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BRAZIL'S INITIAL NATIONAL COMMUNICATION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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Preface

The presentation of Brazil's National Communication is a decisive institutional step in President Luiz Inácio Lula da Silva's government towards honoring the country's commitment to the United Nations Framework Convention on Climate Change. In addition to sustaining the country's frame of mind as an active participant in theme-related issues, the text contributes to a better understanding of the global problem and of climate change-related science advances.

A priori, it should be highlighted that, according to the principle of common but differentiated responsibilities among nations and their respective capacities, the initiative of addressing climate change and its adverse effects should come from developed countries, considering their historical emissions. Developing countries have no commitments to reduce or limit their anthropogenic greenhouse gas emissions, as established by the Convention and confirmed by the Kyoto Protocol.

The priorities in these countries refer to meeting pressing social and economic needs, such as poverty eradication, improving education and health conditions, fighting hunger, ensuring decent living conditions, among others. Thus, developing countries such as Brazil are faced with challenges of the 21st century, without having overcome the problems of the 19th century.

Brazil was the first country to sign the Convention on Climate Change, a result of the United Nations Conference on Environment and Development, held in Rio de Janeiro in June 1992. The Convention was ratified by the Brazilian National Congress in 1994.

The presentation of this document to the Convention, as well as the ratification of the Kyoto Protocol by Brazil and the approval of the first Brazilian projects under the Clean Development Mechanism, confirm the country's commitment to strengthening the role of multilateral institutions. These actions are the appropriate institutional benchmark for the solution of global problems that will affect all countries.

This act expresses the importance that Brazil gives to seeking a sound environment, both at the local and global levels, and it has become the key to the significant role the country plays in international negotiations on climate change. The Brazilian Government has always been aware of the fact that this is a matter of concern for humankind which can be decisive for the survival of the human race in the long term.

For Brazil to meet its commitments in this field, the Ministry of Science and Technology (MCT) took the responsibility of coordinating the preparation of this document, conceived so as to be developed through partnerships. It involved over a hundred institutions and over 700 experts with recognized capacity in every specific area of the various sectors energy, industry, forestry, agriculture, waste, among others. The activities were developed in a decentralized manner, by gathering data which were often either unavailable in the national scientific literature or restricted to national companies.

By thoroughly reviewing the results, MCT's coordination sought quality control, reliability and transparency of information. The sectoral reports and other background documents were, as soon as completed, made available on the website www.mct.gov.br/clima, in Portuguese, English and Spanish. Also, these documents underwent a broad review process by experts of various areas.

The joint work undertaken represents a small step towards understanding the different greenhouse gas emission processes by anthropogenic activities in Brazil, but it represents a considerable advance for the country. This document is important for the dissemination of the climate change subject, as well as to educate and raise the awareness of society regarding the future adverse impacts of global warming, while providing new opportunities for the development of cleaner technologies and fostering the advance of science. Certainly, issues related to climate change will be relevant in the national and international agenda in the future.

Eduardo Campos
State Minister of Science and Technology
Brasilia, November 2004

One of the commitments made by Brazil under the United Nations Framework Convention on Climate Change is to develop and periodically update national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, in addition to providing a general description of the steps taken or envisaged to implement the Convention. The document containing such information is called National Communication by the Convention.

The form of the Brazilian National Communication follows the guidelines contained in Decision 10 of the Second Conference of the Parties to the United Nations Framework Convention on Climate Change (document FCCC/CP/ 1996/15/Add.1, of July 17, 1996) Communications from Parties not Included in Annex I to the Convention: Guidelines, Facilitation and Process for Consideration. Therefore, the structure of each chapter was developed based on this decision, adjusting it, evidently, to the national circumstances and to the programs and actions developed in the country.

Thus, the Brazilian government presents Brazil's Initial National Communication, composed of three parts. The first part presents the national circumstances and special arrangements in Brazil; it seeks to present an overview and the complexity of this immense country, as well as its development priorities. The second part comprehends the first Brazilian greenhouse gas inventory regarding the period of 1990 to 1994, a result of the consolidation of 15 sectoral reports developed by institutions of excellence in the country, and it also provides additional information gathered from various entities. Finally, the last part presents the steps envisaged or already taken in the country that contribute directly or indirectly to achieving the Convention objectives.

The scientific complexity of global warming and the resulting difficulty in understanding it, along with the limited number of experts on this issue in Brazil make the preparation of the Brazilian inventory of greenhouse gas emissions a complex and pioneering effort. These difficulties were aggravated by the limited number of publications available in Portuguese about the issue, the lack of human and financial resources to develop more comprehensive studies, and by doubts about the benefits accruing to institutions involved in the process of developing the document.

In order to fulfill its commitments under the Convention, Brazil established an institutional framework in the form of a Program, under the coordination of the Ministry of Science and Technology, and with financial resources provided by UNDP/GEF and, initially, additional financial support from the US government. Given the wide-range and detailed nature of the inventory, every attempt was made during the preparation of the inventory to involve diverse information producing sectors and experts from a range of ministries, federal and state institutions, industry associations, public and private companies, non-governmental organizations, universities and research centers.

However, the methodological difficulties, as well as the difficulties in gathering data/information were significant. Because of its origins, the IPCC methodology to estimate anthropogenic greenhouse gas emission is largely based on research and methodologies developed by experts from developed countries, where fossil fuel burning represents a large proportion of greenhouse gas emissions. Consequently, important sectors to developing countries, such as Agriculture and Land-Use Change and Forestry, are not developed in sufficient depth. Therefore, the default emission factors and even the methodologies presented by the IPCC must be examined with due caution, because they do not necessarily reflect the national realities. In many cases, there is no research in the country that allows an evaluation of the values presented or the proposed methodology itself. In the cases where scientific results were available in the country, the national values were not always consistent with those presented by the IPCC, even showing, in some cases, significant discrepancies. The assessment of emissions from intensive biomass use in Brazil is not supported in the methodology, although these emissions, in relation to CO_2 emissions, are not accounted for in the national totals, because of the renewable nature of biomass.

The application of the IPCC methodology by developing countries requires these countries to adjust their research and data to a system that they had little role in developing. Anyway, during its application, some adjustments were made to the methodology proposed, such as, for instance, is the case with the Land-Use Change and Forestry sector. These adjustments were possible due to the existence, in the country, of large scale projects, such as the project that provides the annual rates of gross deforestation in Amazonia and the Atlantic Forest remnants, among others. Some pioneering studies were undertaken under the Inventory, aimed at enhancing the scientific knowledge of emissions from forest conversion into other uses, from hydroelectric reservoirs, and from prescribed burning of the *Cerrado*. Care should also be taken while comparing the total emission figures by type of greenhouse gas. The application of different methodologies in the development of inventories produced by other countries, especially those related to the Land-Use Change and Forestry sector, prevents the immediate comparison of the results presented.

In Brazil the search for and collection of information are not adequate because of the cost of obtaining and storing data, and there is little institutional concern with organizing or providing information, particularly at the local level. There is also a lack of legislation obliging companies to provide information, especially with respect to greenhouse gases. On the other hand, measurements are often not justified for the greenhouse gas inventory alone, because of the relatively high cost of measurements in comparison with improvements in the precision of estimates

Despite these difficulties, we sought to present the best estimates possible in the Inventory, taking into account the current stage of scientific knowledge and the availability of human and financial resources. In some cases, the country statistics did not allow the adequate assessment of the emissions. For some sectors, were there were no specific information available, methods to appraise the level of activities were developed, always in good faith, with the objective of minimizing uncertainties.

The development of a national inventory is a resource-intensive undertaking. Priorities should be established for carrying out research and studies of emissions for the main sectors and greenhouse gases, because the estimation methodology and the quality of data could improve with time. Because of this fact, the sectoral reports are normally based on work previously carried out by a range of national institutions.

Finally, it should be noted that even though the assessment of the annual emissions by each country is important to provide the dimension of the global emissions and the understanding of the evolution of climate change (both current and future), annual emissions of greenhouse gases do not represent the responsibility of a given country for causing global warming, since increased temperatures are a function of the accumulation of historic emissions of countries, which increase atmospheric concentrations of greenhouse gases. Corresponding to the concentration of each greenhouse gas, there is an accumulation of energy deposited at the surface of the Earth over the years. As noted in the Brazilian proposal presented during the negotiations for the Kyoto Protocol (document FCCC/AGBM/1997/MISC.1/Add.3), the responsibility of a given country can only be correctly assessed if all its historic emissions are taken into account, as well as the consequent accumulation of gases in the atmosphere and the resulting increase in average temperature at the earth's surface. Therefore the developed countries, which have emissions of greenhouse gases dating back to the Industrial Revolution, bear most of the responsibility for causing climate change. In addition to that, historical emission data indicate that these countries will continue to be the main contributors for another century.

Although developing countries like Brazil do not have commitments to reduce or limit their anthropogenic greenhouse gas emissions as established in the Convention, the country develops programs and actions that result in a significant reduction of these emissions. Some of these initiatives are responsible for the fact that Brazil has a relatively clean energy matrix, resulting in less greenhouse gas emissions per energy unit produced or consumed. Several other initiatives under implementation will also contribute to changing the curve of greenhouse gas emissions in the country.

Thus, the present National Communication also includes a description of these initiatives that contribute towards the implementation of the Convention in the country, by analyzing the various sectors, using the experience of the greatest experts in Brazil in their respective areas.

The part regarding the description of steps envisaged or already taken to implement the Convention in the country was developed by about 90 authors, representative of various sectors, whose texts were made available on the Internet, as part of a policy of total transparency and public participation. After compiling and restructuring these texts, they were submitted to 134 reviewers, among authors and other individuals directly linked to the programs and actions mentioned in this part.

So, by the end of this comprehensive and participative development and review process, the National Communication presents the state-of-the-art implementation of the Convention in the country up to the end of 2000. An effort was made, however, to update some data, considered relevant for the second national communication and included as footnotes, up to 2002.

Due to the time limit established for the "Description of Steps Taken or Envisaged", covering the period up to 2000, this Initial National Communication did not address the 2001 energy crisis and the changes caused by this crisis in the Brazilian energy sector.

With this work, we hope the reader realizes that Brazil is a country of continental dimensions and great complexity, and that, despite its socioeconomic problems, the country develops a number of programs and actions that show Brazil's commitment to sustainable development, a legacy of the United Nations Conference on Environment and Development, held in the country in 1992.

José Domingos Gonzalez Miguez
General Coordinator on Global Climate Change

The Initial National Communication is proof of the importance Brazil gives to the commitments made by the country under the United Nations Framework Convention on Climate Change.

Despite the scientific complexity of global warming related issues, the lack of awareness of the subject, the existence of development projects with a higher priority, the lack of material available in Portuguese on the subject and mostly the lack of data in the country, Brazil devoted a considerable effort to developing this complex and pioneering document.

This work is divided into three parts. The first presents an overview of national circumstances and complexities of this country of continental dimensions, as well as its development priorities. The second provides the consolidated data of the first Brazilian greenhouse gas inventory, regarding the period of 1990 to 1994. This inventory is the result of the consolidation of 15 sectoral reports referring to the following sectors: energy, industry, forestry, agriculture, and waste, and it also provides additional information from various participating institutions. Finally, the third part describes the steps envisaged or already taken in Brazil that directly or indirectly contribute to achieving the Convention's objectives.

BRAZIL UNDER PERSPECTIVE

Brazil is a country of continental dimensions and of great complexity.

The Federative Republic of Brazil is divided into 26 states, 5,507 municipalities (according to 2000 data) and the Federal District, where the Capital of the Republic, Brasilia, is located, seat of government and the executive, legislative and judiciary branches. The country has a Presidential system and is governed under the 1988 Federal Constitution.

With an area of 8,514,876.6 km^2, Brazil is the largest country in South America. Data from the Demographic Census for 2000 show that Brazil had a population of 169,799,170 people (IBGE, 2000). The country had an average population growth of 1.64% per year from 1990 to 2000. In 2000, most of the population (81.2%) lived in urban centers.

In addition to harboring over a third of Earth's tropical forests the Amazonian Forest there are phytoecological regions of great extent in the country, such as the *cerrado* (or savanna). It is estimated that Brazil has over 55,000 vegetation species, corresponding to approximately 22% of the world's total. The Brazilian fauna is very rich in species, with a relatively small number of individuals, many of which endemic, characterizing its fragility.

Brazil is a tropical country, with moderate winters. The available water resources are abundant, though not always well distributed or used. With a vast and dense hydrographic net, many of its rivers stand out for their extent, width or depth. Therefore, more than 95% of Brazil's electricity is generated by hydroelectric power plants and over 60% of its energy matrix is supplied by renewable sources.

Brazil is a developing country with a very complex and dynamic economy. It is among the ten largest world economies, in addition to being a large agricultural producer (the country has about 170 million cattle heads and it is a large exporter of a number of agricultural products) and one of the greatest producers of several manufactured products in the world, including cement, aluminum, chemical products, petrochemical feedstocks and oil.

In 2000, not taking into account the financial intermediation services, the Gross Domestic Product (GDP) of the country was generated as follows: 55% from service activities, 37% from industry (including construction, electricity and water) and 8% from agriculture. This year, the Brazilian GDP corresponded to US$ 594 billion. Between 1990 and 2000, the Brazilian economic growth outdid the population growth, increasing the per capita GDP by 13% (US$ 3,492.63 in 2000).

However, a significant fraction of the Brazilian population is poverty-stricken, and there are also great regional disparities. Therefore, the national priorities are to meet the pressing social and economic needs, such as eradicating poverty, improving health conditions, fighting hunger, creating decent living conditions, among others. Despite improved social indicators, especially in the last decade, the country still has a long way to go.

NATIONAL INVENTORY OF GREENHOUSE GAS EMISSIONS

Estimates from 1990 to 1994

Brazil, a Party to the United Nations Framework Convention on Climate Change (Climate Convention), has committed itself to prepare and periodically update the National Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases not Controlled by the Montreal Protocol (Inventory).

As determined by the Climate Convention, the Inventory should include only the greenhouse gas emissions and removals that result from human (anthropogenic) activities. Thus the present Inventory considered the emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). Emissions were also estimated for the so-called indirect greenhouse gases, such as nitrogen oxides (NO_x), carbon monoxide (CO) and other non-methane volatile organic compounds (NMVOCs). Emission of these gases was estimated according to the following emission sources or sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Land-Use Change and Forestry, and Waste.

The Inventory was developed according to the guidelines of the Intergovernmental Panel on Climate Change (IPCC) and involved an important part of the Brazilian scientific and business communities, in addition to different governmental sectors. The results of such an effort are presented in Table I, which summarizes the estimates of greenhouse gas emissions for the base year of 1994, separated by sectors and followed by the percentage increase in relation to emissions in 1990.

Table I - Estimates of greenhouse gas emissions in Brazil, in 1994

Sector	Energy	variation 90/94	Industrial Processes	variation 90/94	Solvent and Other Product Use	variation 90/94	Agriculture	variation 90/94	Land-Use Change and Forestry	variation 90/94	Waste	variation 90/94	TOTAL	variation 90/94
Gases	(Gg)	(%)	(Gg)	(%)	(Gg)	(%)	(Gg)	(%)	(Gg)	(%)	(Gg)	(%)	(Gg)	(%)
CO_2	236,505	16	16,870	0					776,331	2			1,029,706	5
CH_4	401	-9	3	8			10,161	7	1,805	12	803	9	13,173	7
N_2O	9	11	14	61			503	12	12	12	12	6	550	12
HFC-23			0.157	30									0.2	30
HFC-134a			0.125										0.1	
CF_4			0.345	19									0.3	19
C_2F_6			0.035	19									0.0	19
SF_6			0.002	0									0.0	0
NO_x	1,601	11	11	39			239	9	449	12			2,300	11
CO	12,266	-12	510	39			2,787	10	15,797	12			31,360	1
NMVOC	1,596	-16	358	3	521	46							2,474	-5

The profile of emissions in Brazil is different from that of developed countries, where emissions from fossil fuel combustion represent the greatest share of emissions. For important sectors to Brazil, such as agriculture and land-use change and forestry, it was necessary to develop adequate methodology to meet the country's needs. For such sectors, the emission factors provided by the IPCC and used in the absence of estimates for the Brazilian context may not necessarily reflect the Brazilian reality. Wherever possible, new studies were carried out in Brazil, and, in some cases, values significantly different from those suggested by the IPCC were found.

Emissions of the Main Greenhouse Gases

In 1994, CO_2 emissions were estimated at 1,030 Tg, mainly from the Land-Use Change and Forestry sector, which accounted for 75% of emissions, followed by the Energy sector, with 23%.

In the same year, CH_4 emissions were estimated at 13.2 Tg, with the Agriculture sector responsible for 77% of emissions, followed by the Land-Use Change and Forestry sector, with 14% of emissions.

N_2O emissions, in 1994, were estimated at 0.55 Tg, with the Agriculture sector accounting for 92% of total emissions.

Estimates presented in Table I, representing the results obtained for the year 1994, are discussed below by sector and subsector.

Energy Sector

In this sector, all anthropogenic emissions from energy production, transformation, and consumption are estimated. They include emissions resulting from fuel combustion and fugitive emissions in the chain of production, transformation, transmission, and consumption.

CO_2 emissions are the most important in the sector, totaling 237 Tg, basically from fossil fuel combustion (98%), showing an increase of 16% from 1990 to 1994, which reflects an increase in consumption. CH_4 comes next, with 0.4 Tg, as a result mainly (70%) of biomass burning (firewood, charcoal, etc.), declining by 9% in the period because of the drop in the consumption of such sources.

The greatest share of indirect greenhouse gases was due to the road transport subsector. Most of such emissions (CO and NMVOC) had a significant reduction in the period because of the technological improvements in the vehicles fleet.

Industrial Processes Sector

In this sector, estimates are made for anthropogenic emissions resulting from industrial production processes and not from fuel combustion.

CO_2 emissions are again the most important 17 Tg basically from cement and lime production (80%), which did not have significant changes. N_2O emissions, on their turn, with 0.014 Tg, are due mainly to adipic acid production (96%) and had an expressive increase in the 1990-1994 period.

Solvent and Other Product Use

Evaporation during solvent use generates emissions of NMVOCs, which are indirect greenhouse gases. Such emissions accounted for 0.5 Tg in 1994.

Agriculture Sector

In this sector, CH_4 emissions reached 10 Tg, as a result of the phenomenon of enteric fermentation of ruminant herbivores (92%), which include the country's cattle herd, the second largest in the world. N_2O emissions totaled 0.5 Tg and were due to various sources, among which manure from grazing animals (43%).

The practice of burning sugar cane before harvest was the main source of indirect greenhouse gas emissions in this sector.

Land-Use Change and Forestry Sector

Because of the large size of the Brazilian territory, the estimation of values for this sector was one of the most complex parts of the Inventory preparation, which required an extensive work of assessment and treatment of remote sensing and statistical data from the forest inventory. Three subsectors are analyzed:

- Forest conversion to agricultural activities, that is, deforestation of native vegetation areas and forest regrowth from abandonment of managed lands. Deforestation means emission of CO_2 to the atmosphere and regrowth, in contrast, implies removal of CO_2.

- Changes in the carbon content of soils, as a result of land-use changes, such as forest conversion to agricultural and grazing lands and vice versa. Such changes depend on a number of factors: the type of use and soil management practices used, assessed over a 20-year period; application of limestone to correct acidness and enhance soil fertility; and conversion of organic soils to agriculture, which causes a rapid oxidation of the organic matter. Carbon changes are associated with CO_2 emissions and removals.

- Planted forests in the country, specifically industrial forests, an expanding activity that also results in an increase in biomass stocks. In this subsector, there are CO_2 emissions and removals, with a predominance of the latter.

Net emissions in this sector totaled 776 Tg CO_2, distributed in the subsectors presented above as follows: 96% of total net emissions can be attributed to forest conversion in agricultural and grazing lands; 10% are due to changes in the carbon content of soils; and a reduction of 6% of this total is due to removals by planted forests.

Biomass burning in the areas of forest conversion to other uses was responsible for total emissions of 1.8 Tg CH_4, in addition to indirect greenhouse gas emissions.

Waste Sector

Solid waste disposal creates anaerobic conditions that generate methane. The emission potential of this gas increases depending on the control conditions in landfills and the depth of the dumps. Waste incineration, on its turn, is not a common practice in Brazil.

Effluents with a high degree of organic content, such as domestic and commercial sewage, and effluents from the food and beverages industry, and from the pulp and paper industry, have a high potential for methane emissions.

Emissions from this sector were estimated at 0.8 Tg CH_4, an increase of 9% since 1990. A great part of this value is generated by solid waste disposal (84%). Domestic wastewater, because of the nitrogen content in human food, also generates nitrous oxide emissions 0.012 Tg in 1994.

DESCRIPTION OF STEPS TAKEN OR ENVISAGED TO IMPLEMENT THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE IN BRAZIL

In accordance with the principle of common but differentiated responsibilities, only the countries included in Annex I of the United Nations Framework Convention on Climate Change must establish measures in order to reduce their emissions. In the framework of the Convention, countries that are not listed in such group do not have qualified commitments to reduce or limit anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol. It is recognized that the global emissions from developing countries will grow considering their needs to achieve social and economic development. Thus, Brazil does not have commitments to reduce or limit its anthropogenic emissions of greenhouse gases.

In spite of this, and despite the fact that is a developing country, there are many programs in Brazil that result in a considerable reduction of greenhouse gas emissions and contribute to the ultimate objective of the UNFCCC. Some of these initiatives are responsible for the fact that Brazil has a relatively “clean” energy matrix, with low levels of greenhouse gas emissions per unit of energy produced or consumed. Several other initiatives that are being implemented also contribute to lowering the curve of greenhouse gas emissions in Brazil.

