of climate issues and other environmental and socioeconomic factors that affect human health, these should be considered when planning climate change adaptation policies.

In the Amazon, which is also a vulnerable region, the possible impacts of a reduction in rainfall and an increase in temperatures are related to four main aspects: worsening in the access to good quality water; reduction in the abundance of extractive goods for subsistence; increase in the inhalation of smoke from forest fires; changes in the cycles of endemic transmissible diseases, such as malaria and leishmaniasis, among others (CONFALONIERI, 2008). The degree of expected impacts on the environment and on health in central Brazilian Amazon can be illustrated by using the drought of 2005 as an example. Small river bank communities were isolated without sufficient water and without any possibility for fishing as a result of the drying up of access bayous (WORLD BANK, 2005).

With respect to endemic diseases, future scenarios for malaria in the Amazon, considering only the environmental factors, will depend on what comes to happen, by influence of the climate with the forest and most especially with its hydrological cycle (CONFALONIERI, 2008). Dengue fever, another amply distributed and climate sensitive endemic disease, suffers a seasonal influence. The result is greater incidence of the disease, currently in the summer. This is caused due to persistent favorable temperatures and humidity as well as greater exposure of the population at this time of year. The direction possible modifications in dengue fever epidemiology will take in Brazil will depend on what happens with climate change at the regional or sub-regional level. For example, the projected scenarios for the Northeast would not be favorable from an environmental perspective to the dengue fever cycle, because the increase in temperature would be accompanied by a reduction in humidity, which is unfavorable for its development.

Urban populations, especially the marginalized ones, are vulnerable to three main risks: landslides on inhabited cliffs during periods of heavy rains; risk of leptospirosis epidemics in floodable areas poorly served by waste collection, during flooding; exposure to air pollutants, such as ozone, whose concentrations can increase as a result of higher temperatures (CONFALONIERI, 2008).

Special attention must be given to seashore metropolitan regions that have historically presented greater morbimortality rates, as a result of their social, demographic and geographic characteristics (MCT, 2007). Coastal impacts resulting from an increase in average sea levels will mainly occur as a result of soil salinization, with the loss of farmable areas and deterioration of drinking water reservoirs. There may also be damage to sanitation, electricity and etc. infrastructure due to erosion. The effects on health would therefore be indirect.

With greater occurrence of extreme rain events in the South and Southeast regions of the country, the greatest risk situation would result from exposure to storms and flooding. In these regions, heavy rains and flooding have historically been recorded with fatal victims on diverse occasions.

Considering the current set of evidence, the following general measures for adaptation are recommended for the health sector (CONFALONIERI, 2008):

- improvement of programs to control widely disseminated infectious diseases across the country with high levels of endemicity and that are sensitive to the climate, especially malaria and dengue fever;

- reduction of general social vulnerability requirements for the population at risk of suffering health problems (infectious diseases and accidents , mainly by critical events), through economic, educational and housing policies;

- creation of early warning systems, coordinating the prediction of extreme climate events with vulnerability maps and contingency plans that also involve health care assistance;

- identification of the impacts of global climate change on human health and its physical and financial quantification, including, among others, information on food production, endemic infectious disease treatment costs and air pollution, morbi-mortality and material impacts.

2.5 Energy and Water Resources

According to IPCC's Fourth Assessment Report, Working Group II's Report, "Impacts, Adaptation and Vulnerability" (IPCC, 2007b), the effects of climate evolution on water body flows and recharging of aquifers vary according to the idealized regions and climatic scenarios, mainly as a result of variations in projected rainfall. In the projections conducted thus far, the results for South America do not present coherence in flow projects, first, because of the different rainfall projections, and second, as a result of the different projections related to evaporation that can counter-balance the increase in rainfall (Figure 1.2).

Brazil has the largest surface water reserve on the planet, nearly 19.4%, and one of the greatest hydraulic potentials. However, there is a gap between water availability and the location of consumptive and non-consumptive water demands (FREITAS, 2003). Indeed, around 90% of the waters are found in the Amazonas River and Tocantins River watersheds, which are low demographic density areas, whereas nearly 90% of the population lives with the remaining 10% of water resources.

There are also regional challenges associated to water resources. If droughts are periodic in the Northeast region, in the Southeast industrial and urban pollution, as well as silting of rivers, causes the most concern (FREITAS & SOITO, 2008). Further to the south, agricultural and animal production is responsible for hard to control disseminated pollution of surface and underground water bodies. Even in the planet's largest watershed, the Amazon, there are problems resulting from demographic expansion and uncontrolled land use. Some are local, such as the pollution of bayous and rivers that bathe urban centers; others are regional in scope, such as water-transmitted diseases and degradation of water quality in smaller communities during drought periods.

In long and mid-term scenarios of water use in Brazilian watersheds, water needs tend to increase as a result of demographic growth, and most of all, economic development. This is associated to the fact that the risk for global climate change can alter the hydrological cycle, and the regime and availability of water in the watersheds, increasing pressure on water resources.

The impacts of climate change will not be uniformly distributed among regions and populations. Populations, production sectors and natural systems can be more or less affected or benefited. Thus, the impacts can vary in magnitude and intensity, according to geographic location, weather and social, economic and environmental conditions and local infrastructure.

In relation to Brazil's main watersheds, the São Francisco River is mainly characterized by serving the demands of consumptive use, such as irrigation for producing foods, supplying water for human consumption and diluting pollutants from urban and industrial sewage. Thus, with a possible change in the water regime due to climate change, conflicts regarding water use could increase. Therefore, actions that increase efficiency in water resource use for irrigation and improve treatment of urban pollutants should be given priority. In relation to hydraulic potential, a reduction could cause a decrease in energy generation throughout the year, which should be complemented by other sources in the interconnected electric system.

The Paraná river watershed is vitally important for the Brazilian electric system, with more than 50% of the country's installed capacity in operation. The Itaipu hydroelectric power plant, with its 14,000 MW of installed capacity deserves special notice. However, this watershed is also the largest in population density, which leads to several conflicts of land and water use, both urban and rural, which can hamper future use of hydraulic potential, and most especially, limit the generation of electric energy at plants in operation. In relation to climate changes, the Paraná river watershed has been mainly characterized by the risk of flooding with greater frequency in years of abnormal heating of the Pacific Ocean, when the *El Niño* event takes place. The flow of water of hydroelectric power plants has been used to regulate water availability and to manage extreme flooding events. Thus, attention must be given to conflicts in water use in Paraná watershed, which translate into hydroelectric power generation vulnerabilities that deserve greater attention from the electrical sector and water managers, because they could get worse in the future.

The continental Amazon basin is world's largest watershed, with a surface of approximately 6,100,000 km^2. It is of enormous importance in the climate dynamics and in the planet's hydrological cycle. The watershed represents approximately 16% of the Earth's surface freshwater stock, and consequently, it plays an important role in the rain and evapo-transpiration regime for South America and the world. Regional changes – notably land use change – have caused alterations in the Amazon's climate and hydrology. The change in global temperature can lead to various other changes in the environment, including intensification of the global hydrological cycle, which will have an impact on water resources at regional level. It must be pointed out that if there is an intensification of abnormal heating phenomena of the Pacific and Atlantic Oceans' surface temperatures, rains, and therefore, river flows may be reduced. Indeed, in relation to the Pacific Ocean, *El Niño* occurrences have determined extreme events of rain deficiencies, and as a consequence, low discharges into the region's rivers, especially in northeastern Amazon. However, the impact of climate variability on hydrology in the Amazon watershed as a whole is still little known. Great extensions of the Amazon have received below average rainfall since September 1997. This had adverse impacts in food security for the riparian populations and in the generation of hydroelectric power, with a reduction in reservoir levels and an increase in demands for thermoelectric energy (MARENGO, 2006). On the other hand, the harshest draught over the past 106 years that affected the Amazon in 2005 did not have its root causes associated to *El Niño*; rather, it was due to an abnormal warming in the tropical portion of the North Atlantic Ocean during summer and autumn in 2005 (MARENGO *et al.*, 2008).

Due to the great participation of hydroelectric power plants in the Brazilian Electric System, electric power generation in the country is heavily dependent on the watershed's hydrological regimes (FREITAS & SOITO, 2008). Since there is a regional disequilibrium in water availability, new and old hydroelectric projects are, to a greater or lesser degree, vulnerable to climate change, whether by the reduction in average flows in watersheds, or by extreme events that could harm plant operation. The crisis that occurred between 2001 and 2002 and which affected electric energy supply and distribution, resulting in power interruptions and rationing, serves as a warning.

Together, the South and Southeast regions hold nearly 59% of all hydroelectric potential in operation or under construction. On the other hand, the North region alone has nearly 52% of the hydroelectric potential under study or estimated (ELETROBRÁS, 2007). In other words, this indicates that in the short term, concerns about vulnerability should mainly focus on the South and Southeast regions. However, for the future, an understanding of global climate change and its relations with the North region's hydraulic potential must be improved.

The "Climate Change and Energy Security in Brazil" study (SCHAEFFER *et al.*, 2008) used IPCC scenarios, 2030 National Energy Plan projections, National Electric System Operator - ONS and National Water Agency - ANA flow data to investigate the vulnerabilities of the energy sector to the effects of climate change. According to preliminary estimates, climate change can imply in an average drop of 8.6% (scenario A2) to 10.8% (scenario B2) in average annual flow, that is, the average annual quantity of water that flows to the plants. The hydroelectric power plants in the São Francisco river watershed will be the most affected. In the large Paraná river watershed, comprised of the Paraná river and the Paranaíba, Paranapanema and Grande river watershed, despite the drop in average annual flow, would have the highest flows in the beginning of the rainy season. Storage of this additional water would mitigate the negative effects of average annual flow reductions, at least at the already existing plants. Studies on rainfall also indicate a possible strong impact of a variation in average annual flow in the Amazon, but there the hydroelectric power generation is not well exploited. If theses drops in average flows are confirmed, there would be negative effects in total average energy production at the Brazilian hydroelectric power plants, which would fall 1% in scenario A1 and 2.2% in scenario B2. The most accentuated effect would be felt at the São Francisco river hydroelectric power plants, where production would fall 7.7%.

The studies conducted as part of Brazil's Second National Communication, based on downscaling and the Eta-CPTEC model, show that in the short and medium terms (2011-2040) the impact on electric power generation in Brazil should not be negative since hydroelectric generation tends to be helped by the climate scenarios produced. Recent studies for the sector point, however, to the opposite direction in terms of the results for longer periods (2070-2010), as shown in Table 2.1.

Table 2.1 Comparison of various studies regarding the impact on electric power generation in Brazil based on future climate change scenarios

	Current Study	SCHAEFFER *et al.* (2008)	SCHAEFFER *et al.* (2010)
Scenarios - Emission	A1b	A2 and B2	A2 and B2
GCM	HadCM3	HadCM3	HadCM3
Downscaling	ETA	PRECIS	PRECIS
Timeframe	2011-2040	2071-2100	2025-2100*
Hydrological Modeling	Water Balance	Estatistics	Water/Statistical Balance
Energy Modeling	MSUI	SUISHI-O	SUISHI-O
Results	Average Energy (+12-16%); Firm Energy (+14-20%); Negative Regional Impacts (East Atl. and Parnaíba)	Average Energy (+12-16%); Strong Negative Regional Impacts (N/NE)	Average Energy (- 1-3%); Firm Energy (-29-32%); Strong Negative Regional Impacts (N/NE)
Adaptation	MAED-MESSAGE	-	MAED-MESSAGE
Results	Decreased Installed Cap.	-	Increased Installed Cap.

* 2025-2070 timeframe based on interpolation by CPTEC/INPE.
Source: COPPE/UFRJ, 2010.

It is therefore important that these results are reviewed with caution, considering that these are studies based on different methodologies and climate data. Such a comparison of results underscores the need for further studies on the impact of future climate on the energy sector. The study on vulnerability of the national energy sector should be continually developed and improved. The main developments include use of a greater amount of future climate scenarios in order to be able to reduce uncertainty about the potential impacts of global climate change. It is also of utmost importance to expand the database on regional climate variables to make it possible to monitor the climate change process and provide better conditions for new studies to be conducted.

Despite the cumulative uncertainties that are inherent to studies on global climate change impacts and the associated adaptation, it is important to note that, because hydroelectric power generation is intrinsically dependent on climate conditions, it is vulnerable to climate change, regardless of confirmed future scenarios. Therefore, it takes an ongoing effort to evaluate the sector's vulnerability while seeking to increase the number of scenarios as well as to improve the methodology in place. Likewise, the Brazilian energy system's vulnerability to global climate change requires a comprehensive investigation, as of now, of adaptation options so that action can be taken in a timely manner, despite the uncertainties about climate scenarios. Thus, adaptation policies should be designed in such a way that their implementation is beneficial, even if the climate scenario does not materialize, to the extent that they focus on reducing the system's vulnerability to weather fluctuations. Finally, expanding the meteorological data measurement and monitoring network is a precondition to the evolution of studies on global climate change impacts in Brazil.

Some of the possible measures to adapt to global climate change are described below:

- promote the multiple and integrated management of the reservoirs;
- integrate water resource plans with hydroelectric power generation planning and operation (and other water uses);
- promote the rational and integrated use of water resources;
- promote implementation of the management systems of the instruments stipulated in the National Water Resource Policy;
- develop new institutional and regulatory arrangements for generating hydraulic energy;
- review operational rules for hydroelectric power plants taking into account the possible impacts of global climate change;
- increase the rational use of energy and energy efficiency;
- expand the supply of electricity through the use of alternative fuels, such as solid urban waste, sugarcane bagasse, wind energy, solar energy and tidal energy; and
- promote the management of demand and increase in the supply of biofuels, especially biodiesel.

2.6 Forests

IPCC's climate models indicate that the most vulnerable regions in South America to climate change, as far as socioeconomy and biodiversity are concerned, are the Amazon and Brazil's Northeast region (MARENGO, 2008). For the middle of this century, the IPCC projects (IPCC, 2007a), with a high degree of confidence, that the increase in temperature and associated decrease in water availability in the soil could lead to the gradual replacement of tropical forest with savannah in a part of the Amazon. Significant losses of Amazon Forest are expected as a result of an average increase in temperature of 2.5 °C above the average pre-industrial era temperature (IPCC, 2007a). It is also very likely[262] that natural disorders such as fires, insects and disease will be altered by climate change in frequency and intensity, with an impact on forests and the forestry sector. However, it is hard to precisely estimate the impact of climate change on these disorders.

Both the climate and non-climate induction forces affect forest systems, making it a challenge to analyze the role of climate change on the changes reported (KRUG, 2008). Non-climate forces include urbanization and pollution, which can influence the systems either directly or indirectly, through its effects on albedo and the soil moisture regime. Socioeconomic processes, including changes in land use (such as the conversion of forests into farmland, or farmland into urban areas) and modification of land cover (such as through degradation or restoration processes) also affect these systems.

An understanding of the impact potential of climate change in forest ecosystems is of particular importance to Brazil,

262 Probability above 90%.

which holds about 30% of the world's tropical forests (FAO, 2005) and more than half of its territory is covered by native forest formations, distributed across its biomes, especially in the Amazon and *Cerrado*.

Primary forest in the Legal Amazon encompasses an area of approximately 3.5 million km² (including the *Cerradão*, a *Cerrado* biome forest formation that, from a profile perspective, is a forest, but in terms of flora resources, it resembles the *Cerrado*). The *Cerrado* (including park *Cerrado* formations, *Cerrado* stricto sensu, *Cerrado* fields, among others) covers nearly 2 million km², throughout Central Brazil. The other biomes have less significant forest cover. For instance, the Atlantic Forest has currently less than 7% of its original vegetation cover.

There is a risk of losing more than 40% of the forest in some parts of the Amazon, for those scenarios that include temperature anomalies of more than 3 °C (SCHOLZE *et al.*, 2006). On the other hand, while there is a tendency for an increase in rainfall, this would counterbalance a reduction in rain due to deforestation and the final result would be more favorable for maintenance of ecosystems and species. The many studies conducted by the Amazon Environmental Research Institute – IPAM show that in a scenario of global warming and more frequent droughts, the Amazon's forests would lose much moisture, becoming much more vulnerable to fires, and there could be a significant increase in tree mortality with the consequent increase in carbon emissions into the atmosphere.

Fragmented forests are more vulnerable to the periodic damage of droughts caused by *El Niño* than pristine forest. Although the IPCC indicates significant uncertainty in *El Niño's* behavior in the future, it also points to the possibility of an intensification of heavy rainfall, drought and flooding extremes. Damage caused by droughts in the Amazon includes the high mortality rate of trees, changes in plant phenology and other ecological changes, especially around the forests' rims. Studies indicate that forest fires are becoming more common and have strong negative effects on the Amazon's vegetation (COCHRANE & LAURANCE, 2002; COCHRANE 2003). For example, the drought caused by *El Niño* in the north of the country in 1997-1998 was responsible for the large scale forest fire in the state of Roraima, which affected a significant portion of its primary forest. However, it is important to underscore that the burning of biomass also increases the quantity of aerosols in the atmosphere, and these have a negative radiation impact at global level. Forest fires have also been detected in larger quantities during the 2005 drought (MARENGO *et al.,* 2008) and during the 2010 dry spell.

On the other hand, some types of forest can benefit from climate change, particularly those currently affected by limitations of their minimum temperature and rainfall requirements, or by gains in net productivity as a result of CO_2 fertilization (although the magnitude of this effect is still uncertain for some types of systems).

It is necessary to add climate alterations caused by changes in vegetation cover to those that stem from global warming. There are projections that deforestation of the tropical forest will lead to a hotter and drier climate in the region (NOBRE *et al.*, 1991; SAMPAIO *et al.*, 2007; COSTA *et al.*, 2007). Studies also indicate that forest loss in the Amazon can change the levels of rainfall in vast areas of South America (MARENGO, 2006). Evapotranspiration in the Amazon feeds the rains that flow through the Andes and reach the South Central, Southeast and South regions of Brazil. Deforestation could thus reduce rains in these regions.

The loss of forests diminishes their potential role as a carbon sink and reservoir, and contributes towards increasing the concentration of CO_2 in the air. On the other hand, it is estimated that negative impacts of climate change will contribute towards forest destruction or degradation, thus promoting greenhouse gas emissions.

Since there is an interplay between deforestation and climate change, where the former intensifies the impacts of the latter, actions to reduce deforestation will consequently reduce forest vulnerability to climate change. However, for forests with low or no management, especially tropical forests, there are fewer options for planned adaptation than for more intensely managed forests, increasing the uncertainties regarding their vulnerability to climate change. Preventing forest fragmentation is an early adaptation measure for native forests, which is also associated with a reduction in deforestation. This reduction will bring benefits for preventing climate change (mitigation) as well as for adaptation, reducing the vulnerability of forests to climate change.

Therefore, forest policies have an important role in mitigating climate change, including reforestation and afforestation, forest management activities, reductions in deforestation rates and use of forest products and waste in the production of bioenergy to replace fossil fuels, among others. Nowadays, under the Convention, there is an effort to reduce emissions caused by deforestation and degradation in developing countries that, although it may be understood as an effort for mitigation, also includes components of adaptation, since it preserves the wealth of species and continuity of forest ecosystems, and resilience.

The adaptation of species to climate change can occur through evolution or migration to more appropriate locations, the latter most probably being the most common response in the past (KRUG, 2008). Among the likely land use and management practices to maintain biodiversity and the ecological functions of forests it can be included protection of primary forests, containing fragmentation and representation of forest types along environmental gradients in reserves, low intensity forest exploitations, maintenance of a diverse genetic bank and identification and protection of functional groups and relevant species.

2.7 Agriculture and Livestock

2.7.1 Infrastructure for Research on Interactions between Climate Change and Agriculture

Agriculture is an activity broadly dependent on climate factors, whose changes can affect productivity and crop management, with social, economic and political consequences (LIMA & ALVES, 2008).

The IPCC points to a great probability of natural resource degradation, such as soil and water, due to changes in temperature and rainfall, with negative consequences for agriculture (IPCC, 2007b). It also projects a decrease in productivity for many crops, even when considering the direct effects of an increase in CO_2 concentration and the adoption of adaptation measures in production areas. Climate change can also cause losses of organic material in the soil, changing the balance of nutrient input and output, thus affecting the yields of agricultural systems.

Therefore, the effects of global climate change on agriculture could result primarily in a drop in productivity and reduction in areas for conducting agriculture and livestock activities. The vulnerability of agricultural establishments varies greatly, which means that its capacity to adopt actions to adapt to climate change vary not only as a result of different climate, region and crop scenarios, but also according to their socioeconomic conditions and access to benefits from public policies that focus on reducing their vulnerability. As a result of the cumulative effect of spatial and scocioeconomic forces, the impacts of climate change on agriculture should be assessed both at national and international levels. Some analyses of agriculture vulnerability are presented below. However, it must be highlighted that the effects of pests and diseases and extreme weather events that could drastically modify the predictions for crop productivity were not considered. In addition, there are also uncertainties regarding the effect of CO_2 fertilization on the productivity of these crops.

Due to the need for decision-making and the development of public policies that will rise to projected climate change, an analysis of production system vulnerability is of vital importance for planning and adopting adaptation strategies. This should be done with the best sets of data available rather than waiting for perfect data that makes any decision-making impossible. In this context, the continuous evolution in quality and definition of uncertainties of climatic projections of regional air circulation models can be seen in improved analyses of crop vulnerability, granting greater security in public policy making.

One of the adaptation measures is the use of agroclimatological zoning as a tool to identify the best areas for each type of crop, affording greater productivity, which has been done in Brazil since the mid 1990s, through the Climate Risk Zoning program for Brazil's main crops, maintained by the Federal Government[263], becoming a catalyst for technology, reducing the production risk for these crops. The same methods used in Climate Risk Zoning have been used to analyze the future vulnerability of crops, by incorporating regional model input data and running the scenarios defined by the IPCC (NAKICENOVIC *et al.,* 2000).

The study "Global Warming and New Geography of Agriculture Production in Brazil" (ASSAD & PINTO, 2008) presents an analysis of vulnerability for nine crops to the impact of climate change in Brazil. For this analysis, regionalized projections for IPCC scenarios B2 and A2, conducted by INPE (MARENGO *et al*., 2007), were used as input for the Climate Risk Zoning models for the crops considered. The results of this study, shown in Table 2.2, show great variation in potential low risk areas for developing each crop.

263 See: <http://www.agritempo.gov.br>.

Table 2.2 Percent variation of potential low risk area for nine Brazilian crops, for scenarios B2 and A2

Crops	Current production	Value of production	Current area	Scenario B2 - percent variation re current area or production			Scenario A2 - percent variation re current area or production		
	(tons)	R$ 1,000	(km²)	2020	2050	2070	2020	2050	2070
Cotton	2,898,721	2,831,274	4,029,507	-11.04	-14.17	-15.71	-11.07	-14.40	-16.12
Rice	11,526,685	4,305,559	4,168,806	-08.56	-12.53	-14.31	-09.70	-12.32	-14.19
Coffee	2,573,368	9,310,493	395,976	-06.75	-18.32	-27.61	-9.48	-17.15	-33.01
Sugarcane	457,245,516	16,969,188	619,422	170.93	146.77	143.42	159.76	138.58	118.18
Beans	3,457,744	3,557,632	4,137,837	-04.35	-10.01	-12.75	-4.36	-10.21	-13.3
Sunflower	-----	-------	4,440,650	-14.10	-16.63	-18.25	-14.16	-16.47	-18.17
Cassava	26,639,013	4,373,156	5,169,601	-02.51	07.29	16.61	-03.15	13.48	21.26
Corn	42,661,677	9,955,266	4,381,791	-12.17	-15.13	-16.98	-11.98	-15.18	-17.28
Soy bean	52,454,640	18,470,711	2,790,265	-21.62	-29.66	-34.86	-23.59	-34.15	-41.39

Source: Adapted from ASSAD & PINTO, 2008.

The analysis in Table 2.2 shows a reduction in low-risk areas for the crop in most cases. With the exception of sugarcane, there are significant reductions for cotton, sunflower, coffee, rice, beans, and primarily corn and soy bean. Cassava, although revealing an increase in area in other regions of Brazil, has its areas reduced in area in the Northeast region, where it is a staple food for the population.