Other programs being implemented in Brazil correspond to the other commitments assumed by Brazil under Article 4.1 (g) of the United Nations Framework Convention on Climate Change, such as promotion of research, capacity building, and activities of systematic observation related to climate change, along with support and cooperation in the area of education, training and public awareness related to the issue.

Programs and Activities Related to Sustainable Development

One of the main programs related to sustainable development is the National Alcohol Program - Proalcool, developed to reduce the need for foreign currency during the oil price shocks. From 1975 to 2000, around 5.6 million vehicles running on hydrated alcohol were produced. In addition, Proalcool allowed the substitution of up to 25%[1] of all previously pure gasoline with anhydrous alcohol consumed by a fleet of more than 10 million gasoline-fueled vehicles, thereby avoided over this period, carbon dioxide emission in the order of 400 million tonnes of CO_2, and this also offset imports of 550 million barrels of oil, as well as reduced the demand for foreign currency by around 11.5 billion dollars[2].

Thus, CO_2 emissions from the Brazilian electrical sector are among the lowest in the world in relation to population and GDP. Generation of electricity in the country emits almost no greenhouse gases. In 2000, the Brazilian electrical energy market demanded the production of 322 TWh from generating stations connected to the public grid. Around 93.5% of this production[3], or 301.4 TWh, was from hydroelectric sources. Of the remainder, a significant amount was produced with nuclear energy (around 1.5%) and biomass (around 3%). Because of this, the Brazilian electrical sector has special characteristics, not only as one of the world's largest producers of hydroelectric energy, but also because of the predominance of hydroelectricity in electrical generation.

Other important programs seek to reduce energy waste, as well as promote the adoption of more energy efficient technologies, and contribute to delaying the need for investments in new electrical generating stations and oil refineries. These programs include the National Electrical Energy Conservation Program - PROCEL, created in 1985, which carries out a range of activities to reduce electricity waste. In the period of 1986 to 1997, PROCEL enabled energy savings of around 4900 GWh, at a cost of less than R$ 236 million, compared with an avoided investment of R$ 2.3 billion in the construction of a plant with an installed capacity of 1133 MW.

There is also the National Program for the Rational Use of Natural Gas and Oil Products (CONPET), created in 1991 with the goal of developing and integrating actions to encourage the rational use of oil and natural gas products. CONPET's goal is to obtain a gain in energy efficiency of 25% in the use of oil products and natural gas in the next 20 years, without affecting the level of activities of the diverse sectors of the national economy.

In 2002, Brazil proposed the “Brazilian Energy Initiative” under the Global Sustainable Development Summit (Rio +10), in Johannesburg, South Africa, which called on countries to commit to increasing the share of new sources of renewable energy to 10% of their domestic energy supply, which demonstrates the country's commitment to these sustainable development measures. In remote areas, there is a pent-up demand that will lead to increased demand for solar photovoltaic energy, small scale wind systems, cogeneration using biomass (sugar cane bagasse and wood gasification), and generation systems using vegetable oils. Over the next five years, these sources are expected to account for around 5% of Brazilian supply, through programs like the Energy Development Program for States and Municipalities - PRODEEM. Institutional and regulatory incentives have been introduced to reduce the space occupied by fossil fuels, in favor of local renewable sources.

Brazil is one of the few countries that still uses charcoal in production processes in the metallurgy sector, especially in the iron and steel industry. In many countries, coal has replaced charcoal in steel making processes. The use of charcoal from plantations has reduced emissions by 50 million tonnes of CO_2 in the industrial sector between 1990 and 2000.

Programs and Activities that Contribute to Addressing Climate Change and its Adverse Effects

Brazilian demand for electricity has grown much more quickly than primary energy production and the economy of the country. This trend will likely continue for the coming years and will require new strategies for energy planning. Although emissions are increasing, because of the priority the country places on its development, it is expected that this trend can be modified and even reversed with the programs and activities mentioned above.

In addition, various programs under way in Brazil seek to replace fossil energy sources in Brazil with high carbon content per unit of energy generated by others with lower content, or which generate greenhouse gas emissions with lower global warming potential. Despite not being sustainable over the long term, certain programs and activities have the objective of helping to mitigate climate change and contribute to the ultimate objective of the UN Framework Convention on Climate Change.

This is the case with natural gas, which has better conversion efficiency than other fossil fuels, resulting in lower CO_2 emissions per unit of energy generated. Compared to burning fuel oil, the use of natural gas enables a 27% reduction in total CO_2 emissions in plants with conventional steam cycle generating technology, 31% in gas turbines, and 28% in combined cycle thermoelectric generation.

As well, other significant programs are been carried out aimed at reducing fugitive emissions of CH_4 in oil and natural gas production in Brazil such as Program Zero Flaring, which will reduce CO_2 emissions by around 15 million tonnes between 2002 and 2005.

Research and Systematic Observation

Brazil is undertaking and cooperating in scientific research and in systematic observations in order to clarify, reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitudes and trends over time of climate change.

In this context, teams of Brazilian researchers are participating in an international effort in global research

[1] According to data from the National Energy Balance (MME, 2000) from 1975 to 2000, the anhydrous alcohol content in the mixture (gasoline/anhydrous alcohol) over the period ranged from a minimum of 1.1% (in 1975) to a maximum of 25% (in 1999).

[2] Given the replacement of 1 liter of gasoline by 1 liter of anhydrous alcohol or by 1.25 liters of hydrated alcohol; 5% of the energy consumed in refining; average prince of “Brent” petroleum (British Petroleum BP); and the percentage of petroleum imports. Given also the emission factor of 0.63 kg of C per liter of gasoline (IPCC, 1997).

[3] Or around 88.5% of the market of 347.7 TWh if electrical self-generators are included.

programs related to climate change, including the Global Climate Observation System - GCOS, the Global Ocean Observation System - GOOS, and the Pilot Research Moored Array in the Tropical Atlantic - Pirata.

Among the research initiatives led by Brazil are the Large Scale Biosphere-Atmosphere Experiment in Amazonia - LBA, which seeks to expand understanding of the climatological, ecological, biogeochemical and hydrological functions of the Amazonian region; the impact of land-use changes on these functions; and the interactions between Amazonia and the global biogeophysical system of the Earth.

The projects carried out under the Pilot Program for the Protection of Tropical Forests of Brazil - PPG7 and the development of regional climate change models are other examples of important research being carried out in Brazil. There is also research under way related to glaciology and climate change.

A significant contribution of Brazil to negotiations for creating the international climate change regime was called the "Brazilian Proposal" the document submitted to the Convention in May 1997 by Brazil titled "Proposed Elements of a Protocol to the United Nations Framework Convention on Climate Change, presented by Brazil in response to the Berlin Mandate". This proposal is intended to produce a paradigm change by defining objective criteria for assessing the responsibility of each country for causing climate change, in terms of the relative and differentiated responsibility of each country in contributing historically, through anthropogenic greenhouse gas emissions, since the Industrial Revolution, to the increase in temperature of the earth's surface.

Education, Training and Public Awareness

Although the issues related to climate change are complex and difficult for lay persons to understand, and in light of the limited reading material in the issue available in Portuguese, there have been attempts to expand education, public awareness, and training regarding issues related to climate change.

Several educational programs implemented in Brazil are in accordance with the objectives of the Convention. Of special note are the National Environmental Education Program - PRONEA and the National Environmental Education Policy - PNEA, that aim at promoting a broad program of environmental education in Brazil. Also of great importance are the programs "PROCEL in Schools" and "CONPET in Schools", directed especially at children and teenagers through partnerships with teaching institutions. Their objectives are to expand the awareness of teachers and students about the importance of using electricity, oil products and natural gas in an efficient manner.

The Brazilian Climate Change Forum - FBMC, created in 2000 and chaired by the president of the Republic, seeks to promote the awareness and mobilization of society about global climate change, through carrying out a range of activities in this area.

The Brazilian Internet site on climate change of the Ministry of Science and Technology - MCT, with around 3000 pages and 14 MB of information available in 2000, provides information about the entire process of negotiation for the Convention, the main references for climate science, and the current stage of preparation of the National Communication (in Portuguese, English and Spanish, and from 2002 onward in French as well). Other websites in Brazil have also contributed to increasing public awareness on the issue. Furthermore, some publications in Portuguese (such as the Portuguese version of the official text of the Convention and the Kyoto Protocol), articles from newspapers, magazines and journals, radio and TV shows, the organization of seminars and presentations have helped in generating awareness of an issue that until a short time ago was totally unheard of in Brazil.

Effects of Global Climate Change on Marine and Terrestrial Ecosystems

Despite the limited available resources, both human and financial, in the early stages of the implementation of the Convention in Brazil, the Brazilian government adopted the strategy of placing emphasis on the studies for the preparation of the Brazilian inventory of net anthropogenic greenhouse gases. However, the limited literature about vulnerability and adaptation to the effects of climate change in Brazil were analyzed, in an attempt to understand the direct and indirect interactions between climate and the Brazilian society.

The research considered as having the highest priority, from a preliminary assessment, were the following:

- drought in the Northeast, as well as in other regions of the country and its impacts in agriculture and hydroelectric generation;
- floods that represent a serious problem in various regions, including the metropolitan region of Rio de Janeiro;
- frost and its impacts, mainly on coffee and orange crops, in particular in the South and Southeast regions;
- impacts of climate change on the productivity of agricultural crops (corn, soybean, wheat, etc.) of considerable importance to the country's GDP;
- vulnerability of coastal zones because of rising sea levels, and a preventative approach must be implemented in selecting sites for urban expansion and industrial development;
- vulnerability in the area of health, especially related to the transmission of various infectious diseases whose vectors and parasites are particularly sensible to climatic changes (malaria, dengue, etc.);
- impacts of climate change on the electrical sector, given the predominance of hydroelectric generation in the country; and
- coral bleaching in Brazilian coastlines.

To face these potential climate change impacts, it is essential to promote and improve disaster warning systems, such as those developed in Rio de Janeiro and other Brazilian states.

However, a notable feature of the climate change issue in Brazil is the problem of the lack of reliable projections of the possible future climates in the country, over a 100-year horizon. Brazil is a vast country, with great regional differences, and includes Amazonia, the semi-arid Northeast, the Center West, the grasslands of the South, and the *Pantanal*. Each specific region could have characteristic future climates. Current knowledge of the regional dimensions of global climate change, however, is still very fragmented.

To carry out vulnerability and impact studies, it is essential to develop long term climate change models with sufficient spatial resolution for regional analysis. Work towards this end has already begun in the Center for Weather Forecasts and Climate Studies - CPTEC of the National Institute for Space Research - INPE.

Creation of National and Regional Capacity

This chapter describes Brazilian capacity-building initiatives related to the Climate Change Convention, in particular activities of the Center for Weather Forecasts and Climate Studies - CPTEC/INPE, as well as the participation of Brazilian scientists in the IPCC process. At the regional level, the role of the Inter-American Institute for Global Change Research - IAI, an intergovernmental organization dedicated to research in climate change, with headquarters in Brazil.

Integration of Climate Change Issues in Medium and Long Term Planning

Awareness of environment issues in the medium and long term is essential to sustainable development. The Brazilian government is aware of this principle, in the process of drafting the Brazilian Agenda 21, an attempt was made to establish strategies to ensure sustainable development in Brazil, with recommendations for actions, partnerships, methodologies and institutional mechanisms necessary for its implementation and monitoring.

Also, Brazil's environmental legislation is among the most advanced in the world, although there are still administrative and institutional difficulties in its implementation.

In terms of national policies for medium and long term planning, for the first time in the 2000-2003 Government Multi-year Plan - PPA, there is a specific program on climate change with budgetary resources to produce scientific information related to greenhouse gas emissions and to support the development of a policy for actions in this area.

Many of the programs developed in the country do not have the direct objective of reducing greenhouse gas emissions, but will have impacts on emissions from different sources. One of the most important factors is that not just the federal level is involved, but also states and municipalities.

At the federal level, the National Program for Air Quality Control - PRONAR seeks to control air quality by establishing national emission limits. The Control Program for Air Pollution from Automotive Vehicles - PROCONVE has the same objective, but deals specifically with air pollution by automotive vehicles. The success of the program can be seen in an analysis of the reduction in emissions of a range of gases by light passenger vehicles, before 1980 and in the year 2000: CO (from 54 g/km to 0.63 - 0.73 g/km), HC (from 4.7 g/km to 0.13 - 0.18 g/km), NO_x (from 1.2 g/km to 0.21 g/km) and CHO (from 0.05 g/km to 0.004 - 0.014 g/km).

Although these programs are aimed at fighting local pollution and not directly at climate change, they are described here in terms of the institutional and legislative aspects involved and could, in the future, enable the creation of similar instruments and legislation to address greenhouse gas emissions from human activities.

Article 4.1 (d) of the UN Framework Convention on Climate Change states that the Parties must "promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems". In this regard, Brazil has some significant programs, as described below.

The Project for Gross Deforestation Assessment in the Brazilian Legal Amazonia - PRODES is one of the most ambitious examples of monitoring of land cover using satellite data, allowing an estimation, annually and in a comprehensive manner, of the rate of gross deforestation in forested areas of the Brazilian Amazonian region. The results of this project have allowed the government to identify strategies and implement measures aimed at reducing deforesting activities in the region.

Brazil has also been a pioneer in the use of meteorological satellite data to monitor burning in the country, culminating in the creation of the Program for Prevention and Control of Burning and Forest Fires in the Arc of Deforestation - PROARCO, implemented by the Brazilian Institute for the Environment and Natural Resources - IBAMA in partnership with the National Institute for Space Research - INPE, aimed at predicting and controlling burning in Brazil, and thereby avoiding forest fires.

Also, there are a large number of conservation units in Brazil, aimed at protecting and conserving samples of existing flora and fauna. These units cover a total of 44,835,960.84 hectares (448,350 km^2), or 5.2% of the Brazilian territory. This does not include indigenous reserves, which cover 97,624,245 ha, or 11.42% of the Brazilian territory. Adding indigenous lands to federal and state conservation units, the percentage of protected areas, including the different degrees of protection, rises to 20.78% of the Brazilian territory, with 94% of this land concentrated in the Legal Amazonia Region.

Financial and fiscal measures (Green Protocol for environmental responsibilities of banks, rural credit restrictions for environmental offenders, Ecological ICMS tax, and others) have also proven of great importance in reducing environmental damage and promoting sustainable development, and have already provided significant results. As one of the concrete examples of these measures, the tax incentive introduced in Brazil for vehicles with 1 liter engines resulted in emissions reductions[4] in the order of 22 million t CO_2 in the period of 1993 to 2000.

[4] Adopting an average of 22% of anhydrous alcohol mixed with gasoline.

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Symbols, acronyms and abbreviations

4DDA - Four Dimensional Data Assimilation Scheme
AAE - Energy Application Agency (*Agência para Aplicação de Energia*)
AAM - Annual Arithmetic Mean
ABC - Brazilian Cooperation Agency (*Agência Brasileira de Cooperação*)
ABEER - Brazilian Association of Renewable Energy and Energy Efficiency Companies (*Associação Brasileira de Energia Renovável e Eficiência Energética*)
ABIOVE - Brazilian Association of Vegetable Oil Industries (*Associação Brasileira das Indústrias de Óleos Vegetais*)
ABIQUIM - Brazilian Chemical Industry Association (*Associação Brasileira da Indústria Química*)
ABRACAL - Brazilian Association of Agricultural Lime Producers (*Associação Brasileira de Produtores de Calcário Agrícola*)
ABRACAVE - Brazilian Renewable Forests Association (*Associação Brasileira de Florestas Renováveis*)
ABRASCO - Brazilian Graduate Association for Collective Health (*Associação Brasileira de Pós-Graduação em Saúde Coletiva*)
AC - State of Acre
ACSYS - Arctic Climate System Study
ACT - Amazonian Cooperation Treaty (*Tratado de Cooperação Amazônica*)
AGM - Annual Geometric Mean
AIA - Environmental Impact Assessment/ EIA (*Avaliação de Impacto Ambiental*)
AIACC - Assessment of Impacts and Adaptation to Climate Change
AIDS - Acquired Immune Deficiency Syndrome
AL - State of Alagoas
Al - aluminum
Al_2O_3 - alumina
ALADI - Latin America Integration Association
ALALC - Latin America Free Trade Association
AM - State of Amazonas
ANA - National Waters Agency (*Agência Nacional de Águas*)
ANEEL - National Electrical Energy Agency (*Agência Nacional de Energia Elétrica*)
ANFAVEA - National Association for Automotive Vehicle Manufactures (*Associação Nacional de Fabricantes de Veículos Automotores*)
ANFPC - National Association of Pulp and Paper Producers (*Associação Nacional dos Fabricantes de Papel e Celulose*)
ANP - National Petroleum Agency (*Agência Nacional do Petróleo*)
AP - State of Amapá
APAs - Environmental Protection Areas (*Áreas de Proteção Ambiental*)
APP - Permanent Protection Areas (*Áreas de Preservação Permanente*)
Apr - April
ARGOS - Advanced Research and Global Observation Satellite
ARIEs - Areas of Relevant Ecological Interest (*Áreas de Relevante Interesse Ecológico*)
ASAS - South Atlantic Subtropical High (*Alta Subtropical do Atlântico Sul*)
ASTM - American Society for Testing Materials
ASV - Soil-Vegetation Linkages (*Associações Solo-Vegetação*)
Aug - August
AVHRR - Advanced High Resolution Radiometer
BA - State of Bahia
bar - barrel (*barril*)
BCB - Brazilian Central Bank (*Banco Central do Brasil*)
BEN - National Energy Balance (*Balanço Energético Nacional*)
bep - barrel of oil equivalent (*barril equivalente de petróleo*)
BIG-GT - Biomass Integrated Gasification - Gas Turbine
BIG-STIG - Biomass Integrated Gasification/ Steam Injected Gas Turbine
BNDES - National Economic and Social Development Bank (*Banco Nacional de Desenvolvimento Econômico e Social*)
BO_5 - Biological Oxygen Demand
BP - British Petroleum
BR - Brazil
BRAMS - Brazilian Regional Atmospheric Modelling System
C - carbon
C - Celsius
C_2F_6 - hexafluoroethane
$Ca(OH)_2$ - hydrated lime
$Ca(OH)_2 \cdot Mg(OH)_2$ - hydrated calcium and magnesium lime
$CaCO_3$ - calcium carbonate
$CaCO_3 \cdot MgCO_3$ - calcium magnesium carbonate (dolomite)
CaO - calcium oxide or quicklime
CaO·MgO - calcium magnesium oxide
CAPES - Coordinating Foundation of Personnel Improvement for Higher Education (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*)
CBCME - Brazilian Committe of the World Energy Council (*Comitê Brasileiro do Conselho Mundial de Energia*)
CBH - Circumference at Breast Height
CBTU - Brazilian Urban Railway Company (*Companhia Brasileira de Trens Urbanos*)
cc - cubic centimeter
CC - climate change
CCC - Fuel Consumption Account (*Conta de Consumo de Combustíveis*)
CCP - Cities for Climate Protection Campaign
CDE - Energy Development Account (*Conta de Desenvolvimento Energético*)
CDM - Clean Development Mechanism
CE - State of Ceará
CEEE - State Electrical Energy Company (*Companhia Estadual de Energia Elétrica*)
CELPE - Pernambuco Electrical Utility (*Centrais Elétricas de Pernambuco*)
CEMIG - Minas Gerais Electrical Utility (*Centrais Elétricas de Minas Gerais*)
CEMPRE - Business Commitment to Recycling (*Compromisso Empresarial para a Reciclagem*)
CENAL - National Alcohol Commission (*Comissão Nacional do Álcool*)
CENBIO - Center of Reference in Biomass (*Centro de Referência em Biomassa*)
CEPEL - Center for Electrical Energy Research (*Centro de Pesquisas de Energia Elétrica*)
CERPCH - Center of Reference in Small Hydroelectric Plants (*Centro de Referência em Pequenas Centrais Hidrelétricas*)
CESP - São Paulo Electrical Company (*Companhia Energética de São Paulo*)
CET - common external tariff
CETESB - Environmental Sanitation Technology Company of the State of São Paulo (*Companhia de Tecnologia de Saneamento Ambiental do Estado de São Paulo*)
CF_4 - tetrafluormethane
CFCs - chlorofluorocarbons
CFs - compact fluorescent lamps
CGDE - Central Electrical Distribution Company (*Companhia Geral de Distribuição Elétrica*)
CGMG - General Coordination of Global Climate Change (*Coordenação Geral de Mudanças Globais de Clima*)
CH_4 - methane
CHESF - São Francisco Hydroelectric Company (*Companhia Hidrelétrica do São Francisco*)
CHO - Aldehydes
CIDE - Contribution for Intervening in the Economic Domain (*Contribuição de Intervenção no Domínio Econômico*)
CIDES - International Committee for Sustainable Development (*Comissão Interministerial para o Desenvolvimento Sustentável*)
CIEL - Incineration and Electrical Energy Company (*Companhia de Incineração e Energia Elétrica*)
CIMA - Interministerial Sugar and Alcohol Council (*Conselho Interministerial do Açúcar e do Álcool*)
CIRM - Interministerial Commission for Ocean Resources (*Comissão Interministerial para os Recursos do Mar*)
CLIVAR - Research Program on Climate Variability and Predicability for 21st Century
cm^2 - square centimeter
CNAL - National Alcohol Council (*Conselho Nacional do Álcool*)
CNP - National Petroleum Council (*Conselho Nacional do Petróleo*)
CNPE - National Energy Planning Council (*Conselho Nacional de Planejamento Energético*)
CNPq - National Council for Scientific and Technological Development (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*)

Symbols, acronyms and abbreviations

CO - carbon monoxide
CO_2 - carbon dioxide
CODEVASF - São Francisco and Parnaíba Valleys Development Company (*Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba*)
COEA - Environmental Education Coordination Office (*Coordenação de Educação Ambiental do MEC*)
COELBA - Bahia Electrical Company (*Companhia Elétrica da Bahia*)
COELCE - Ceará Electrical Company (*Companhia Elétrica do Ceará*)
COLA - Center for Ocean-Land-Atmophere Interactions
COMGAS - São Paulo Gas Company (*Companhia de Gás de São Paulo*)
CONAMA - National Environmental Council (*Conselho Nacional de Meio Ambiente*)
CONPET - National Program for the Rational Use of Natural Gas and Oil Products (*Programa Nacional da Racionalização do Uso dos Derivados do Petróleo e do Gás Natural*)
CONSEL - Committee for the Conservation and Rational Use of Electrical Energy of ELETROBRAS System Companies (*Comitê de Conservação e Uso Racional de Energia Elétrica das Empresas do Sistema Eletrobras*)
CONSERVE - Efficiency in Energy Use Program (*Programa de Uso Eficiente da Energia)*
CONTRAN - National Traffic Council (*Conselho Nacional de Trânsito)*
COPEL - Paraná Electrical Company (Companhia Elétrica do Paraná)
COPERSUCAR - Coperative of Producers of Sugar Cane, Sugar and Alcohol of the State of São Paulo Ltd. (*Cooperativa dos Produtores de Cana, Açúcar e Álcool do Estado de São Paulo*)
COPPE - Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering of the Federal University of Rio de Janeiro (*Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa em Engenharia - UFRJ*)
CORINAIR - Co-ordinated Information
CP - Conference of the Parties
CPDS - Sustainable Development and National Agenda 21 Policies Commission (*Comissão de Políticas de Desenvolvimento Sustentável da Agenda 21 Nacional*)
CPFL - São Paulo Power and Light Company (*Companhia Paulista de Força e Luz*)
CPTEC - Center for Weather Forecasts and Climate Studies (*Centro de Previsão do Tempo e Estudos Climáticos*)
CRESESB - Center of Reference in Solar and Wind Energy (*Centro de Referência em Energia Solar e Eólica*)
CS - Mesoscale convective system
CTB - Brazilian Transit Code (*Código de Trânsito Brasileiro*)
CTC - Copersucar Technology Center (*Centro de Tecnologia Copersucar*)
CTPetro - National Science and Technology Plan for the Oil and Natural Gas Sector
CVM - Brazilian Securities Commission (*Comissão de Valores Mobiliários*)
CVRD - Vale do Rio Doce Company (*Companhia Vale do Rio Doce*)
DAS - apparent soil density
DBH - Diameter at Breast Height
DEPV - Airspace Control Department (*Departamento de Controle do Espaço Aéreo*)
DETRAN - State Transit Department (*Departamento Nacional de Trânsito*)
DF - Federal District (*Distrito Federal*)
DHN - Hydrography and Navigation Directorate (*Diretoria de Hidrografia e Navegação da Marinha*)
DIREC - Ecosystems Directorate of IBAMA (*Diretoria de Ecossistemas do IBAMA*)
DNAEE - National Department of Waters and Electrical Energy (*Departamento Nacional de Águas e Energia Elétrica*)
DNDE - National Department of Energy Development (*Departamento Nacional de Desenvolvimento Energético do MME*)
E - estuary
E10 - 10% ethanol and 90% gasoline
E85 - 85% ethanol and 15% gasoline
ECR - representative carbon stock
EFEI - Federal Engineering School of Itajubá (*Escola de Engenharia de Itajubá*)
EGTD - Guaranteed Energy for a Specified Time (*Energia Garantida por Tempo Determinado*)
EIA - Environmental Impact Assessment (*Estudo de Impacto Ambiental*)
ELETROBRAS - Brazilian Electric Power Company (*Centrais Elétricas Brasileiras S.A.*)
ELETRONORTE - North Region Eletric Power Company (*Centrais Elétricas do Norte do Brasil S.A.*)
ELETROPAULO - São Paulo Electricity S.A. (*Eletricidade de São Paulo S.A.*)
EMBRAPA - Brazilian Agricultural Research Corporation (*Empresa Brasileira de Pesquisa Agropecuária*)
ENSO - El Niño Southern Oscilation
EPS - expandable polystyrene foam
ES - State of Espírito Santo
ESCOs - Energy Conservation Service Companies (*Empresas de Serviços de Conservação de Energia*)
ESE/HB - Environmental Strategy for Energy: Hydrogen Fuel Cells Buses for Brazil (*Estratégia Ambiental para a Energia: Ônibus de Célula Combustível de Hidrogênio para o Brasil*)
ESEC - Ecological Stations (*Estações Ecológicas*)
ETA - Greek letter
EU - European Union
FAB - Brazilian Air Force (*Força Aérea Brasileira*)
FAO - Food and Agriculture Organization of the United Nations
FAPEX - Foundation for Research and Extension Support (*Fundação de Apoio à Pesquisa e Extensão*)
FBDS - Brazilian Sustainable Development Foundation (*Fundação Brasileira para o Desenvolvimento Sustentável*)
FBMC - Brazilian Climate Change Forum (*Fórum Brasileiro de Mudanças Climáticas*)
FCCC - Framework Convention on Climate Change
FEMA - State Environmental Foundation (*Fundação Estadual do Meio Ambiente - MT*)
FERRONORTE - Ferrovia Norte Brasil
FETRANSPOR - Federation of Urban Passenger Transport of the State of Rio de Janeiro (*Federação de Transportes de Passageiros Urbanos do Estado do Rio de Janeiro*)
FGV - Getulio Vargas Foundation (*Fundação Getulio Vargas*)
FIEP - Interstate Federation of Private Schools (*Federação Interestadual de Escolas Particulares*)
FINEP - Funding Agency for Studies and Projects (*Financiadora de Estudos e Projetos*)
FIOCRUZ - Oswaldo Cruz Foundation (*Fundação Oswaldo Cruz*)
FISET- F/R - Fiscal Incentives for Forestation/ Reforestation (*Fundo de Investimentos Setoriais*)
FLONAs - National Forests (*Florestas Nacionais*)
FLORAM - Research Program on Forestation in Brazil (*Programa de Pesquisa em Florestação no Brasil*)
FNDCT - National Fund for Development of Science and Technology (*Fundo Nacional de Desenvolvimento de Ciência e Tecnologia*)
FNMA - National Environmental Fund (*Fundo Nacional do Meio Ambiente*)
FUMIN - Multilateral Investment Fund (*Fundo Multilateral de Investimentos*)
FUNAI - National Indian Foundation (*Fundação Nacional do Índio*)
FUP - Price Equalization Charge (*Frete de Uniformização de Preços*)
FURNAS - Furnas Electrical Utility (*Furnas Centrais Elétricas S.A.*)
g - gram
G7 - Group of the Seven
G77 - Group of 77
GAIM - Global Analysis, Integracion, and Modelling
GATT - General Agreement on Tariffs and Trade
GCE - Electrical Energy Crisis Management Chamber (*Gestão da Crise de Energia Elétrica*)
GCMs - general circulation models
GCOS - Global Climate Observing System
GCTE - Global Change and Terrestrial Ecosystems
GDP - Gross Domestic Product
GEF - Global Environment Facility
GEWEX - Global Energy and Water Cicle Experiment
GFDL - Geophysical Fluid Dynamic Laboratory
Gg - gigagram (10^9 g or 1000 tonnes)

GISS - Goddard Institute for Space Studies
GJ - gigajoule
GL - Gay-Lussac
GLOSS - Global Sea Level Observing System
GO - State of Goiás
GOALS - Global Ocean-Atmosphere-Land System
GOOS - Global Ocean Observing System
GW - gigawatt
GWh - gigawatt hour
h - hour
ha - hectare
HadCM3 - Hadley Center's coupled global climate model
HadCM3H - Special version of HadCM3 with higher horizontal resolution
HC - Hydrocarbons
HCFC-22 - hydrochlorofluorocarbon
HFC-134a - hydrofluorocarbon
HFC-23 - hydrofluorocarbon
HFCs - hydrofluorocarbons
HIV - Human Immunodeficiency Virus
I - offshore platform or artificial island
I/M - Inspection and Maintenance Program for Vehicles (*Inspeção e Manutenção de Veículos*)
IAI - Inter-American Institute for Global Change Research (*Instituto Interamericano para Pesquisas em Mudanças Globais*)
IBAMA - Brazilian Institute for the Environment and Renewable Nature Resources (*Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis*)
IBD - Interamerican Development Bank
IBDF - Brazilian Institute for Forestry Development (*Instituto Brasileiro de Desenvolvimento Florestal*)
IBGE - Brazilian Institute for Geography and Statistics (*Fundação Instituto Brasileiro de Geografia e Estatística*)
IBSNAT - International Benchmark Sites Network for Agrotechnology Transfer
ICLEI - International Council for Local Environmental Initiatives
ICMS - Tax on the Circulation of Goods and Services (*Imposto sobre Circulação de Mercadorias e Serviços*)
ICSU - International Council for Science
IEA - International Energy Agency
IEA/USP - Institute for Advanced Studies of the University of São Paulo (*Instituto de Estudos Avançados da Universidade de São Paulo*)
IF - impact factor
IGAC - International Global Atmospheric Chemistry
IISI - International Iron and Steel Institute
INCRA - National Institute for Settlement and Agrarian Reform (*Instituto Nacional de Colonização e Reforma Agrária*)
INMET - National Institute of Meteorology (*Instituto Nacional de Meteorologia*)
INPA - National Institute for Research in Amazonia (*Instituto Nacional de Pesquisa na Amazônia*)
INPE - National Institute for Space Research (*Instituto Nacional de Pesquisas Espaciais*)
IOC - Intergovernmental Oceanography Comission
IPCC - Intergovernmental Panel on Climate Change
IPEA - Institute for Applied Economic Research (*Instituto de Pesquisa Econômica Aplicada*)
IPI - Industrial Products Tax (*Imposto sobre Produtos Industrializados*)
ISO - International Organization for Standardization
ITCZ - Intertropical Convergence Zone
ITR - Rural Property Tax (*Imposto Territorial Rural*)
IUC - Information Units for Conventions
Jan - January
JICA - Japan International Cooperation Agency
JSF - Japan Special Fund
KB - kilobyte
kcal - kilocalorie
kg - kilogram
kgf - kilogram-force
km - kilometer
km^2 - square kilometers
ktoe - kilo-tonne of oil equivalent
kW - kilowatt
kWh - kilowatt-hour
kWp - kilowatt-peak
l or L - liter
LAPAG - Antarctic and Glaciology Research Laboratory (*Laboratório de Pesquisas Antárticas e Glaciológicas*)
LAU - Single Environmental License (*Licenciamento Ambiental Único*)
LBA - Large Scale Biosphere-Atmosphere Experiment in Amazonia
LGN - liquefied natural gas
LPG - liquefied petroleum gas
LSF/USP - Photovoltaic System Laboratory of the University of São Paulo (*Laboratório de Sistemas Fotovoltáicos da Universidade de São Paulo*)
M - million
m^2 - square meter
m^3 - cubic meter
MA - State of Maranhão
MAA - annual arithmetic average
max. - maximum
MB - monobuoy
MCT - Ministry of Science and Technology (*Ministério da Ciência e Tecnologia*)
MDA - Ministry of Agriculture Development (*Ministério do Desenvolvimento Agrário*)
MDIC - Ministry of Development, Industry and Foreign Trade (*Ministério do Desenvolvimento, Indústria e Comércio Exterior*)
MEC - Ministry of Education (*Ministério da Educação e do Desporto*)
MEG - mixture of hydrated alcohol, methanol and gasoline (*mistura de metanol, etanol e gasolina*)
MERCOSUL - Southern Common Market (Mercado Comum do Cone Sul)
MG - State of Minas Gerais
MGA - annual geometric average
MIC - Ministry of Industry and Commerce (*Ministério da Indústria e Comércio*)
MINC - Ministry of Culture (*Ministério da Cultura*)
MJ - Ministry of Justice (*Ministério da Justiça*)
mm - millimeter
MMA - Ministry of Environment (*Ministério do Meio Ambiente*)
MME - Ministry of Mines and Energy (*Ministério de Minas e Energia*)
MPO - Ministry of Planning and Budget (*Ministério de Planejamento e Orçamento*)
MRE - Ministry of Foreign Relations (*Ministério das Relações Exteriores*)
MS - State of Mato Grosso do Sul
MT - State of Mato Grosso
Mtoe - million tonnes of oil equivalent
MW - megawatt
MWh - megawatt hour
N - North
N_2O - nitrous oxide
Na_2CO_3 - neutral carbonate of soda or soda ash
Na_3AlF_6 - cryolite
NA - not available
NASA - National Aeronautics & Space Administration
NCEP - National Center for Environmental Prediction - USA
NE - Northeast
NGL - natural gas liquids (*líquido de gás natural*)
NGOs - Non Governmental Organizations
NH - Northern Hemisphere
NH_3 - ammonia
NMVOCs - Non Methanic Volatile Organic Compounds
No. - number
NOAA - National Oceanic and Atmospheric Administration
NO_x - nitrogen oxides
NW-SE - northwest-southeast
O - open sea
OEMA - State and Municipal Environmental Agencies (*Órgãos Executivos Estaduais e Municipais de Meio Ambiente*)
OVEG Project - National Program for Energy form Vegetable Oils (*Programa Nacional de Energia de Óleos Vegetais*)
P.E.A. - economically active population (*População Economicamente Ativa*)
PA - State of Pará
PACD - Plan of Action to Combat Desertification
PAGES - Past Global Changes
PARNAs - National Parks (*Parques Nacionais*)
PB - State of Paraíba
PCDs - Data Collection Platforms (*Plataformas de Coletas de Dados*)
PCH - small hydroelectric plant
PCPV - Pollution Control Plans for Vehicles in Use (*Planos de Controle da Poluição por Veículos em Uso*)
PD/A - Type A Demonstration Projects (*Projetos Demonstrativos Tipo A*)
PD/I - Indigenous Demonstration Projects (*Projetos Demonstrativos Indígenas*)

Symbols, acronyms and abbreviations

PE - State of Pernambuco
PERC - perchloroethylene
PET - polyethylene terephthalate
PETROBRAS - Brazilian Petroleum S.A. (*Petróleo Brasileiro S.A.*)
PFCs - perfluorocarbons
Pg - petagram (10^{15} g or one billion tonnes)
PI - State of Piauí
PICE - Integration and Economic Cooperation Program (*Programa de Integração e Cooperação Econômica*)
PIN - National Integration Program (*Programa de Integração Nacional*)
PIRATA - Pilot Research Moored Array in the Tropical Atlantic
PLC - Population per Length of Coastline
PM - particulate material
PMAGS - Program of Global Environmental Changes in Health (*Programa de Mudanças Ambientais Globais em Saúde*)
PNA - Pacific North America
PNAD - National Household Sampling Study (*Pesquisa Nacional por Amostra de Domicílios*)
PNEA - National Environmental Education Policy (*Política Nacional de Educação Ambiental*)
PNSB - National Basic Sanitation Study by IBGE (*Pesquisa Nacional de Saneamento Básico - IBGE*)
POAG - Gas Optimization Plan (*Plano de Otimização de Gás*)
POLAMAZÔNIA - Program for Agriculture, Livestock, and Agro-mineral Poles in Amazonia (*Programas de Pólos Agropecuários e Agrominerais na Amazônia*)
POLANTAR - National Policy for Antarctic Issues (*Política Nacional para Assuntos Antárticos*)
pp. - pages
PPA - Multi-Year Plan (*Plano Plurianual*)
PPG7 - Pilot Program for the Protection of Tropical Forests of Brazil (*Programa Piloto para a Proteção das Florestas Tropicais do Brasil*)
ppm - parts per million
PPT - Priority Thermoelectric Generation Plan (*Plano Prioritário de Geração Termelétrica*)
PQZ - Project Zero Flaring (*Projeto Queima Zero*)
PR - State of Paraná
PREVFOGO - National System of Forest Fire Prevention and Control (*Sistema Nacional de Prevenção e Combate aos Incêndios Florestais*)
PROÁLCOOL - National Alcohol Program (*Programa Nacional do Álcool*)
PROANTAR - Brazilian Antarctic Program (*Programa Antártico Brasileiro*)
PROARCO - Program for Prevention and Control of Burning and Forest Fires in Legal Amazonia (*Programa de Prevenção e Controle de Queimadas e Incêndios Florestais na Amazônia Legal*)
PROBEM - Brazilian Program of Molecular Ecology for the Sustainable Use of Biodiversity (*Programa Brasileiro de Ecologia Molecular para Uso Sustentado da Biodiversidade*)
PROBIOAMAZON - Program for Production of Biomass for Energy in INCRA Settlements in Amazonia, Clean Energy and Integrated Local Development (*Programa de Produção de Biomassa Energética em Assentamentos do Incra na Amazônia, Energia Limpa e Desenvolvimento Local Integrado*)
PROBIODIESEL - Brazilian Biofuels Program (*Programa Brasileiro de Biocombustíveis*)
PROCEL - National Electrical Energy Conservation Program (*Programa Nacional de Conservação de Energia Elétrica*)
PROCLIMA-SP - Global Climate Change Program of the State of São Paulo (*Programa Estadual de Mudanças Climáticas Globais de São Paulo*)
PROCONVE - Motor Vehicle Air Pollution Control Program (*Programa de Controle da Poluição do Ar por Veículos Automotores*)
PRODEAGRO - Agroenvironmental Development Program of the State of Mato Grosso (*Programa de Desenvolvimento Agroambiental do Estado do Mato Grosso*)
PRODEEM - Energy Development Program for States and Municipalities (*Programa de Desenvolvimento Energético de Estados e Municípios*)
PRODES - Project for Monitoring of Deforested Areas in the Amazonian Region (*Projeto de Estimativa do Desflorestamento Bruto da Amazônia Brasileira*)
PROECOTUR - Program for the Development of Ecotourism in the Legal Amazonia (*Programa para o Desenvolvimento do Ecoturismo na Amazônia Legal*)
PROEÓLICA - Emergency Wind Energy Program (*Programa de Incentivo às Fontes Alternativas de Energia Elétrica*)
PROINFA - Program for Alternative Sources of Energy (*Programa de Incentivo às Fontes Alternativas de Energia Elétrica*)
PRONAR - National Air Quality Control Program (*Programa Nacional de Controle da Qualidade do Ar*)
PRONEA - National Environmental Education Program (*Programa Nacional de Educação Ambiental*)
PROTERRA - Program for Land Redistribution and Agro-industry Incentives for the North and Northeast (*Programa de Redistribuição de Terras e Estímulos à Agroindústria do Norte e Nordeste*)
R.O.M. - run-of-mine
RA - Annual operational revenue
RADAM - Radar in Amazonia (*Radar na Amazônia*)
RCHO - formaldehyde + acetylide
REBIO - Biological Reserves
Reluz - National Program for Efficient Public Lighting (*Programa Nacional de Iluminação Pública Eficiente*)
RESEX - Extractive Reserve (*Reservas Extrativistas*)
RGR - Global Reversion Reserve
Rio 92 - United Nations Conference on Environment and Development
RIO + 10 - Global Sustainable Development Summit
RJ - State of Rio de Janeiro
RL - Legal Reserves
RMSP - São Paulo Metropolitan Region (*Região Metropolitana de São Paulo*)
RN - State of Rio Grande do Norte
RO - State of Rondônia
RPPN - Private Natural Heritage Reserves (*Reservas Particulares de Patrimônio Natural*)
RPSAS - Regional Physical-space Statistical Analysis System
RR - State of Roraima
RS - State of Rio Grande do Sul
SABESP - Basic Sanitation Company of the State of São Paulo (*Companhia de Saneamento Básico do Estado de São Paulo*)
SACZ - South Atlantic Convergence Zone
SAE - Secretariat of Strategic Issues (*Secretaria de Assuntos Estratégicos da Presidência da República*)
SBI - Subsidiary Body for Implementation
SBSTA - Subsidiary Body for Scientific and Technological Advice
SC - State of Santa Catarina
SCAR - Scientific Committee on Antarctic Research
SCD - Data Collecting Satellite
SE - State of Sergipe
SEA - Secretariat of Strategic Issues of the Presidency of the Republic (*Secretaria de Assuntos Estratégicos da Presidência de República*
SEAIN - Secretariat for International Issues (*Secretaria de Assuntos Internacionais*)
SEMA - Special Environment Secretariat (*Secretaria Especial do Meio Ambiente*)
SENAC - National Commercial Training Service (*Serviço Nacional de Aprendizagem Comercial*)
SENAI - National Industrial Training Service (*Serviço Nacional de Aprendizagem Industrial*)
SF_6 - sulfur hexafluoride
SH - Southern Hemisphere
SHPs - small hydroelectric plants
SIESE - Corporate Information System of the Electrical Sector (*Sistema de Informações Empresariais do Setor de Energia Elétrica*)
SIG - Geographic Information System (GIS)
SIGAME - Integrated Wood Gasification System for Electrical Generation (*Sistema Integrado de Gaseificação de Madeira para Geração de Eletricidade*)
SIMEGO - Meteorological and Water Resources System of the State of Goiás (*Sistema de Meteorologia e*