Given these future agro-scenarios, it is worth analyzing which measures for adapting to climate change can be taken to reduce the vulnerability of agriculture systems. Genetic improvement of plants is key to adapting crops to conditions of stress. However, management of production systems, such as irrigation, landscaping for the production of grains and pasture, direct planting and incentive for a mixed production system, as well as incentives for the maintenance and expansion of forested areas, forest corridors and integrated crop-forest systems, can contribute more immediately to mitigate the problem.

The essential factor for growing crops that will be most affected if any projected future climate scenario holds true is water availability. Thus, provided it is possible to store water in an efficient manner for use in crop irrigation, this activity can also be seen as one of the most evident ways for crop management systems to adapt in face of climate change.

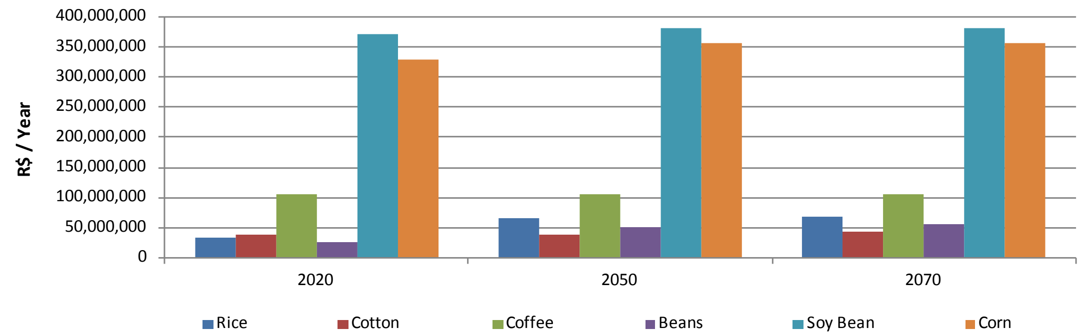
In relation to agriculture, the study "Climate Change Economy in Brazil: Costs and Opportunities" (MARCOVITCH *et al.*, 2010) shows an analysis of investments in these two options for adapting the production system, genetic improvement and irrigation, aimed at supporting decision-making and defining public policies that deal with actions for adapting to climate change impacts on Brazilian agriculture. Genetic improvement or irrigation actions were considered individually and were deemed sufficient to avoid economic losses associated to a reduction in potential low-risk area for crops, presented in Table 2.2 as a means to conduct a simplified cost/benefit analysis. Thus, Tables 2.3, 2.4, 2.5, and 2.6 and in Figures 2.1, 2.2, 2.3, and 2.4 have been adapted from that study, and they show a comparison between adaptation costs and losses that would result from a reduction in crop area in the analyzed scenarios, if planting of the existing cultivars continued, or, in the case of irrigation, the water management currently adopted persisted. The "Cost/Loss" column (Tables 2.3, 2.4, 2.5, and 2.6) provides a notion of the advantage of investing in the adaptation or not, where, the greater its value, the less advantageous the investment.

Table 2.3 Estimated annual costs for the genetic adaptation of all cultivars registered at MAPA for 2020, 2050 and 2070, PRECIS RCM, scenario A2

	PRECIS RCM A2 - 2020			PRECIS RCM A2 - 2050			PRECIS RCM A2 - 2070		
Crops	Cost/Year* (R$1,000.00)	Loss/Year** (R$ 1,000.00)	Cost/ Loss	Cost/Year* (R$1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss	Cost/Year* (R$ 1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss
Rice	34,000	417,639	8%	65,000	530,444	12%	68,000	610,958	11%
Cotton	38,000	313,422	12%	38,000	407,703	9%	44,000	456,401	10%
Coffee	104,000	882,463	12%	104,000	1,596,749	7%	104,000	3,073,393	3%
Beans	27,000	155,112	17%	51,000	363,234	14%	55,000	473,165	12%
Soy bean	369,000	4,357,240	8%	378,000	6,307,747	6%	378,000	7,645,027	5%
Corn	328,000	1,192,640	28%	354,000	1,511,209	23%	354,000	1,720,269	21%

*Estimated annual cost of crop improvement.
**Estimated losses from production value and changes shown in Table 2.2.
Source: Embrapa, 2010.

Figure 2.1 Estimated annual costs for the genetic adaptation of all cultivars registered at MAPA for 2020, 2050 and 2070, PRECIS, scenario A2



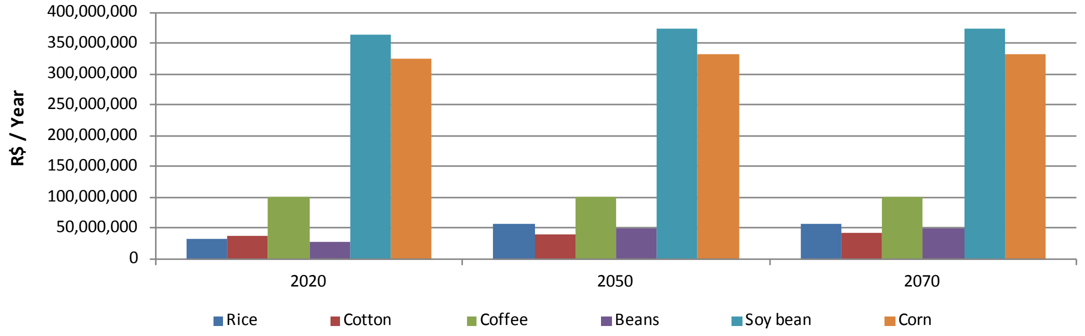
Source: Embrapa, 2010.

Table 2.4 Estimated annual costs for the genetic adaptation of all cultivars registered at MAPA for 2020, 2050 and 2070, PRECIS RCM, scenario B2

	PRECIS RCM B2 - 2020			PRECIS RCM B2 - 2050			PRECIS RCM B2 - 2070		
Crops	Cost/Year* (R$1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss	Cost/Year* (R$1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss	Cost/Year* (R$1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss
Rice	34,000	368,555	9%	58,000	539,486	11%	58,000	616,125	9%
Cotton	38,000	312,572	12%	40,000	401,191	10%	43,000	444,793	10%
Coffee	104,000	628,458	17%	104,000	1,705,682	6%	104,000	2,570,627	4%
Beans	28,000	154,756	18%	51,000	356,118	14%	51,000	453,598	11%
Soy bean	369,000	3,993,367	9%	378,000	5,478,412	7%	378,000	6,438,889	6%
Corn	327,000	1,211,555	27%	337,000	1,506,231	22%	337,000	1,690,404	20%

*Estimated annual cost of crop improvement.
**Estimated losses from production value and changes shown in Table 2.2.
Source: Embrapa, 2010.

Figure 2.2 Estimated annual costs for the genetic adaptation of all cultivars registered at MAPA for 2020, 2050 and 2070, PRECIS, scenario B2



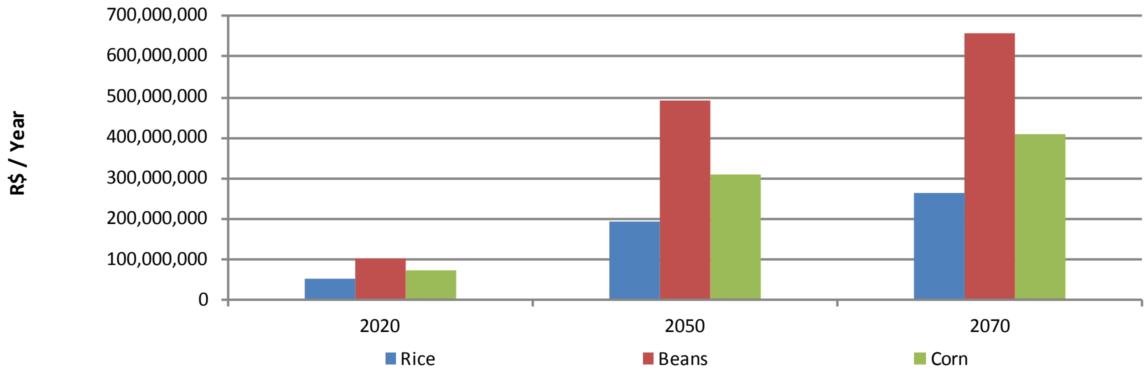
Source: Embrapa, 2010.

Table 2.5 Estimated annual costs for the irrigation of rice, beans and corn in municipalities excluded from apt regions in scenarios for 2020, 2050 and 2070, PRECIS, scenario 2

	PRECIS RCM A2 - 2020			PRECIS RCM A2 - 2050			PRECIS RCM A2 - 2070		
Crops	Cost/Year* (R$1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss	Cost/Year* (R$1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss	Cost/Year* (R$1,000.00)	Loss/ Year** (R$ 1,000.00)	Cost/ Loss
Rice	56,336	417,639	13%	197,480	530,444	37%	264,173	610,958	43%
Beans	102,358	155,112	66%	493,802	363,234	136%	660,725	473,165	140%
Corn	72,175	1,192,640	6%	309,338	1,511,209	20%	409,001	1,720,269	24%

*Estimated annual cost of crop irrigation.
**Estimated losses from production value and changes shown in Table 2.2.
Source: Embrapa, 2010.

Figure 2.3 Estimated annual costs for the irrigation of rice, beans and corn in municipalities excluded from apt regions in scenarios for 2020, 2050 and 2070, PRECIS, scenario A2



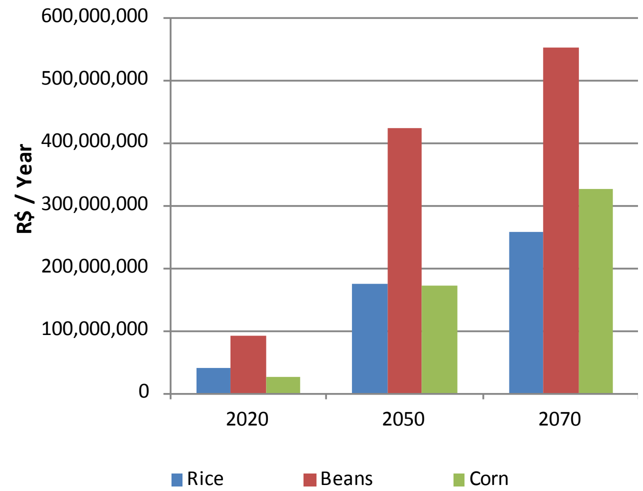
Source: Embrapa, 2010.

Table 2.6 Estimated annual costs for the irrigation of rice, beans and corn in municipalities excluded from apt regions in scenarios for 2020, 2050 and 2070, PRECIS, scenario B2.

	PRECIS RCM B2 - 2020			PRECIS RCM B2 - 2050			PRECIS RCM B2 - 2070		
Crops	Cost/Year* (R$1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss	Cost/Year* (R$1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss	Cost/Year* (R$1,000.00)	Loss/Year** (R$1,000.00)	Cost/ Loss
Rice	40,813	368,555	11%	172,870	539,486	32%	255,380	616,125	41%
Beans	92,152	154,756	60%	418,333	356,118	117%	544,242	435,598	120%
Corn	27,965	1,211,555	2%	170,315	1,506,231	11%	322,271	1,690,404	19%

*Estimated annual cost of crop irrigation.
**Estimated losses from production value and changes shown in Table 2.2.
Source: Embrapa, 2010.

Figure 2.4 Estimated annual costs for the irrigation of rice, beans and corn in municipalities excluded from apt regions in scenarios for 2020, 2050 and 2070, PRECIS, scenario B2



Source: Embrapa, 2010.

Tables 2.3 and 2.4 and Figures 2.1 and 2.2 show genetic adaptation costs, and it can noted the need for significant contributions of resources, especially in scenario A2 for 2020, for all crops, with these values dependent on the number of cultivars.

- The difference in investments needed for all crops is little or nonexistent between scenarios A2 and B2, and according to these analyses, investment in genetic adaptation that meets the demands of municipalities that will be affected in 2020, would already produce 85 to 90% of the cultivars needed to those municipalities, which would still be affected in future scenarios. This statement is not valid for rice and bean crops, which would require new cultivars by 2050. The study concluded that:

- there is little time to decide on investments in the genetic adaptation of most crops since the great need of cultivars will occur in the very near future;

- there is the possibility for adaptation to scenarios that could occur later in time;

- in the case of rice and beans, part of the estimated investments could be postponed, but only for 15 or 20 years.

Irrigation costs by area, according to Tables 2.1 and 2.2 and Figures 2.3 and 2.4, vary from one crop to another. Furthermore, although annual production loss may also depend on area, it incorporates the production differences by area and the prices differences for each crop. This leads to a very great variation in the ratio between annual adaptation cost with irrigation and annual production loss. Thus, based on this ratio in the study, the following conclusions are drawn:

- irrigation is an advantageous means of adaption for corn, which maintains values that are small or close to those for genetic adaptation, around 20%;

- in the case of rice, although investing in irrigation is advantageous, since maximum cost is 43% of the production that would be lost, there is a disadvantage in relation to genetic adaptation of currently existing cultivars;

- investment is disadvantageous in the case of beans, since the annual irrigation cost is greater than annual production loss, with genetic adaptation as the only alternative.

In terms of immediate action, studies on the genetic adaptation of plants are being carried out, especially on soy bean, beans and coffee, where for beans, cultivars are already being commercialized that have greater tolerance to high temperatures. Institutions for agricultural research, such as Emprapa, the Agricultural Research Institute of Paraná - IAPAR and the Santa Catarina Agriculture Research and Rural Extension Company - EPAGRI, prioritized research in the genetic improvement of plants, thus seeking to reduce possible impacts on agriculture production as a result of the increase in temperature and water deficiency.

Another possible impact is an intensification of outbreaks of pests and diseases as a result of gradual climate changes (through an alteration in invertebrate vectors or increases in temperature and water stress on plants) and greater frequency in uncommon climate events (dry weather tendencies favor insects, vectors and viruses, whereas wet weather favors fungal and bacterial pathogens) (ANDERSON *et al*., 2004).

Simultaneous to agricultural crop vulnerability studies as a result of alterations caused by global warming, project "Global Climate Change Impacts on Phytosanitary Problems - CLIMAPEST"[264] has been focusing on the effects of climate change on pests, diseases and weeds in Brazilian crops. In this specific case, the effects of the future climate are analyzed – negative in most cases for agriculture – of rising temperatures, CO_2 and ultraviolet ray concentrations, not on the crops, but rather on their pathogenic agents or competitive species, that is, on the phytosanitary problems of diverse crops.

There are also uncertainties regarding the effects of global climate change on animal production systems. Animal production in Latin America, predominantly characterized by pastures, is projected to be negatively affected by greater variability in rainfall. The seasonal pattern for water availability and low availability of soil nutrients are limiting factors in pasture areas for a good part of the region, and the already low nutritional value of tropical pastures can further decrease as a consequence of the increase in the carbon/nitrogen ratio (ZHAO *et al*., 2005).

In relation to the direct effect on animals, temperature is the most important factor. Heat stress has a negative effect on milk production and daily cow reproduction, as well as swine fertility (BERMAN, 1991; HAHN & MADER, 1997; HAHN, 1999, *apud* ZHAO *et al*., 2005). A variation in the rainfall regime can also affect animals as a result of the drying up of reservoirs and impossibility in supplying water for animal consumption.

The cattle herd in Brazil, the largest exporter of meat in the world, is predominantly Zebu, which is a favorable aspect in relation to thermotolerance, considering a future scenario with higher temperatures. Zebu cattle (*Bos indicus*) have advantages over European cattle (*Bos taurus*) in relation to thermotolerance, because Zebu animals are better able to regulate body temperature in thermal stress conditions, and the high temperatures have less effect on the cells of their bodies compared to European cattle. Furthermore, Zebu cattle hairs have properties that increase heat loss and reduce the absorption of solar radiation (HANSEN, 2004).

264 See: <http://www.macroprograma1.cnptia.embrapa.br/climapest>.

Raising chickens, where Brazil is ranked second worldwide, may also be affected by climate change. Adult animals have optimal development at temperatures between 18 °C and 20 °C, and they are sensitive to high temperatures, with high mortality rates at ambient temperatures greater than 38 °C. Heat stress is responsible for big losses in chicken yield, with a reduction in body weight and increase in mortality (FABRÍCIO, 1994).

Brazil is a major exporter of agricultural and forest products. Agriculture tends to be more vulnerable to hydrological and temperature extremes, especially those of short duration, such as severe frosts, hail, very high temperatures and persistent dry weather. An example in Brazil of impacts related to floods and prolonged droughts occurred in the state of Rio Grande do Sul recently. These events were related to the *El Niño* (warming of Pacific Ocean waters) and *La Niña* (cooling of Pacific Ocean waters) phenomena, respectively, and resulted in crop losses. From the statistics available for the last two decades, four out of every ten harvests were affected by dry weather events. Rainfall in the three months of summer of 2004-2005 was less than 200 mm in most of the state, the lowest in the past 53 years (BERLATO & CORDEIRO, 2005). According to the authors, the intense dry weather led to crop losses in grains of around 20 million tons in Brazil.

However, the consequences of changes in the frequency of extreme events have not yet been properly assessed, and it is necessary to increase efforts in evaluating its effects on agriculture and its economic impacts. Besides the direct impacts of climate change, indirect impacts must also be considered, such as the effects of changes in food availability and grain prices, which could affect food security in the country.

2.8 Readiness for Disasters

Natural disasters cause great losses in human life and property throughout the world. As highlighted in the document from the first session of the Global Platform for Disaster Risk Reduction, held in 2007 in Geneva, Switzerland, 134 million people suffered from natural disasters in 2006, at a cost of $35 billion in damages, including devastating droughts in China and Africa and extensive flooding in Asia and Africa. Furthermore, the document highlighted that for each dollar invested in disaster risk reduction, there was a 4 dollar savings in future costs of reconstruction and rehabilitation. In the 1990s, economic losses caused by disasters exceeded US$ 608 billion, a sum greater than that for the four previous decades put together (DIFD, 2006).

The vulnerability of populations in developing countries to natural disasters is high. The reasons are complex and they are associated to different stages of socioeconomic development in the countries. Furthermore, vulnerability is also associated with land use change and in income distribution inequities, relegating high-risk housing sites to low-income population brackets.

Brazil is a country of vast territorial size and it is relatively populous. Thus, it is subject to a variety of natural events (severe storms, torrential rains, floods, mudslides and landslides on cliffs, droughts and dry weather, forest fires, wind storms, hail, undertows, etc;) that can unleash natural disasters. Most of the environmental disasters in the country are climate related, due to its variability and its extremes. Frequently, due to a lack of early predictions, actions by government authorities and organized civil society are only seen after the event that triggered the natural disaster, that is, they try to fix the damage already caused because they were unable to properly prevent and mitigate it.

Since it was implemented at the end of 1994, CPTEC-INPE has been disseminating weather warnings and alerts to the entire country when there is a prediction of some weather phenomenon with the potential to adversely affect society, the environment and the economy. As part of its operational routine, CPTEC-INPE developed an information system to support Civil Defense in situations of predicting some extreme weather phenomenon involving intense or prolonged rains. Good predictions of weather and extreme meteorological events can support effective actions for preventing and mitigating adverse effects of these extremes, resulting in cutting losses in human lives and material, as well as environmental protection.

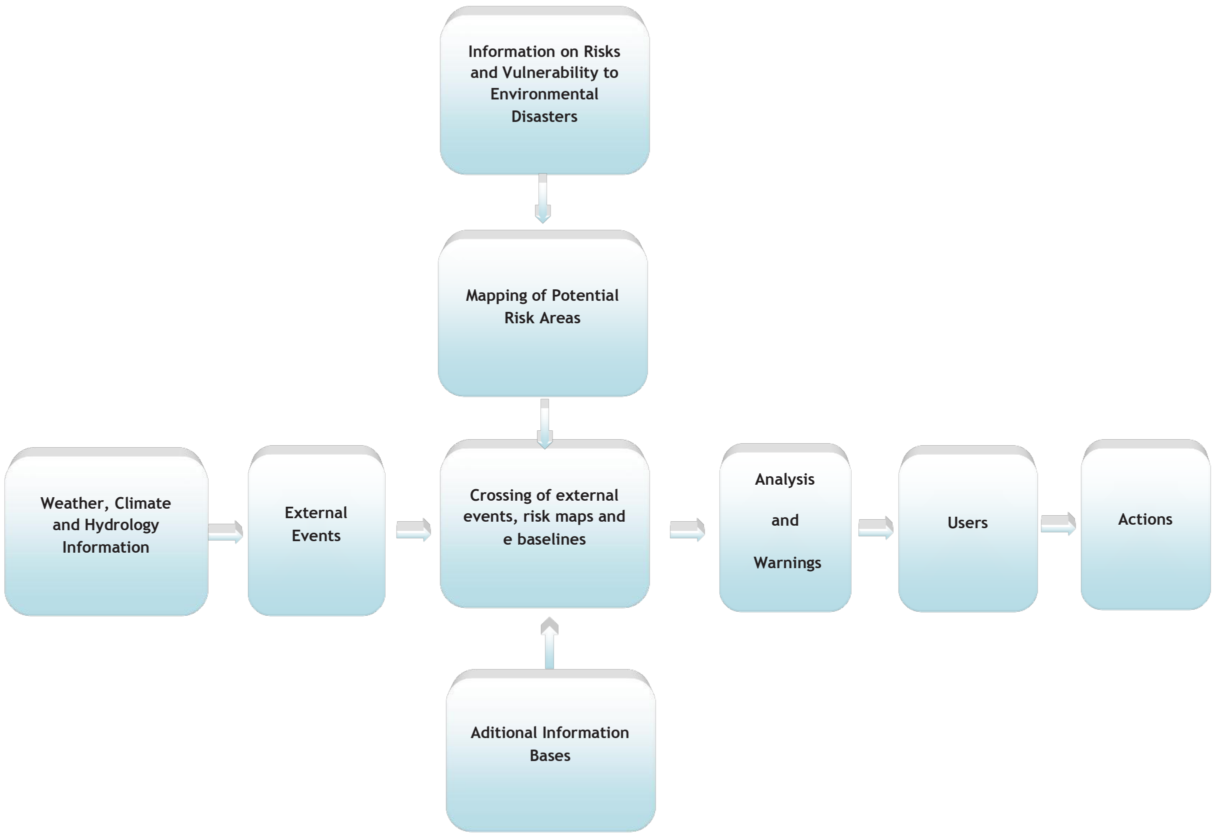
Furthermore, for several decades, INPE has been developing modern technologies for environmental monitoring using space platforms that make it possible, for example, to raise changes in land use and in vegetation cover, a factor that usually worsens the severity of natural disasters. It also develops the capacity for optimized analysis of this information using geoprocessing techniques from environmental databases. Recently, the INPE created the Center for Earth System Science[265], which coordinates and integrates all of INPE's scientific and technological efforts on natural disasters and deals with interdisciplinary issues of the complex interactions between social systems and natural systems.

Starting in 2002, INPE, within the general policy of the Brazilian government to stimulate the production of open source software, it began development of the "TerraLib" library[266]. "TerraLib" helps generate geoprocessing applications that integrate space data (images and maps) in database management systems – DBMS and can be used for different applications. A recently created application using the "TerraLib" library was the Natural Disaster Monitoring and Warning System – Sismaden[267].

The proposal of the Sismaden program is to go beyond the meteorological warning in operation at CPTEC, enabling any user of the program to have the same meteorological data as CPTEC and/or other meteorology institutes, enabling the data to be crossed and analyzed in real time with vulnerability of the region where the system is being used (Figure 2.5).

265 See Part IV, Section 4.7, on the Center for the Earth Science System - CCST/INPE.
266 See: <http://www.terralib.org>
267 See: <http://www.dpi.inpe.br/sismaden>.

Figure 2.5 General scheme of the monitoring and warning system for natural disasters - Sismaden



Source: INPE/SISMADEN, 2010.

It must also be underscored that the preventive work by Brazil's Civil Defense is of utmost importance to reduce the number of deaths in the case of disasters. The results obtained from applying the Civil Defense Preventive Plan – PPDC, which has been in operation since 1988, is an example. It is believed that use of the PPDC has provided most cities involved good organization of their civil defense systems and concern with more definitive measures to attack the risk problem, such as works, surveillance of areas, occupation planning, among others.