Recursos Hídricos do Estado de Goiás)
SIMEPAR - Paraná Meteorological System (*Sistema Meteorológico do Paraná*)
SIMERJ - Meteorology System of the State of Rio de Janeiro (*Sistema de Meteorologia do Estado do Rio de Janeiro*)
SIMGE - Minas Gerais Meteorology and Water Resources System (*Sistema de Meteorologia e Recursos Hídricos de Minas Gerais*)
SISNAMA - National Environmental System (*Sistema Nacional do Meio Ambiente*)
SMA - State Environmental Secretariat (*Secretaria do Meio Ambiente*)
SMMA - São Paulo State Environment Secretariat (*Secretaria Municipal do Meio Ambiente - São Paulo*)
SNIEC - National Union of the Coal Extraction Industry (*Sindicato Nacional da Indústria de Extração de Carvão Mineral*)
SNUC - National System of Conservation Units (*Sistema Nacional de Unidades de Conservação*)
SO_2 - sulfur dioxide
SO_x - sulphur dioxides
SOYGRO - Soybean Crop Growth Simulation Model
SP - State of São Paulo
sp - species
SPARC - Stratospheric Processes And their Role in Climate
SPE - Society of Petroleum Engineers
st - cubic meter
START - Analysis, Research and Training (*Sistema de Mudança Global para Análise, Pesquisa e Treinamento*)
SUDAM - Amazonian Development Superintendence (*Superintendência de Desenvolvimento da Amazônia*)
t - tonne
TEC - Common External Tariff (*Tarifa Externa Comum*)
TECPAR - Paraná Institute of Technology (*Instituto de Tecnologia do Paraná*)
Tg - teragram (10^{12} g or one million tonnes)
Tier - level (of detail)
TM/Landsat - Thematic mapping sensor of the Landsat satellite
TO - State of Tocantins
toe - tonnes of oil equivalent
TOGA - Tropical Ocean Global Atmosphere
TRENSURB - Porto Alegre Urban Railway Company S.A. (*Empresa de Trens Urbanos de Porto Alegre S.A.*)
TSP - Total Suspended Particulates
TWh - terawatt-hora
UCS - Conservation Units (*Unidades de Conservação*)
UFPR - Federal University of Paraná (*Universidade Federal do Paraná*)
UFRGS - Federal University of Rio Grande do Sul (*Universidade Federal do Rio Grande do Sul*)l
UFRJ - Federal University of Rio de Janeiro (*Universidade Federal do Rio de Janeiro*)
UK - United Kingdom
UKMO - United Kingdom Meteorological Office
UN - United Nations
UNCED - United Nations Conference on Environment and Development
UNDP - United Nations Development Program
UNEP - United Nations Environmental Program
UNEP/ IUCC - Information Unit on Climate Change of the United Nations Environmental Program
UNESCO - United Nations Educational, Scientific and Cultural Organization
UNFCCC - United Nations Framework Convention on Climate Change
UNISOL - Rio Solimões Institutional Support Foundation (*Fundação de Apoio Institucional Rio Solimões*)
UPGN - Natural Gas Processing Units (Unidades de Processamento de Gás Natural
US$ - US Dollar
USP - Federal University of São Paulo (Universidade de São Paulo)
VALEC - Engineering, Construction and Railways S.A. (*Engenharia, Construções e Ferrovias S.A.*)
VN - regulatory rates (*valor normativo*)
VOC - volatile organic compounds
W - West
WBP - Brazilian Wood Biomass Program
WBP/SIGAME - Brazilian Wood BIG-GT Demonstration Project/Integrated Wood Gasification and Electricity Generation System
WCRP - World Climate Research Program
WG - Working Group
WMO - World Meteorological Organization
WSP - World Petroleum Congress
WTO - World Trade Organization
WWF - World Wildlife Fund
ZCAS - South Atlantic Convergence Zone (SACZ) (*Zona de Convergência do Atlântico Sul*)
ZCIT - Intertropical Convergence Zone (ITCZ) (*Zona de Convergência Intertropical*)
µ - micro gram

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"The backlands will turn into ocean,
the heart fears
someday the ocean
will also turn into backlands"

"Sobradinho"
(Brazilian popular song, by Sá and Guarabyra)

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Priorities for National and Regional Development

1 PRIORITIES FOR NATIONAL AND REGIONAL DEVELOPMENT

1.1 Characterization of the Territory

Brazil is located in South America between the parallels of latitude 5°16'20" North and 33°45'03" South, and the meridians 34°47'30" and 73°59'32" west of Greenwich, with the geodesic center located at the coordinates 10°35' of latitude south and 52°40' west of Greenwich. The eastern limit is the coast of the Atlantic Ocean, and it has many oceanic islands, including Fernando de Noronha, Abrolhos and Trindade. To the north, west and south, Brazil borders on all the countries of the South American continent, with the exception of Chile and Ecuador. The country is crossed by the Equator and the Tropic of Capricorn, with most of its land located in the lower latitudes of the globe, giving it the characteristics of a tropical country.

With an area of 8,514,876.6 km^2, Brazil is the largest country in South America and the fifth largest country in the world. The size of its territory makes it a country of continental dimensions, since its land area occupies 1.6% of the globe, 5.7% of the planet's land area and 20.8% of the surface of the American continent.

The Federative Republic of Brazil is divided into 26 states, 5,507 municipalities (according to 2000 data) and the Federal District, where the capital of the Republic, Brasília, is located, seat of government and the Executive, legislative and judiciary branches. The country is governed under the 1988 Federal Constitution.

Brazil has a presidential system where the president of the Republic is elected by direct and secret ballot for a period of four years. Reelection for one additional mandate is permitted for the president of the Republic, governors and mayors. The legislative branch has a bicameral system consisting of the National Congress, with two representative houses: The Chamber of Deputies, with 513 federal deputies, who represent the people; and the Federal Senate, with 81 senators of the Republic, representatives of the Units of the Federation.

The vastness of Brazilian territory, both in terms of latitude and longitude, is home to an extraordinary mosaic of ecosystems, along with extensive climatic and topographic diversity.

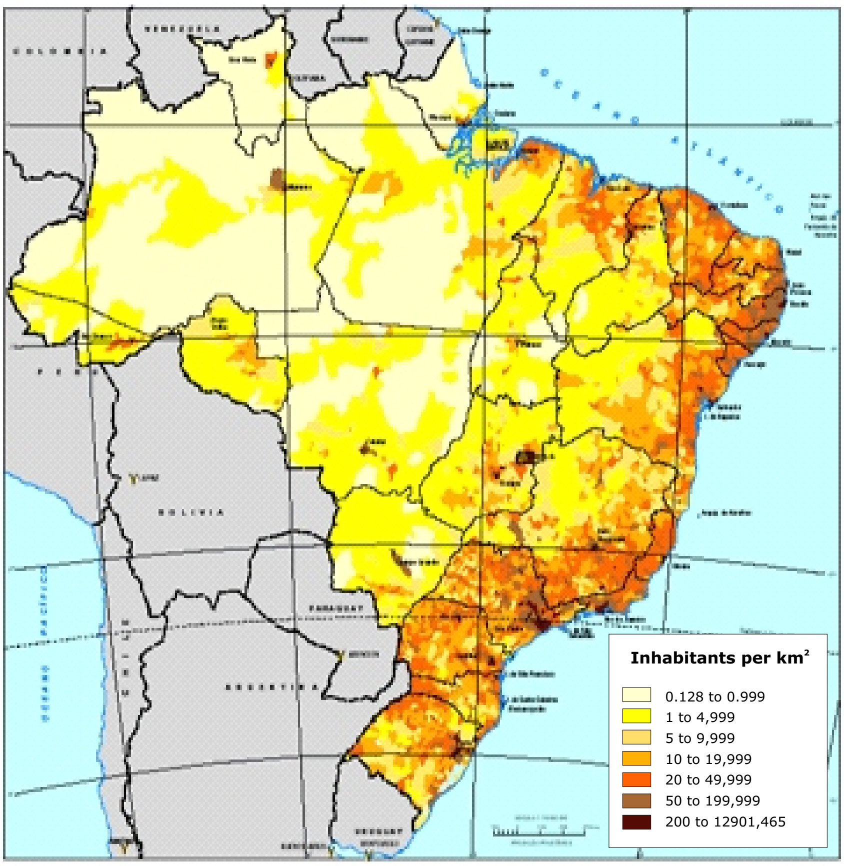
These characteristics have over time determined the various forms of occupation and use by society of the spaces molded by the country's tropical and subtropical nature, distributed over five large geographic regions: North, Northeast, Southeast, South and Center West. Each region is made up of the following states or districts:

- North region - occupies 45% of the territory of the country and consists of the following states: Acre - AC, Amapá - AP, Amazonas -AM, Pará - PA, Rondônia - RO, Roraima - RR and Tocantins - TO.
- Northeast region: covers 18% of the country and consists of the following states: Alagoas - AL, Bahia - BA, Ceará - CE, Maranhão - MA, Paraíba - PB, Pernambuco - PE, Piauí - PI, Rio Grande do Norte - RN and Sergipe - SE.
- Center West region: covers 19% of the country and consists of the following states: Goiás - GO, Mato Grosso - MT, Mato Grosso do Sul - MS and the Federal District - DF.
- Southeast region: covers 11% of the country, with four states: Espírito Santo - ES, Minas Gerais - MG, Rio de Janeiro - RJ and São Paulo - SP.
- South region: covers 7% of the country's area, and includes the following states: Paraná - PR, Santa Catarina - SC and Rio Grande do Sul - RS.

The country had an average population growth of 1.64% per year from 1990 to 2000. Data from the Demographic Census for 2000 show that Brazil had a population of 169,799,170 people, of which 83,576,015 are men and 86,223,155 are women. The Southeast is the most populous region of the country, with 72,412,411 people and the North is the least populous, with 12,900,704 people.

Most of the population (137,953,959 people) lives in urban centers while 31,845,211 live in rural areas. Only 55.9% lived in urban areas in 1970 while by 2000 this figure had grown to 81.2%, and in the most urbanized region of the country, the Southeast, it reached 90.5%. Although the greatest concentration of population is in cities of more than 1 million inhabitants, the greatest growth occurs in cities with a population of between 250,000 and one million.

Figure 1.1 - Demographic density in Brazil



Source: IBGE, 2000a.

Figure 1.2 - Political/Administrative Division of Brazil

Source: IBGE, 2000.

Figure 1.3 - Distribution of Brazilian Municipalities

Source: IBGE, 2000.

1.1.1 Vegetation and Flora Resources

The vegetation of Brazil, almost all of which is included within the Neotropical Zone, for geographical purposes can be divided into two territories: the Amazonian and the extra-Amazonian. In the Amazonian territory (equatorial rainforest area), the plant ecological systems responds to a climate of average temperature around 25°C, with rains well distributed over the year, with no monthly hydric deficit in the annual ombrothermic balance. In the intertropical area, the plant ecological system is linked to two climates: tropical, with average temperatures of around 22°C, and seasonal precipitation marked by a period with a hydric deficit of more than 60 days in the annual ombrothermic balance; and subtropical, with cooler temperatures in the winter of around 18°C, which reduces the annual average, with moderate rainfall well distributed throughout the year, without monthly hydric deficit in the annual ombrothermic balance, but with a thermal seasonality caused by the coolest days of the year.

Phytoecological regions are areas defined by a flora of typical genera and characteristic biological forms that repeat within a given climate, and can occur in terrains of different lithologies, but with a well defined relief. In Brazil, the following are identified:

- Savannah region (*Cerrado*) - vegetation occurring predominantly in the Center West region. Discontinuous areas also appear in the Amazonian region, and in the Northeast, Southeast and South of Brazil. Because of the intense anthropic activities to which it is subject, much of its native vegetation has been replaced by agriculture, pasture and reforestation. It is characterized by a vegetation structure of low and twisted trees, isolated or grouped over a continuous grassy surface.

- Savannah Steppe region - neotropical vegetation type, generally with vegetation cover composed of phanerophytes, spiny chamaephytes and various cacti, covering a grassy hemicryptophyte strata, interspersed with some therophytes, represented in Brazil in four geographically distinct areas: the Caatinga of the arid northeast backlands, in the *Pantanal* of the State of Mato Grosso, in the *Campos* of Roraima and the *Campanha Gaúcha* of Rio Grande do Sul.

- Steppe region - covers the *Campanha Gaúcha*, with fragments in Uruguaiana and in Southern Brazil (*Campos Gerais*). Characterized by an essentially grassland vegetation. Cespitose and rhizomatous grasses dominate, with rare annual and oxalis grasses, as well as leguminous and compound grasses. The phanerophytes are represented by spiny and deciduous species.

- Campinarana region - type of vegetation restricted to areas of the upper Rio Negro and adjacent to its tributaries, penetrating into Colombia and Venezuela, where it occurs in similar areas. It covers lowland areas, almost always flooded periodically, being characterized by groupings of a thin, high arboreal vegetation, which results from the lack of mineral nutrients in the soils.

- Dense Tropical Rainforest region - occupies part of the Amazonian area and extends to the Atlantic coast, from the States of Rio Grande do Norte to Espírito Santo, in pockets contained between the coast and the pre-Cambrian coastal mountains, and extending along the mountain slopes to Rio Grande do Sul. It consists of large trees in the alluvial terraces and in the tertiary plateaus, along with smaller trees on the coastal slopes.

- Open Pluvial Forest region (Faciations of the Dense Pluvial Forest) - a vegetation type situated between Amazonia and the extra-Amazonian space. Forest physiognomy consists of widely spaced trees, with a sparse shrubby stratum.

- Mixed Pluvial Forest region (*Araucária* Forest) - characteristic of the Southern Brazilian Plateau, presenting, but also including isolated areas in the higher altitudes of the Coastal Mountains and the Mantiqueira Mountain Range.

- Seasonal Semideciduous Forest region (Tropical Semi-Evergreen Forest) - the percentage of semi-deciduous trees is between 20% and 50% of the forest total in the unfavorable period.

- Seasonal Deciduous Forest region (Tropical Caducous Forest) - presents a predominantly deciduous tree stratum, with more than 50% of individuals dropping their leaves in the unfavorable period. It occurs in the

Brazilian territory in a dispersed and fragmented manner.

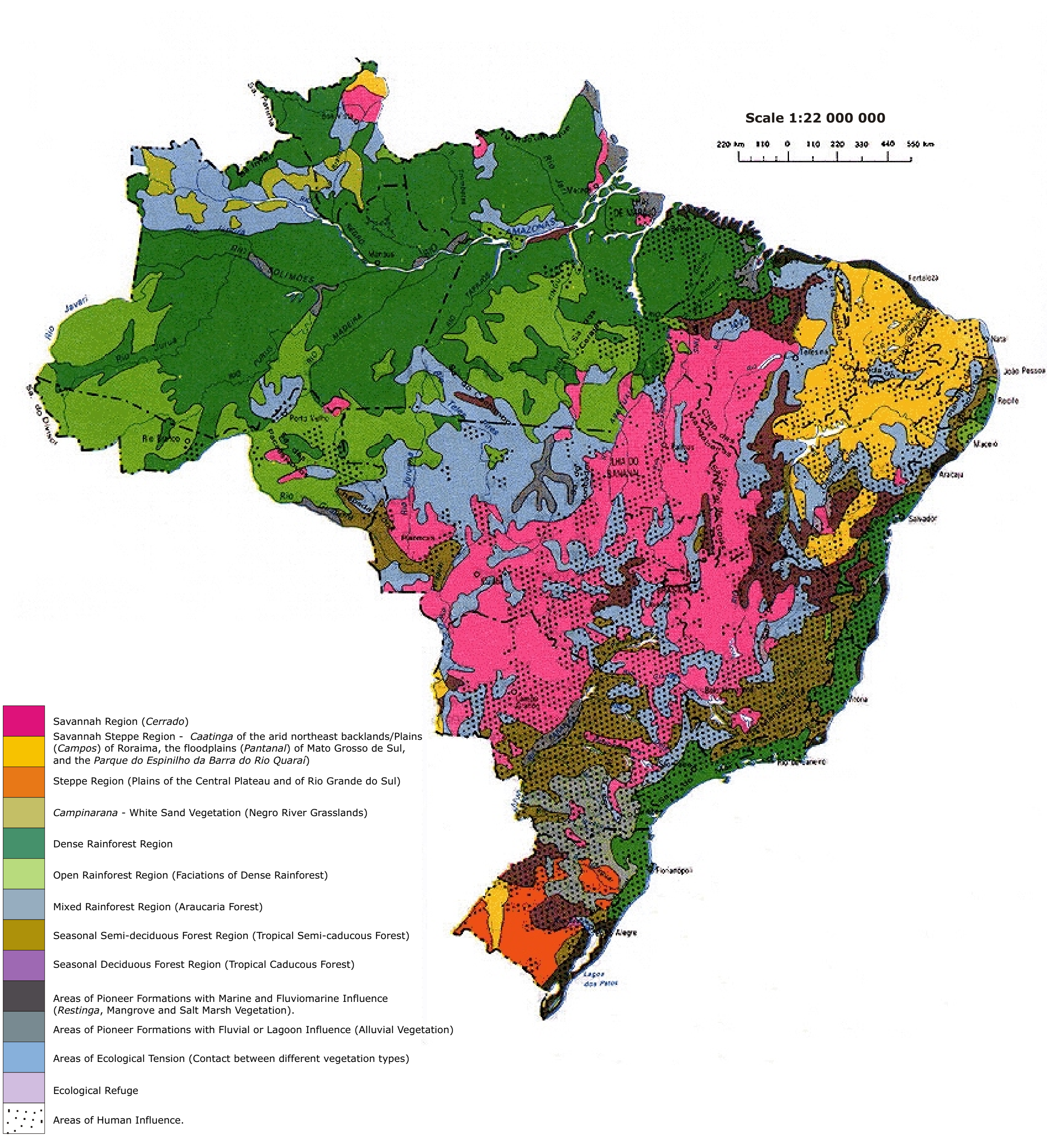
Vegetation Areas should not be confused with phytoecological regions, because they have a broader meaning and can comprise several environments and cover more than one trophic system. These include:

- Areas of Pioneer Formations with Marine and Fluvio-marine Influence (*Restinga*, Mangrove and Salt Marsh Vegetation). The areas with Marine Influence (*Restinga*) constitute the barrier beaches and dunes that occur along all the coast, formed by the constant deposition of sand because of the direct influence of sea action, where physiognomies range from herbaceous to arboreous. Areas with Fluvio-marine Influence (Mangrove and Salt Marsh) constitute the salt-water environments where watercourses discharge into the sea, where the vegetation presents either an arboreous or herbaceous physiognomy.

- Areas of Pioneer Formations with Fluvial or Lagoon Influence (Alluvial Vegetation). These areas of discharge of watercourses, lagoons, etc., forming alluvial terrain that may or may not be subject to periodical flooding. The vegetation that develops in these environments varies according to the intensity and duration of flooding, presenting arboreous or herbaceous physiognomy.

It is calculated that Brazil has over 55,000 plant species, or

Figure 1.4 - Distribution of Brazilian Vegetation



Source: IBGE, Atlas Nacional do Brasil, 1992.

1.1.2 Fauna

Brazilian fauna is very rich in species with a relatively small number of individuals, many of which are endemic. These characteristics indicate a fragile fauna. Given the preponderant influence of vegetation upon fauna, the latter is distributed in zoogeographical regions, in accordance with the dominant phytophysiognomy and vegetation composition in the respective territories. Thus, Brazilian fauna types can be distinguished according to those adapted to dense forests, open forest formations, fields, mangroves, and all other different forms of vegetation cover, which, in turn, correspond to the various rain, temperature, and relief conditions, as well as other ecological factors.

Brazil is one of the richest countries in the world in terms of the number of species, with 524 species of mammals (of which 131 are endemic), 517 species of amphibians (294 endemic), 1622 birds (191 endemic) and 468 reptiles (172 endemic). There are more than 3000 species of freshwater fish, along with 750 marine species. In terms of invertebrate fauna, there are an estimated 10 to 15 million species of insects.

1.1.3 Water Resources

For a large part of the world's population, water shortage is a fundamental and growing problem. In Brazil, there are abundant available water resources, although not always evenly distributed or well utilized. Brazil possesses a vast and dense hydrological network, and many of its rivers are noted for their length, width, and/or depth. Brazil contains eight great drainage basins: the Amazonas river basin; the Tocantins river basin; the South Atlantic basin North and Northeast regions; the São Francisco river basin; the South Atlantic basin East region; the Paraná river basin; the Paraguay river basin; and the South Atlantic basin Southeast region. Because of the nature of the continental relief, there is a predominance of plateau rivers, which are characterized by sudden drops in altitude, deep narrow valleys and other features that give them a high potential for electric energy generation. The same characteristics, however, prejudice navigability. Of the great Brazilian rivers, only the Amazonas and the Paraguay are predominantly flatland rivers and are extensively used for navigation. The main plateau rivers are the São Francisco and the Paraná.

The utilization of hydro-electric energy in Brazil began in 1883 and the huge experience accumulated in the building of hydroelectric plants and the transmission systems associated to them, as well as in the production of equipment for energy generation and distribution represents a great advantage to the country.

An analysis of the energy generation capacity of drainage basins shows the contrast between the real supply capacity and the demand from industrial, residential, commercial, and public uses. The Amazonas river basin, for example, has a potential for 105,550.59 MW, while only 0.5% is in operation or under construction.

The São Francisco river basin, the South Atlantic basin East region, the South Atlantic basin Southeast region, the Uruguay river basin, and the Paraná river basin are, at present, responsible for the supply of hydroelectric energy to the regions of the country with the greatest demographic and industrial concentration. The Paraná river basin stands out, not only in terms of its potential, but also as having the highest percentage in operation or under construction (64.5% of its 57,322.52 MW potential).

The uneven distribution of rainfall, along with the possibility of a long period of time between rainy seasons, accounts for the intermittent character of many rivers in the Northeast region of Brazil. In view of this climatic peculiarity, ponds are used for water storage and distribution, both for household consumption and for development of irrigated agriculture.