Warning systems are efficient non-structural measures to reduce social losses, especially when the resources for reducing risks through structural measures are limited. In cities where there was actual preventive work, no deaths were reported (MACEDO *et al*., 1999). On the other hand, in every municipality where preventive work was not implemented, deaths were reported. From 2007 to August 2010, 3,510 disasters were reported to the Ministry of Integration's National Secretariat of Civil Defense[268]. In 2010, 4,299 Brazilian municipalities had Municipal Civil Defense Coordination Offices[269].

268 See: <http://www.defesacivil.gov.br/desastres/desastres/2009/index.asp>.
269 See: <http://www.defesacivil.gov.br/download/download.asp?endereco=/publicacoes/publicacoes/idc_03.pdf&nome _ arquivo=idc_03.pdf>.

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Other Information Considered Relevant to the Achievement of the Objective of the Convention

PART 4

PART 4

TABLE OF CONTENTS

Chapter 1

Transfer of Technologies

1 Transfer of Technologies

As described in the institutional arrangements section of this National Communication[270], in Brazil MCT is responsible for coordinating the implementation of commitments under the Convention. This demonstrates the importance the country has attributed to the science and technologies associated with climate change.

The problem of global climate change is eminently scientific and technological in the short and mid term. It is scientific because it deals with defining climate change, its causes, intensity, vulnerabilities, impacts and reduction of inherent uncertainties. It is technological because the measures to combat global warming include actions that aim at promoting and cooperating for the development, application and diffusion, and even the transfer, of technologies, practices and processes that prevent the problem and its adverse effects.

In compliance with article 4, paragraph 1(c) of the Convention, and taking into account its common but differentiated responsibilities and development priorities, objectives and specific national and regional circumstances, Brazil contributes towards promoting and cooperating "in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors (...)." It is also necessary to stress the Convention's provisions on the transfer of technology, found in its Article 4, paragraphs 3, 5, 7, 8, and 9.

It must be recognized that a fast and effective reduction in greenhouse gas emissions and the need to adapt to the adverse effects of climate change require access to, diffusion and transfer of sustainable technologies.

Brazil understands the expression "transfer of technology" in a more comprehensive manner, encompassing the different stages of the technological cycle, including research and development – R&D, demonstration, increase in scale (deployment), diffusion and the transfer of technology per se, in relation to mitigation as well as adaptation.

Brazil believes the development and transfer of technology related to global climate change should support mitigation and adaptation actions in order to achieve the Convention's ultimate objective. In seeking this objective, identification of technological needs must be determined based on national circumstances and priorities.

270 See Part I, Section 3, on Relevant Institutional Arrangements for Elaborating The National Communication on Permanent Bases.

1.1 Energy-Related Technological Needs

This section highlights the country's technological needs in relation to energy in a manner that combines meeting growing demands with the use of sources that emit fewer greenhouse gases. However, this section does not merely identify the technologies the country needs to receive, but also the great potential for endogenous technologies that can be disseminated and/or transferred to other countries, especially developing ones, through South-South or triangular (North-South-South) cooperation. Sugarcane ethanol is one of these examples, as are technological advances achieved in the agriculture sector.

Brazil's great challenge over the coming decades is to find solutions that meet the growing demand for energy and at the same time satisfy the criteria of economicity, supply security, public health, guarantee of universal access and environmental sustainability. In order to satisfy these criteria, significant efforts in research, development and innovation - R,D&I must be initiated immediately and in coming years to meet expected energy demands in 2030-2050.

In this context, the CSMS has conducted studies[271] that focus on identifying the current status of diverse technologies related to energy generation, and to explore the interest and the opportunities for transfer/cooperation between Brazil and other countries in relation to the same. These studies aim at offering inputs for international negotiations that concern energy-related technologies with the potential of mitigating greenhouse gas emissions. The results from these studies are summarized in In the case of technologies for generating electricity from nuclear power, Brazil has knowledge in the fuel production area, including the uranium enrichment step. It can even consider exporting know-how for uranium enrichment with the centrifuge developed in the country in accordance with safety policies and agreements involved in this area. Brazil does not have advanced nuclear reactor technologies (generation III+ and IV), though there is knowledge about generation II).

As regards technologies for the generation of electricity from natural gas and coal, Brazil has the need for the most modern technologies based on these fuels, including from other developing countries, like South Africa. Brazil has knowledge in the area of pulverized coal, since plants of this type currently exist in the country; however, there are no research initiatives in ultra super critical coal systems. In the case of large gas turbines, it is a technology already in use on a commercial scale in the country through multinational companies. There is a budding interest in small gas turbines in Brazil and there are already research groups working in this area, making room for international collaboration in applied R&D.

271 These studies can be found on the CGEE website. Available at: <http://www.cgee.org.br/busca/Consulta ProdutoNcomTopo.php?f=1&idProduto=4825>.

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Table 1.1 Opportunities for the transfer of technologies for energy generation from/to Brazil and developing countries (South-South) and from/to Brazil and developed countries (South-North/North-South)

	Transfer of Technology from Brazil		Transfer of Technology to Brazil	
	SOUTH-SOUTH	SOUTH-NORTH	SOUTH-SOUTH	NORTH-SOUTH
Electricity generation Technologies				
Natural Gas				
Turbines (large)	No	No	No	Yes
Microturbines	No	No	No	Yes
Coal				
Pulverization (critical, super critical and ultra super critical)	No	No	Yes	Yes
Gasification (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				
Photovoltaic Solar Energy	No	No	No	Yes
High temperature thermal solar energy	No	No	No	Yes
Wind Energy	Yes	No	No	Yes
Gasification of biomass	Yes	No	No	Yes
Hidroelectricity				
SHP	Yes	No	No	Yes
Medium and large	Yes	No	No	Yes
Hydrogen				
Cell to fuel	Yes	Yes	Yes	Yes
Production and storage	Yes	Yes	Yes	Yes
Fuels and heat				
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				
Resulting from sugar fermentation	Yes	Yes	No	No
Lignocellulosic ethanol	Yes	Yes	No	No
Solar Energy	Yes	No	Yes	Yes
Charcoal	Yes	No	No	Yes
Biodiesel	Yes	Yes	Yes	Yes

Interface Technologies				
CCS	No	No	No	Yes
Smart Grid	No	No	No	Yes
Storage (batteries)	No	No	No	Yes
Social Technologies				
Stoves, clean fuels – cooking LPG/ethanol	Yes	No	Yes	Yes
Energy efficiency for low income population	Yes	No	Yes	Yes
Solar thermal energy for low income population	Yes	No	Yes	Yes

Source: CGEE, 2009.

There is an interest to seek better technologies in the photovoltaic solar energy field and to promote cooperation agreements with internationally recognized centers of excellence with the objective of training human resources, enabling exchange of information (such as experiences, standardizations, measurements and support) and promoting project execution. Brazil has a large industrial park that extracts and processes quartz, transforming it into metallurgical grade silicon, but it does not yet have companies that transform metallurgical grade silicon into solar grade. The production of electricity from high temperature solar energy is another area in which the country lacks knowledge. There has been very little research in the area thus far and few researchers are involved. However, on an international level, the situation of technologies involved in Concentrated Solar Power - CSP is advancing to demonstration and market stages.

Wind energy is one of the fastest growing sources and its technological advances are rapidly reaching the market. The country needs to accompany these advances. There is need to adapt softwares, technologies and materials to make them more appropriate for Brazilian conditions. There is room for R&D and applied research and for the nationalization of components. There are already industries in the country with technology transfer agreements. Brazil also has an industrial structure potentially capable of meeting the demand for new aerogenerators and their components. The main countries that have these technologies are Germany, Denmark and the United States. China and India already have expressive programs for manufacturing and installing aerogenerators.

Brazil is interested in greater use of biomass gasification, a technology currently under development at the international level. The 2030 Energy Plan already considers systems that use gasification and combined cycles in the sugar and alcohol sector. There are already some groups working on this theme at Brazilian universities and more recently efforts at developing prototypes have been observed in the industrial sector. This is an area that can benefit from greater international cooperation with research centers in the USA and Europe. The academic knowledge the country has could be transferred to countries in the South and North.

Medium and large hydroelectric power technology is already mature in Brazil and around the world. But the SHPs have potential for technological development in the world and are already in the commercialization phase. The country has expertise mainly in hydraulic turbine optimization projects and civil engineering. Currently, most of these activities are being carried out by private companies. Brazil's industrial park is capable of providing hydrodynamic equipment of up to 10 MW. In terms of transfer of technology, this is an area where Brazil could export knowledge, products and services to both Southern and Northern countries.

The country already produces hydrogen, but its use on a greater scale for energy purposes requires additional cost reduction efforts. There are possibilities for joint developments between Brazil and several developed and some developing countries as already explored under the "International Partnership for a Hydrogen Economy". Brazil already has knowledge in some hydrogen production areas and technologies (water electrolysis, reformation of ethanol and natural gas[272] and cell to Proton Exchange Membrane - PEM[273] fuel types for stationary and reduced size applications), and there are even some small companies working in this field.

In relation to natural gas, although liquefied natural gas - LNG technology is already being used on a commercial scale in the world, Brazil still does not have sufficient knowledge in the area and at present efforts are mostly employed in purchasing natural gas liquefication and regasification technology. Petrobras' Leopoldo Américo Miguez Research and Development Center – CENPES is trying to acquire knowledge and studies on the state-of-the-art for LNG technolo-

272 See Part III, Section A.1.7, on Hydrogen.

273 The Proton Exchange Membrane - PEM fuel cell uses a proton conducting polymer membrane. An electrode is attached to each side, which serves as the conductor that provides or removes electric current from a system where reactions occur.

gies, but there is still no industrial training in this area. There is also limited knowledge with regard to gas to liquids - GTL and even coal to liquids – CTL technology in the country, and it is more developed at the CENPES, although some universities and other research centers also have knowledge, but there is no industrial training in Brazil yet.

The technology to produce ethanol from sugarcane glucose is considerably advanced in the country and it is a technology that Brazil can certainly transfer to other countries, whether developed or developing, including the know-how for integrating it to the oil byproducts system. Lignocellulosic ethanol[274] is in R&D stages and beginning stages of demonstration, and still in need of some fundamental research. The country has several researchers and centers where most of the knowledge is concentrated, including some sugar and alcohol industries. The Center for Bioethanol Science and Technology – CTBE was recently created. In this area, it is possible to say that Brazil has the possibility to transfer knowledge to developing countries and to benefit from collaborative research with both developed and developing countries.

In relation to low temperature solar thermal energy, Brazil masters flat collector technology. It would be important to develop other applications, such as refrigeration, air conditioning, selective surfaces, vacuum tubes and automated manufacturing processes. Although training exists at universities, coordinated efforts and greater interaction with companies are yet to be observed. It is also necessary to promote the modernization of domestic industry. Brazil will benefit from greater cooperation with other countries, like China and Israel, for example.

Brazil is currently the world's largest product of farmed charcoal and it stands out in mastering the technology, although it needs to incorporate advances, mainly to increase efficiency in the carbonization process[275]. Therefore, the country would have the opportunity to transfer technology to other countries that depend heavily on charcoal, especially in Latin America, Africa and Asia. There are national and international companies in the country dedicated to producing charcoal for the steel industry.

wIn relation to CO_2 capture and storage technologies, although still in initial R&D stages, the country is interested in the area. In 2006, Petrobras created a Thematic Network for Sequestering Carbon and Climate Change and set up the Carbon Storage Research Center – CEPAC. All of the technologies involved in Carbon Capture and Storage - CCS (capture, transport, storage and monitoring) deserve attention and require cooperation with other countries. The country also expects to develop carbon capture and storage from renewable sources (Renewable CO_2 Capture and Storage - RCCS) with the objective of sequestering and storing CO_2 from the sugar fermentation process, especially in ethanol production, in the soil.

Smart grid related technologies are being developed around the world. Australia, the United States and the European Union are investing in pilot projects, including not only the technological aspects, but also regulatory reforms that will help develop the market for these technologies. Aspects such as interconnection for distributed generation, storage systems, real time load management systems and automation, among others, are important areas for developing these technologies. Brazil already has some knowledge, with good training at universities, at CENPES and at the Electric Energy Research Center - CEPEL. Expansion of this knowledge will be fundamental for encouraging greater deployment of sources such as photovoltaic solar, wind and hydrogen, and therefore, transfer of technology and knowledge from developed countries is desired.

There has recently been great interest in lithium batteries for automotive purposes, which could help disseminate electric vehicles. This technology is in its demonstration phase and is strongly mastered by multinational companies related to the automotive industry. Brazil has both the capacity and companies that manufacture several types of battery and which could, if duly trained, also master this new technology.

As for social technologies, for many years Brazil has invested in some technologies that were capable of transforming the energy market with important social impact. An example of this is the introduction of LPG to replace wood, as well as sugarcane ethanol. There were concerns related to transforming the existing market, creating suppliers, distributors and points-of-sale for the new stoves, and to subsequently consolidate the market. There are nearly two billion people in the world who still use wood for cooking, mostly in Africa and Asia. This is an opportunity to take this know-how to those regions, as well as other cleaner fuels for this final purpose, such as ethanol, which could also be produced in small distilleries (another technology mastered by the country). Brazil has invested nearly R$ 100 million in energy efficiency programs for the low-income population. These programs have been conducted by the electricity concessionaires and have contributed towards stimulating the domestic market for suppliers of more efficient equipment

274 It is the ethanol produced from every type of plant biomass, including organic waste. Bagasse and straw are excellent alternatives for Brazil in the production of lignocellulosic ethanol. These technologies include the thermochemical (FisherTropsh) and biochemical (acid hydrolysis, enzymatic hydrolysis) routes for biofuel production.

275 See Part III, Section A.1.9, on Charcoal-Powered Industry.

such as lamps, refrigerators and solar heaters for household use. These programs are being developed for the urban and peri-urban populations in situations of great logistical difficulty. Thus, there is know-how for implementing programs of this sort on a large scale, which could be transferred to other developing countries.

It is worth emphasizing that there is still a need to develop more research geared towards the transportation sector, especially in relation to hydrogen-driven bus technology[276] and flex fuel technologies[277], particularly those aimed at heavy vehicles.

1.2 South-South Cooperation

Brazil gives special importance to South-South cooperation, understanding that the exchange of experiences and of knowledge among developing countries creates the feeling of solidarity and responsibility among peoples, benefiting all parts involved in the cooperation. Technical cooperation projects prove to be efficient promoters of social development and represent the efforts by many professionals, demonstrating that with drive and political will it is possible to carry out activities with important socioeconomic value.

This sub-section focuses on Brazil's main joint initiatives and partnerships with other developing countries in the area of renewable sources of energy (mainly the dissemination of ethanol) and agricultural techniques.

1.2.1 Structured Program to Support other Developing Countries in the Area of Renewable Energies - Pro-Renova

The objective of the Structured Program to Support other Developing Countries in the Area of Renewable Energies - Pro-Renova is to create long-lasting bases for a broad range of actions by Brazil with developing countries in the area of renewable energies, especially in Africa.

Growing interest around the world for the theme has contributed towards increasing South-South cooperation, on solid foundations, and also promoting the sustainable development of Brazil's partner countries. Furthermore, specifically referring to bioenergy, agreements are fundamental for establishing new centers for production and consumption, a precondition for making this product a commodity and for the consequent development of an international market that guarantees the inclusion of bioenergy in the global energy grid.

276 See Part III, Section A.1.7.2, on Brazil's Hydrogen-Powered Bus Project.

277 See Part III, Section A.1.1, on Sugar-cane Ethanol in Brazil to obtain information on flex fuel fuels.

Development of Pro-Renova involved several areas of the government and observed the following premises: collective treatment (because the growing demand for negotiations and actions on this topic has made the MRE and other Brazilian governmental institutions involved in the theme face difficulties to meet international partner requests); selection based on geographic, linguistic and political criteria; association with the private sector; structure-building pilot projects; and eventual involvement of international bodies.

The actions under Pro-Renova include holding regional seminars with parallel commercial fairs; periodic thematic courses in Brazil; on-site training in groups of selected countries; educational cooperation in research and development; demonstration projects; and Brazilian technical missions.

1.2.2 Triangular Partnerships[278]

The incentive for the sustainable production and use of bioenergy, including biofuels, is an important opportunity for developing countries since Brazil sees bioenergy as one of the energy solutions capable of combining benefits at the social (due to its income and energy generation potential in rural regions of developing countries), environmental (especially through the reduction in greenhouse gas emissions and recovery of degraded areas) and economic (with a reduction in dependence on oil and the generation of jobs) levels. Expansion in the number of producer and consumer countries becomes a *sine qua non* for biofuels to become commodities and for the creation of an international market, guiding Brazil's actions in this sector. Brazil has thus been trying to build triangular partnerships.

The "Brazil-USA Memorandum for Advancing Cooperation in Biofuels", especially the component that aims at promoting the production and use of biofuels in third countries through feasibility studies and technical assistance, is a pioneer initiative in this field. In a first phase, the program included El Salvador, Haiti, Dominican Republic and St. Kitts and Nevis, and in a second phase, Guatemala, Honduras, Jamaica, Guinea-Bissau, and Senegal. At the moment, extending cooperation to Asian countries is under analysis.

Brazil has been negotiating joint actions with Sweden aimed at promoting biofuel production and use in Tanzania, within the scope of the "Brazil-Sweden Memorandum of Understanding for Cooperation in the Area of Bioenergy, including Biofuels".

278 Triangulation is the cooperation modality where two countries implement joint actions with the objective of providing professional training, institutional strengthening and technical exchange to a third.

1.3 Main Initiatives and Indication of Science, Technology and Innovation Polices related to Vulnerability, Impacts and Adaptation

With the objective of developing more in-depth knowledge on global climate change, its vulnerabilities, its potential impacts and possible responses by society to adapt to its effects, the main areas that deserve greater support through science, technology and innovation policy are listed below.

These areas were identified from studies conducted by the Center for Strategic Studies and Management in Science, Technology and Innovation - CGEE[279] (CGEE, 2008), which were published in the Strategic Partnerships Journal nº 27 (CGEE, 2008) as well as in the five thematic workshops carried out, which had the presence of 104 specialists active in their respective areas during the first semester of 2009.

As a result of these activities, the need for more in-depth knowledge in the following general areas was recognized:

a) Climate and global climate change

Although knowledge in this area has evolved a great deal, future projections regarding global climate change are imprecise, especially in relation to themes such as rainfall volume in each region. Brazil must continue to invest in climate science, improving the information base and incorporating new technologies and local models to allow the generation of more reliable scenarios about the future climate. The events caused by climate variability have occurred throughout history, will continue to occur and could become more severe in the future due to global climate change.

b) Economic, social and environmental vulnerability

In principle, every region and economic and social agent has some sort of vulnerability to global climate change and extreme weather events. More in-depth knowledge of these vulnerabilities is needed, including from a conceptual perspective, since it is a relatively new subject in specialized literature. Vulnerability represents the degree of susceptibility of a region, a group, an activity or a natural resource to climate-related events such as droughts, floods, temperature peaks, rising sea levels, and hurricanes. Knowledge of the social, economic and environmental vulnerabilities is of utmost importance to improve the quality of society and government adaptation policies to these events.

c) Social, economic and environmental impacts

We need to improve knowledge on how variability and global climate change impacts occur and their consequences in terms of damage to property, human life and others. It is necessary to create conditions to measure these impacts, including the resulting costs. Different productive sectors will be affected in different manners, and it is possible for some sector or activity to be affected in a positive manner in different regions.

d) Adaptation to climate variability and to climate change

Brazil already has a history of adaptation policies to climate variability as in the case of droughts in the semi-arid northeast. The country's Civil Defense System also has a history with many lessons learned. With global climate change, there will be greater need to formulate social and governmental responses to confront the risks of extreme climate events and rising sea levels. Adaptation measures are important for reducing the vulnerability of regions, ecosystems, populations and activities, and thus to reduce the resulting impacts and damage.

As a result of the studies and thematic workshops held, the following points were also recognized:

- the IPCC projected that in the mid 21st Century, the most intense impacts from global climate change in Latin America will occur in the Amazon and northeastern Brazil. Therefore, these regions deserve special attention for science, technology and innovation - ST&I actions related to vulnerabilities, impacts and adaptation - VIA;
- it became evident that poor communities and low-income areas are more vulnerable to the impacts caused by global climate change. The development, improvement and integration of early warning services are of vital importance to anticipate responses when extreme events occur, reducing the vulnerability of these peoples and of production systems;
- although it is imperative to mitigate emissions as the only long-term solution, it is inevitable that some degree of climate change will occur somehow, which is why emphasis must also be given to the need to adapt to global climate change;

279 See Part III.B for Programs Containing Measures to Facilitate Proper Adaptation to Climate Change, introduction, for further information on the studies carried out.

- potentialities and opportunities resulting from global climate change also exist and must be explored, such as the carbon market, environmental services and gains in agricultural productivity, as a result of CO_2 fertilization;

- there is a need to improve institutional and intersectorial interaction, as well as to improve and increase the availability of information and databases, especially historical data on rains and sea levels;

- it is of utmost importance to promote technical and institutional capacity and environmental education through training, integral educational programs (children, teens and adults) and awareness campaigns, aimed at developing in-depth knowledge on possible impacts and adaptation responses, thus reducing the vulnerabilities to global climate change;

- scientific investigation must be supported – with the integration and participation of government entities, productive sectors, scientific entities and civil society representatives – aimed at identifying vulnerabilities, constructing Brazilian impact scenarios and formulating strategies and policies for adaptation over coming decades;

- the Brazilian Research Network on Climate Changes – Climate Network[280], created by the MCT, geared towards generating scientific information to help the country respond to global climate change challenges, must be highlighted;

- PBMC [281], which periodically gathers and summarizes Brazilian scientific production on the theme, also deserves to be highlighted;

- it is necessary to disseminate global climate change information in a language that is accessible by the public (for example, through networks, such as the Climate Network and other means of communication) recognizing the press' role as being of fundamental importance;

- more in-depth knowledge on synergies between mitigation and adaptation practices is needed.

Thus, as a result of the abovementioned studies and workshops, it was specifically recommended that the ST&I system should provide incentives for in-depth knowledge on VIA, using the initiatives listed below.

280 See in this Part, Section 4.4 on the Brazilian Research Network on Global Climate Change - Climate Network.

281 See Part IV, Section 4.3, on the Brazilian Panel on Climate Change - PBMC.

1.3.1 Forests

- expand the quantity and quality of data and information needed for climate change vulnerability, impact and adaptation studies, and use methods and tools that permit a better regional and local evaluation of forest ecosystems, in particular;

- expand scientific knowledge on the potential impacts of climate change on forests and on the productive forest sector in general, as well as identify the systems' vulnerabilities;

- evaluate each ecosystem's potential for carbon storage;

- monitor the economic and environmental impacts of extractivist activities, emphasizing the permanent follow-up on direct and indirect environmental impacts of logging;

- disseminate information on already perceived impacts and their locations, and project the expected impacts of global climate change from diverse emissions scenarios, warning about the irreversible impacts, estimating the different risks and identifying opportunities related to climate change;

- develop technologies, methods and practices to make forests more resilient to the impacts of climate change;

- establish methodologies and practices to define priority areas in order to create ecological corridors in ecosystems that are sensitive to climate change.

1.3.2 Agriculture and Livestock

- map agriculture and livestock sector vulnerabilities in the country;

- establish and implement solid ST&I programs on the evaluation of global climate change impacts on agriculture and possible adaptation measures, considering the main agricultural and fodder crops, including significant extreme events for agriculture;

- evaluate the spatial distribution of plant diseases based on current climate conditions and global and regional climate change estimates;

- implement agroclimatological and agro-ecological zoning;

- develop and implement thermal comfort technologies for livestock production systems;

- implement integrated production systems and crop-livestock-forest systems;

- develop research on emissions of the main greenhouse gases in different areas and planting methods (direct planting x traditional planting) (pulp, grains, sugarcane, etc.) and forests;

- evaluate the effects of growing CO_2 concentrations in the soil-plant system of existing agricultural ecosystems in the country, together with projected increases in temperature, water balance and nutrients;

- develop genetic improvements for animals and plants to deal with new climate conditions and the increase in pest and disease incidence;

- develop rural extension aimed at adapting the productive sector to the effects of global climate change, aimed at providing guidance about adaptation measures;

- implement integrated ST&I actions aimed at food security in rural areas, especially semi-arid regions;

- implement public policies guided by modern scientific and technological knowledge in agronomy that maximize and intensify the use of biome areas that were already altered, together with policies for adding value, via industrialization, to primary agricultural or forest products.

1.3.3 Biodiversity

- survey of paleoecological, paleoenvironmental and paleoclimate issues and environmental and ecological records, incorporating knowledge of the current distribution of species and communities, reconstruction of migratory processes and evolution of threatened fauna and flora communities in each state;

- restructure and integrate initiatives related to biological inventories (species and genetic variability) and environmental information (study of soils and climate and hydrological data) and implement a national program that includes the private sector;

- support the consolidation of an organized and shared infrastructure of data (biological and abiotic) through the dynamic integration of distributed information systems with the adoption of internationally accepted standards and protocols that facilitate the development of consistent analyses and predictive modeling;

- improve and develop models that are able to simulate synergic effects associated with ecosystems (climate change, fire, climate extremes, soil use, socioeconomic aspects and ecological niche for species);

- design and implement monitoring systems for global climate change impacts on species (native, endemic, threatened, exotic), defining the biological indicators of the impact on species, populations and ecosystems;

- develop models to recover degraded areas, restore ecosystems and control biological invasions;

- implement research programs that study the role of ecological complexity and interactivity in ecosystem functioning, including ecophysiological studies related to water and thermal stress;

- review conservation priorities and establish ecological corridors, taking into account the impact of global climate change on biodiversity;

- structure the National Program for Biological Resource Centers (off-site conservation, such as germplasm).

1.3.4 Semi-arid

- assess the vulnerability of semi-arid areas to land use change, climate change, population increases and conflict regarding the use of natural resources, including a risk and vulnerability map, integrating the different sectorial vulnerabilities;

- evaluate water potential in the watersheds and hydrogeological basins in semi-arid areas;

- evaluate food security in semi-arid areas;

- conduct a multicriteria analysis for mapping regional vocation and proposing appropriate policies for identified regional vocations;

- develop applied research directed at evaluating global climate change impacts and mapping their risks, and identify vulnerable populations to establish adaptation measures;

- study the impacts on biodiversity, especially on Caatinga vegetation, riparian forests, and mountainside forests;

- implement technological improvements for capturing, storing and treating water;
- develop crops and agricultural systems adapted to semi-arid areas in the context of variability and global climate change;
- define, at the Northeast region state level, awareness and environmental education programs on global climate change and vulnerabilities, their impacts and possible adaptation measures, with an emphasis on semi-arid regions.

1.3.5 Energy and Water Resources

- elaborate climate vulnerability maps by watershed taking into account the multiple uses of water;
- reduce generation vulnerability in the electricity system by integrating energy sources and enterprises at various scales;
- develop models for the energy sector capable of taking into account global climate change scenarios to increase the reliability of simulation results for the sector;
- develop integration strategies, at the hydroelectric generation planning and operation levels, as well as water resource plans, for aspects tied to global climate change to reduce the vulnerability of energy and water supply;
- review operational rules for hydroelectric plants taking into account the possible impacts of global climate change;
- review hydroelectric generation arrangements in the already installed park, mainly in relation to the multiple uses of water, whether for extreme drought and flooding periods or to guarantee better adaptation to population and economic growth needs of watersheds;
- assess the factors that can influence agricultural crops for alcohol and biodiesel production;
- R&D, demonstration and deployment that speeds up production of lignocellulosic biofuels on a commercial scale within the context of sustainable regional development;
- establish strategies to stimulate greater continental and regional integration between watersheds and electric systems;
- promote the National Water Resource Policy, supporting the implementation of its management instruments (such as the Water Resource Plans, classification of water bodies, licensing and charging for the use of water) and its management system (such as Water Basin Committess and Water Agencies);
- promote management of water resource demand (rational use, multiple uses, reuse, saving equipment, loss control);
- intensify and expand sector energy efficiency programs;
- promote a savings policy and production incentives for reducing consumption and increasing energy efficiency in residential, industrial and service sectors.

1.3.6 Coastal Zones

- map and identify more susceptible regions and the evolution of their occupation, considering, among other things, urban areas, port regions, public roads, production activities and biodiversity;
- preserve and recover the technical records of coastal and port engineering works, including cartographic information, technical drawings, images and reports;
- elaborate risk studies for coastal zones, considering environmental, technical, engineering and socioeconomic aspects;
- implement a permanent and long-term environmental monitoring program involving meteorological, oceanographic, geodesic and geomorphological parameters;
- implement an environmental monitoring system for the most threatened ecosystems (such as mangroves, coral reefs, etc.);
- update nautical cartography as a condition for conducting coastal engineering studies and compatibilize cartography (vertical and horizontal datum points) between IBGE maps and nautical charts from the Brazilian Navy's Directorate of Hydrography and Navigation – DHN[282], aimed at construction of a Digital Land Model - MDT for the coastal zone, including emerged and submerged areas;

282 The mandate of this agency linked to the Brazilian Navy is to support enforcement of Naval Power through activities related to hydrography, oceanography, cartography, meteorology, navigation and nautical signaling; to ensure the quality of navigation safety activities within the scope of Brazil's maritime interests and inland waterways; and to contribute towards national research projects in Brazilian waters and the international commitments that result from such. For more information, see: <https://www.mar.mil.br/dhn/dhn/index.html>.

- update land cartography of the coastal strip between 0 m and 20 m of altitude, with a 1 m vertical resolution, or greater, vertical datum compatible with nautical charts, encompassing the entire width of coastal plains from the coastline;

- elaborate guidelines and technical norms for coastal and maritime works that incorporate possible global climate change impacts on works and constructions;

- develop techniques for biological improvement of mangroves, aimed at reforestation;

- promote Integrated Coastal Management through the integration of water resource management programs and plans with those for coastal management.

1.3.7 Urban Areas

- evaluate the vulnerability and map the areas of risk for flooding and landslides in cities;

- assess the economic, social and environmental impacts in relation to climate related events, such as floods and landslides;

- evaluate the possibilities of water supply in major cities and alternative sources for water supply during emergency and post-disaster periods;

- identify alternatives to low-income population housing in risk areas;

- reformulate the road system and sewage collection system, especially in coastal cities;

- regulate constructions through the Building Code and Director Plan, adapting them to future global climate change scenarios (rising temperatures, intense rains and rising sea level);

- renaturalize (recreate micro climates, revegetation, drainage, revitalization of watercourses) urban areas;

- adopt construction techniques that can adapt to higher temperatures, such as ecological roofs, buildings with natural illumination and ventilation, etc.

1.3.8 Human Health

- researches aimed at developing and applying methods for analyzing population vulnerability to the adverse effects of climate on health;

- analyze political and institutional adaptive capacity of the National Civil Defense System and other entities linked to human health;

- update and expand available studies by incorporating data and information from other sectors that have direct relevance, such as determining factors for the state of the population's health (water quality/availability; food security, etc.);

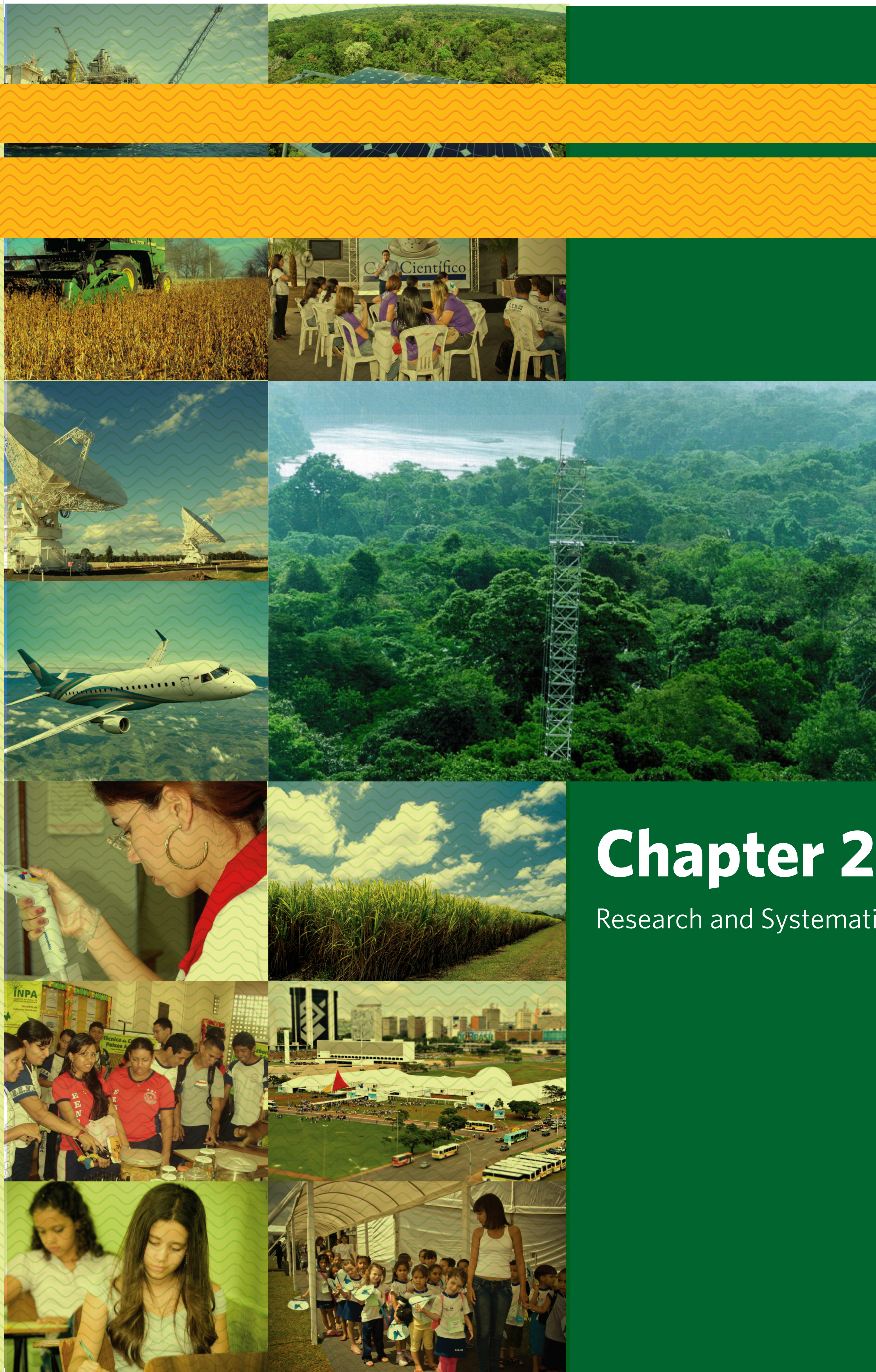
- conduct research to improve the model for morbi-mortality projections (Brazilian Climate and Health Model) with the objective of providing early warnings to the population from changes in weather and climate conditions;

- extend regional climate modelling studies to produce climate scenarios for shorter periods of time, aimed at creating compatibility with socioeconomic and health scenarios;

- identify the impacts of global climate change on human health and its physical and financial quantification, including, among others, information on food production, endemic infectious disease treatment costs and those related to air pollution, morbi-mortality and material impacts;

- integration between civil defense databases (municipalities and states) and medical care bodies, aimed at improvements in the quality of records on health problems caused by extreme climate events;

- implement systems directed at environmental, epidemiological and entomological surveillance in specific locations and situations aimed at the early detection of signs of climate change's biological effects (phenology, geographic distribution of species, etc).



Chapter 2

Research and Systematic Observation

2 Research and Systematic Observation

In compliance with article 4, paragraph 1, sub-paragraph (g) of the Convention, various systematic observation research studies and activities related to the global climate change problem have been carried out in the country.

In this context, teams of Brazilian researchers are participating in the international effort of global research programs related to global climate change, such as the Global Climate Observation System - GCOS, the Global Oceanic Observation System - GOOS and the Pilot Research Moored Array in the Tropical Atlantic, among others.

Among the research initiatives led by Brazil, the Large Scale Biosphere-Atmosphere Program in Amazonia - LBA stands out. It aims at expanding the understanding of the climatological, ecological, biogeochemical and hydrological functioning of the Amazon; of the impact of land use changes on this functioning; and of the interactions between the Amazon and the Earth's global biogeophysical system. It is also important to underscore the research relating glaciology and climate change.

Finally, this section analyzes the "Brazilian Proposal", that is, Brazil's document entitled "Proposed elements for a protocol for the United Nations Framework Convention on Climate Change, presented by Brazil in response to the Berlin Mandate", submitted in May 1997. The purpose of the proposal is to promote a change in paradigm by defining objective criteria to evaluate each country's historical responsibility for climate change. It is based on each country's historical and differentiated contributions towards rising temperatures of the earth's surface caused by anthropogenic greenhouse gas emissions since the Industrial Revolution.

Thus, the country is promoting and cooperating in scientific research and in systematic observations aimed at explaining, reducing or eliminating existing uncertainties regarding the causes, the effects, the magnitude and the evolution of climate change over time.

2.1 World Climate Programs

Several international research initiatives, generally conducted under the auspices of the WMO and the IPCC, are carried out on a global level. Through these initiatives, Brazil participates in a global effort to better understand the current situation and the future perspectives of climate on the planet, as shown in Table 2.1.

Table 2.1 Brazil's participation in world climate programs up to 2010

International Program / Project	Activities	Institutions / Officers in charge
International Monitoring and Data Collection		
Global Climate Observation System - GCOS	Ensure the acquisition of information to monitor and detect climate change; apply this information to socioeconomic development and seek a better understanding, modelling and prediction of climate.	INMET (A. D. Moura) INPE/ CPTEC (L. A. T. Machado)
Global Oceanic Observation System - GOOS	Collect, analyze and disclose data and information from the oceans, coastal region and closed and semi-closed seas to permit reliable predictions of oceanic and atmospheric conditions, as well as facilitate management of the coastal region and meet research needs regarding global environmental changes.	DHN – Navy (J. Romaguera Trotte)
WCRP - World Climate Research Programme		
GEWEX - Global Energy and Water Cycle Experiment	Study the atmospheric and thermodynamic processes that determine the global hydrological cycle, its equilibrium and its adjustment to global changes.	INPE (J. Marengo) USP (P. Silva Dias e M. A. Dias)
CLIVAR - Climate Variability and Predictability	Investigate the variabilities of the climate system and means to predict these variations by monitoring surface condition variations (sea temperature, soil moisture and vegetation, snow and ice coverage), which affect the atmospheric climate. South American Monsoon Studies.	INPE (J. Marengo e C. Nobre) USP (P. Silva Dias) UFPR (A. Grimm)
SPARC - Stratospheric Processes And their Role in Climate	Focusing on the interaction of dynamic, radioactive and chemical processes, it aims at constructing a stratospheric, climatological reference and improving the understanding of temperature, ozone and water vapor trends in the stratosphere.	INPE (V. Kirchoff)
ACSYS - Arctic Climate System Study	Understand the variations in the Atlantic Ocean and the changes that include sea—ice processes.	INPE (A. Setzer)

IGBP - International Geosphere-Biosphere Programme		
International Geosphere-Biosphere Programme – IGBP	Direction of the International Geosphere-Biosphere Programme – IGBP. Research program that studies the global climate change phenomenon.	INPE (C. Nobre)
GCTE - Global Change and Terrestrial Ecosystems	Understand how global changes will affect land ecosystems.	INPA (N. Higuchi)
IGAC - International Global Atmosphere Chemistry	Understand how the atmosphere's chemistry is regulated and the role of biological processes in the production and consumption of gases present in small quantities in the atmosphere.	USP/Instituto de Física (P. Artaxo)
PAGES - Past Global Changes	Discover the significant climate and environmental changes that occurred in the past and their causes.	INPE (J. Marengo)
GAIM - Global Analysis, Interpretation and Modeling	Develop comprehensive prognostic models for the global biogeochemical system and associate these models to the climate system.	INPE (C. Nobre)
Intergovernmental Panel on Climate Change – IPCC		
Brazilian participation in the elaboration of the SREX - Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation	Elaboration of the SREX-IPCC Report as lead authors, relevant to IPCC AR5	INPE (J. Marengo, C. Nobre)
ESSP - Earth System Science Partnership		
GWSP - Global Water System Project	Study how the water resource system works and how it could be affected by human factors in the context of impacts and society's adaptation.	INPE (J. Marengo)
Training		
Climate change and impacts on Andean ecosystems and biodiversity - IAI-SCOPE - Scientific Committee on Problems of the Environment	Develop global climate change impact studies in the Andean ecosystems.	INPE (J. Marengo)
START - Global Change System for Analysis, Research and Training	Develop a regional network system for collaboration between scientists and institutions to conduct research on regional aspects of global change, assess its causes and impacts, and provide relevant information to policy makers and heads of government, mainly by means of increasing capacity building in developing countries.	INPE (C. Nobre)
AIACC - Assessments of Impacts and Adaptations to Climate Change	Develop a regional training system for START projects on the use of global and regional climate scenarios related to vulnerability assessment studies of global climate change.	INPE (J. Marengo)

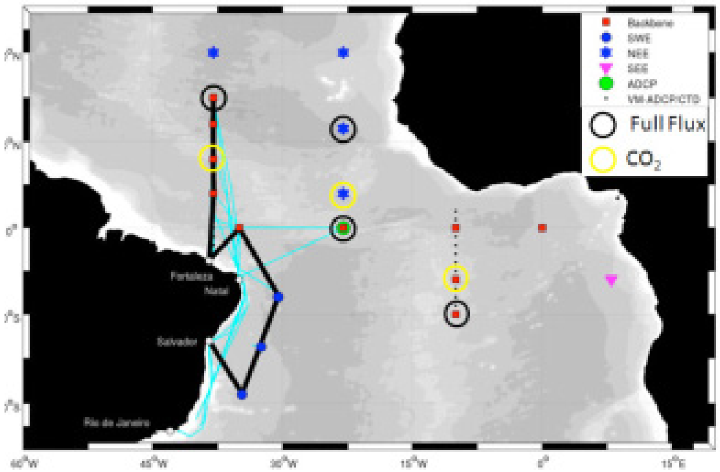
2.2 Pirata Program

Prediction and Research Moored Array in the Tropical Atlantic – Pirata is a project involving Brazilian, French and American scientists, implemented through international cooperation involving the National Space Research Institute – INPE, in Brazil; Metéo France and the French Research Institute for Development *(Institut de Recherche pour le Développement – IRD*, in French), in France; and the National Oceanic and Atmospheric Administration - NOAA, in the USA. It is considered one of the major oceanographic programs in the world. In Brazil, the Pirata Project is governed by the Pirata Project National Committee, which involves five institutions: INPE, which presides over it; DHN; the Oceanographic Institute of the University of São Paulo – IOUSP; the Cearense Meteorology Foundation – FUNCEME; and INMET. The Pernambuco Meteorology Laboratory - LAMEPE and the Federal University of Pernambuco – UFPE also contribute to the Brazil Pirata Project.

It consists of implementing a pilot system in the tropical Atlantic Ocean that permits obtaining atmospheric and oceanic data. It involved launching and maintaining twelve Atlas (Autonomous Temperature Line Aquisition System) buoys between 1997 and 2000, anchored in high seas, in the middle of the Atlantic Ocean and near the equator, at a depth of five thousand meters. More recently, (June/2010) it counted on a total of seventeen anchored systems, ten from the original arrangement along the equator (35W, 23W, 10W, 0W) and on longitudes 38W (4N, 8N, 12N, and 15N) and 10W (6S, 10S), and seven along two southwest extensions, launched in 2005, and northeast, in 2007. The southwest extension of the Pirata network has three Atlas system anchored along the coast of Brazil at the latitudes of Recife, Salvador and Vitória, approximately 500 kilometers from the coast. The northeast extension has four Atlas systems, three of which along the meridian 23W on the north tropical Atlantic and on at 20N on longitude 38W from the original arrangement.

The buoys, together with tide graphs and weather stations equipped with Data Collection Platforms – DCP in the archipelagos of São Pedro and São Paulo and in Fernando de Noronha, measure the temperature and salinity from the sea's surface layer to a depth of 500 m and it obtains data on weather conditions and sea level in the region. The data obtained is transmitted via satellite by the ARGOS[283] and INPE/SCD[284] services and are available in quasi-real time on the Internet. Besides those, there is also a sub-set of buoys for the Pirata arrangement that continuously measure O_2 and CO_2 concentrations dissolved in the sea water. Figure 2.1 shows the spatial distribution and the variables monitored in the Pirata network in schematic format.

Figure 2.1 Arrangement of Atlas buoys for the Pirata Project in April 2009 and routes[285] of the Pirata-BR oceanographic commissions (April 2009)



Note: The black line denotes the Pirata BR-XI commission's route.
Source: NOBRE & URBANO, 2010.

The data helps scientists better understand ocean-atmosphere interactions and the ocean circulation in the Tropical Atlantic region, permitting the formulation of seasonal prediction models for the climate in this region and in subjacent continental areas.

During the Pirata program's pilot phase, from 1997 to 2000, the logistics, maintenance and engineering problems that could arise from implementing the observation system were evaluated. During the consolidation phase, from 2001 to 2007, the longevity of maintenance procedures was tested and the logistics aspects of material exchanges between the USA, Brazil and France were improved. Starting in 2008, the network entered its "permanent" phase, that is, it became an international reference network for monitoring the Tropical Atlantic, recognized by the WCRP/Atlantic Panel and the Oceans Observations Climate Panel - OOCP. Also, information raised by Pirata is a great contribution towards the international research effort carried out by the WCRP - World Climate Research Program, especially for activities that followed the Tropical Ocean Global Atmosphere – TOGA (CLIVAR-GOALS), which monitored the Pacific Ocean, under the same guidelines from 1985 and 1994.

Buoy construction, equipment assembly and maintenance are being financed by NOAA. Brazil was responsible for installing seven buoys between 1998 and 1999 and three additional systems in 2005, two tide graphs and weather stations located in Fernando de Noronha (by LAMEPE) and in the Archipelagos of São Pedro and São Paulo (through co-operation between the DHN and INPE), with expenses that exceed US$ 15 million in equipment costs and ship time expenses, around forty sea days per year from 1998 to 2009.

Brazil has great interest in the Pirata program. This interest results from the fact that, from a meteorological and oceanographic perspective, permanent monitoring of this region is necessary, including the inter-hemisphere heat transfer aspects that occur in the sub-surface of the ocean in that region. The collected data is also indispensable for improving climate forecasts, as well as short term weather forecasts. Temperature anomalies end up determining extreme rain events in the northeast of the country, which are only predictable if there is permanent monitoring of this variable.

With more than 350 thousand data files distributed by the PMEL/NOAA website alone and for free through the Internet and 85 articles published in journals between 1998 and 2008, the Pirata Project is a remarkable demonstration of scientific success and an example of international cooperation aimed at global oceanic monitoring for climate variability studies and global climate change. A scientific paper on the main results and learning during the first ten years of the Pirata Project (1998-2007) was published in the BAMS - Bulletin of the American Meteorological Society, in August 2008 (BOURLÉS *et al.*, 2008).

2.3 Large-scale Biosphere-Atmosphere Program in the Amazon - LBA

In 2007, the LBA[286] became a government program and revitalized the research agenda launched in 1998, when it was under an international cooperation agreement. It is a network that brings together countless researchers who aim at understanding Amazonia's role as a regional entity in the Earth's system. The research in LBA is guided by the

283 Argos is an artificial satellite system that collects, processes and disseminates environmental information from fixed and mobile platforms around the world.
284 SCD is a Brazilian data gathering satellite.
285 The term "route" means the trajectory followed by a vessel during an oceanographic cruise.