Occasionally, heavy rains exceed the runoff capacity of watercourses, and cause flooding that affect urban and rural population centers.

1.2 Economy

Between 1990 and 2000, the per capita Gross Domestic Product - GDP grew by around 13%, reaching US$ 3,492.63 in 2000. After the crisis of the beginning of the decade, there were five consecutive years of positive growth rates in per capita GDP, associated with the monetary stability provided by the Real Plan of 1994. The international crises and restrictive macroeconomic policies led to a recession at the end of 1998. The difficulties in external financing that followed were addressed through a successful currency devaluation in 1999. This allowed a resumption of growth without a great impact on inflation rates.

The detailed information presented in Table 1.2.1 shows that the percentage share of total fixed capital formation in the GDP, at current prices, remained around 19.5% of GDP. This is a relative low rate by historical and international standards. The increases in values for exports and imports seen since 1999 are explained by the exchange devaluation.

Table 1.2.1 - Gross Domestic Product (GDP), Gross National Product, and Available Gross National Income - 1996-2000

Specification	Value (1,000,000 R$)				
	1996	1997	1998	1999	2000
End use consumption	630,814	704,200	741,038	783,277	868,061
Consumption by families	486,813	545,698	566,192	597,418	658,726
Consumption by public administration	144,001	158,502	174,847	185,858	209,334
Gross capital formation	162,953	187,187	193,056	195,401	236,169
Gross Formation of Fixed Capital	150,050	172,939	179,982	184,087	211,225
Changes in Inventories	12,903	14,248	13,074	11,314	24,944
Exports of goods and services	54,430	65,356	67,862	100,148	117,422
Imports of goods and services (-)	69,311	86,000	87,769	114,957	134,951
Gross Domestic Product	778,887	870,743	914,188	963,869	1,086,700
Less: net income sent to rest of the world	12,228	17,436	21,241	34,115	34,427
Gross National Product	766,659	853,307	892,947	929,754	1,052,273
Less: Unilateral net transfers to rest of the world	-2,580	-2,009	-1,661	-3,013	-2,799
Available Gross National Product	769,239	855,316	894,608	932,767	1,055,072

Fonte: IBGE, 2002.

Table 1.2.2 disaggregates the total according to economic sectors and shows the growing importance of services in the Brazilian economy. Not counting financial intermediation services, in 2000, 55% of the GDP was generated by services, 37.5% by industry (including construction, electricity and water), and 7.7% in agriculture.

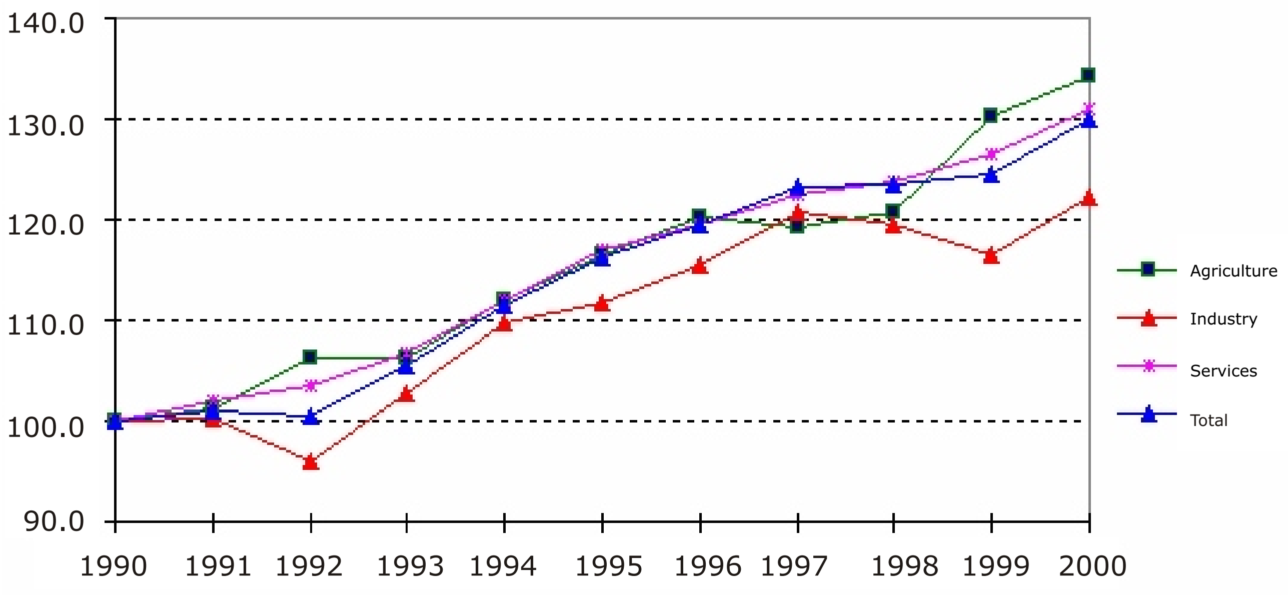
Table 1.2.2 - Gross Domestic Product (GDP), by sector of activity - 1991-2000

Specification	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gross Domestic Product	100	100	100	100	100	100	100	100	100	100
Agriculture	7,79	7,72	7,56	9,85	9,01	8,32	7,87	8,23	8,19	7,69
Industry	36,16	38,70	41,61	40,00	36,67	34,70	34,84	34,62	35,60	37,52
Services [1]	56,05	53,58	50,83	50,15	54,32	56,98	57,29	57,15	56,21	54,79

Source: System of National Accounts: Brazil: 1990-2000. Rio de Janeiro: IBGE, 1997, 2000, 2002.
[1] Excludes financial intermediation services

Figure 1.5 presents the indexes for real product and shows the improved performance in recent years of the agricultural and service sectors, compared to the industrial sector, which had weaker indexes.

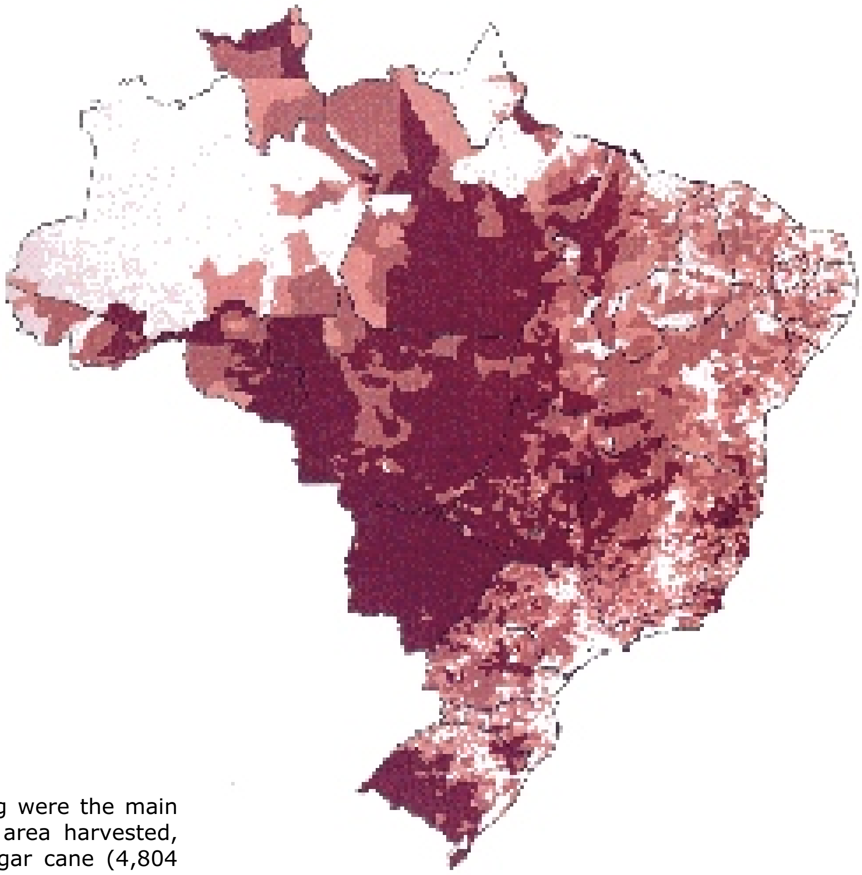
Figure 1.5 - Indexes of real product (base year 1990 = 100)



Source: IBGE, 2002.

In the agriculture sector, animal production shows the greatest growth, and in the year 2000 the greatest production was of cattle, with 169.87 million heads, followed by swine, with 31.56 million animals, 14.78 million sheep, 9.35 million goats, and 5.83 million horses. The total for hens, roosters, chickens, and chicks reached 659.25 million in the same year.

Figure 1.6 - Distribution of Cattle on Brazilian Territory



From 0 to less than 10,000 cattle heads

From 10,000 to less than 25.181 cattle heads

From 25,181 to less than 68,944 cattle heads

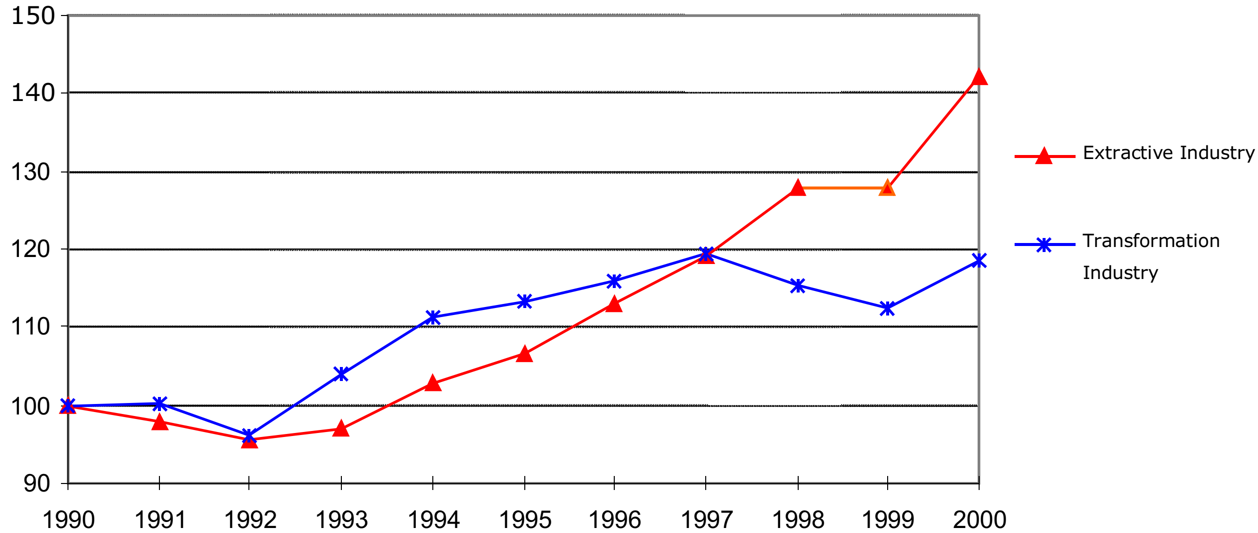
From 68,944 or more cattle heads

Source: IBGE, 1996a.

In terms of crop production, the following were the main products in the year 2000, in terms of area harvested, soybean (13,656 thousand hectares), sugar cane (4,804 thousand hectares), beans (4,332 thousand hectares), rice (3,664 thousand hectares), coffee (2,267 thousand hectares), manioc (1,708 thousand hectares), wheat (1,138 thousand hectares), oranges (856 thousand hectares) and herbaceous cotton (801 thousand hectares). In 1999, in terms of crop production, Brazil was the world's largest producer of sugar (21 million tonnes), coffee (2 million tonnes) and oranges (23 million tonnes); the second largest producer of soybeans (31 million tonnes) and beans (2 million tonnes); and the seventh largest producer of rice (12 million tonnes).

In terms of industrial performance (Figure 1.7), it is clear that the growth trend is determined solely by mineral extraction, with the leading products being oil, iron, limestone, bauxite, and manganese.

Figure 1.7 - Index of real product - Industry (base year 1990 = 100)



Source: IBGE, 2002.

1.3 Brazilian Climate

Brazil's geographic location at the eastern edge of the Atlantic Ocean, along with the variations in its relief, results in different characteristics for the atmospheric macro-systems, both continental and oceanic, creating a diversity of climatic domains ranging from equatorial to subtropical, with gradations of type and subtype produced by the geo-ecological variability that exists in the country.

South America extends from the tropics to mid-latitudes and is affected by tropical, subtropical, and mid-latitude regimes. One of the main characteristics of the South American tropical region is the Amazonian forest, which contributes to the moisture and precipitation of the region and also to the energy balance of the planet. During the Southern Hemisphere - SH summer, this region is very active with strong convection, especially in Central Amazonia. During the Southern Hemisphere winter, the convective activity dislocates to the northwest, reaching Central America.

The South American climate has interannual variability, which can be observed by the differences in wind flow, cloudiness, precipitation, and behavior of the synoptic systems. One of the large-scale factors responsible for climate variability is the *El Niño* Southern Oscillation - ENSO. South America is directly influenced by ENSO and indirectly influenced by the variation in atmospheric circulation. The direct influence is by the convection increase in the Eastern Equatorial Pacific region, which affects the continent's western tropical area. The displacement and the intensity of the Walker Circulation, the Pacific North America - PNA teleconnection patterns, and the displacement of the Hadley cell northward are related to the dry conditions in the Northeast of Brazil. The strengthening of the subtropical jet, which increases convection of frontal systems and blocking situations, is related to flooding in the South and Southeast of Brazil. Other large-scale anomalies affect South America, such as persistent wave trains and patterns of wave number 3 and 4 around the Southern Hemisphere.

Convective activity over the Central and Western regions of South America is associated with an upper level anticyclonic circulation, which in the SH summer is called Bolivia High. This is associated with the strong warming of the surface, an upward motion, and upper level divergence. In some periods during summer and spring, convection over this region is also associated with a persistent northwest-southeast band of cloud cover, called the South Atlantic Convergence Zone.

The Northeast portion of the continent has a high interannual and annual variability in precipitation. This region is affected by the Intertropical Convergence Zone - ITCZ, upper level cyclonic vortices, easterly disturbances, instability lines associated with the sea breeze, and by frontal systems over the ocean. The South and the Southwest are affected by frontal systems, upper level cyclonic vortices, and mesoscale convective complexes, which in turn are affected by the subtropical jet and by the low-level jet.

1.3.1 Climatology of Precipitation and Temperature

Brazil, with its great territorial expanse, presents a wide variety of precipitation and temperature regimes. From north to south, a great variety of climates with distinct regional characteristics can be found. The North of Brazil has a rainy equatorial climate, with practically no dry season. In the Northeast, the rainy season is restricted to a few months with low rainfall levels, giving a semi-arid climate. The Southeast and Center West regions are influenced not only by tropical systems but also by mid-latitudes, with a well-defined dry season in the winter and a rainy summer season with convective rain. The South of Brazil, because of its latitudinal position, is affected mostly by mid-latitude systems, in which the frontal systems cause most of the rain throughout the year.

With regard to temperatures, high temperatures are observed in the North and Northeast regions, with little variability during the year, giving these regions a hot climate. In the mid-latitudes, temperature variation throughout the year is very important for climate definition. During winter, there is greater penetration of high-latitude cold air masses, which contributes to the predominance of low temperatures.

It should be noted that modern technology permits to some extent overcoming the climatic conditions to enable expansion of temperate crops to areas with higher temperatures and lower precipitation.

North region

The North region has spatial and seasonal temperature homogeneity, but the same is not true for rainfall. This region has the greatest total annual rainfall, especially notable at the coast of the State of Amapá, at the mouth of the Amazonas river and at the western part of the region, where precipitation exceeds 3,000 mm. The North region has three centers of heavy precipitation. The first is located in the Northwest of Amazonia, with rainfall above 3000 mm/year. This center is associated with the condensation of moist air carried by easterly winds from the Intertropical Convergence Zone - ITCZ, which rise when they reach the slopes of the Andes (NOBRE, 1983). The second center is located in the central part of the Amazonia, around 5º S, with precipitation of 2,500 mm/year, and the third is in the eastern part of the Amazonia, close to the city of Belém, with precipitation of 2,800 mm/year.

Three rainfall regimes have been documented (MARENGO, 1995) in the northern region of South America: one in the Northwest of the continent, where rain is abundant throughout the year, reaching a maximum in April-May-June, with more than 3,000 mm/year; the second in a ZONE-oriented band, extending to the central part of the Amazonia, where the rainy season occurs in March-April-May, and the third is in the Southern part of the Amazonian region where the rainfall peak occurs in January-February-March. Rain in the Northwest of the Amazonia can be seen as a response to the dynamic fluctuation of the quasi-permanent convection center in this region (MARENGO and HASTENRATH, 1993).

The rainy season of the North region (Dec-Jan-Feb) changes progressively from January-February-March, in the South of the Amazonia, to April-May-June, in the Northwest of the Amazonian basin. This variation appears to be related to the position of the ITCZ, since the precipitation nuclei migrate from the central part of the country, in the SH summer, to the northwest of South America in the SH winter, following the annual migration of the deep convection. Weather stations located in the Northern Hemisphere - NH, such as Oiapoque (3º N 60º W), present maximum rainfall during the SH winter (June-July-August) and minimum rainfall during the austral summer (Dec-Jan-Feb) (RAO and HADA, 1990).

With regard to temperature, during the SH winter all the southern portion of the North region, specially the southwest (States of Acre, Rondônia and part of Amazonas), is frequently invaded by high-latitude anticyclones that cross the Andes Mountains in the south of Chile. Some of them are exceptionally intense, and may cause sudden drops of temperature, known as *friagem* (NIMER, 1979). Because of the relative high moisture and heavy cloud cover of the region, there are no excessively high daily maximum temperatures during the year.

Northeast region

In terms of the rainfall regime, there is a high climatic variability in the Northeast - NE, ranging from a semi-arid climate inland, with a total precipitation of less than 500 mm/year, to a rainy climate mainly observed in the eastern coast of the region, with an annual precipitation of more than 1500 mm (KOUSKY and CHU, 1978). The northern part of the region receives between 1000 and 1200 mm/year (HASTENRATH and HELLER, 1977).

Similar to the North region, temperature in much of the NE has a great seasonal and spatial homogeneity. Only in the south of the State of Bahia is there a greater seasonal variability in temperature, because of the penetration of relatively cold air masses in winter.

The Northeast contains different rainfall regimes. In the north of the NE region, the main rainy season is from March to May; in the south and southeast, rain occurs mainly during the period from December to February; and in the east, the rainy season is from May to July. The main rainy season in the NE, including the north and east of the region, is from April to July and provides 60% of the annual rainfall, while the dry season for most of the region occurs from September to December (RAO *et al*., 1993). Observations from satellite images suggest the importance of easterly disturbances in the NE precipitation (YAMAZAKY and RAO, 1997). It was observed that they propagate over the Atlantic Ocean, towards the continent, during fall and winter (CHAN, 1990).

Rainfall interannual variations in the east of the NE may be attributed to anomalies in the position and intensity of the ITCZ, caused by positive anomalies in the South Atlantic sea surface temperature (MOURA *et al*., 1981 and NOBRE, 1994), and by the occurrence of the *El Niño* in the Equatorial Pacific.

South region

The annual distribution of rain over the south of Brazil is quite uniform. Throughout almost the entire region, annual average precipitation is between 1250 and 2000 mm. Only a few areas are outside of this rainfall range. Areas above 2000 mm/year include the coast of the State of Paraná, the west of the State of Santa Catarina and the area around São Francisco de Paula, in the State of Rio Grande do Sul. Values below 1250 mm/year are found only for the southern coast of the State of Santa Catarina and the north of the State of Paraná (NIMER, 1979). It was thus concluded that the generally level relief does not exert a great influence on rainfall distribution. Temperature, for its part, plays a similar role to precipitation, reinforcing the uniform climate in the south of the country. However, this region of Brazil has the greatest temperature variation over the year.

Some atmospheric phenomena affecting this region are essential in determining temperature and precipitation climatology. Key among these is the movement of frontal systems over the region, which are responsible for much of the total rainfall (OLIVEIRA, 1986). The trajectory of these systems is closely related to the position and intensity of the South American subtropical jet. Some studies (KOUSKY *et al*., 1984) point to the importance of the jet stream to precipitation.

The inverted troughs are situated, on average, over the States of Rio Grande do Sul and Santa Catarina, reaching Argentina and Paraguay, and are more frequent during the SH summer and spring (FERNANDES *et al*., 1994), with a northwest-southeast (NW-SE) oriented axis, parallel to the frontal surface, and are responsible for the development of severe weather over the affected regions.

Mesoscale convective systems - CSs are also responsible for great amounts of precipitation in this region, as well as in the south of the Southeast and Center West regions (CUSTÓDIO, 1994).

The cold air cyclonic vortices, which are formed in the rear of some cold fronts, are often associated with high precipitation (MATSUMOTO *et al*., 1982). Some studies (SILVA DIAS *et al*., 1994) have sought to establish advance indicators of the initial stages of this phenomenon.

The occurrence of cyclogenesis and frontogenesis over the south of Brazil is also a preponderant factor in determining precipitation and temperature climatology in this region. Statistical studies (GAN and RAO, 1991) show that the greatest frequency of cyclogenesis occurs over Uruguay during SH winter. On average, there are around 60 cyclogenesis events over the South region each year.

With regard to temperature, frost can be considered one of the main atmospheric phenomena in the south of Brazil, with formation of ice on exposed surfaces when air temperature is below 0ºC. Studies have identified some characteristics of atmospheric circulation and the dynamic processes associated with the occurrence of frost in the South of Brazil.