286 See <http://lba.cptec.inpe.br/lba/index.html>.

recognition that Amazonia is undergoing rapid and intense transformation related to its development and occupation. It thus seeks to understand how changes in land use and climate can affect the biological, chemical and physical processes as well as the region's sustainable development and its interaction with the global climate.

The LBA focuses on two issues dealt with by means of multidisciplinary research that combine studies in physical, chemical, biological, and social sciences:

- How does the Amazon function as a regional entity?
- How do changes in land use and climate affect the biological, chemical and physical functions of the Amazon, including the region's sustainability and the Amazon's influence on global climate?

2.3.1 First Phase of LBA

LBA activities covered seven research components: physical climate; carbon dynamics; biogeochemistry; atmospheric chemistry; water chemistry and surface hydrology; changes in land use and coverage; and human dimensions of environmental changes in the Amazon. The first six themes were developed in its initial scientific plan (LBA – Concise Scientific Plan, 1996) while the seventh was incorporated after a recommendation by the LBA's International Scientific Committee, in 2002.

At the LBA, emphasis is given to observations and analyses that will expand the knowledge database on the Amazon in six areas: physical climate, carbon storage and exchange, biogeochemistry, atmosphere chemistry, land hydrology and uses and plant coverage. The network was designed to deal with the main issues raised in the Convention and it provides a knowledge database geared towards the sustainable use of land in the Amazon. For such, data and analyses are used to define the current state of the Amazon system and its response to current disturbances, and they can be complemented by results from models to provide an understanding of possible changes in the future.

The LBA combines new analytical instruments and innovative and multidisciplinary experiments in a summary that generates new knowledge with the objective of focusing on pending issues. It also provides a new understanding of environmental controls regarding flows of energy, water, carbon, nutrients and trace gases between the atmosphere, hydrosphere and biosphere in the Amazon, establishing the scientific bases in the policy making process geared towards the sustainable use of the region's natural resources. Furthermore, improvement of research capacities and networks in Amazonian countries that are members of the LBA encourages education and applied research on sustainable development.

The LBA was complemented by a group of research modules, each of which with a sub-set of objectives and specific funding. Brazil's contributions cover all modules. During the first phase, a fundamental contribution was given by NASA's LBA-ECO module, under a Term of Complementary Adjustment to the Brazil-United States Scientific Cooperation Treaty. Other important research modules include: Tropical Rainfall Measuring Mission – LBA - TRMM-LBA, Atmospheric Mesoscale Campaign - AMC, Cooperative LBA Airborne Regional Experiment - CLAIRE, European Studies on Trace Gases and Atmospheric Chemistry - EUSTACH, Brazilian-European Study of the Carbon Cycle of Amazônia - CARBONCYCLE and LBA-HYDROMET. The LBA conducted research within each module in a parallel manner, integrating knowledge through various measures: joint planning of programs; sharing of research sites, equipment and logistical support; exchange of data through the LBA Data and Information System - LBA-DIS; development of simulation models including key chemistry, physics and biology processes at various temporal and spatial scales; joint synthesis and integration of results. The scientific coordination of these activities depends on LBA Scientific Committee recommendations – SC-LBA.

During the first phase of the LBA, the main research modules set up field activities in 1998 and most of these activities were concluded by 2005. The field work covered climate and land use and coverage gradients, based on regions of the Amazon where forest conversion or the selective logging affected the landscape structure. Cooperation, interaction and sharing infrastructure allowed Brazil to implement this unique scientific experience on global terms.

2.3.2 Results of LBA's First Phase

Within the context of climate change and its expected impacts, it is projected that by the end of the century 43% of the 69 arboreal species studied will be extinct in the Amazon (MILES *et al.,* 2004). The greatest impact will be felt in northeast Amazon and the smallest impact in the west, in terms of redistribution of species and biomes. Forty percent of the Amazon's forests would react sensitively to a slight reduction in rainfall; this could mean that South America's tropical vegetation, hydrology and climate system would quickly be altered, not necessarily presenting gradual stages between the current and future situation.

The LBA promoted significant advances in the knowledge of the physical climate, atmospheric chemistry and surface hydrology mechanisms in the Amazon, and it has also promoted studies on the biogeochemical cycles; however, it has not reached a definite conclusion on whether the region is a carbon source or sink.

The LBA has already produced many results on the carbon cycle in natural ecosystems and in areas affected by land use change. Research based on parcels of the RAINFOR project throughout the Amazon revealed a strong trend towards growth of the forest and an accumulation of aerial biomass (MALHI *et al.*, 2004). This trend is especially accentuated in western Amazon forests, but the cause remains unknown. Measures of CO_2 flows also reveal a predominating trend for carbon sequestration by forests, with examples of sites that seem to have suffered ecological disturbances, as evidence by the large quantities of dead wood (SALESKA *et al.*, 2003). These flow studies also changed the conception of Amazon forest seasonality. Various sites revealed greater net carbon sequestration during the dry season, compared to the rainy season, possibly due to the availability of water in deep soils.

The studies carried out in the first part of the LBA program demonstrated that changes in land use and coverage, such as the conversion of forests into pasture, substantially alter the physical and chemical characteristics of first and second order rivers, influencing the structure and functioning of small rivers.

Riparian areas also demonstrated that they can have regional importance that is not proportional to the size of their areas. There are preliminary indications that part of the CO_2 fixed via photosynthesis in firm land forests decomposes in these riparian areas and is once again transformed into CO_2 or CH_4. The transportation mechanism for this organic matter to riparian areas is still uncertain, as is the magnitude of these transformations.

In the LBA's first phase, four core issues defined the component for changes in land use and coverage: what are the rates and mechanisms of forest conversion into crop fields, and what is the relative importance of these land uses; at what rates are abandoned areas converted into secondary forests, what is the destination of these areas and what are the dynamic patterns of land conversion and abandonment; which is the forest area most affected annually by logging; what are the possible scenarios for future land coverage changes in the Amazon.

Significant advance have been obtained in understanding the intensity and extension of logging in the Amazon and the possible environmental damage cause by this activity. Innovative studies indicated that logging was more significant in terms of area and with impacts on the remaining areas. Approximately 16% of the explored area converts to a deforested area the following year and about 32% is deforested in 4 years. This means that logging does not naturally precede deforestation, but rather is a form of disturbance in itself and increases the area being affected by human activities (ASNER *et al*., 2005).

Thus, land use change can affect environmental processes, especially those related to long-term ecosystem functioning (DEFRIES *et al*., 2004). These long-term changes were assessed by analyzing various LBA results (FOLEY *et al*., 2007). The results revealed four examples of environmental processes negatively affected by deforestation and forest degradation: carbon storage, hydrological flow, influence on the regional climate and vectors for disease.

Even when using two fundamental LBA issues as a starting point – understanding how the Amazon functions as a regional system and how changes in land use and coverage and the climate can affect this functioning – the LBA did not intend to ignore a third issue, the position of humankind in face of the regional and global environmental changes (ALVES *et al*., 2004).

Significant action efforts were developed on research on the human dimensions of environmental changes in the Amazon within the LBA. First, *ad-hoc* partnerships were encouraged to discuss scientific issues identified by the Program's community, mainly for a better understanding of the change processes in land use and coverage. This action catalyzed the construction of more solid bridges with social sciences, initially bringing social scientists to its Scientific Committee and then promoting systematic or programmatic initiatives. These initiatives included a study of scientific production in human sciences, seminars and courses dedicated to the theme and several publications can be considered as the most significant results of this project component (COSTA *et al*., 2007).

2.3.3 Proposal for a Second Phase of the LBA

From a scientific perspective, despite the notable advances in recent years, there are still important gaps in knowledge that encourage a second phase of the LBA, notably:

- the future of the Amazon forest and its role in the global system;
- the forest's environmental processes;

- CO_2 sequestration and storage in forest biomass and Amazon ecosystems;
- correlation between deforestation and rainfall quantities and patterns;
- dry and wet deposition rates of nutrients in the Amazon;
- integration of processes that occur in pre-Andean Amazon;
- sustainability indicators and models;
- correlation between climate and environmental changes and human health;
- upscaling studies form local to regional level;
- social and economic aspects related to changes in land use and coverage;
- changes in Amazon production systems;
- biotechnology and regional production chains.

2.4 Climate Modeling of South America using the Regional Eta Model for Weather Forecasting, Climate and Projections of Climate Change Scenarios

The Eta model is a full atmospheric model that produces numerical simulations of weather and climate. In Brazil, the model is used by INPE and is undergoing development at CPTEC[287], and is generally identified as Eta/CPTEC. This limited area model covers the South American continent and includes part of the adjacent Atlantic and Pacific Oceans. The model operationally runs in the weather forecasting mode for up to 11 days in advance periods at 40 km; 7 days at 20 km; and 3 days at 5 km, and in the latter case, only for the southeast region. It is currently also run to generate seasonal climate predictions with 40 km horizontal resolutions. Due to greater spatial resolution, the regional model can provide a better definition of surface orography and characteristics than the global models or General Circulation Models – GCMs. For South America, with the marking presence of the Andes, the response to the synoptic and subsynoptic systems is crucial, particularly for the south and southeast regions, frequently affected by meteorological phenomena such as cold fronts and deep convection cells.

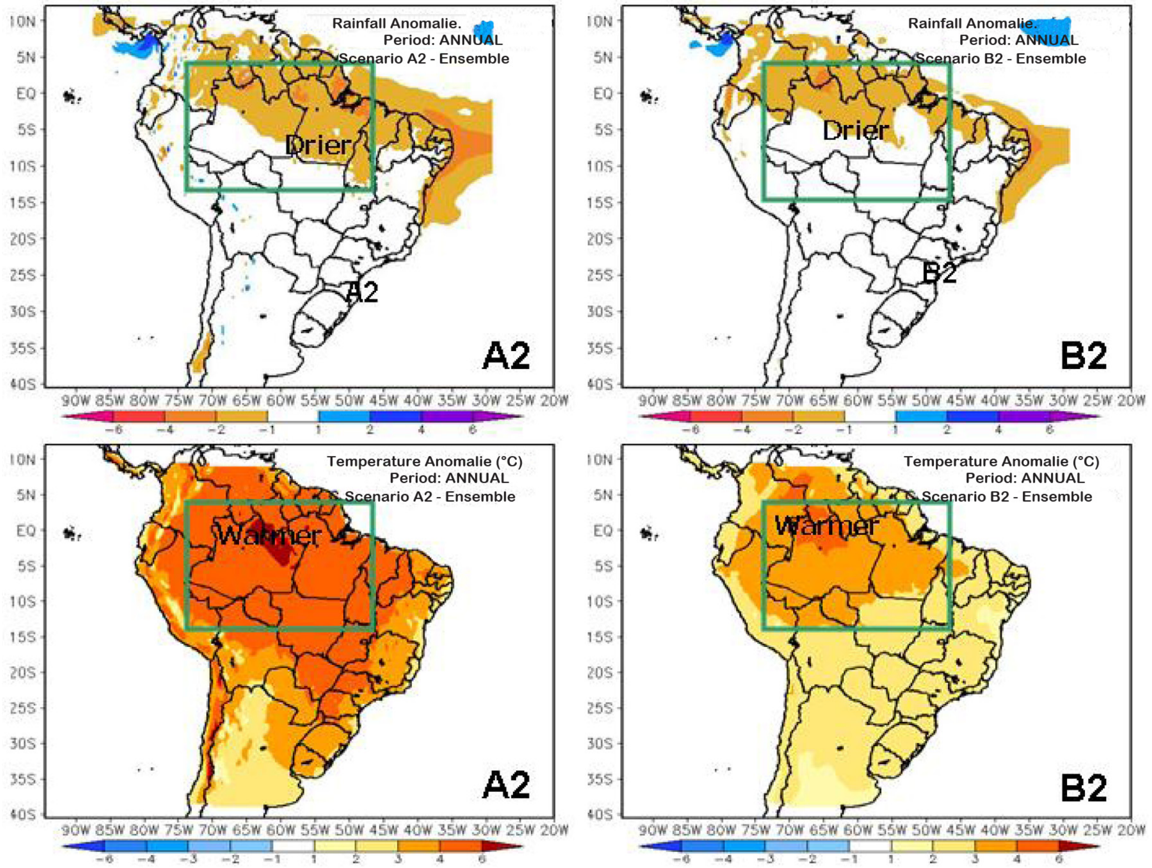
The Eta-CPTEC model proved to be capable of producing climate predictions months in advance for South America in continuous rounds. Results were compared to GCM predictions to assess the positive contribution of regional rounds. Seasonal climate predictions with the regional model revealed that greater resolution can provide more details to the predictions, particularly in the cases of temperatures near the surface and rainfall. In general, the magnitude of variable predictions was closer to the observations. It must be kept in mind that part of the regional prediction quality depends on the quality of global model predictions. The regional Eta-CPTEC model presented good quality rainfall predictions, with the best indexes obtained in the central south region of South America, and the Amazon. Thus, continuous and operational seasonal predictions similar to those made with a global climate model[288] are made with the Eta regional model. A new version with more layers of modified dynamic and physical soil is being developed and tested at the CPTEC. An evaluation of the predictions compared to the previous version is underway. As soon as the indexes prove to be better, a 10 year period of climatology will be constructed and the new version will replace the previous one for generating seasonal climate predictions.

A version of the Eta model (called Eta CCS - Climate Change Studies) was used to generate future climate scenarios for 2071-2100, within the context of the MMA-PROBIO and GOF-UK (British Government) project (MARENGO *et al*., 2009). Average projections for 2071-2100 for the Amazon vary 4-8 °C for the high emissions scenario (pessimist) A2 and 3-5 °C for the low emissions scenario (optimist) B2 (Figure 2.2), with great spatial variation. For the northeast region, warming can reach 4 °C in the pessimistic scenario A2 and up to 2-3 °C in the optimistic scenario B2. In scenario A2, warming in the Central-West and Southeast regions can reach 4-6 °C whereas scenario B2 presents values of up to 2-3 °C. In the south, scenario A2 suggests warming of around 3-4 °C in scenario A2 and up to 2-3 °C in scenario B2. Even though warming may be greater in South America's tropical region for the various models used, projections for these models differ on where greater warming will occur (over 8 °C): in eastern or in western Amazonia, depending on the regional model used. It should be stressed that the Eta CCS version model used in these rounds does not consider increases in CO_2 concentration.

287 See Part IV, Section 4.6, on Center for Weather Forecasting and Climate Studies - CPTEC / INPE.

288 See Part III.B.1, on Program for Modeling Future Climate Change Scenarios.

Figure 2.2 Annual rainfall (upper panel, in mm/day) and temperature (lower panel, in °C) anomalies (for South America) for 2071-2100 compared to 1961-90, for IPCC A2 (pessimistic) and IPCC B2 (optimistic) scenarios*



* The projections represent the arithmetic average for the scenarios produced by the regional Eta CCS, RegCM3 and HadRM3P (50 km of resolution) models.
Source: AMBRIZZI *et al.*, 2007.

More recently, new rounds were run with a new version of the model, Eta/CPTEC, which uses the conditions from the HadCM3 model, a global model with ocean-atmosphere included that considers changes in effective CO_2 concentrations[289], variation in vegetation status and uses different cloud schemes. Results of the rounds using the new version of the model have shown better quality in rainfall, temperature and wind representation when compared to present climate observational data, from 1961-1990. Future scenarios were produced for the 2011-2100 period with 4 members (variations) from the HadCM3 Model rounds. This new version was developed within the context of Brazil's Second National Communication to the Convention (MCT/PNUD BRA/05/G31 Project)[290]. In a next phase, the intention is to introduce more greenhouse gases by changing the model's radiation scheme and by including a scheme with dynamic vegetation that permits verifying the responses of biome types, natural vegetation and the predominating soil to the future climate. Improvements in surface mapping are also being sought.

INPE is currently developing the Brazilian Global Climate System Model – MBSCG[291]. Development of this model brings together the Brazilian community of specialists in climate system studies and modelling and its components (atmosphere, oceans, biosphere, cryosphere[292], aerosols and chemistry, computational methods) to design its features and mechanisms. Up to now, the MBSCG development process resulted in greater integration among the teams of researchers from the institutions involved in the project. As a result, the MBSCG, which currently uses the CPTEC/INPE atmospheric component model, will also be able to integrate with the CSIR (Council for Scientific and Industrial Research) atmospheric component model, from South Africa. In modelling surface processes, inclusion of forest fire modelling

289 It is given the name of effective CO_2 because the effects of the other gases are in the CO_2. CO_2 profiles for the scenarios are based on effective CO_2, since not every model has the complexity to include the radioactive processes of all the greenhouse gases and aerosols.

290 See: Part III.B.1.1, on Eta-CPTEC Model.

291 See: Part III, Section B.1.2, on the Brazilian Global Climate System Model - MBSCG.

292 Regions permanently covered by ice and snow.

and the impacts of smoke in atmospheric circulation and chemical composition are the highlights of the developments currently in progress. In oceanic modelling, the main results include coupling the MOM4 version p0 oceanic model with the CPTEC global atmospheric model.

The surface component model, called Integrated Land Model - INLAND is under development based on the Integrated Biosphere Simulator – IBIS model, which has a land carbon cycle, photosynthesis and ecophysiological processes, vegetation dynamics and a surface hydrological model with river maps. A forest fire (natural and anthropogenic) model and details of plant coverage in South America will be added to the IBIS model. The surface model will also incorporate a high resolution spatial hydrological surface model and representation of floodable areas, as well as an agriculture crop model, which should at least represent four of the main agriculture crops in Brazil. Inclusions of the CATT (Coupled Aerosol and Tracer Transport) model for chemical modelling and of aerosols are underway in the CPTEC global atmospheric model.

The efforts in developing the Brazilian Global Climate System Model – MBSCG will be shown in the vulnerability, impact and adaptation studies under Brazil's Third National Communication to the Convention.

2.5 Brazilian Antarctic Program - Proantar

Brazil's condition as an Atlantic country, the seventh closest to the Antarctic region, as well as the influences of natural phenomena that occur in its territory, justify Brazil's historical interest in the southern continent. Brazil adhered to the Antarctic Treaty in 1975, and in 1982 it developed the Brazilian Antarctic Program - Proantar/Brazil, which established policy guidelines for scientific explorations in that continent, considering its importance to humanity and especially to Brazil. The program is a governmental action managed by the Secretary of the Interministerial Commission for Sea Resources – SECIRM.

Antarctica is an essential component of the global environmental system. The region in which Brazil develops its work in Antarctica presents one of the fastest responses to global changes in the past decade. The atmospheric, oceanic and cryosphere processes that occur there have a direct impact on Brazil's climate. Both the continent and the ocean surrounding Antarctica function as a living laboratory, especially in relation to climate change issues. Brazil's research on Antarctica intends to understand the interactions between natural processes and systems in Antarctica and those that take place in Brazil's land, sea and spatial regions.

The Brazilian Antarctic Program is a governmental program whose main objective is science. This program has been supporting research projects uninterruptedly for more than 28 years. As a result of this effort, historical and continuous series of data collected in Antarctica guarantee an active national role in discussions on environmental preservation and future policy for the region and southern ocean.

Brazilian scientific participation in Antarctica is organized by MCT, which supports Brazilian glaciology research through CNPq. The National Committee on Antarctic Research – Conapa was also created within the MCT with the purpose of defining Proantar scientific guidelines. Conapa recently approved S&T's National Policy in Antarctica, a sign of the growing importance Brazil gives to research in that region. This policy meets the commitments assumed by the country in the international acts in which it is a signing member that establish the general legal framework and guide countries' actions in that region. These aim at achieving objectives of common use of Antarctica for peaceful purposes, especially through scientific research, the free exchange of information and protection of the environment, inserted in a regime called the Antarctic Treaty System. The interdisciplinary character and integration of efforts by researchers of different specialties as well as international cooperation have been strongly encouraged as stipulated in National S&T Policy for Antarctica.

Logistical support for Proantar research projects is provided by Brazil's Navy, encompassing the operation of the Ary Rangel Oceanographic Support Ship and the Almirante Maximiano Polar Ship, installation and maintenance of glaciology camps and the transportation of researchers. These latter activities also have the collaboration of the Brazilian Air Force – FAB. At present, logistical support for glaciology expeditions is also contracted from private enterprises using MCT funds.

2.5.1 Investigation of the Cryosphere: Antarctica and Andes Program

Investigation of the planet's ice mass (the cryosphere) by Brazil's scientific community has advanced rapidly since Brazil's Initial National Communication to the Convention. This progress is the result of recognizing the role of the Antarctica continent's ice layer (13.6 million square kilometers of ice with an average thickness of 1,829 meters, 90% of the cryosphere's volume) in controlling the South American climate system. The role of this enormous cold mass is as important as the Amazon in global atmospheric circulation. If this ice layer melts in its entirety, it will be the equivalent to a 60 meter rise in average sea levels. Consequently, the slightest change will have important implications for the country and especially the coastal regions. Antarctica's ice is extremely sensitive to environmental change and it can react in an abrupt, still not completely known, manner to climate change caused by human action. Thus, the glaciology community is mainly interested in understanding how this ice interacts with other parts of the earth's environmental system, its response to global changes (especially those caused by human activity), and in monitoring changes in the planet's ice volume and extension.

The scientific interest in the region is also justified by the importance of stratigraphy and chemical studies of polar ice snow and high glaciers that provide one of the best paleoclimatic techniques, permitting reconstruction of the atmosphere's evolution over the past 800 thousand years. It is worth noting that the determination of greenhouse gas concentrations (CO_2 and CH_4) was only possible in the past using this method.

Over the past five years, the increase in investments, especially by the MCT, in Brazilian and South American Antarctic research enabled the rapid advance of cryosphere research, with the following highlights:

- Participation in several scientific expeditions to collect and analyze ice cores that allow investigating climate connections between Antarctica and South America over the past 1000 years.
- Beginning of Brazilian glaciology research in the Andes, including the first investigation of the role of Bolivian and Peruvian glaciers in the Madeira River basin's water balance (part of the Amazon River's watershed).
- Creation of a Polar and Climate Center - CPC at the Federal University of Rio Grande do Sul - UFRGS, in Porto Alegre - RS, to lead Brazil's glaciology research in Antarctica, South America and soon the Arctic.
- Creation and implementation of the National Institute of Cryosphere Science and Technology, involving 7 associated laboratories in four states in the country and under the coordination of the CPC/UFRGS. The program includes setting up a national laboratory of ice cores and a laboratory for remote monitoring of the cryosphere.

2.6 Simplified Climate Change Model

Brazil's document entitled "Proposed elements of a protocol for the United Nations Framework Convention on Climate Change", presented in May 1997, introduced two elements for discussion in relation to the Berlin Mandate process. The first element was to establish the historical responsibility of each country in terms of causing the greenhouse effect. The second element established the idea of a Clean Development Fund to replace the unpopular concept of joint implementation at the time and put an end to the North-South impasse that was growing during the process. Quantification of the principle of common but differentiated responsibilities was one of the underlying basic goals to the proposal.

The first problem faced when writing the proposal, while seeking to change the approach from the causes (emissions) to the effects (global warming), was how to establish objective criteria to measure climate change.

It thus became of utmost importance to establish the relationship between net anthropogenic emissions and the resulting climate change. While recognizing that this phenomenon has a complex geographic distribution, it would be important to have a single measure of global climate change.

The variable chosen to measure climate change was the increase in global mean surface temperature. This criterion is closely linked to the physical reality of warming caused by the greenhouse effect, a property that cannot be applied to absolute emissions. Furthermore, global mean surface temperature can be used as an indicator of global warming, and attribution of a country's historical responsibility can be made in terms of each country's relative contribution to total temperature increase. The core of the model corresponds to a double accumulation process that is the essence of global warming. The accumulation of emissions increases concentrations, and for each annual level of concentration, the accumulation of energy deposited on the Earth's surface increases the global mean surface temperature.

Temperature change is also an objective measure of climate change, because it can be argued that the adverse effects of climate change maintain certain proportionality in relation to it.

It must be underscored that the remaining uncertainties in current knowledge of the absolute value of projected temperature change do not affect conclusions regarding the relative contributions of countries. Climate sensitivity is the global mean surface temperature increase that means doubling CO_2 concentration in relation to the concentration prior to the Industrial Revolution, which was 280 ppmv. The likely range for climate sensitivity is 1.5°C-4.5°C. Insofar as uncertainties are progressively reduced, future improvements can be easily incorporated by updating the calibration constants of proportionality in order to improve the accuracy of absolute results, without affecting the relative contribution.