Southeast and Center West regions

Because of their latitudinal positions, the Southeast and Center West regions are transitional regions between low latitude hot climates and mid-latitude temperate mesothermic climates (NIMER, 1979). The south of the Southeast and Center West regions are affected by the majority of synoptic systems that affect the south of the country, with some differences in terms of system intensity and seasonality. The inverted troughs act mainly during winter (FERNANDES and SATYAMURTY, 1994), causing moderate weather conditions, especially in the States of Mato Grosso do Sul and São Paulo. High level cyclonic vortices from the Pacific region organize with intense convection associated with the instability caused by the subtropical jet. Pre-frontal lines of instability, generated by the association of large-scale dynamic factors and mesoscale characteristics, are responsible for high precipitation (CAVALCANTI *et al*., 1982).

Especially over the Center West region, the Bolivia High, generated from strong convective warming of the atmosphere (release of latent heat) during the SH summer (VIRJI, 1981), is considered a typical semi-stationary system of the region. Stationary large-scale circulation in mid-latitudes may directly influence precipitation and temperature in the Southeast, whether or not the region is being affected by systems associated to undulatory atmosphere flows. This kind of situation is called blocking and affects not only the Southeast but also the South region of Brazil.

Systems in the Southeast and Center West regions combine tropical system characteristics with those typical of mid-latitude systems. During the months of greater convective activity, the South Atlantic Convergence Zone - SACZ is one of the main phenomena that influence the rainfall regime in these regions (QUADRO and ABREU, 1994). The fact that the band of cloud cover and rainfall remain semi-stationary for several consecutive days contributes to flooding in the areas affected.

In general, precipitation is evenly distributed in these regions, with the accumulated annual average precipitation ranging from 1,500 to 2,000 mm. Two maximum nuclei are registered in the central region of Brazil and on the coast of the Southeast region, whereas in the north of Minas Gerais there is a relative shortage of rain throughout the year.

1.4 Social Development

This section examines the state of human development in the country (UNDP/IPEA, 1996), focusing on health, education and income (IBGE, 2000). This presentation reflects the transformation that has occurred since the 1980s, with the collapse of the economic growth trend in Brazil and the increase in inequality and poverty, continuing the long-standing trend towards greater concentration of income and reversing the equally long-standing trend towards reduction of poverty. The nature of poverty has also been changing. It is no longer predominantly rural, but today has a more balanced spatial distribution, with a strong presence in urban areas. Thus while the proportion of people living in poverty remains highest in rural areas (39%), most of Brazil's poor are now found in urban areas (29.7 million, compared to 12.2 million in rural areas).

Poverty has also diversified and is today more socially heterogeneous and includes an increasing number of poor who, although living below the poverty line, are to some degree meeting their basic needs.

The pattern of economic growth that prevailed in Brazil since the 1930s and the crisis of its collapse that marked the last 15 years of Brazilian society left the twin legacy of a modern and complex urban-industrial society, coexisting with desperate social conditions marked by profound inequalities.

The 1980s brought improvements in particular sectors, such as the reduction of illiteracy rates and an increased level of formal schooling, the eradication of polio, an increase in the number of residences served by adequate water and sewage infrastructure, and a reduction in the infant mortality rate.

The profound changes that have been occurring in the scientific, technological, financial, organizational and industrial spheres demand, and at the same time permit, a profound redefinition of Brazil's model of development, in terms of a search for a productive structure that is more competitive, open to and integrated with the rest of the world.

1.4.1 Degree of Inequality: Brazil in the World

At the beginning of the 1990s, Brazil had one of the highest rates of inequality in the world in relation to another 55 countries, using as the measure of inequality the ratio between the average incomes of the richest 10% and the poorest 40% of the population.

For the great majority of countries (36 out of 55 presented), the income of one individual among the richest 10% is, on average, less than 10 times that of a person among the poorest 40%. In Brazil, this parameter is a completely different order of magnitude the average income of the richest 10% is almost 30 times higher than the average income of the poorest 40%.

To discover the income level responsible for this inequality, the population is divided into six strata. The first is constituted by the poorest 20%, the second by the next poorest 20% and so on, but with the richest 20% divided into two strata of 10% each. These strata are called, respectively, the “extremely poor”, “poor”, “lower middle class”, “middle class”, “upper middle class”, and “rich”.

The results indicate that inequality in Brazil is concentrated mainly in the upper income strata.

1.4.2 Changes in Poverty and Inequality over Recent Decades

The data presented in Table 1.4.1 reflect trends in the Brazilian economy over the preceding decades. The growth of the Brazilian economy benefited all strata of the population, raising the average income of all income levels, which meant an overall reduction of poverty.

But the growth of the economy did not benefit all groups equally, and the result was greater inequality. The groups in the lower income brackets (the poorest half of the population) benefited less, while from the third decile up, income growth increases regularly, contributing to large gains concentrated among the richest 30% of the population. Therefore, the proportion of income appropriated by the highest 20% income bracket increased by 11% between 1960 and 1990, while the proportion appropriated by the poorest 50% declined by six points.

The decline of overall per capita income in the 1980s resulted in negative growth rates for all income brackets, thus leading to an increase in poverty. But the decline in income was also distributed very unequally, and was highly concentrated in the lower income strata. The result was a clear increase in the level of inequality of income between 1980 and 1990, with the fraction of income appropriated by the richest 20% increasing by two percentage points, while the fraction for the poorest 50% declined by two points. The simultaneous decrease in average level of income and the increase in the level of inequality indicate that poverty increased during the 1980s.

It should be noted that trends in the distribution of income have two common characteristics. First, since 1960, there has been a continual increase in inequality. And second, changes in poverty levels have corresponded to economic trends, with improvement during periods of strong economic growth, and worsening during periods of economic decline. The combination of these two characteristics meant that while the increased inequality has reduced the positive effects of growth for the poor, it was never sufficient to offset them completely.

In the 1960s the income of the richest 10% of the population was 34 times higher than that of the poorest 10%, while by 1990 this proportion had increased to 78 times, at the same time that per capita incomes had declined from 1980 levels. In addition, unlike the situation in the 1960s when the group most adversely affected by the economic crisis was the middle class, in the crisis of the 1980s the lower classes suffered the greatest setback. As a result, the profile of income distribution in Brazil has the following characteristics: while the richest 10% receive almost half of the total income (48.1%) and the richest 1% claim 13.9% of the total, the poorest 10% are left with only 0.8% of the total income, and for the poorest 50%, only 12.1% of the total.

Table 1.4.1 - Percentage share by income strata (%)

Income Strata	1960	1970	1980	1990
Poorest 20%	3.5	3.2	3.2	2.3
Next 20%	8.1	6.8	6.6	4.9
Next 20%	13.8	10.8	9.9	9.1
Next 20%	20.2	17.0	17.1	17.6
Richest 20%	54.4	62.2	63.2	66.1
Richest 10%	39.7	47.8	47.8	49.7
Richest 5%	27.7	34.9	34.9	35.8
Richest 1%	12.1	18.2	18.2	14.6

Source: IBGE Demographic Census from 1960, 1970 and 1980, and 1991.
Notes: 1. PNAD data are not directly comparable with the IBGE Demographic Census 1960, 1970, 1980.
2. Data from 2000 depend on the release of detailed sample data from the 2000 Demographic Census (IBGE, 2000b), which were still not available by the completion of this report.

1.4.3 The Number and Proportion of Poor in Brazil

The above analysis focused on poverty levels in relative terms and did not address the magnitude of poverty in the country as a whole. The assessment of the extent of poverty is important, however, not least for its implications for public policies.

Aside from income levels, there are other well-known attributes that determine a situation of poverty. These include low educational levels, characteristics of the head of the family, family size and structure, and place of residence.

The definition of poverty in terms of insufficient income depends of the establishment of a "poverty line", a value equivalent to the cost of meeting all the basic needs of an individual in a specific time and place. This value is greater than what could be called a "line of indigence", which takes into consideration only the cost of meeting basic food needs.

The methodology used here estimates the poverty line according to residence strata, based on the basket of goods observed in low-income families in several regions and the consumer prices in effect in 1990. The use of specific values for each residence stratum has the objective of taking into account the cost of living for the poor. Thus, those classified as poor are those whose per capita family income is below the poverty line. The proportion of poor, the most common indicator of poverty being insufficiency of income, is given by the number of poor (individuals whose per capita family income is below the poverty line) as a percentage of the total population.

Based on this methodology, the number of poor in Brazil in 1990 was estimated to be 42 million, or 30% of the Brazilian population. The indigent population, that is, the number of poor whose income is insufficient even to meet their basic nutritional needs, is substantially less, representing 12% of the Brazilian population, or 16.6 million people.

A comparison of the indicators for 1990 with those of the beginning of the previous decade shows that the magnitude of poverty and indigence did not increase during this period; rather what happened was an increase in the level of inequality in society as a whole, which was aggravated by the economic recession and the accelerated process of urbanization. Strong discontinuities in the economic policy four different price shocks between 1986 and 1990, reduction of levels of investment and sudden oscillations in inflation rates resulted, over the 1980s, in an annual real increase in GDP of only 1.5%, and a decline in per capita GDP from US$ 3000 to US$ 2856 (despite a drop in the rate of population growth of 1.9%), contributing to the worsening of income distribution inequality (the richest 10% increase their proportion of the national income to almost half).

1.4.4 Hunger and Infant Malnutrition

To assist in the formulation of a program of food security, a study carried out by IPEA, in 1993, produced a map of hunger in Brazil. Although there is some controversy about the magnitude of the problem, the document indicates that 31,679,096 Brazilians (or 9 million families) are facing hunger. The distribution of the problem follows a regional pattern: 17.2 million of those affected live in the Northeast, and 7.9 million in the Southeast. The rural Northeast is home to 63% of the indigent population, with another 30% living in metropolitan and urban areas. The Southeast region, which contains the largest metropolitan areas of the country, also contains the second greatest indigent population, but the phenomenon of urban hunger exists throughout Brazil.

A study of infant growth retardation based on 1989 data, using as a comparison the normal pattern with adequate nutrition and in the absence of frequent illness (with all the pre-conditions that this implies), shows that 15.9% of children with less that five years of age had abnormally short stature.

An important finding presented in the map of hunger is that the food problem in Brazil does not result from any lack of internal availability or production of grains or other products traditionally consumed in the country, but rather from the mismatch between the acquisitive power of a large part of the population and the cost of acquiring the amount of food necessary to meet the needs of the workers and their families.

1.4.5 Programs to Address Poverty: Dominant Conceptions and Recent Trends

Since the end of the 1980s, new conceptions began to be integrated into the public agenda, and new emphases in formulation can be detected:

- Emphasis on selectivity and focus prioritizing, in terms of planning, resources and social actions, programs for the poorest sectors, concentrating spending and actions on the basic needs of the most vulnerable groups of particular ages and spatial locations.

- Combination of universal and selective programs rather than the opposition of universalism versus selectivity, there appears to be a broader understanding in Brazil that public programs of basic education and health are crucial and strategic, both for these services in themselves, and because they can also host other mass programs. Thus, focused programs can complement universal ones, in a relation of mutual support.

- Minimum income programs financial transfers to guarantee minimum levels of individual or family income joined the list of programs to address poverty, especially through approaches that couple income objectives to improved school performance and the health of young children.

- Partnerships between the public and private sectors there was growing acceptance of participation of non-governmental organizations in providing social services, and understanding that, alone, the State is incapable of responding to the great challenge of poverty. There was also an increase in initiatives by organized sectors of civil society in providing social services.

- Increase in employment and income-generation programs in the design of new programs, there is a growing interest in those that can contribute to reinforcing the capacity and productivity of the poor to generate incomes; for example, training programs, support for small and micro businesses, make-work projects.

The strongest innovative trends can be seen at the institutional level, including decentralization and integration of programs to combat poverty.

1.4.6 Human Development and Changes in Demographic Patterns

One of the most important structural transformations of Brazilian society in the last few decades has been changes in its demographic patterns. These changes have been accelerating since the end of the 1960s.

Despite the immense regional and social inequalities, the mortality rate of the Brazilian population underwent a rapid and sustained decline beginning in the early 1940s, bringing about an increase in life expectancy at birth of the population, which rose from 41 to 54 years between the 1930s and 1960s. On the other hand, fertility rates remained high until the mid-1960s, declining only in the South and Southeast regions (and there only slightly), and remaining constant or even increasing in the North, Northeast and Center West regions. Thus, the overall fertility rate fell only from 6.5 to 5.3 during this period. The result of this change was a significant increase in the average rate of growth of the population, which rose from 2.4% in the 1940s to 3% in the 1950s, and to 2.9% in the 1960s.

As the Brazilian population remained basically closed, that is, without significant immigration or emigration, and with high and basically stable fertility levels, the age distribution remained approximately constant and young between 1940 and 1970, despite the rapid decline in mortality and the rise in the population growth rate. Thus, during those entire three decades, around 52% of the population was less than 20 years old.

At the end of the 1960s, a rapid and widespread decline in fertility began to take place. Previously limited to the more privileged urban social groups in the more developed regions, this process soon extended to all social classes and regions. Thus, the overall fertility rate fell from 5.8 in 1970 to 4.3 in 1975, and to 3.6 in 1984, which corresponds to a decline of more than 37% in a period of only 15 years, a very rapid transformation when compared with any international experience.

The preliminary data of the 1991 Census confirm the tendency of a rapid decline of fertility in Brazil. Contrary to all expectations, the Brazilian population reached only 147 million in 1991, which meant that the annual rate of growth between 1980 and 1991 fell to 1.9%, compared to 2.4% in the 1970s.

Data from the year 2000 show that life expectancy at birth rose by 2.6 years, going from 66 years in 1991 to 68.6 years in 2000. This increase occurred in all ages, with the most significant increases taken place with the female population.

In fact, it can be stated that the fertility decline in Brazil is not a temporary or circumstantial phenomenon, but rather is an irreversible process known as the "demographic transition". Information about the use of contraceptives in Brazil supports this assertion.

According to census data of 1980, 1991 and 2000, the change in demographic growth patterns produced some significant short term consequences: the average annual population growth rate, which in the 1960s was 2.9%, fell to 2.5%, 1.9% and 1.6% over the three following decades, and the proportion of the population below 10 years of age dropped significantly. Furthermore, the Brazilian population began a continuous process of decline in the rate of growth and of destabilization of the age distribution. Furthermore, the Brazilian population began a continuous process of declining growth rates and destabilization of the age distribution.

A fundamental fact demonstrated by this data is the increasing average age of the population, with a progressively reduced weight of the young, which results from the declining fertility between 1970 and 1991. The population has aged significantly since the 1970s (5.85% of the population, or more than 15 million Brazilians, are 65 or older), while the same data reveal that 29.6% of Brazilians are less than 14 years old an age group of approximately 50 million people. The 2000 Census shows that for every 100 children, Brazil has 30 elderly persons. Among the elderly, females are in the majority, have an average age of 69 years and 3.4 years of study, and 8.9 million (62.4%) of the elderly are responsible for the household with the great majority living in large cities. Thus the elderly occupy an increasingly prominent role in Brazilian society.

Families in Brazil have an average of 3.4 members, and 74% have male family heads. However, there is a considerable increase in families headed by women (25% of households), indicating a new profile for Brazilian families, an increase in female autonomy and their incorporation into the labor market.

Projections show that by around the year 2040, the Brazilian population will consist almost entirely of generations born after the beginning of the rapid decline of fertility. At this time, the fertility rate will probably be close to replacement levels (with an overall fertility rate of around 2.1), and the population growth rate will quickly approach zero, with a relatively old age distribution. This is the current situation of most developed countries.

1.4.7 Education Profile

Indicators of education levels in Brazil have improved significantly over the last few decades, with reduced illiteracy rates, increased enrolment at all levels of education, and an increase in average education levels of the population. Despite this, the situation of education in the country is still very unsatisfactory, not only from a qualitative point of view, but also with respect to quantitative indicators. Some of these indicators are presented below.

The changes in educational levels throughout the last few decades reveal that, despite the observed growth from an average of two years of study in 1960 to around six years in 2000, this increase is less than could be expected given the growth of per capita income during the same period.

In 1991, 79.9% of persons 15 years or older were literate, and this figure rose to 86.4% in 2000.

The South region has the greatest number of persons with the age of 10 or older who are literate 93% and the Northeast has the lowest number, with 75.4%. In Brazil as a whole, the illiteracy rate dropped from 20.1% in 1990 to 13.6% in 2000. There was a significant increase in education levels due to intense policy efforts aimed at this area. In terms of the states, the Federal District has the highest literacy rate in Brazil, with 94.8%. The other states with the best indicators are Santa Catarina, with 94.3%, São Paulo and Rio Grande do Sul, with 93.9%, and Rio de Janeiro with 93.7%. Alagoas has the lowest literacy rate, with 68.2%. In rural areas, there was a significant increase in literacy rates, which has risen from 59.9% in 1991 to 72.4% in 2000. The South region, with 93%, has the highest proportion of literate persons in rural areas. The Northeast has the worst performance of the country, with only 75.4% of persons aged 10 or over considered literate.

Between 1991 and 2000, the number of illiterates fell from 22.3 million persons to 17.6 million. The greatest fall was seen in the 10-14 year old range. The illiteracy rate for adults dropped from 17.7% in 1991 to 7.2% in 2000. In the 15 years and older age bracket, the rate fell from 20.1% to 13.2% in this period.

There was a significant increase in education levels due to policy efforts aimed at this area. In 2000, school attendance improved in all age groups, and 79% of students were registered in the public school system. The greatest proportion of children in school is between the ages of 7 and 14, with 94.9% attendance.

Table 1.4.2 - Educational Indicators - Brazil, 1960-2000

Indicator	1960	1970	1980	1991	2000
Adult literacy rate*	60.4	66.4	74.5	79.9	86.8
Illiterate	39.6	33.6	25.5	20.1	13.2
Education Level of Population**					
Primary School (grades 1-4)	41	40	40	38	43
Grade School (grades 5-8)	10	12	14	19	13
High School (grades 9-11)	2	4	7	13	16
Post Secondary	1	2	5	8	7
Average Number of Years of Study	2.1	2.4	3.6	5.0	5.7

Source: UNDP/IPEA 1996 and IBGE 1960, 2000b
*Persons with an age of 15 years or more.
** Persons of 25 of more years of age, by education level completed.

The low educational levels of the Brazilian child population appears to reflect, among other factors, the mismatch between the attractiveness of the labor market and a very unattractive educational system, because of its poor quality and/or its unsuitability to the demands of the poor population.

The low quality of the educational system is less related to the scarcity of resources than to the inefficiency with which they are distributed and utilized. This inefficiency results to a large extent from the institutional form of the system, with a high level of fragmentation, lack of effective coordination and inadequate mechanisms for evaluation and exchange of information. In this context, the poor quality of teaching is related to the low efficiency with which the educational inputs are used.

1.4.8 Health Profile

This section will present a profile of health in Brazil, focusing on epidemiological characteristics, the supply of and demand for health services, and the expenditures made by various levels of public administration.

Infant mortality

Based on the data from the 1991 Demographic Census, it is possible to estimate with precision the trends of the infant mortality rate in the 1980s. This rate has been dropping significantly, declining from 163/1000 in 1940 to 73/1000 in 1980, 47.2/1000 in 1990 and to 29.6/1000 in 2000.

The Northeast region had the greatest improvement over this decade, going from an infant mortality rate of 73 per thousand in 1990 to 44 per thousand in 2000, which is a significant decline. For other regions the changes in rates of infant mortality were: from 45.1 to 29.2 in the North region, from 30.2 to 20.6 in the Southeast region, from 28.7 to 19.7 in the South region, and from 31.3 to 21.2 in the Center West region.

The available data suggest a strong drop in infant mortality over the last decade, reflecting the improvement in living conditions resulting form increased spending on health programs, sanitation, food and nutrition that has occurred since 1986.

The changes in infant mortality rates over the 1980s reflect mainly the transformations resulting from urbanization and the increasing role of health institutions in relation to childbirth and early infant care. While most births now occur in hospitals and there has been a strong increase in access to medical care, the quality is still low, which is reflected in the high rate of prenatal causes and septicemia (blood poisoning) in the structure of infant mortality.

Also the rates of maternal mortality had been dropping steadily over the last few decades, but had stabilized in the 1980s at levels that were still high: 124/100,000 live births in the country as a whole in 1989.

Overall mortality

The leading causes of death in Brazil are diseases of the circulatory system, which in 1991 had an incidence of 152/100,000 and were responsible for 30% of deaths in the country. Next were external causes (98/100,000), predominantly accidents and especially traffic accidents. The third group is made of "unknown causes" (69/100,000), which demonstrates the fragility of the information system of the country and indicates that a large proportion of deaths occur in the absence of health services. The fourth largest cause of death is cancer. It is worth noting that malignant tumors represent the leading cause of death for females between the ages of 25 and 64.

Demand and supply for health services

The demand for health services appears to be linked to the level of development as well as the supply of these services. The rates of utilization of health services increase according to income levels. Moreover, the higher the per capita family income, the greater the percentage of persons that pay for the health services used close to 60% in classes with per capita family income above twice the monthly minimum salary.

In terms of the supply of services, the 1980s saw a strong growth in the number of hospitals, outpatient clinics and beds. Between 1980 and 1989, the number of public hospitals increased from 1,2 thousand to 2,0 thousand, while the number of public outpatient clinics rose from 8,8 thousand to 20,8 thousand, for growth rates of 61% and 136% respectively. The rates of growth in the private sector, although still large, were lower the number of private hospitals increased from 4,9 thousand to 5,2 thousand, and private outpatient clinics from 3,6 thousand to 6,9 thousand.