By reconstructing the series of anthropogenic emissions by sources and removals by sinks of greenhouse gases in all sectors in the past, it is possible to calculate the relative portion of the total increase in temperature that can be attributed to each country individually. Therefore, estimating the relative responsibility of a given country for contributing to global warming can be made even with current uncertainties of absolute temperature increases that can be attributed only to the greenhouse effect.

Considering that the Convention contains the fundamental principle of common but differentiated responsibilities, Brazil's proposal provides an objective criterion for the differentiation of these responsibilities. It is also a means to quantify the relative responsibility of developed countries in relation to developing ones as a result of their contribution to atmospheric concentrations of greenhouse gases in 1990, when the Convention's negotiation process began[293].

Using this simplified approach, an evaluation was conducted on the relative responsibility of Annex I countries compared to non-Annex I countries throughout the period that extends to 2200, taking into consideration the estimated concentration in 1990 attributed to both groups of countries. Historical data on CO_2 emissions were used from the energy and cement sectors for each country from 1950 to 1990[294], together with a retroactive extrapolation for the period preceding 1950, to estimate atmospheric concentrations in 1990.

The effect of emissions of other greenhouse gases was not considered due to a lack of available data. However, it is known that this effect is small when compared to CO_2, according to the IPCC's Second Assessment Report. Furthermore, the relatively short life of CH_4 in the atmosphere tends to reduce the importance of historic emissions of this gas.

The Brazilian proposal argues that the Global Warming Potential - GWP does not adequately represent the relative contribution of different greenhouse gases to climate change. Hence, the use of GWP for methane would provide inappropriate mitigation policies. Furthermore, it overemphasizes – and erroneously – the importance of greenhouse gases that remain in the atmosphere for short periods of time.

Meira Filho & Miguez (2000) have demonstrated that the IPCC's GWP is a special case of generalized global warming potential. The metrics presented in IPCC's AR4 include the Global Temperature Potential - GTP, described by Shine *et al*. (2005), which implements the generalized global warming potential, as proposed in 2000.

For these reasons, CO_2 emissions from energy and cement sectors are probably a good proxy for estimating the increase in global mean surface temperature with the proposal of evaluating the relative responsibility of Annex I and non-Annex I countries.

The conclusions presented demystify the relevance of the discussion about the year in which emissions from Annex I and non-Annex I countries will be equal, because in that hypothetical year the vast majority responsibility for causing global warming will still be attributed to Annex I countries.

A review process of this model was established under the SBSTA - Subsidiary Body on Scientific and Technical Assessment of the Convention to consider the Brazilian proposal[295]. Several countries also organized groups of scientists to analyze the new approach being proposed. In its 28th session, the SBSTA decided to conclude its considerations on the subject. That same session, the SBSTA agreed that the work carried out until then within the scope of the Brazilian proposal had established a robust methodology for quantifying the historical contributions to climate change and that its work provided very useful information. The SBSTA observed that there are uncertainties in relation to data that refers to historical emissions, particularly in relation to land changes and forestry. The SBSTA also noted that the results of the study conducted under the Brazilian Proposal can be of relevance for the work of the Parties within the scope of other bodies and other processes under the Convention and its Kyoto Protocol[296].

Much work still needs to be done to create a consensus about a metric for climate change that simultaneously considers equity and responsibility and that is accepted by all countries. However, it is undeniable that the Brazilian Proposal has represented an important step in this sense.

293 The estimate for the initial concentration of each country in 1990 may take into account the differences in starting points for each Part, as mentioned in article 4.2.a of the Climate Convention.

294 The data was obtained from the Oak Ridge National Laboratory (USA). It is a comprehensive and very well elaborated collection of data. The current available set of data was improved after submission of Brazil's proposal. See: <http://cdiac.esd.ornl.gov/>.

295 See: <http://unfccc.int/methods_and_science/other_methodological_issues/items/1038.php>.

296 FCCC/SBSTA/2008/6, paragraphs 109-113.

Chapter 3

Education, Training and Public Awareness

3 Education, Training and Public Awareness

In compliance with article 4, paragraph 1(i) of the Convention, Parties, taking into account their common but differentiated responsibilities, and their specific national and regional development priorities, objectives and circumstances, shall "promote and cooperate in education, training and public awareness related to climate change and encourage the widest participation in this process, including that of non-governmental organizations". Furthermore, article 6 of the Convention directly addresses this issue.

The fact that the country hosted the 1992 Earth Summit made climate change-related issues more accessible to Brazilians. However, in general, most of the population does not yet have more specific information about climate change or the Convention, although the issue has been increasingly covered by the media. However, global climate change is recognized as being a technical and complex issue, hard to be understood by non-specialists.

Despite these difficulties, education, public awareness and training activities related to climate change have been expanded.

The MCT's Brazilian homepage on climate change has contributed towards an increase in public awareness on the matter, as it provides information on the Convention's entire negotiation process, the main references about climate science and preparation of the National Communication. Furthermore, publications in Portuguese (such as the official version of the Convention and Kyoto Protocol texts), newspaper and magazine articles, as well as seminars and debates, have been helping disseminate a theme that was relatively unknown not long ago in the country.

Established in 2000 and chaired by the President of the Republic, the Brazilian Climate Change Forum - FBMC's objective is to promote awareness and engagement of the society regarding the issue of global climate change.

The *Procel nas Escolas* (Procel at Schools) and *Conpet nas Escolas* (Conpet at Schools) programs are especially aimed at children and adolescents through partnerships with educational institutions, and they are also of great importance. They aim at expanding teacher and student awareness about the importance of using electric energy, oil and natural gas products in the best way possible and to broadly promote such attitudes.

3.1 Awareness in Brazil about Climate Change Related Issues

3.1.1 Official Website on Climate Change

To build an official Brazilian site on climate change, a project initiated in September 1995, when the Internet was still incipient in Brazil, was a pioneer and innovative idea that has collaborated significantly with the development of the National Communications of Brazil and contributed towards enhancing public awareness on the subject in the country. CGMC/MCT's website (http://www.mct.gov.br/clima) thus constitutes an important tool for implementing Brazil's commitments undertaken under the Convention.

The website reflects the entire National Communication preparation process, while gathering and providing all information generated by the various institutions and specialists involved in preparing greenhouse gas inventories and other documents, including the contact information of each expert responsible for preparing them.

Furthermore, the country runs its quality control and assurance program of results generated through the elaboration of National Communications through its website, especially through public consultations on each document produced to feed into the National Communications, ensuring transparency and permitting the participation of specialists not directly involved in the process but who want to make comments or recommendations.

Thus, Brazil's global climate change website has strengthened the coordination unit's capacity and helped decentralize preparation of the National Communications, permitting complete involvement of all relevant institutions regardless of its location.

The website also makes possible to make available, all over Brazil, as well as to other Portuguese-speaking countries, important texts in Portuguese such as the full text of the Convention and the Kyoto Protocol; documents related to negotiations under the Convention, especially the Conference of the Parties' decisions; documents related to the implementation of the Kyoto Protocol in Brazil; documents and information on the National Climate Change Policy; and documents, lectures and proposals that reflect Brazil's position on the issue. The website also points to existing relevant information on the *internet* related to climate change, with information for beginners as well as detailed scientific data (such as IPCC reports).

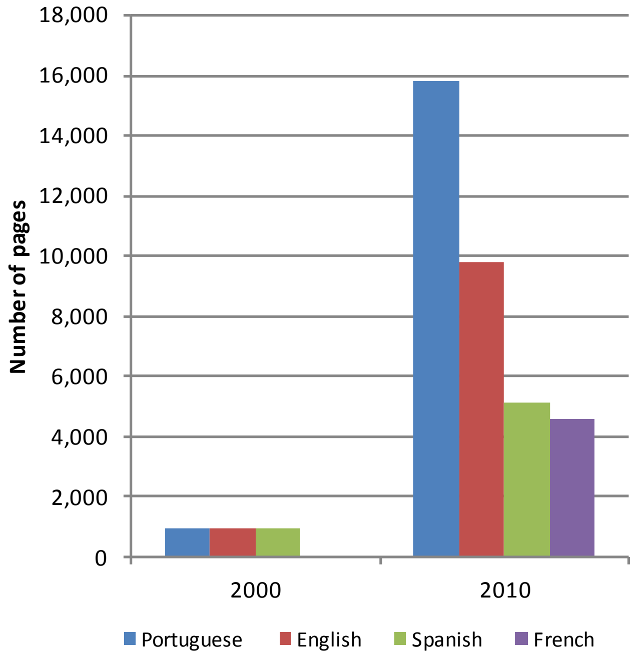
Besides being the locus where information is disclosed, the website is also the place where information can be obtained, because it is very clear about the Coordination unit's attributions, identifying the main stakeholders and informing how to make requests and send questions. The Internet has been an effective means to put the external public in direct contact with the Coordination team, which seeks to clarify doubts sent by students, journalists and professionals from other areas.

Since it is currently presented in four languages – Portuguese, English, Spanish and French – Brazil's website on climate change goes beyond the country's public. It is also an international source of reference, which facilitates Brazil's insertion in the global debate on climate change.

In 2000, a survey conducted for the Initial National Communication, showed that there were nearly 3,000 pages available, in just three languages, since the country had yet to implement the website in French, which occurred in 2003.

In September 2010, the total number of pages available exceeded the survey conducted in 2000 by more than tenfold – when data was collected for inclusion in this text, the website had 35,363 published pages, in four languages. This result is mainly due to elaboration of Brazil's Second Communication, which permitted the reformulation, maintenance, updating and expansion of this website as shown in Figure 3.1.

Figure 3.1 Evolution of the number of pages in Portuguese, English, Spanish and French on Brazil's official website on climate change



Source: CGMC/MCT, 2010.

In general, Internet use has contributed towards ensuring the quality of the work, facilitating public awareness, permitting better dissemination of information and greater reach of the Convention and its implementation in Brazil.

Importance of Brazil's Website on Climate Change

Google conducts one of the most important and efficient surveys of website classification, called Google PageRank. The PageRank (TM) system[297] is used by the Google search site to help determine the relevance or importance of a page.

Until 1998, the search tools counted the number of times a word appeared on a website to determine its relevance, which represented a system that was completely open to manipulation. Google's innovation was to count the number of clicks on links from other Internet pages. These links act as "votes" on what Internet users consider to be good content. More links suggest that a website is useful, just as more citations of a book suggest it is better.

Although the Google system has been an improvement, it was also open to abuse by "link spams" created for the sole purpose of fooling the system. Company engineers perceived that the solution would be to consider search results where users actually accessed a website and stayed there. A Google search can result in two million pages in one-fourth of a second, but users generally only want one page, and by choosing this page, they inform Google what they were looking for. So, the algorithm was readapted to automatically feed that information back to the service, making the system efficient and the result reliable.

The higher the pagerank of a website, the more important it is. Most websites have a pagerank of 0, in accordance with Google information.

In the specific case of Brazil's website on climate change, according to Google PageRank, for every 10 (ten) searches conducted on the Internet about climate change, 8 (eight) are directed to Brazil's website on climate change, for a relevance of 8/10, as can be observed in Figure 3.2.

297 This system was developed by Google.

Figure 3.2 Relevance of Brazil's official website on climate change in accordance with PageRank

Source: Search conducted on <http://pagerank.gratuita.com.br>.

3.2 Brazilian Climate Change Forum

The Brazilian Climate Change Forum – FBMC, chaired by the President of the Republic, was created[298] with the objective of including the organized civil society in discussions related to global climate change, as well as educating and mobilizing society to debate, and providing inputs for decision-making on problems resulting from global climate change and regarding the CDM. The FBMC should also assist the government to incorporate global climate change issues in the various levels of public policies. The Forum has the participation of the Ministers as well as civil society personalities and representatives, appointed by the President of the Republic due to their renowned expertise or relevant knowledge on climate change.

More recently, the FBMC contributed in a significant manner towards developing the National Climate Change Plan and the National Climate Change Policy, coordinating public hearings and sectoral meetings that resulted in important inputs for these processes.

One of the Forum's attributions is to encourage the creation of state climate change fora at state level, and hold public hearings in diverse regions of the country.

State fora are an important means of raising society's awareness and mobilization at the state level to discuss global climate change. At present, 14 Brazilian states have their own state climate change forum: Bahia, Ceará, Espírito Santo, Mato Grosso, Minas Gerais, Pará, Paraná, Pernambuco, Piauí, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, São Paulo, and Tocantins.

In the state of São Paulo, a Municipal Committee on Climate and Economics Changes was created. In the state of Minas Gerais, in Belo Horizonte, the Municipal Committee on Climate Change and Ecoefficiency was created.

Since its creation, the FBMC has been promoting various activities and disseminating diverse information related to global climate change, which can be verified by visiting the Forum's website[299].

3.3 Education Programs on the Conservation of Electric Energy and Rational Use of Oil and Natural Gas Products

3.3.1 Procel at Schools (Procel nas Escolas)

Procel at Schools is a project that disseminates information on how to combat energy waste, developed by the National Program for Electric Energy Conservation – Procel, directed at children and adolescents through educational institutions.

The Guidelines for Procel at School project actions, signed in 1993 as a Technical Cooperation Agreement between the MME and MEC, decided to:

- train elementary and high school teachers to work with their students on aspects of electricity waste, including the National Service for Industrial Apprenticeship - SENAI and the National Service for Commercial Apprenticeship - SENAC;
- develop pedagogical and didactic materials on energy to be distributed free-of-charge to teachers and students;
- establish a means to involve students from high school level technical schools and higher learning institutions, in the sense of using technological resources to combat energy waste and to create a change in habit regarding its use.

Through a partnership with the MME and MEC, Procel at Schools strives to enable the action of basic education teachers (nursery, elementary and high schools) as multipliers/attitude advisers to combat electric energy waste with their students.

298 Decree nº 3.515, of June 20, 2000.

299 See: <http://www.forumclima.org.br>.

Procel in Basic Education (Procel na Educação Básica)

Procel in Basic Education is an interdisciplinary project by Eletrobras/Procel and the country's electric energy utilities. It acts in the education area, within the transversal theme of the environment, involving teachers from all subjects given at the schools.

In order to successfully impart the information, the communication channel is Environmental Education, using the "The Nature of Landscape – Energy – Resource for Life" methodology. This material[300] focuses on different age groups and is made available at schools. By 2007, nearly 19.36 million students were introduced to this new universe of information. Operationalization of Procel for Basic Education is up to the electric energy utilities, which receive specific training for the work, and it then establishes an institutional relationship with the education area for implementing the project. Schools should contact their supreme body to participate in the project through the local electric energy utility.

It is estimated that between 1990 and 2008, thanks to the results achieved by the Procel in Basic Education project, an accumulated savings of energy of nearly 2,841,912,000 kWh has been achieved. Each student who participated in the Procel at Schools Project corresponded to nearly 84 kWh/year of avoided electric energy waste. With the "The Nature of Landscape - Energy" methodology, this sum jumped to 150kWh/year, on average, per trained student, as can be seen in Table 3.1.

Table 3.1 Results achieved by the Procel in Basic Education Project up to December 2008

Year	Number of students	Savings: kWh/ student/year	Total savings KWh/year	Accumulated Savings kWh
1990	100,000	84	8,400,000	8,400,000
1991	150,000	84	12,600,000	21,000,000
1992	170,000	84	14,280,000	35,280,000
1993	180,000	84	15,120,000	50,140,000
1994	200,000	84	16,800,000	67,200,000
1995	200,000	84	16,800,000	84,000,000
1996	271,948	84	22,843,000	106,843,000
1997	319,276	84	26,811,000	133,662,000
1998	800,000	84	67,200,000	208,862,000
1999	1,000,000	84	84,000,000	284,862,000
2000	1,500,000	84	126,000,000	410,862,000
2001	2,000,000	150	300,000,000	710,862,000
2002	1,500,000	150	225,000,000	935,862,000
2003	3,000,000	150	450,000,000	1,385,862,000
2004	2,500,000	150	375,000,000	1,760,862,000
2005	2,000,000	150	300,000,000	2,060,862,000
2006	3,000,000	150	450,000,000	2,510,862,000
2007	1,602,000	150	240,300,000	2,751,162,000
2008	605,000	150	90,750,000	2,841,912, 000

Source: Procel,2010. Available at: <http://www.eletrobras.gov.br/elb/procel/main.asp?TeamID={47593290-EFB7-4E08-92A2-8E6679154F7F}>. Accessed on June 2, 2010.

Procel at Institutions of Higher Education (Procel nas Instituições de Ensino Superior)

The Procel at Institutions of Higher Education Project aims at disseminating "Conservation and the Efficient Use of Energy" with undergraduate Engineering programs in various Brazilian higher education institutions.

The objective of this activity by Procel is to transform the teacher into the core element for disseminating information on energy efficiency among his/her students, transmitting the issues related to energy conservation as a main focus of practical and technological concepts of energy efficiency. The teachers can also transmit the material to other professors through seminars at the country's main institutions of higher learning. Furthermore, students of higher learning institutions can change habits as well as get involved with energy efficiency tools and become energy conservation collaborators.

Procel at Technical Schools (Procel nas Escolas Técnicas)

Procel also runs a pilot project at technical schools, in partnership with the Federal Center of Technological Education of Bahia – CEFET-BA, in Salvador, with the objective of elaborating specific content on energy conservation that focuses on changing habits and on energy efficiency. The project is at an experimental stage at CEFET BA. After it has been evaluated, it will be extended to the other federal centers of technological education - CEFETs in the country.

This PROCEL activity also seeks a change in attitudes that lead to wasting electric energy, transforming the professor into the core element for expanding the projects, allowing them to transmit to the students issues related to combating energy waste by means of energy efficiency, thus consolidating a change in habit in the efficient use of electric energy.

3.3.2 Conpet at Schools (Conpet na Escola)

The National Program on the Rationalization of the Use of Oil and Natural Gas Products – Conpet was created by the Federal Government in 1991. The Conpet Program involves government agencies and private organizations that are in charge of its planning, implementation and monitoring towards one objective – efficient energy use.

The primary objective of Conpet at School is to integrate and encourage teachers to act as awareness-raising agents and trend-setters for habits and attitudes, not only for their students, but also for their own school and community re-

300Procel nas Escolas works in accordance with the National Education Guidelines and Bases Law - LDB, within the transversal theme of "Environment".

garding issues relating to energy, society and the conservation of natural resources and the environment.

It is understood that this is the most effective and permanent way of raising the awareness of the Brazilian society over the mid-term regarding the concern for the efficient use of oil and natural gas products.

The project involves educators/students from 5th to 9th grades of public and private elementary schools, and its methodology may be expanded and adapted for high school students.

Under the agreement between the MME and the MEC, Petrobras establishes agreements with State Secretariats for Education and/or the Environment, Schools Associations, which makes it possible to implement the project in public and private schools across the various Brazilian states.

The methodology has been successfully applied since 1992, and it consists of working with the teacher and not directly with the students. The methodology is established on a permanent basis in the classroom, and the teachers become true project partners for the awareness and motivation of students regarding energy conservation issues.

Thus, the teacher is offered an improvement program on oil, natural gas and their products, in addition to providing basic insight into the geopolitics of oil and energy efficiency policies in order to train and encourage them to become involved with the project and facilitate discussion of the topic in the classroom. Program results until 2009 are shown in Table 3.2.

Table 3.2 Evolution of Conpet at Schools Project results

Year	Workshops	States	Municipalities	Schools	Teachers
2005	46	5	261	685	2349
2006	56	5	136	1409	3180
2007	81	7	49	1720	4596
2008	96	10	80	2061	4995
2009	100	8	214	2014	5497
Total	**379**	**10**	**740**	**7889**	**20617**

Source: Conpet, 2010. Available at: <http://www.conpet.gov.br/>.

Distance Learning Conpet

This is a work proposal that brings together education, research and extension, with a strong focus on the latter, through an eighty-hour distance learning course on environment and energy efficiency, based on a proposal for the training of teachers committed to sustainability in view of social, educational and professional co-responsibility principles of all members of the project.

The purpose of Distance Learning Conpet is to train Elementary Education practitioners in order to encourage students to discuss environmental issues and develop actions to promote education for sustainability and energy efficiency values, thus bringing the syllabus in line with the legislation in force.

The target audience includes elementary education teachers in public and private schools, education managers (administrators, coordinators, supervisors, counselors) in order to build new knowledge and develop social values, thus leading to an increasingly sustainable development; to propose prevention plans; achieve energy efficiency; and find solutions within the possibilities and limitations of the existing environmental education in schools.

Chapter 4

National and Regional Capacity Building

4 National and Regional Capacity Building

Brazil has special needs related to institutional structure to deal with climate change related issues. Development of human resources is one of the main objectives that involve building national and regional capacity, considering that this theme is a new area of study and there are few specialized courses on the subject.

This chapter describes the initiatives for national training related to climate change. Within a regional scope, work by the Inter-American Institute for Global Change Research – IAI, an intergovernmental organization dedicated to research stands out. In relation to research on a national scope, activities by the Climate Network, established at the end of 2007, and the National Institute of Science and Technology for Climate Change must be underscored. The text also addresses increasing the participation of Brazilian scientists in the IPCC process, as well as the recent creation of the Brazilian Panel on Climate Change, based on the IPCC. The country's efforts are also addressed in relation to work done on future climate change scenarios by CPTEC/INPE and by CCST/INPE.

This chapter also reports on the cooperation initiatives in relation to Brazil's regional capacity building with other developing countries (South-South cooperation). Training on modeling future regional scenarios of climate change for Latin American and Caribbean countries is reported as an example of regional capacity building. Within the scope of national capacity building, Brazil has also collaborated with capacity building that refers to the elaboration of National Communications and the CDM in other developing countries.

4.1 Inter-American Institute for Global Change Research - IAI

The IAI was established in 1992 with a mandate that covers the Americas. It is an intergovernmental organization dedicated to research, with headquarters in the city of São José dos Campos in the state of São Paulo, with the objective of developing scientific capacity aimed at understanding the integrated impact of present and future global change on the American continent's environment, and to foster scientific cooperation and disseminate information at every level.

Guided by principles of scientific excellence, international cooperation and counting on the ample exchange of scientific data, the Institute's main objectives are:

- promote and facilitate regional and international cooperation for interdisciplinary research from global change aspects;
- conduct research on a regional scale that cannot be conducted by an individual country or institution;
- prioritize the study of those aspects related to global change that have regional importance;
- contribute towards the dissemination of information, education and technical-scientific training; and
- promote the free exchange of scientific information.

IAI work is developed through four basic actions:

- contribute towards advancing the continent's scientific knowledge, whether through research, education or transfer of technology, complying with a scientific agenda with well-defined priorities;
- support the international Conventions and Protocols contributing towards elucidating scientific issues and their political implications related to these instruments, supporting national interests;
- support ample international cooperation, contributing towards international programs on global changes, promoting information policies that ensure free access to data; and
- support the interests of IAI member countries and provide scientific information that serves the interests of federal, state and local governments, private sectors and the public in general.

As an intergovernmental body, the IAI was conceived as a collaboration network among research institutions, ensuring its member countries can develop collaborations in research related to global changes.

The IAI has several research programs and Brazil has had strong representation through projects. Below, we present a description of the most recent scientific programs, of which Brazil was part, from 1999 to 2010.

4.1.1 IAI Scientific Programs - 1999-2010

Collaborative Research Network

The Collaborative Research Network Program - CRN began in 1999, in the form of a five-year program, renewed in 2006 (CRN II), with a total investment of nearly US$

22 million for 27 projects (27 CRNs). The CRN program was not only conceived to provide support to research work, but also to stimulate the development of synergic networks among scientists in the Americas aimed at having the scientists and scientific research institutions work together in an integrated and collaborative manner. These multidisciplinary networks were conceived to permit in-depth investigation of an ample scale of global issues related to environmental change, and they generated significant, high quality scientific information that is used by interested specialists, by public policy makers and decision makers to help in the mitigation and adaptation to environmental changes.

Three CRN projects shown in Table 4.1 were led by Brazilian teams: the University of São Paulo - USP, the Oswaldo Cruz Foundation – Fiocruz and the Federal Rural University of Rio de Janeiro – UFRRJ, respectively.

Table 4.1 Collaborative Research Network projects with the participation of Brazilian teams

Title	Main Investigator	Countries
Biogeochemical Cycles under Land Use Change in the Americas	Tiessen, H.	Canada, Argentina, Brazil, Mexico, Venezuela
Cattle, Land Use and Deforestation in Amazonia: A Comparative Analysis of Brazil and Peru	Wood, C.	USA, Brazil, Ecuador, Peru, Canada
Enhanced Ultraviolet-B Radiation in Natural Ecosystems as an added Perturbation due to Ozone Depletion	Vernet, M.	USA, Argentina, Brazil, Canada, Chile
ENSO Disaster Risk Management in Latin America: A Proposal for the Consolidation of a Regional Network for Comparative Research, Information and Training from a Social Perspective	Franco, E.	Peru, Argentina, Brazil, Colombia, Costa Rica, Ecuador, Mexico, USA
Comparative Studies of Global Change Effects on the Vegetation of Two Tropical Ecosystems: The High Mountain and the Seasonal Savannah	Silva, J.	Venezuela, Colombia, Brazil, Argentina
Andean Amazon Rivers Analysis and Monitoring	McClain, M.	USA, Peru, Brazil, Bolivia, Colombia, Ecuador
Diagnosis and Prediction of Climate Variability and Impacts on Human Health in the Tropical Americas	Confalonieri, U. (Fiocruz)	Brazil, USA, Colombia, Mexico, Jamaica, Venezuela
Development of a Collaborative Research Network for the Study of Regional Climate Variability and Changes, their Prediction and Impact, in the MERCOSUR area	Nuñez, M.	Argentina, Brazil, Paraguay, Uruguay, USA
An International Consortium for the Study of Global and Climate Changes in the Western South Atlantic	Campos, E. (USP)	Brazil, Argentina, Uruguay, USA
Climate Variability and its Impacts in the Mexican, Central American and Caribbean Region	Magaña, V.	Mexico, USA, Costa Rica, Brazil, Colombia
Documenting, understanding and projecting changes in the hydrological cycle in the American Cordillera	Luckman, B.	Canada, Argentina, Bolivia, Brazil, Chile, Mexico, USA
An International Consortium for the Study of Oceanic Related Global and Climate Changes in South America – SACC	Piola, A	Argentina, Brazil, Chile, Uruguay, USA
Functional links between aboveground changes and belowground activity with land use in the Americas: Soil biodiversity and food security	Berbara, R. L. L. (UFRRJ)	Brazil, Bolivia, Canada, Chile, Cuba, Ecuador, Mexico, USA
Understanding the human, biophysical and political dimensions of tropical primary and secondary dry forests in the Americas	Sanchez Azofeifa, A.	Canada, Brazil, Costa Rica, Cuba, Mexico, USA, Venezuela
Land use change in the Rio de la Plata river watershed: linking biophysical and human factors to predict trends, assess impacts, and support viable land-use strategies for the future	Jobbagy, E.	Argentina, Brazil, Paraguay, Uruguay, USA
The impact of Land Use and Cover Changes on the Hydroclimate of the La Plata river watershed[1]	Berbery, H.	Argentina, Brazil, USA
South American Emissions, Megacities, and Climate - SAEMC	Klenner, L. G.	Chile, Argentina, Brazil, Colombia, Peru, USA
Designing a methodology to evaluate local knowledge on global change and its role in the construction of future land use scenarios by local actors	Tourrand, J. F.	Brazil, Argentina, Canada, Uruguay, USA
Decision support system for risk reduction in agriculture, Soybean DSS for Eastern Paraguay and Rio Grande do Sul	Fraisse, C.	USA, Brazil, Paraguay
Conservation Policy Impacts in Tropical Dry Forest regional & spatially focused analyses given other social and natural drivers of land use	Pfaff, A.	USA, Brazil, Costa Rica

Notes: All CRN projects are interdisciplinary and include some component of climate change.

[1]This project is essentially a climate change project.

Source: IAI, 2010. Available at: <http://www.iai.int/>. Accessed on March 4, 2010.

In 2007, the IAI created a new program, primarily in researching the human dimensions of global change. The program developed research in human dimensions together with projects within the ambit of CRN II, integrating natural and social sciences. Three of these projects involve Brazilian institutions and scientists, and one is being led by a Brazilian team from the University of Brasilia – UnB.

IAI also collaborates with the project "Change in land use and management, biofuels and rural development in the La Plata river watershed - 2008-2010", with the objective of providing guidance to public policy formulators and decision makers in rural development processes and changes in land use in the La Plata river watershed. As part of this project, dynamic interaction is being analyzed between the natural and human components of agro-ecosystems in the La Plata river watershed to permit the exploration of opportunities offered by the growing global demand for agriculture commodities and biofuels, as well as to minimize the negative impacts of expansion and agriculture intensification, notably within the ambit of risks and opportunities created by global climate change. Three of the projects within the scope of this initiative are being conducted by Brazilian teams, Embrapa Solos, USP and UnB.

In relation to training, the IAI has contributed towards the dissemination of information, education and technical-scientific training and the free exchange of scientific information. Thus, with the intent of contributing towards advances in scientific knowledge on the continent, whether through research, education or transfer of technology, with a scientific agenda and well-defined priorities, IAI has promoted several courses and thus far contributed towards the scientific education of 131 Brazilian students involved in projects and 71 Brazilian scholarship holders.

4.2 Intergovernmental Panel on Climate Change - IPCC

The IPCC was created in 1988 by the World Meteorological Organization - WMO and the United Nations Environment Program - UNEP to evaluate scientific, technical and socioeconomic information available in the field of global climate change.

In principle, IPCC is comprised of scientists chosen from among specialists in global climate change from around the world. However, in practice, most of the specialists who participate in Panel evaluation reports come from developed countries.

Work Group I evaluates the scientific aspects of climate systems and climate change; Work Group II assesses the scientific, technical, environmental, socioeconomic aspects of vulnerability to climate change, as well as the negative and positive impacts on ecological systems, socioeconomic sectors and human health; Work Group III evaluates the scientific, technical, environmental, socioeconomic aspects of climate change mitigation, and finally, a multidisciplinary group assesses the methodological aspects of transversal themes; the Task Force works with the elaboration of guidelines for the preparation of national greenhouse gas emission inventories.

In the IPCC's First Assessment Report of 1990, only six Brazilian scientists participated as collaborators, four in Group I and two in Group II. In 1995, in IPCC's Second Assessment Report, five Brazilians participated as authors (three in Group I and two in Group II), and six as collaborators (one in Group I, two in Group II and three in Group III) and six as reviewers (one in Group I, two in Group II and three in Group III). In the Third Assessment Report, released in 2001, 12 Brazilian scientists contributed as authors (three in Group I, three in Group II and six in Group III), one as a collaborator (Group II) and ten as reviewers (two in Group I, three in Group II and five in Group III). In 2007, in the Fourth Assessment Report, fourteen Brazilian scientists participated as authors (three in Group I, five in Group II and six in Group III) and twenty-one as reviewers (three in Group I, thirteen in Group II and five in Group III)[301]. For the Fifth Assessment Report, which should be released in 2011, Brazil will have the participation of 25 authors (six in Group I, seven in Group II and twelve in Group III). The participation of Brazilian scientists is of utmost importance, mainly due to the fact of having a more specific understanding of processes (for example, those related to the Amazon) and important technologies (for example, use of ethanol fuel in vehicles) for developing countries.

The progressive increase in the participation of Brazilian scientists is the result of an increase in national training programs involving climate related subjects, and consequently, an increase in the number of Brazilian scientists who develop research related to the theme and offer subsidies for a better understanding of the subjects in question.

However, the participation of scientists from developing countries, which includes Brazil, is proportionally small and they are still poorly represented in the three Work Groups found in the Assessment Reports.

301 The IPCC Assessment Reports are available for consultation at <http://www.ipcc.ch/publications_ and_data/publications_and_data_reports.htm>.

4.3 Brazilian Panel on Climate Change - BPCC

Established by the MCT and MMA, the Brazilian Panel on Climate Change[302] is a national scientific body with the objective of providing decision makers and society technical-scientific information about global climate change. The BPCC's role is to assess, in a comprehensive, objective and transparent manner, the information produced by the scientific community regarding the environmental, social, economic and scientific aspects of climate change to permit a better understanding of the science of climate, the risks of climate change observed and projected for the future, as well as the impacts, vulnerability and associated actions for adaptation and mitigation.

The following will be elaborated and published periodically as results of the Panel's works: "National Assessment Reports", "Technical Reports", "Summaries for Decision Makers" on global climate change, as well as "Special Reports" on specific themes that will provide important elements for implementing policies in Brazil, such as the National Climate Change Plan[303]. As its main goal, the Brazilian Panel on Climate Change shall produce the First National Assessment Report on Climate Change, planned for 2012. Volumes I, II and III of the National Assessment Report correspond to the works from the IPCC Working Groups and they will compile all the scientific information available in Brazil, in accordance with the following structure:

- Working Group I - WGI: assesses the scientific bases for the climate system and its changes;
- Working Group II - WG2: assesses the vulnerabilities of natural and socioeconomic systems, the positive and negative consequences of global climate change, and adaptation options;
- Working Group III - WG3: assesses the options for mitigation in relation to global climate change; and
- Task Force in Greenhouse Gas Emission Inventory Methodologies

Thus, the BPCC seeks to insert itself in National Climate Change Plan implementation activities, especially in its axis of research and development, but it also supports the other axes of mitigation, adaptation and dissemination of knowledge.

The Panel's structure and functioning are based on the same rules that apply to IPCC. The Panel is comprised of a Plenary, Board of Directors, Scientific Committee, Executive Secretary, Work Groups and Technical Support Units. The four Working Groups will gather a total of 100 researchers tied to national research institutions, specialists in global climate change.

The BPCC offers an opportunity to organize and expand Brazilian scientific and research production on global climate change. It is the first experience developed in the country that will seek to unify and systematize existing knowledge on climate change in Brazil, focusing on regionalization, in a single publication and knowledge platform.

4.4 Brazilian Research Network on Global Climate Change - Climate Network

The Climate Network was created by the MCT in 2007. It is supervised by a Board of Directors comprised of four more Ministries (Environment; External Relations; Agriculture, Livestock and Food Supply; and Health), as well as representatives from the Brazilian Academy of Sciences - ABC; Brazilian Society for the Progress of Science - SBPC; Brazilian Climate Change Forum; National Council of State Secretaries for Science, Technology and Innovation; National Council of State Research Support Foundations; and the business sector. It is managed by an Executive Secretary exercised by the INPE and assisted by a Scientific Committee.

Among other things, the Board of Directors is responsible for defining the Network's research agenda, with the assistance of the Scientific Committee; promoting Climate Network management, making all decisions necessary for its operation, except for those within the scope of participating institutions; and articulating Network integration to public programs and policies in the global climate change area.

The Climate Network's Scientific Committee is comprised of representatives of thematic sub-networks and by scientists external to the Network. The Committee assists the Board of Directors on research themes and the evaluation of scientific results, as well as in elaborating public announcements for research.

The Climate Network's objectives are:

- generate and disseminate knowledge and technologies so Brazil can respond to the challenges represented by the causes and effects of global climate change;
- produce needed data and information to support Brazilian diplomacy in negotiations concerning the international global climate change regime;

302 Instituted by MCT/MMA Interministerial Administrative Rule nº 356, of September 25, 2009.

303 See Part III, Section 3.3, on the National Policy on Climate Change.

- conduct global and regional climate change studies in Brazil, emphasizing the country's vulnerability to global climate change;

- study alternatives for adapting Brazil's social, economic and natural systems to global climate change;

- research the effects of changes in land use and in social, economic and natural systems on Brazil's emissions of gases that contribute towards global climate change; and

- contribute towards the formulation and monitoring of public policy on global climate change within the ambit of Brazilian territory.

One of Climate Network's first collaborative products is the regular elaboration of analyses on the status of global climate change knowledge in Brazil, along the lines of the IPCC reports, but with more specific sector analyses for formulating national and international public policies.

Another of Climate Network's tasks, through the Climate Modeling sub-network, is to lead development of the Brazilian Global Climate System Model – MBSCG to generate future climate scenarios with the regional specificities that meet the country's interests. This effort, which is strategically important for the country to have autonomy and training in global climate system modeling, will have the support of several national and international institutions.

4.5 National Institute of Science and Technology – INCT for Climate Change

The INCT[304] for Climate Change aims at implementing and developing a comprehensive network of interdisciplinary research on global climate change, with the cooperation of various research groups from Brazil and abroad, aimed at creating the largest research network ever developed in this area in the country. The mission of the INCT for Climate Change is to develop a scientific agenda that will enable Brazil to expand scientific excellence in various areas of global environmental change and broaden its implications for sustainable development, especially when taking into account that the economy of developing countries is closely tied to renewable natural resources, as in the case of Brazil.

The objectives of the INCT for Climate Change program are:

- detect environmental changes in Brazil and South America, especially related to global climate change, and attribute causes to the observed changes (global warming, changes in land use, urbanization, etc.);

- develop Global Climate System models and scenarios for global and regional environmental changes, particularly scenarios in high spatial resolution of global climate change and land uses for the 21st Century;

- significantly increase knowledge of the impacts of global climate change and identify Brazil's main vulnerabilities in the following sectors and systems: ecosystems and biodiversity, agriculture, water resources, human health, cities, coastal zones, renewable energies and economy;

- develop studies and technologies to mitigate greenhouse gas emissions; and

- provide quality scientific information to subsidize public policies for adaptation and mitigation.

The INCT for Climate Change is organized in 26 sub-projects for research and it is closely tied to at least two other global climate change research networks, one of which is the MCT's Brazilian Research Network on Climate Change - Climate Network, since its structure will cover all scientific and technological aspects of interest to that network[305]. Likewise, the program shall be associated with several existing global climate change research programs in the states, particularly the São Paulo Research Support Foundation - FAPESP for Global Climate Change Research - PFMCG.

The INCT for Climate Change website was created with the intent of disseminating the program's activities[306].

304 The National Institutes of Science and Technology Program projects the creation of dozens of National Institutes of Science and Technology - INCTs spread about the country that will function in a multicentric form under the coordination of an institution-headquarters that already has competence in a specific area of research. The program is conducted by the Ministry of Science and Technology - MCT, through the National Council on Scientific and Technological Development - CNPq, in partnership with FAPESP and with other state Research Support Foundations. The INCT for Climate Change is under the coordination of the INPE. See: <http://www.fapesp.br/materia/4961/inct/inct-para-mudancas-climaticas.htm>.

305 See this Part, Section 4.4 on the Brazilian Research Network on Global Climate Change – Climate Network.

306 See: <http://www.ccst.inpe.br/inct>

4.6 Center for Weather Forecasting and Climate Studies - CPTEC / INPE

The CPTEC/INPE is equipped with supercomputers, including its latest acquisition – a supercomputer with a speed of 244 Teraflops per second (floating point arithmetic operations per second), which will permit running numeric models for weather forecasting with greater spatial resolution, with a five kilometer-level of detail for South America and 20 km for the entire planet. Extreme events, such as intense rains, hail, frost, fog, strong winds and heat waves, among others, will have more reliable forecasts. Furthermore, this new supercomputer will permit incorporating advances in the numeric modeling of weather, data assimilation (which incorporates meteorological observation data to forecasting models), chemicals and aerosols, atmosphere and oceans, which will bring improvements to weather and climate forecasting.

In seasonal climate forecasting, released for up to three months, besides improved detail of the predictions, with the increase in spatial resolution from 200 to 80 kilometers, the expectation is for improvements in atmospheric physics modeling. For example, the idea is to improve the representation of clouds, soil moisture and cryosphere and thus generate more reliable predictions.

Improvements in weather forecasting shall be obtained mainly by improving the ensemble technique, or the joint prediction. This methodology, which takes into account the chaotic nature of the atmosphere and the high degree of uncertainty of its status over time, is based on the processing of different initial atmospheric conditions. The CPTEC currently uses 15 different members that correspond to 15 predictions initiated from slightly different atmospheric statuses. The number of members will be increased to 40, which should better define the degree of certainty and uncertainty of meteorological tendencies, generating more reliable weather, climate and air quality forecasts. This improvement will enable predictions for longer periods and increase the reliability of extreme event prognoses, such as intense rains that tend to cause flooding in major cities and landslides in risk areas.

The CPTEC computer system is fed by information derived from the Meteosat and GOES satellites; the WMO database network; national networks under the responsibility of the National Institute of Meteorology – INMET, Ministry of Agriculture; the Air Force's Department of Air Space Control - DEPV; the Navy's Directorate of Hydrography and Navigation - DHN; state meteorology centers; and other international centers.

CPTEC recently achieved the status of "Global Producing Center" for Long-Term Weather Forecasts - GPC, granted by the WMO. After being indicated as a GPC, CPTEC joins a select club of world centers that includes the Climate Prediction Center (NOAA-USA), European Centre for Medium-Range Weather Forecasts - ECMWF, Japan Meteorological Agency - JMA, Meteo-France, and UK Met Office.

Besides the institute's various activities, which guarantee the good quality of meteorological predictions, climate tendency activities and studies in the country and the implementation of a study group for elaborating climate scenarios are projected using the experience of CPTEC researcher participation in the IPCC.

4.7 Earth System Science Center -CCST/INPE

With the creation of the CCST/INPE, observational study and global climate change modeling activities have migrated from CPTEC to CCST. In collaboration with the Hadley Centre, Tyndall Centre and University of East Anglia of the United Kingdom, observational studies and development of climate modeling capacity continue to be carried out in Brazil, and directed at global climate change. The CCST, in collaboration with the CPTEC, leads development of the MBSCG, which will be directed towards generating future climate scenarios on a global level, making Brazil the only country in Latin America to generate future climate scenarios on a global scale, compatible with the models used by the IPCC.

Implementation of a regional modeling capacity at the CCST is also expected to elaborate regional climate scenarios from the projections of climate models run by the most important climate centers in the world for the IPCC. Dynamic downscaling is used for this, where the Hadley Centre global model (HadCM3), which was granted by UK Met Office, will be aligned with the Eta-CPTEC regional model, making it possible to implement regional climate predictions for the country and for South America, with a resolution of up to 40 km for all of Latin America and the Caribbean. The activity involves strong national and international scientific collaboration in generating knowledge and capacity for implementing global climate change scenarios on a more detailed and precise scale than ever before.

One of the CCST's main objectives is to construct high-resolution global climate change scenarios that will be used to develop studies aimed at increasing the awareness and training of policy formulators and government authorities in relation to the impacts of global climate change on the different vulnerabilities and on possible adaptation measures. Important applications will be used in hydroelectricity (due to its importance in generating electric energy in Brazil), agriculture, human health and natural disasters, among other areas, which will be provided with needed information to favor the decision-making process.

4.8 Training in Future Regional Climate Change Scenario Modeling for Latin American and Caribbean Countries

The INPE developed the Eta regional model[307] to obtain regional projections of future climate. The INPE strategy in relation to the regional climate change model is to constantly improve it and attach it to the global climate models used by IPCC, which have been run at other climate centers in the world with the objective of generating future climate change projections until 2100. Regional climate change models can have a much better spatial resolution than global climate models and thus provide climate information with important local details, including more precise predictions of extreme events. Thus, the predictions using regional climate change models can promote a substantial improvement in evaluating a country's vulnerabilities to climate change and how the country can adapt to them.

With development of the regional Eta model, the INPE also began to have the capacity to assist other countries to complement their studies on climate change, providing the future scenarios generated in Brazil, and offering the experience of their researchers in variability and global climate change studies. Brazil also has a supercomputer with the capacity to obtain future climate scenarios that can be used by other South American countries.

In the spirit of South-South cooperation, after obtaining the first results from the Eta model, training was considered with specialists from Latin America where the model's preliminary results would be demonstrated. So, Latin American countries were invited to participate in training activities in Brazil.

The MCT, through the General Coordination of Global Climate Change - CGMC, in partnership with the INPE, and with additional financing from the government of Spain and collaboration of the Economic Commission for Latin America and the Caribbean - ECLAC, organized two training sessions in numerical modeling called "Training in numerical modeling for Eta-CPTEC climate change scenarios", at INPE headquarters in Cachoeira Paulista, state of São Paulo. This training was agreed upon within the ambit of the Iberian-American Climate Change Network – RIOCC.

307 See Part III.B.1.1, on Eta-CPTEC Model.

Two training activities were performed in this sense: the first in 2008, which had the participation of representatives from the following countries: Argentina, Bolivia, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Dominican Republic, Uruguay, Venezuela and Spain. A total of 52 people participated in this activity, including Brazilian teachers and students. The second training activity was held in 2009 and had the participation of two representatives from each of the following countries: Argentina, Bolivia, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Mexico, Panama, Paraguay, Peru, Dominican Republic, Uruguay, Venezuela and Spain. A total of 47 people participated in this activity, including teachers and students. The activities were held at INPE installations located in the city of Cachoeira Paulista, state of São Paulo.

The training contributed towards the training of other developing countries that can benefit from the Eta-CPTEC regional climate model processing results. Furthermore, this event enabled an exchange of experiences between INPE and Latin American specialists, jointly participating in Eta-CPTEC model improvement, making it better fitted for the region's needs. This activity also strengthened vulnerability, impact and adaptation evaluations of climate change on priority sectors in Latin American countries.

4.9 Analyses of Economic Impacts of Climate Change in Brazil

Pursuant to the commitments undertaken under Article 4, paragraph 1(f) of the Convention, the Parties shall, according to their common but differentiated responsibilities and their respective capacities, "take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, and employ appropriate methods, for example impact assessments, formulated and determined nationally, with a view to minimizing adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change." Also, under sub-paragraph (g) in this paragraph, it has been agreed that it is important to foster research "intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the (...) economic and social consequences of various response strategies."

Hence, it is necessary to assess the effects of implementation of public policies aimed at reducing greenhouse gas emissions on Brazil's economy.

After the Stern Report was released in 2006, there was a great concern in the sense of assessing the economic losses that could be caused by climate change worldwide. It should be pointed out that, up to the present moment, the impacts on the Brazilian economy of greenhouse gas emission reduction actions have not yet been reviewed extensively. Studies in this regard are beginning to be developed, and there is recognition that much remains to be done. In this sense, Brazil's experience has produced two studies of greater impact, which are discussed below.

4.9.1 General Equilibrium Model and Climate Change Study

Applied general equilibrium models can be used to simulate the effects of actions related to emission reduction policies, including taxes on fossil fuel emissions in certain sectors of the economy or regions.

A research project was conducted by ESALQ/USP (FERREIRA FILHO & ROCHA, 2007), and its purpose was to quantify the effects of implementation of public policies aimed at reducing greenhouse gas emissions on Brazil's economy. To this end, an applied general equilibrium model – AEG called MOSAICO-GEE was developed to simulate the effects of actions related to emission reduction policies, including taxes on fossil fuel emissions in certain sectors of the economy or regions. In addition to the core component of the economic equations, the model has an emission module, which interacts with the equations in order to respond to economic policy interventions. This is a static interregional bottom-up AEG model derived from the MMRF-GREEN model used in the Australian economy (ADAMS *et al*., 2002). The model was modified and adapted for the Brazilian economy, and the main change was the introduction of a mechanism for the substitution of gasoline/alcohol, a typical possibility of the Brazilian economy due to the introduction of the dual-fuel (flex-fuel) vehicle technology in Brazil.

The model simulations involved the introduction of a carbon tax, or tax on emissions (R$ 10 per ton of CO_2), implemented in the economy in different ways and in different scenarios (with and without an endogenous technological change).

The impacts (in terms of percentage changes) of the introduction of a tax of a ten-*reais* per ton of CO_2 on the Brazilian economy are shown below.