Thus at the end of the 1980s, Brazil had a total of 7,2 thousand hospitals, mostly from the private sector, and 27,7 thousand outpatient clinics, where the public sector predominated.

Despite the growth in the number of hospitals, the number of hospital beds declined between 1980 and 1989, from 4.3 to 3.7 per 1000 inhabitants. As a result of the reduction in the number of beds per capita, between 1980 and 1989 there was a reduction of hospital admissions, dropping from 0.162 to 0.151 per inhabitant/year.

Table 1.4.3 - Health Indicators - Brazil, 1960-2000

Indicator	1960	1970	1980	1990	2000
Infant Mortality (per 1000 live births)	117.9[1]	104.1	73.0	47.2	29.6
Children of one year of age immunized against:					
.Tuberculosis (%)				87[2]	100.00[4]
. Measles (%)		27.9[3]	56.5	78.1	98.21(*)
Incidence of malaria per 1000 inhabitants	1.39	1.30	3.40	8.32	
Number of doctors per 1000 inhabitants				1.3	1.4
Number of nursing professionals per 1000 inhabitants				0.4	0.3
Beds per 1000 inhabitants			4.3	3.3[5]	2.9

Source: Ministry of Health (Datasus).
Notes:
[1] Values refer to year 1965;
[2] Values refer to year 1991; for 1995: 89.6%;
[3] Values refer to year 1976;
[4] Value refers to year 1999;
[5] Value refers to year 1993.
* Refers to infants of less than one year old.

1.4.9 Access to Urban Sanitation Services

In general, access to sewage treatment services in Brazil shows significant discrepancies between the different social strata. Between the years 1981 and 1990, the proportion of the poorest part of the urban population having access to sewage treatment (33% of those with income below the minimum salary and 41% of those with between one and two times the minimum salary) remained far below the national average of 69%. In 2000, it was shown that sewage systems are the service with the lowest incidence, being offered in only 52.2% of Brazilian municipalities.

Four out of 5 cases of illness are caused by contaminated water and the lack of adequate sewage treatment.

The supply of drinking water also privileges higher income levels. In 1991, after an expansion of 12.3 percentage points in the 1980s, 87% of the urban population of Brazil had access to potable water. The poorest population, with an income of less than 5 times the minimum salary, has rates of access well below the national average. The rate of supply of these services to the population with an income below the minimum salary is only 71%; for the income level above 5 times the minimum salary, the figure is 95%.

The National Basic Sanitation Study for 2000 revealed that 97.9% of Brazilian municipalities have water supply services, 78.6% have an urban drainage system, and 99.4% have garbage collection.

The data for the year 2000 show that 76.1% of households are connected to a municipal water distribution system, 62.3% have sewage and septic tank, and 79.7% have garbage collection. These data show that sewage systems are still inadequate, even with the increased proportion of homes with access to the sewage collection system or to a septic tank.

Table 1.4.4 - Households with access to sanitation and garbage collection systems - Brazil, 1960-2000

Type of Service	Households with access to sanitation and garbage collection systems (%)				
	1960	1970	1980	1990	2000
Water supply through central system	21	33	55	71	76.1
Sewage collection/treatment					
Centralized network	13	13	28	35	47.3
Septic tank	11	13	15	17	14.95
Simple pit	26	34	29	26	23.65
Destination of domestic garbage (%)					
Garbage collection				63.80	79.01
Burning				18.64	11.23
Buried				2.57	1.16
Dumped on vacant land				-	6.93
Dumped in river, lake or ocean				-	0.43

Source: IBGE 1981, 1989, 1990 and 2000.
Note: Data on collection and disposal of garbage in 1991 came from the IBGE Demographic Census (1991 and 2000b).
Data left blank (1960/1970 and 1980) are not available.

It is worth noting that this unfavorable situation at the lower income levels still persists despite the fact that investment in sewage treatment systems and clean water supply carried out in the 1980s was predominately directed at this segment of the population.

Such results show that historically the supply of sanitation services was oriented to the upper income classes to such an extent that the accumulated disparities could not be overcome, not even through a pattern of public investments more favorable to the poorer populations such as occurred in the 1980s.

Access to sanitation services in rural areas lags far behind that of urban areas. The available information is not very precise, but estimates for 1990 indicate that the population connected to a public water supply is 16%, and to sewer lines around 5%.

The proportion of urban sewage in Brazil treated in treatment plants is very low only 10% of the total generated. If septic tanks were included, the national average would rise to 28%.

Another source of problems in urban centers is solid waste, from domestic and industrial sources. The garbage collected but inappropriately disposed of in open dumps and in areas prone to flooding, causes sanitary problems and contamination of water. Toxic discharges, usually from industrial or agricultural sources, have even more severe environmental consequences for human health and for the preservation of flora and fauna. Its disposal is problematic: incineration is expensive and also presents risks of contamination; and recycling is not always possible, depending on the quality of the materials and the costs of collection and transport.

Of the 125,000 tonnes of waste collected daily in Brazil in 2000, approximately 30% are deposited in open dumps or in flood-prone areas, with no measures taken to avoid contamination. The other half receives some form of treatment: 22% is sent to controlled landfills, where the garbage collected is dumped and simply covered with a layer of earth; 43% is taken to sanitary landfills, where the garbage is disposed of in a manner that does not pose health risks or affect sanitary safety; 3% is composted, which transforms the waste into organic compost for use in agriculture; 2% is recycled; and the portion incinerated is negligible. This means that the disposal of 52% of the garbage collected in Brazil (the sum of that disposed in open dumps and in controlled landfills) threatens the health of the population. The percentage would be still higher if the garbage that remains uncollected were taken into account.

Of the 5,507 Brazilian municipalities, only 451 have curbside recycling programs. Of the 3,466 municipalities that collect hospital waste, 1,193 do not treat it in any way.

In spite of the significant expansion of urban garbage collection in the 1980s, 273 municipalities still had no garbage collection service in 1989, and 309 had irregular collection. This expansion of coverage had similar characteristics to those observed with water and sewage service: the expansion was strongly directed at the poorest populations. Even so, the lower income brackets still have the least access to service in many regions of the country, especially in the least economically developed areas. The national indicators show that 83% of the urban population had access to garbage collection services in 2000. The access by those with an income of less than the minimum salary is only 51%, while in the income bracket between one and five times the minimum salary garbage collection goes up to 70%, and it reaches 89% for those classes with income of over 5 minimum salaries. One individual in metropolitan regions produces approximately 800 grams per day of garbage. There is an upward trend because of current consumption patterns, based on the waste of natural resources. Any effort to find solutions to the problem of solid waste demands not only cleaner and less polluting technology, but also changes in consumption habits and development of new personal, business and institutional attitudes.

1.5 Summary of National Circumstances

Table 1.5 - Summary of Brazil's National Circumstances

Criteria	1994	2000
Population	156,755,230	169,799,170
Surface area (km^2)	8,514,876.599	8,514,876.599
GDP (million US$ from 1994)	543.087	594.247
GDP per capita (US$ from 1994)	3,464.11	3,492.63
Share of the informal economy in GDP (%)	NA	12.98
Share of industry in GDP (%)	36.1	35.5
Share of services in GDP (%)	49.7	57
Share of agriculture in GDP (%)	14.2	7.5
Surface area used for agricultural purposes (km^2)	2,278,049.55[1]	NA
Urban population as a percentage of total population (%)	79[2]	81.25%
Number of cattle heads	158,243,229	169,875,524
Forest area (in km^2)	5,611,070[3]	5,439,050[3]
Number of inhabitants in conditions of absolute poverty (million)	32[4]	22[5]
Life expectancy at birth (years)	66.4	68.6
Literacy rate (%)[6]	84	86.4

Notes:

NA = Not available.
1 - Arable land available for production (IBGE, 1996a).
2 - IBGE data from 1995.
3 - 1995 data from the Food and Agriculture Organization - FAO.
4 - IPEA data from 1993.
5 - Data from IPEA. FGV indicates the number of 50 million and the World Bank 15 million.
The methodology used by the IPEA to reach this value is that of regional poverty lines (minimum of R$ 68 and maximum of R$126 constant in 1999, per person per month, depending on the region of the country and the urban/rural location), which results in proportions of poor or indigent around two times higher than those calculated by international bodies. International bodies such as the UNDP and the World Bank adopt as a poverty line an income of US$ 2 per person/day, and as an extreme poverty line (indigence), an income of US$ 1 per person/day.
6 - Persons with an age of 15 years of more according to IBGE.

Mercosul

2 MERCOSUL

2.1 Background, Objectives and Main Characteristics

Historically, the process of integration between Latin American countries began in 1960, with the Montevideo Treaty, followed by the Latin American Free Trade Association - ALALC, the Latin American Integration Association - ALADI of 1980, the Integration and Economic Cooperation Program - PICE of 1986, and the Integration, Cooperation and Development Treaty of 1988.

However, the greatest stimulus to integration occurred on March 26, 1991, with the creation of the Southern Common Market, or MERCOSUL, which was the outcome of a long process of building closer relations between Brazil, Argentina, Paraguay and Uruguay. Its objective was set out in the "Asunción Treaty for the Creation of the Southern Common Market" and reaffirmed in the Protocol of Ouro Preto, of December 17, 1994 these two agreements being the principal legal instruments of the process of integration.

The Asunción Treaty is a framework agreement an instrument to be continually complemented by additional instruments, negotiated by the four states Parties, as a function of progress in integration. The Treaty established the basic conditions allowing the achievement of a Customs Union, by December 31, 1994, which is the step prior to the Common Market. In this regard, the Treaty established the following:

- establishment of a trade liberalization program consisting of progressive, linear, and automatic tariff reductions, accompanied by the elimination of non-tariff barriers;
- the coordination of macroeconomic policies;
- establishment of a Common External Tariff (TEC);
- establishment of lists of exceptions to the liberalization program for products considered sensible;
- the creation of a general regime of origin and a dispute resolution system.

The signing of the Protocol of Ouro Preto signaled the end of the "transition period" for Mercosul. The Protocol gave to the process of integration all the elements of a Customs Union. Mercosul gained a definitive institutional structure for the negotiation and deepening of integration in the direction of the desired Common Market.

2.2 Institutional Structure

The Summit of Ouro Preto set out additional details about Mercosul's institutional structure. Along with the basic structure, it established the decision-making bodies, the specific powers and responsibilities of each of them, and its decision-making system. The current structure of Mercosul has around 50 negotiating fora, some exclusively technical, and others with policy or executive functions.

The working languages are Portuguese and Spanish, the official languages of Mercosul.

As well, the Protocol of Ouro Preto established the legal personality of Mercosul in international law, which enables the bloc to acquire the rights and be subject to the obligations as an entity distinct from its member countries. In practice, this means that Mercosul can negotiate international agreements as a bloc.

Thus, since the Ouro Preto Summit, Mercosul has had an institutional base that allow for a greater integration among member countries, as well as with other countries, including other economic blocs, thus establishing it as an important economic arena.

2.3 Mercosul Basic Indicators

Mercosul is today an economic reality on a continental scale: a total area of more than 11 million square kilometers (more than 58% of Latin American land area); a market of more than 210 million inhabitants; and a cumulative GDP of more than 1 trillion dollars, which places it among the four largest economies of the world.

The region is one of the main areas of the world in terms of attracting investments, an important reserve of the planet's natural resources, and a considerable source of energy resources. The agricultural potential of the bloc is another striking characteristic. Mercosul figures among the largest global producers of wheat, coffee, cocoa, citric fruit, rice, soybean, milk and meat.

Since its creation, Mercosul has been strengthening its operations and achieving significant results, contributing to the creation of a receptive climate for trade expansion. Intra-Mercosul trade increased from US$ 4.1 billion in 1991 to around US$ 20 billion in 1998. Imports to Mercosul countries from the rest of the world have also grown significantly. As a result, Mercosul's share of total global imports has tripled, going from US$ 29.296 billion in 1990 to US$ 98.763 billion in 1998. And these figures will certainly improve in the future, given that it is a new regional market of more than 210 million inhabitants, with a Gross Domestic Product of around US$ 1 trillion.

Relevant Institutional Arrangements for the Preparation of the Inventory on a Permanent Basis

3 RELEVANT INSTITUTIONAL ARRANGEMENTS FOR THE PREPARATION OF THE INVENTORY ON A PERMANENT BASIS

3.1 Institutional Framework

Brazil has always sought to play a leadership role in the arena of global environmental issues, following the example of the United Nations Conference on Environment and Development - UNCED, also known as Rio-92, held in Rio de Janeiro from June 3 to 14, 1992.

Brazil was the first country to sign the United Nations Framework Convention on Climate Change - UNFCCC during Rio-92. After Brazil's signature, eventually more than 185 Parties would be added (including the European Union), which demonstrates the practically universal character of the Convention. The Convention entered into force on March 21, 1994, ninety days after the deposition of the 50th ratification by national parliaments. In Brazil, the UNFCCC was ratified by Congress on February 28, 1994 and entered into force ninety days later, on May 29 of that year.

Since activities related to climate change began in Brazil, institutions have been created to address the issue and coordinate the domestic implementation of the Convention.

3.1.1 Interministerial Commission for Sustainable Development - CIDES

In June of 1994, the government of Brazil established an Interministerial Commission for Sustainable Development - CIDES by presidential decree (Decree no. 1160 of June 21, 1994). CIDES was chaired by the Ministry of Planning and Budget and composed of representatives from other ministries. The objective of CIDES was to provide assistance to the president of the Republic in decision-making about national strategies and policies for sustainable development, in a manner compatible with Agenda 21, in recognition of the complexity of this task and the need for involvement of a large number of institutions.

3.1.2 General Coordination on Global Climate Change - CGMGC

The responsibility for coordinating the implementation of commitments under the UN Framework Convention on Climate Change was given to the Ministry of Science and Technology - MCT by Presidential Decree no. 1160/94. Thus, in response to the mandate conferred by CIDES, the General Coordination on Global Climate Change[1] - CGMGC was created within the MCT in August of 1994, and was given this responsibility.

The main task of the CGMGC is to coordinate the preparation of the first National Communication, in accordance with the commitments assumed in the Convention. The elaboration of the National Communication is a multidisciplinary effort involving around 150 institutions and 600 experts from all regions of the country. This Communication poses a great challenge, because of the need to develop technical capacity in the area, and because in many cases it involves pioneer and complex work.

Because of its breadth and level of detail, it involves experts from many disciplines in various institutions, including ministries and federal, state, and sectoral trade institutions, non-governmental organizations, universities and research centers.

Along with coordinating the implementation of Brazil's commitments under the Climate Change Convention, the General Coordination participates in negotiations on implementation issues and technical and scientific aspects that are discussed in the subsidiary bodies of the Convention (Subsidiary Body for Implementation - SBI and Subsidiary Body for Scientific and Technological Advice - SBSTA).

Since 1996, the CGMGC has actively participated in the discussions leading to the signing of the Kyoto Protocol in December 1997 in Japan, particularly in the document submitted by the Brazilian government to support the preparation of the Protocol. This document proposed the creation of a Clean Development Fund, which would be adopted in modified form as one of the articles of the Protocol, and also proposed a new criteria for allocation of the burden of mitigation of climate change based on the responsibility of industrialized countries in causing temperature rise, which is currently being studied by the Convention in the Subsidiary Body for Scientific and Technological Advice - SBSTA.

Since then, the General Coordination has participated in the discussion of technical and scientific aspects of the negotiations over the rules for the Protocol, in conjunction with the Ministry of Foreign Relations.

Additionally, among Brazil's commitments under the Convention are those of promoting and cooperating in scientific, technological, technical, socioeconomic and other research, in observation systems and in the development of databanks related to the climate system, whose objective is to clarify and reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and changes over time of climatic changes and the economic and social consequences of various response strategies.

The CGMGC coordinates, on behalf of the Brazilian government, the review of the scientific assessments conducted by the IPCC with the growing support of the scientific community, and also actively participates, together with the Ministry of Foreign Affairs, in IPCC meetings, providing the perspectives of the Brazilian government in the discussion and approval of the IPCC reports.

Another important area of activities of the Coordination Office is building awareness of the issue of climate change. To facilitate the integration of all the experts and institutions involved, a climate change home page was constructed (http://www.mct.gov.br/clima) within the website of the Ministry of Science and Technology. This serves as a forum for bringing together experts from different sectors who can accompany and contribute to the work, as well as opening up a space for the public in the discussion of climate change.

Furthermore, the CGMGC organizes and supports events about climate change in the diverse areas related to the issue, publishes and disseminates relevant information, especially regarding the Convention, the Protocol and the IPCC, seeking to develop and disseminate legal, technical and scientific information, as well as participate in discussions about global warming, its causes and consequences, in order to build awareness among opinion leaders, policy-makers, business leaders, students and the general public about the problem.

[1] Titled Coordination Office for Global Change Research, at the time it was created.

3.1.3 The Interministerial Commission on Global Climate Change

The prospect of the Kyoto Protocol entering into force and of development of rules for the Clean Development Mechanism - CDM highlighted the importance of formalizing a mechanism within the Brazilian government that can direct this potential towards national development priorities. Also, the concern for greater institutionalization of the issue of climate change in Brazil, because of its strategic characteristics, led to the creation, by Presidential Decree of July 7, 1999, of the Interministerial Commission on Global Climate Change, for the purpose of coordinating government actions in this area.

Given that the Ministry of Science and Technology had already been carrying out national activities related to complying with Brazil's initial commitments related to the UN Framework Convention on Climate Change, this body was chosen to chair the Commission and to serve as Executive Secretariat, since the scientific aspects of global climate change will continue, in the foreseeable future, to dominate the political negotiations, and scientific knowledge necessary to support the discussions can be facilitated through the support instruments of this ministry. The General Coordination on Global Climate Change serves as the Executive Secretariat of the Commission and the General Coordinator of the CGMGC serves as its Executive Secretary. The Ministry of the Environment serves as the Vice Presidency of the Commission.

The Commission is made up of representatives of the Ministries of Foreign Affairs; Agriculture and Supply; Transport, Mines and Energy; Planning, Budget and Management; Environment; Science and Technology; Development, Industry and External Trade; and the Civil House of the Presidency of the Republic. In addition, the decree empowers the Commission to request the collaboration of other public or private bodies and representative civil society organizations in carrying out its responsibilities.

The responsibilities of the Commission are:

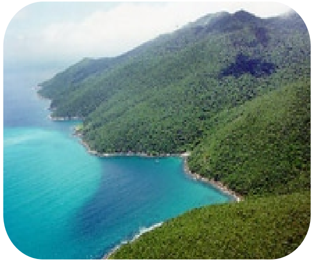
I - issuing opinions, when requested, about proposals for sectoral policies, legal instruments and regulations that contain a component relevant to the mitigation of global climate change and to the adaptation of the country to its effects;

II - provide support to the positions of the government in the negotiations under the auspices of the UNFCCC and subsidiary instruments to which Brazil is a party;

III - define eligibility criteria additional to those considered by the Convention bodies responsible for the CDM, as called for in Article 12 of the Kyoto Protocol to the UNFCCC, according to national sustainable development strategies;

IV - consider opinions about projects that result in reduction of emissions and that are considered eligible under the CDM, discussed in the above paragraph, and approve them, where appropriate; and

V - coordinate activities with representative civil society organizations, in order to facilitate activities of governmental and private bodies aimed at complying with the obligations assumed by Brazil under the UNFCCC and the subsidiary instruments to which Brazil is a party.



Special Circumstances

4 SPECIAL CIRCUMSTANCES

This section examines the special circumstances that result in specific needs and concerns arising from the adverse effects of climate change and/or the impact of the implementation of response measures, in accordance with Article 4.8 of the United Nations Framework Convention on Climate Change.

4.1 Maritime Islands

Brazil has 7,367 km of coastline shared by 17 states (Amapá, Pará, Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia, Espírito Santo, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul). Given the length of the Brazilian coast, there is a great number of islands.

From an environmental point of view, the islands are known for their unique flora and fauna, which are particularly vulnerable to disturbances and destruction by human activities. In relation to the problem of climate change, islands are some of the most fragile and vulnerable resources of the planet, because of the threat of rising sea levels resulting from global warming.

The main Brazilian islands are listed below, with information about their area and location.

There is very little research on islands in Brazil. There is a small amount of information about animals and plants, and specific information about geomorphology and geology of islands. Research on vulnerability of Brazilian islands to rising sea levels resulting from climate change is not well developed in Brazil.

The Brazilian coast can be categorized into three types of tidal regimes, with the different states characterized as follows:

- Macrotide: From Amazonas to Rio Grande do Norte;
- Mesotide: From Rio Grande do Norte to Bahia;
- Microtide: From Espírito Santo to Rio Grande do Sul.

Following this, the criteria related to population, area and altitude, allowing a preliminary categorization of Brazilian coastal islands, should be combined with the coastal classification. In relation to population, all islands with urban centers should be considered special (high risk). The type of coastline in which the island is located should be considered, to create important geological and geomorphological information for identifying areas subject to flooding. The tidal regime is a highly important factor in relation to altitude for example, islands with low altitudes in a macrotide regime are more endangered than islands of the same altitude with a mesotide regime.