Table 4.2 Impacts on the Brazilian economy of the introduction of a carbon tax in different scenarios

Variable	carbtax1	carbtax05	carbtax05x	carbtxat	carbtxets	carbtmet6
Real GDP	-0.32	-0.32	-0.34	-0.00	0.35	-0.25
Capital stock	-0.60	-0.60	-0.82	-0.20	0.28	-0.67
Household real consumption	-0.05	-0.05	-0.55	-0.50	0.05	-0.30
Real investment	-0.60	-0.60	-0.82	-0.20	0.28	-0.67
Balance of Trade/PIB	-1.01	-1.01	1.91	2.99	1.82	0.93
Exports (quantum)	-2.94	-2.93	3.05	6.14	3.84	1.08
Imports (quantum)	-0.59	-0.59	-0.97	-0.35	0.25	-0.75
Terms of trade	0.34	0.34	-0.78	-1.13	-0.20	-0.32
Real devaluation	0.29	0.29	2.34	2.05	0.33	1.52
Real wage	-0.25	-0.25	-1.04	-0.80	-0.41	-0.76
Total emissions of CO_2e	-1.68	-1.67	-8.50	-6.83	0.65	-5.56

The effect of introducing a carbon tax on the economy could be considerably magnified through policies that facilitate technological change in those sectors with the most relevant emission patterns. Thus, this type of policy should come with other policies, such as special credit lines for the relevant sectors, incentives for equipment and services imports, in addition to specific research policies that may make it easier for companies to embrace the technological change that will enable them to maximize emission reductions according to the tax amount involved.

A major conclusion of this study is that the introduction of a tax on carbon emissions has complex impacts on the economy, with differing results across the various production sectors. Whether the tax will only apply to fuels or also to emissions associated to the activities performed by the sectors; the sectors to be covered by the policy; and other structural features of the economy all have a critical impact on the results. The results of this study show the importance of emissions associated to activity level for the Brazilian economy. Emission tax policies would be more effective if they were also applicable to emissions associated with activities, rather than just emissions associated with fossil fuels. The results show that the social cost of this policy (measured in terms of real GDP reduction) would be virtually the same, with a significantly greater reduction in emissions in the second case.

Another result worth noting is that obtained from the taxation of selected sectors, such as those listed in the European Union's European Trading System. The overall balance results show that even an opposite result to that intended could occur, with an increase in overall emissions. These results derive from the interrelationships between sectors in the economy as a whole, as well as the proposed adjustment assumptions, and are helpful to illustrate the complexity of the policy being considered. Finally, the scenarios involving long-term simulations and endogenous technological progress, which are induced by the very emission taxation policy, underscore the importance of this phenomenon in the process.

Thus, it emerges as a fundamental element for the analysis and adoption of complementary policies to mere taxation on emissions, which would enhance the results to be obtained. Industrial policies that allow for technological change in response to changing relative prices that would be caused by taxation could increase sharply the efficiency of taxation on the reduction of emissions. Estimates show that the results on the reduction of emissions could be twice as big, at a virtually identical social cost (measured in terms of real GDP reduction).

4.9.2 The Economy of Climate Change in Brazil

Climate change will affect natural resources, the economy and societies around the world at a scale that is yet unknown. The study Economy of Climate Change in Brazil - EMCB is an initiative to analyze and quantify the impact of climate change on the country's development agenda so that decision makers may have tools to identify the most serious and urgent risks and to evaluate and implement the most efficient prevention and adaptation measures in terms of costs and benefits.

This study brought together a large multidisciplinary team to integrate projections on various sectors, primarily comprised of scientists from the main Brazilian research institutions (MARCOVITCH *et al*., 2010). The starting point was computational models that provided projections about the future behavior of the climate in the national territory, such as temperature and rainfall levels. These projections (provided by INPE) fed simulation models in some strategic segments of the economy that translated in economic terms the expected impacts on the individual segments, according to two possible trends of future climate developed by the IPCC – scenarios A2 and B2.

This study attempts to simulate the future behavior of the Brazilian economy so as to be compatible, to the maximum extent possible, with the same assumptions by the IPCC for the global economy. The scenarios generated for the Brazilian economy are called simulated A2-BR scenario without climate change and simulated A2-BR scenario with climate change, based on IPCC's A2 climate scenario; and B2-BR scenario, which was also simulated without climate change and with climate change according to IPCC's B2 climate scenario. They represent future trends for the Brazilian economy if the world develops globally according to the (economic) assumptions of IPCC's A2 and B2 climate scenarios.

Although the climate problems associated with global warming are long term ones, the year 2050 was adopted as the timeframe for the simulations, thus excluding the most severe effects on productivity and GDP growth, which will be felt most strongly during the second half of the 21st Century. This was necessary because the uncertainties involved – especially the macroeconomic uncertainties – are still too large and the database does not support longer-term projections. However, some of the sectoral analysis go beyond 2050. Beyond this time limit, the simulations in the study focus on the average behaviors of the variables due to the difficulty of adequately representing in the models the uncertainties involved in extreme climate change scenarios.

It was estimated that, in the absence of climate change, Brazil's GDP will be R$ 15.3 trillion (real figure for 2008) under scenario A2-BR in 2050, and R$ 16 trillion under scenario B2-BR. With climate change impacts, these GDPs would drop to 0.5% and 2.3%, respectively.

If brought to present value, with a discount rate of 1% per annum, such losses would be between R$ 719 billion and R$ 3.6 trillion, which would amount to the loss of at least one year of growth over the course of the next 40 years.

Either with or without climate change, the GDP is always greater under B2-BR than under A2-BR. In other words, under scenario B2-BR, economic growth would be greater.

Under either scenario, poverty would increase on account of climate change, but this increase would be virtually negligible.

The average annual loss for Brazilian citizens in 2050 would be between R$ 534.00 (US$ 291.00) and R$ 1,603.00 (US$ 874.00). The present value in 2008 of reductions in consumption accumulated by 2050 would be between R$ 6,000.00 and R$ 18,000.00, thus representing 60% to 180% of the current annual consumption per capita.

The most vulnerable areas to climate change in Brazil are the Amazon and the Northeast. In the Amazon, warming could reach 7-8 °C in 2100, which would herald a radical change in the forest.

The decline in rainfall rates would affect the flow in river basins in the Northeast region, which are key for energy generation, such as Parnaíba and Eastern Atlantic watersheds, and flow rates would diminish up to 90% between 2070 and 2100. There would be significant losses to agriculture in all states, except for the coldest states, in the South and Southeast regions, which would then have milder temperatures.

However, because not many studies on the subject are available in the country, this study has a number of limitations. There are five main limitations:

- The use of a single global climate model, on which sectoral and economic analyses were based, a decision based on the level of knowledge available when the study began, with simulated probability distribution functions for various parameters and INPE's experience with the downscaling of global models.

- The deterministic approach of the study, i.e., no explicit consideration of risk and uncertainty, and emphasis on expected average values, with a narrow focus on the immediate costs of small temperature changes on a limited set of measurable impacts.

- The incompleteness of the database and technical information available, from climate models and projections for future climate to ecological and socioeconomic data, including economic valuation. In more complex sectors or with limited technical knowledge (such as biodiversity and coastal zones), the analyses and economic valuation are preliminary.

- Failure to incorporate long-term technological changes, due to the lack of scenarios and analyses on which to base projections, a decision derived from the paucity of models and technical restrictions for the interconnection of all models, from climate change projections to their socioeconomic impacts.

Future studies will include the local analyses and the analyses of impacts on institutional, legal and cultural aspects. The social analyses were limited to the outputs from the macroeconomic analysis and only partially from the various sector chapters. Moreover, the impacts of climate change on infrastructure have not been estimated and even less so on adaptation alternatives, which are aspects yet to be researched.

4.10 South-South Cooperation on Climate Change Related Issues

Besides training in future regional climate change scenario modeling for Latin American and Caribbean countries, Brazil has also collaborated with the development of national capacity in other developing countries. In a spirit of cooperation and solidarity, without imposing concepts, and guided by the premise of respecting specificities and needs of each country, Brazilian technicians have worked with teams from other non-Annex I countries, mainly to promote training for elaborating the National Communication to the Convention and installation of the Designated National Authority in those countries, with the consequent identification of opportunities and elaboration of projects activities under the CDM.

These activities include:

- training in methodological, practical and legal aspects of the Clean Development Mechanism, with a visit by General Coordination of Climate Change (Executive Secretariat of the Brazilian DNA) technicians to Haiti aimed at establishing the CDM's Designated National Authority in that country in 2005 and 2006;

- training in methodological, practical and legal aspects of the CDM, with a visit by technicians from the Botswana Designated National Authority to the General Coordination of Climate Change (Executive Secretariat of the Brazilian DNA) and to CDM project activities in Brazil in 2008;

- training in methodological, practical and legal aspects of the CDM, with a visit by General Coordination of Climate Change (Executive Secretariat of the Brazilian DNA) technicians to Cape Verde aimed at establishing the CDM's Designated National Authority in that country in 2009;

- training in methodological, practical and legal aspects of the Clean Development Mechanism, with a visit by General Coordination of Climate Change (Executive Secretariat of the Brazilian DNA) technicians to Sao Tome and Principe aimed at establishing the CDM's Designated National Authority in that country in 2009;

- training in greenhouse gas emission inventories for Cape Verde technicians with a visit by General Coordination of Climate Change (Executive Secretariat of the Brazilian DNA) technicians to the country in 2009;

- training in greenhouse gas emission inventories for Sao Tome and Principe technicians with a visit by General Coordination of Climate Change (Executive Secretariat of the Brazilian DNA) technicians to the country in 2009;

- training in greenhouse gas emission inventories for Angolan technicians with a visit by General Coordination of Climate Change (Executive Secretariat of the Brazilian DNA) technicians to the country in 2009;

- training in institutional arrangements and legal issues concerning the structuring of Clean Development Mechanism Designated National Authorities in Africa, in Addis Abeba, Ethiopia, in 2009;

- training to strengthen the capacity of Cape Verde technicians in identifying the country's needs in relation to vulnerabilities, impacts and adaptation measures to the possible adverse effects of global climate change, as well as options for the transfer of mitigation and adaptation technologies, within the context of Cape Verde's First National Communication to the Convention in 2010;

- training to strengthen the capacity of Angolan technicians in identifying the country's needs in relation to vulnerabilities, impacts and adaptation measures to the possible adverse effects of global climate change, as well as options for the transfer of mitigation and adaptation technologies, within the context of Angola's First National Communication to the Convention in 2010;

- support for the Group of Specialists in Least Developed Countries - LDCs in translating the "Step by step guide for implementing national adaptation programmes of action" into Portuguese in 2010.

Chapter 5

Information and Networking

5 Information and Networking

The global climate change issue is broadly understood as being related to development, and therefore has a transversal nature. There are multiple causes and effects of global climate change, involving various areas, which requires a systemic approach to the subject. Considering this approach, it is fundamental to have a continuous exchange of information among different areas; otherwise, there is risk of making reductionist and mistaken analyses.

5.1 Exchange of Information

The General Coordination of Global Climate Change – CGMGC, as the coordinator of Brazil's National Communication, seeks to promote and cooperate in the full, open and immediate exchange of scientific, technological, socioeconomical and legal information related to climate change, as well as the economic and social consequences of several response strategies with diverse government bodies (MDIC, MMA, Embrapa, Cetesb, state and municipal governments, etc.) and non governmental organizations (TNC and WWF Brazil), and also with the private sector (Petrobras, Vale, Unica, etc.). This cooperation also seeks to make these entities aware of taking into account, whenever possible, the facts related to climate change in their pertinent social, economic and environmental policies and measures, aimed at minimizing the negative effects on the economy, public health and quality of the environment, caused by projects or measures applied to promote the mitigation of or adaptation to climate change.

The degree of complexity of climate change related issues and their transversal nature have required proper institutional arrangements for dealing with these realities. In light of this, interministerial arrangements were created within the ambit of Brazil's federal government, as is the case of the Interministerial Commission on Global Climate Change and the Interministerial Committee on Climate Change[308] , aimed at the full exchange of information and on-line work, which allows for a better informed and more comprehensive decision-making process. In a scientific scope, interdisciplinary research on global climate change is the rule. This research generally has the cooperation of several research groups from Brazil and abroad. Many of the examples mentioned in the systematic observation and research sections, as well as the development of national and regional capacity function through networks, such as the World Climate Programs, Pirata, LBA, PPG-7, Proantar, Climate Network, INCT for Climate Change, and the efforts for modeling future climate change scenarios.

308 See Part I, Section 3, on Relevant Institutional Arrangements for Elaborating the National Communication on Permanent Bases

Besides these scientific networks, Brazil has engaged in coordination networks related to efforts regarding mitigation and adaptation to climate change, as in the examples below.

5.1.1 Ibero-American Network on Climate Change - RIOCC

In 2004, the Ibero-American Network on Climate Change - RIOCC (Spanish abbreviation for *Red Iberoamericana de Oficinas de Cambio Climático*) was created during the IV Iberian-American Forum for Ministers of Environment, held in October of that same year, in Cascais, Portugal.

The Network unites the national coordinations/secretaries on global climate change from the 21 countries of the Ibero-American Community of Nations: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Portugal, Spain, Uruguay and Venezuela. Different regional and international bodies and institutions are invited to participate in annual meetings and actively contribute towards the RIOCC's works and objectives[309]. RIOCC works in synergy with the Convention, whose Secretariat generally participates in the Network's annual meetings, and under the guidance of the Ibero-American Ministers of Environment and Science and Technology (in the case of Brazil). These Ministers present the most important conclusions derived from the RIOCC at the Ibero-American Conferences, comprised of heads of state.

The RIOCC's main objective is to guarantee the sustainable development of the Ibero-American region as part of the bilateral and multilateral development plans and cooperation programs in the fight against climate change and the measures for adapting to its adverse effects.

309 The following are international and regional bodies and institutions that collaborate with the RIOCC: Inter-American Development Bank - IDB, World Bank - WB, Centro Agronômico Tropical de Investigación y Enseñanza - CATIE, Centro del Agua del Trópico Húmedo para América Latina y el Caribe - CATHALAC (Panama), Centro Internacional para la Investigación del Fenómeno de El Niño - CIIFEN (Ecuador), Economic Commission for Latin America and the Caribbean - ECLAC and Andean Community - CAN, United Nations Framework Convention on Climate Change – UNFCCC, Andean Promotion Corporation - CAF, International Disaster Reduction Strategy - EIRD, Inter-American Institute for Research on Global Change - IAI, United Nations Development Program - UNDP, United Nations Environment Programme - UNEP and Global Climate Observing System - GCOS.

The network's main specific objectives are:

- to maintain a permanent fluid dialogue to better learn the priorities, difficulties and experiences of Ibero-American countries in climate change policies;
- to enable the actual implementation of the Convention's decisions, particularly on adaptation and mitigation;
- to promote the creation of capacities and knowledge, including, among other subjects, the transfer of technology, systematic observation and options for adaptation to climate change;
- to contribute towards forming consensus positions in international negotiation *fora* on climate change and sustainable development;
- to promote the integration of climate change in official assistance strategies for development;
- to facilitate the relation between public and private sectors in network countries in order to increase the benefits from CDM project activities and work together in identifying and removing barriers to CDM.

5.1.2 Portuguese-Speaking Network of Specialists in Climate Change - RELAC

The Community of Portuguese-Speaking Countries – CPLP was formalized in 1996, with the aim at being a forum for political-diplomatic consensus; promoting active and engaged cooperation, supporting or framing actions in diverse domains of governing and civil society activity; and contributing towards the promotion and dissemination of the Portuguese language. Creation of the CPLP served as a driving force or framework for governmental meetings on a ministerial or technical scope in diverse sectors.

Thus, in the climate change area, the RELAC was created in 2005, with the objective of promoting cooperation in relation to the mitigation and adaptation of climate change and promoting the approximation of government units that deal with this issue in their respective countries. The countries involved in the RELAC are the same as those in the CPLP: Angola, Brazil, Cape Verde, Guinea Bissau, East Timor, Mozambique, Portugal, and Sao Tome and Principe.

Thus far, cooperation within the ambit of RELAC has mainly been carried out bilaterally. Brazil is particularly engaged in constructing capacity in Portuguese-Speaking African Countries and East Timor concerning climate change related issues. Several activities have been carried out in this sense thus far, not only promoting training to support these countries in the elaboration of their national communications, but also in the installation and functioning of their CDM Designated National Authorities[310].

310 See Part IV, Section 4.9, on South-South Cooperation on Climate Change related Issues.

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Constrainsts and Gaps, and Related Financial, Technical and Capacity Needs

Part 5

PART 5

TABLE OF CONTENTS

Chapter 1

Constrainsts and Gaps, and Related Financial, Technical and Capacity Needs

1 Constrainsts and Gaps, and Related Financial, Technical and Capacity Needs

The budget for elaborating Brazil's Second National Communication to the Convention was established in 2005, when the document for the BRA/05/G31 project was signed. It was set up at US$ 3,400,000 and was provided by the GEF – which is an operational entity of the financial mechanism under the Convention – and US$ 4,175,600, from Brazil's contribution, for a total original budget of US$ 7,575,600.

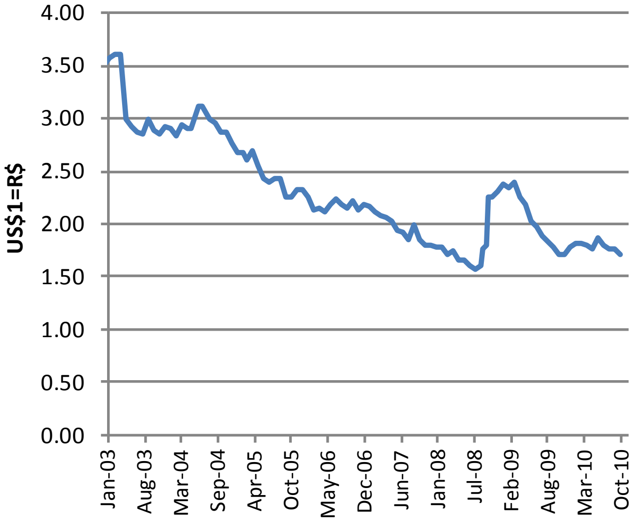
The MCT is the executing agency of this project, as it was when the Initial Communication of Brazil was elaborated, also financed with GEF resources. MCT uses this Fund's resources to leverage contributions from diverse partner institutions that participate directly in the execution of each project result. The budget originally made available is only sufficient for conducting projected basic results, without any expansion in their content or detail, which often proves necessary since these are highly complex technical studies for which the expansion of content and detail greatly contributes towards the quality of the final result.

In the specific case of Second National Communication of Brazil, the executing agency of this project, i.e., the MCT, had to make additional efforts in relation to financial execution of the project. Besides those contributions that are normally expected for expanding and detailing results, additional funds were necessary to permit carrying out some studies, given the real's appreciation in relation to the dollar, throughout project execution, from 2006 to 2010.

The dollar exchange rate at the time the project was negotiated with the GEF was R$ 3.15. In that scenario, the approved budget for the project (US$ 3,400,000 from GEF plus the original national contribution of US$ 4,175,600), would certainly be sufficient for carrying out all the projected basic studies, and the expansions and details, that is, the additional activities would be implemented at the expense of the contributions that would be negotiated during project execution, with each partner.

However, the dollar exchange rate, according to the official United Nations exchange rate for October 2010, was at R$ 1.71, having oscillated throughout the execution of the project (Figure 1.1) at rates lower than those considered when the project was proposed. This created several financial difficulties for the project to comply with its basic commitments, since all of its expense commitments were paid in Brazilian reais.

Figure 1.1 Dollar exchange rate oscillation throughout the execution of the project of the SNC



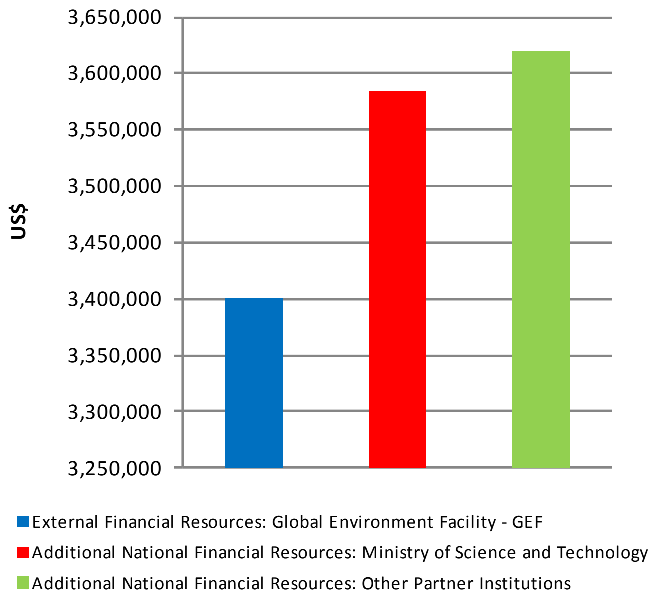
The efficient elaboration of Brazil's Second National Communication, with the proper expansions and details of those studies deemed necessary by the technical area, as well as the solution of the difficulties faced with the exchange appreciation, demanded funds of around US$ 10,604,222.

Of these funds, US$ 3,400,000 were provided by GEF and US$ 7,204,222 came from national contributions. Initially, this contribution was US$ 4,175,600. However, in face of the exchange rate appreciation and the determined need for additional activities during execution of the project, this contribution was not sufficient, which forced the MCT to work with several of the Ministry's institutions and entities in order to obtain additional funds, otherwise the work would not be completed.

Through active participation and thanks to a solid construction of partnerships by the MCT, it was possible to leverage contribution funds of US$ 3,028,622 to finalize the project in an efficient manner, maintaining the expected quality of the results. In addition to the MCT, these additional contributions came from other partner institutions, such as MME, INPE, Embrapa, Cetesb, Funcate, e&e, the Brazilian Coal Association - ABCM, etc.

Figure 1.2 shows the allocated contributions, separating the MCT from the other institutions, as well as the original budget provided by GEF. As can be observed, the MCT provided more funds than those coming from the GEF, demonstrating the Brazilian government's commitment to the work performed.

Figure 1.2 Source of the resources allocated to elaborate Brazil's Second National Communication to the United Nations Framework Convention on Climate Change



In relation to administrative execution, it is important to mention the diligence and effort put into executing the project on the part of the UNDP as well as the Brazilian Cooperation Agency of the Ministry of External Relations – ABC/MRE, which had positive impacts on the results achieved by the project.

As the implementing agency, the UNDP established a specific unit to serve the project. This unit was located in Brasília and had three supervisors who monitored all activities and every action developed and implemented within the referred to project. Every action or measure taken by the Executing Agency, the MCT, for executing the project, was previously evaluated by this unit, which advised regarding applicable procedures and participated in the selections made, evaluating each product presented to the project, whether from national consulting firms or from partnerships with public and private institutions. This unit also played the role of continuous monitoring of project activities, paying constant visits to the MCT. This provided the project with extraordinary efficiency gains in relation to its implementation, having guaranteed greater security to the MCT, which was able to obtain the unit's support for all execution procedures adopted.

The MCT worked in collaboration with this UNDP unit to define innovative procedures that contributed towards efficient execution of the project and observed a great difference in the quality of the cooperation offered by UNDP, since to execute the project for the Initial National Communication, implemented between 1996 and 2000, the UN Agency did not offer this type of support to a specific unit, which certainly made the difference in the elaboration of Brazil's Second National Communication.

Although UNDP's action has been very positive and fundamental to project success, minor setbacks were found in certain sectors of the UN specialized Agency that need to be strengthened. The tender area is an example. The main problems encountered in executing the project were related to the bureaucratic process and the delay in acquisitions of goods and services, which, in a way, hampered the work's good progress and had a negative impact on the project execution timetable, even though in the end, these difficulties had been overcome with the support of UNDP's direction.

In relation to technical difficulties, particularly concerning the Inventory, the most important issues involved the Land-Use Change and Forestry Sector, due to the complex methodology employed, involving the interpretation of a very large number of satellite images. As a result of the decision to use parts of previous works, also due to fund limitations, there was a delay in the timetable after ascertaining the need to correct and adapt these works.

There was also an unexpected delay in the Agriculture and Livestock Sector as a result of delays in obtaining 2006 Agriculture and Livestock Census results, which were only published in October 2009, and which contained essential results for the detailed methodologies adopted in the Inventory.

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