Table 4.1.1 - Main Brazilian Islands

Name	Area (Km^2)	Location		
		State	Latitude	Longitude
Coastal				
Grande de Gurupá	3,958.5	Pará	-01° 00′	-51° 34′
Caviana de Fora	2,128.8	Pará	+00° 10′	-50° 00′
Marajó	50,000	Pará	-00° 57′	-49° 56′
Mexiana	1,534	Pará	-00° 02′	-49° 34′
Maracá	463.4	Amapá	+02° 03′ 48″	-50° 30′ 16″
Maiau	10.1	Maranhão	-01° 07′ 00″	-44° 54′ 20″
São Joãozinho	71.3	Maranhão	-01° 04′ 48″	-45° 58′ 24″
São Luís	914.2	Maranhão	-02° 31′ 47″	-44° 18′ 10″
Grande de Santa Isabel	198.5	Piauí	-02° 51′ 07″	-41° 49′ 02″
Itaparica	192.2	Bahia	-12° 53′ 18″	-38° 40′ 43″
Vitória	33.9	Espírito Santo	-20° 19′ 10″	-40° 20′ 16″
Grande	179.8	Rio de Janeiro	-23° 08′ 25″	-44° 10′ 09″
Jipóia	5.9	Rio de Janeiro	-23° 02′ 34″	-44° 21′ 49″
Bom Abrigo	1.1	São Paulo	-25° 07′ 16″	-47° 51′ 31″
São Sebastião	337.5	São Paulo	-23° 46′ 39″	-45° 21′ 30″
São Francisco	269.2	Santa Catarina	-26° 17′ 26″	-48° 40′ 08″
Santa Catarina	423.1	Santa Catarina	-27° 35′ 48″	-48° 32′ 57″
Oceanic				
Fernando de Noronha	18.4	Pernambuco	-03° 50′ 25″	-32° 24′ 38″
Da Trindade	10.1	Espírito Santo	-20° 30′ 16″	-29° 18′ 46″
Martim Vaz	0.3	Espírito Santo	-20° 29′ 10″	-28° 50′ 22″

Source: IBGE, 2001.

4.2 General Implications of a Rise in Sea Level for Coastal Zones

4.2.1 Mangroves

Mangroves are primarily found in tropical coastal areas. In Brazil their locations have been mapped at scales of 1:2,500,000 (for national coverage) and 1:1, 000,000 (for two selected areas of the North region) using LANDSAT images and nautical and other maps. Studies have identified five tree species in these areas: *Rhizophora mangle, Avicennia schaueriana, Avicennia nitida, Laguncularia racemos* and *Conocarpus erectus.* These species extend from Cabo Orange located at 4º N to the latitude 28º 20'S. An atlas of the distribution of mangroves of Brazil was published in 1991.

Mangrove swamps feed the food chain for marine fauna and also retain sediments, often preventing or reducing sediment problems in ports (MUEHE *et al*., 1995). Depending on relations between topography, sediment supply and sea level, the biological communities that inhabit mangrove swamps can decline or expand, while the proportion of the different species can vary. These variations can be studied through different scenarios, using a combination of physical and biological models, but the currently insufficient level of data and knowledge prevents their application to Brazil. Thus simple methods, such as continuous mapping of mangrove areas, along with the adoption of legislation for protection and study of the changes taking place in these areas, are recommended. The mangroves are protected by a range of laws, the application of which has not always proven effective.

4.2.2 Ports and Terminals

Ports play a significant role in domestic and international commerce in Brazil, and would be directly affected by changes in sea level (MUEHE *et al*., 1995). Changing sea levels would bring serious consequences for port installations (for example, breakwaters, mooring buoys, dykes) as well as for port operations (for example, time between dredging, size of oscillations in anchorage, frequency of flooding).

The table below lists the main ports of Brazil, and presents the amount of cargo handled in 2000, the type of operation and its location (open sea, bays or estuaries). The vulnerability of each port to increasing sea levels could be partially assessed by comparing the registry of the rise in high tides and the height of the quays (elevation of the structure). The significance of the impacts can be assessed by the type and amount of cargo that is handled. The interruption of operation would have a local effect (at state level); while the interruption of operation of a specialized terminal could have greater economic consequences.

Table 4.2.1 - Main ports in Brazil: Location and amount of cargo handled in 2000

Region	Port	State	Type of cargo	Amount	Location	Maximum Tide	Structure
North	Macapá	AP	General	812,253	E	3.7	1.5-2.5
	Santana*	AP	Manganese ore	842,669	E	-	-
	Belém	PA	General	13,956,665	E	3.3	4.5
	Vila do Conde	PA	Bulk/General	8,161,792	N/A	N/A	N/A
Northeast	Itaqui	MA	General	58,551,672	B	6.2	9.0
	Fortaleza	CE	General	3,632,385	O	3.6	5.0
	Ubarana*	RN	Oil	1,438,000	I	N/A	N/A
	Areia Branca	RN	Salt	4,928,895	I	0.9	6.8-7.1
	Natal	RN	General	5,323,432	E	-	4.3
	Cabedelo	PB	General	854,248	E	3.4	4.0
	Recife	PE	General	2,356,723	E	2.6	4.0
	Suape	PE	Bulk liquid/General	3,900,147	N/A	N/A	N/A
	Aracaju*	SE	Oil	3,821,000	MB	2.5	4.0
	Barra dos Coqueiros	SE	Bulk/General	2,757,367	N/A	N/A	N/A
	Maceió	AL	General	3,009,125	O	2.8	4.0
	Aratu	BA	Bulk	18,943,990	B	2.8	4.5
	Salvador	BA	General	1,992,246	B	2.6	1.8-4.0
	Madre de Deus*	BA	Oil	7,374,000	B	-	-
	Ilhéus	BA	General	748,791	M	2.3	4.0
Southeast	Barra do Riacho	ES	Pulp/General	2,204,807	M	-	4.0
	Vitória	ES	General	6,337,408	E	3.5	4.0
	Tubarão	ES	Iron ore	72,610,733	O	-	-
	Praia Mole	ES	Solid Bulk/General	19,709,923	O	1.7	4.0
	Regência	ES	Oil	545,822	N/A	N/A	N/A
	Ubu	ES	Solid Bulk	15,067,457	O	-	-
	Enchova*	RJ	Oil	2,808,000	I	N/A	N/A
	Garoupa*	RJ	Oil	1,136,000	I	N/A	N/A
	Pampo*	RJ	Oil	1,673,000	I	N/A	N/A
	Forno	RJ	Salt	530,935	O	2.4	3.6
	Rio de Janeiro	RJ	General	13,638,719	B	2.4	3.6
	Niterói	RJ	Wheat	142,944	B	2.4	3.7
	Sepetiba	RJ	Solid Bulk	39,830,861	B	2.4	6.8
	Ilha Guaíba*	RJ	Iron ore	572,000	B	-	-
	Angra dos Reis	RJ	Oil and Wheat	16,283,337	B	2.2	3.2
	São Sebastião	SP	Oil/General	45,695,189	B	2.1	4.2
	Santos	SP	General	43,084,383	E	2.7	3.9-4.3
South	Antonina*	PR	General	275,000	B	-	-
	Paranaguá	PR	Bulk/General	21,107,518	B	3.0	4.0
	Panorama	PR	Soybean	41,580	N/A	N/A	N/A
	Imbituba	SC	Coal	1,156,047	O	1.5	6.5
	Itajaí	SC	General	2,235,617	E	1.8	3.2
	S. Francisco do Sul	SC	Oil/General	14,404,543	B	2.6	4.0
	Charqueadas	RS	Coal	198,968	N/A	N/A	N/A
	Estrela	RS	Bulk	505,352	N/A	N/A	N/A
	Pelotas	RS	Clinker/Solid Bulk	239,322	N/A	N/A	N/A
	Porto Alegre	RS	Bulk/General	11,056,407	N/A	N/A	N/A
	Presidente Epitácio	RS	Soybean	912,238	N/A	N/A	N/A
	Tramandaí*	RS	Oil	458,000	MB	N/A	N/A
	Rio Grande	RS	Bulk	13,872,474	E	0.6	1.8-2.9

O = open sea, B = bay, E = estuary, I = offshore platform or artificial island, MB = monobuoy; N/A = not available.
Note: *Data from 1984. These ports were deactivated by 2000.

With a rise of 1 meter in sea level, several ports would be flooded or their freeboard (height above high tide level) would be less than 0.5 meter. In Macapá (in the State of Amapá), which is influenced by both the flow of the Amazonas river and high ocean tides, flooding of the port area is already a problem. In the North and Northeast regions, three ports (Macapá, Itaqui and Cabedelo) could be flooded, and five (Belém, Fortaleza, Recife, Maceió and Salvador) would have their freeboard reduced; all handle general cargo and, with the exception of Fortaleza and Maceió, are located within bays or estuaries. In the South and Southeast regions, three ports (Vitória, Angra dos Reis and Paranaguá) could be flooded, and four (Forno, Rio de Janeiro, Niterói and São Francisco do Sul) would have less than 0.5 m of freeboard. It is estimated that operations in all these ports would be adversely affected and some type of improvements would likely be necessary. Given the location of these ports and their economic importance, it appears evident that the North and Northeast regions are more vulnerable than the South and Southeast regions.

The port of Suape, located 35 km south of Recife, is the first example in Brazil where rising sea levels were taken into account in the planning. An additional height of 0.25 meter was included in the plans for the structure of the future port based on the preliminary studies of sea level changes in Recife, over a 50 year horizon. In 2000, the port of Suape handled 3,900,147 t of general cargo.

Other effects should also be considered. Higher sea levels allow waves to reach the coast with a greater height, because of the reduction of friction with the sea bottom. The force of waves is proportional to the second or third power of the height of the wave, meaning that an increase of 10% in the height of the wave increases the force on pillars by 20%, and increases by 30% the weight of stone blocks used in construction of breakwaters. Such changes would be especially important for the ports located on the open sea, as is the case with, for exemple, Recife and Suape (in the State of Pernambuco), Ilhéus (in the State of Bahia), Praia Mole (in the State of Espírito Santo), Imbituba (in the State of Santa Catarina) or on artificial islands, such as Areia Branca (in the State of Rio Grande do Norte) and Sergipe (in the State of Sergipe). As shown in Table 4.2.1, four terminals in the State of Espírito Santo are located on the open sea and there is very little data available about the performance and maintenance of their breakwaters.

Changes in sediment transport and deposition patterns also would interfere with port operations. Santos is located on an estuary and has a long history of saline intrusion with what has been estimated at 1.5 million m^3/year of fluvial sediments and 0.3 million m^3/year of marine sediments. Belém and Itaqui are both located in estuaries with high variations in tides and significant sediment movement; currently in Belém, the average amount dredged annually is around 1.0 million m^3, while it appears that there is no such problems in Itaqui. Rio Grande (in the State of Rio Grande do Sul) is in the mouth of Lagoa dos Patos where the astronomical tide is negligible and flow conditions are determined by meteorological conditions in the ocean and in the lagoon: saline intrusion is in the order of 0.35 million m^3/year. The extent and locations of sedimentation will vary with changes in sea level; at the moment it is difficult to make precise estimates of these changes. On open sea coastal areas, an increase in the rate of sand transport along the coast should be expected as a result of larger waves, as is the case with Recife, for example. Three sites where deposition in the access channel has been severe are Fortaleza (0.6; 1.6 and 2.5 million m^3/year in the years 1960, 1970 and 1980, respectively), Paranaguá (38 million m^3 between 1968 and 1979) and São Francisco do Sul (3.4 million m^3 between 1974 and 1979 in the access channel and 16,000 m^3 in the maneuvering area).

Increases in wave height have already been described in the North Atlantic. Similar changes in the South Atlantic would be cause for concern for the off-shore oil industry, which supplies the majority of oil and natural gas produced in Brazil, and for all coastal structures.

4.2.3 Human Occupation of the Coastline

Brazilian legislation establishes that a strip of land 33 meters in width bordering the ocean and estuaries belongs to the Federation, although private use is permitted pursuant to specific legislation and payment of taxes. Therefore, funds for protecting the shore and coastal areas are normally obtained from public sources (at the municipal, state, or federal levels). This means that the costs of responding to sea-level rise would be indirectly imposed on and divided among the population of the affected municipality, in the form of increased taxes, loss of revenue, reallocation of public funds (which might be used elsewhere) or changes in property values.

For comparative purposes, the unit cost of shore protection works is often reported. Therefore, it seems reasonable for an exploratory analysis to establish the population per length of coastline - PLC as one of the indicators of the potential impacts caused by sea-level rise (MUEHE *et al.*, 1995). A higher degree of occupation would be related to more diversified economic activities on the coast such as housing, tourism, need for drinking water supply and waste disposal, and consequently a higher probability that a rise in sea level would bring some form of adverse impact. On the other hand, higher population density indicates that financial resources would more easily be obtained for responding to that impact.

For management purposes and political decisions related to the best response to sea-level changes, the PLC parameter should be used in conjunction with other information such as coastal geomorphology, types of land use and economic activities, and historical data. However, the PLC parameter alone suggests the degree of stress being imposed on the coastal zone. Limited action towards coastal zone management has been taken only at a municipal level to date; thus a high value of PLC for a municipality shows the need for future management efforts and also suggests that a "protection" response might be the most appropriate response to a given sea-level rise. In contrast, low PLC values indicate the opportunity to promptly establish regulatory land use measures that help to prevent misuse of the coastal area and high cost engineering works in the future therefore "retreat" or "accommodation" might be more appropriate responses to sea-level rise[2].

To calculate PLC values, micro-regions were chosen as the basic coastal unit. Micro-regions were established by the Brazilian Institute for Geography and Statistics - IBGE as a group of municipalities with homogeneous geographical characteristics, and the division made in 1980 was adopted in this work. Within each of the 61 micro-regions that were located on the open coast or along bays and estuaries, only those municipalities that possessed a coastline were considered. The length of the coast for each micro-region was obtained from nautical charts and the population of the coastal counties was obtained from the 1980 and 1991 censuses. In most cases, towns and cities are located right on the coast or next to estuaries and bays; the maximum inland distance between any town considered and the coast would not exceed 30 km.

Considering the present administrative structures in Brazil, such a spatial limit seems appropriate from a socioeconomic point of view. The different types of impacts caused by sea-

[2] For more details regarding these response strategies, see IPCC, 1990.

level rise (e.g., salt water intrusion, flooding along estuaries, erosion of recreational beaches) will bring consequences to the population of the municipality as a whole. Therefore, for the purpose of PLC analysis, the coastal zone could be roughly considered as a strip of land at most 30 km wide.

In terms of distribution of population, a comparison of the PLC values from 1980 and 1991 for each micro-region shows that they have increased with time. It should be noted that in 1991 about 45% of the coastline corresponded to municipalities with < 1,000 people/km, which characterizes a sparsely-populated coastal area. From 1980 to 1991, significant expansion occurred in the category of large city (PLC > 10,000 people/km) which indicates increasing concentration of population around urban centers, mainly in Vitória, Maceió, and São Luís.

Another way to assess the relative importance of coastal areas was by computing the percentage of population within each state that lives in coastal municipalities. According to 1980 data, the highest concentrations of population on the coast were found in the States of Amapá (83%), Rio de Janeiro (69%), and Pará (50%); the same pattern was found in 1991, although the percentages changed to 84%, 67%, and 43%, respectively. Rio de Janeiro is a more important case, because it is the second most populated state in the country, with about 8.5% of the total population. The city of Rio de Janeiro, the state capital, has its metropolitan region located around two bays and it is the largest coastal urban center in Brazil (about 15 million people in 2000).

Table 4.2.2 - Length of coastline by occupation density - PLC

Year		Occupation Density (inhabitants/km) <1,000	1,000-5,000	5,000-10,000	>10,000	Total
1980	Length (km)	3,824	2,683	385	560	7,452
	Percentage (%)	51.3	36.0	5.2	7.5	100
1991	Length (km)	3,328	2,867	512	745	7,452
	Percentage (%)	44.7	38.5	6.9	10.0	100

The States of Ceará, Rio Grande do Norte, Pernambuco, Alagoas, and Sergipe, all in the Northeast region, show a percentage between 30% and 40% of their population living in coastal municipalities, which is above the national average. Because of the semi-arid climate of the interior, which causes periodic migrations during extreme droughts, much of the population has concentrated around the state capitals and in areas closer to the coast where fresh water is available.

Moreover, the State of São Paulo, with 37 million people (22% of the total population) and the largest city in South America (São Paulo, 18 million people according to the 2000 Census), has only 3% of its population living in coastal municipalities. This is because most of the state is located at 800 m above sea level; the coastal plain is very narrow and delimited by the Coastal Mountain Range (where native Atlantic rainforest can still be found) which hinders movement. The city of Santos, with the largest port in South America has a relatively small permanent population.

The lowest coastal population is found in the State of Paraná. The coastline is restricted to the bays of Paranaguá and Antonina, which are bordered by the same mountain range as in São Paulo. Population in low areas is comparatively small.

For the country as a whole, about 20% of the population lives in coastal municipalities and may be affected by sea-level rise. This is a surprisingly low figure, and this result challenges a commonly held view of Brazil as a country whose population is concentrated along the coast. However, at a regional and smaller scale, many areas are highly vulnerable to sea-level rise.

4.3 Desertification

Desertification is not a new problem. In 1977, the United Nations Conference on Desertification took place in Nairobi, Kenya, establishing the guidelines of the Plan of Action to Combat Desertification - PACD, which aimed at taking action at the global level. Nevertheless, the progress achieved has been extremely modest.

In 1992, within the broad agenda of the United Nations Conference on Environment and Development, the foundations for negotiation of an International Convention on the issue were established and proposed to the UN General Assembly, based on issues discussed in the International Conference on Climate Variations and Sustainable Development in Semi-Arid regions, held in the State of Ceará in January of the same year.

For the purposes of the United Nations Convention to Combat Desertification, the areas prone to desertification are those with arid, semi-arid and dry sub-humid climates. Such climate classes, in terms of the desertification issue, are determined according to the Aridity Index (THORNTHWAITE, 1941) and adopted for the determination of susceptible areas and for the preparation of the World Atlas of Desertification, published by UNEP. This index is defined as the ratio between the amount of rainfall and potential evapotranspiration, that is, the maximum water loss that is possible through evaporation and transpiration, determining the following categories:

- Hyper-arid < 0.03
- Arid 0.03 - 0.20
- Semi-arid 0.21 0.51
- Dry sub-humid 0.51 - 0.65
- Moist sub-humid > 0.65

Areas prone to desertification comprise more than 30% of the planet's land surface, where more than 1 billion people live. In Brazil, areas prone to desertification are those located in semi-arid and dry sub-humid regions, found mainly in the Northeast region and in the North of the State of Minas Gerais, totaling about 980,000 square kilometers.

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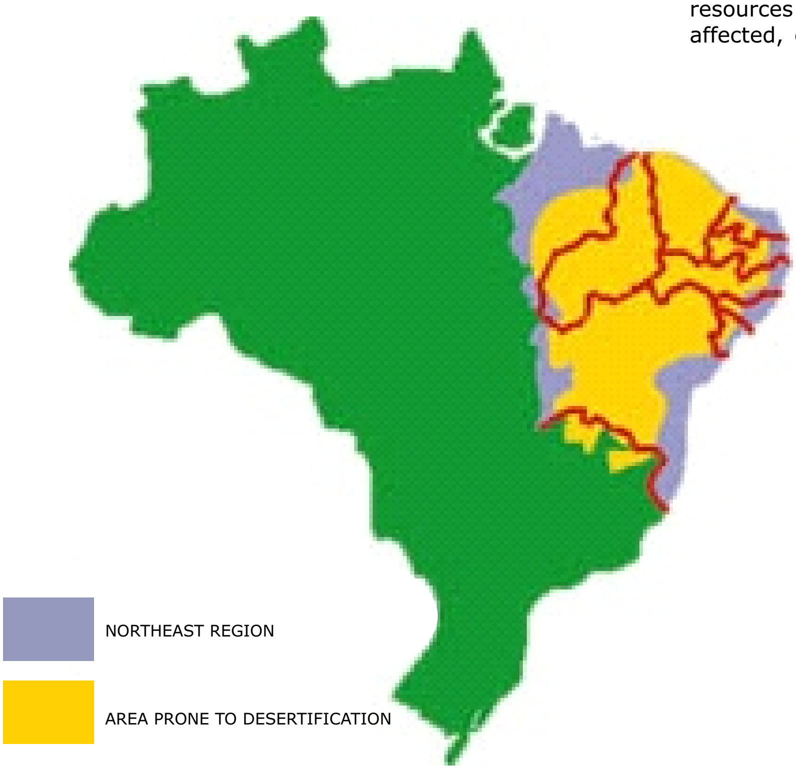
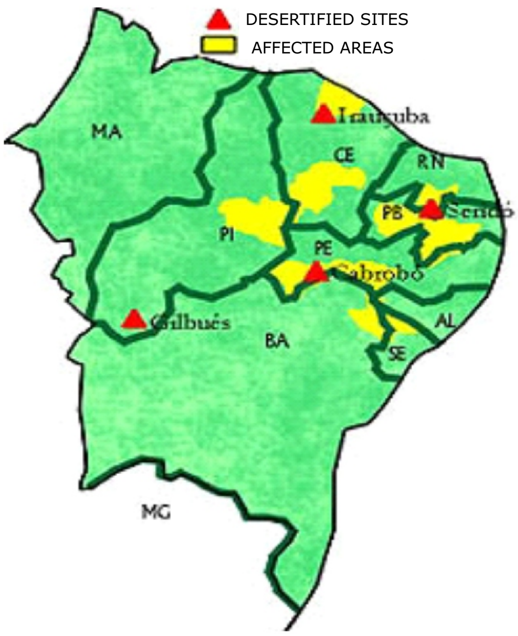
Figure 4.1 - Areas prone to desertification



The Brazilian semi-arid region is characterized by high evapotranspiration, droughts, shallow soils, high salinity, low fertility and reduced water retention capacity, which restricts its productive potential. Moreover, the desertification process is intensified by poverty, and vice-versa. This region, where 42% of the Northeast population live (20,051,518 people, according to the 2000 census), has the most alarming social indicators in Brazil.

Figure 4.2 - Areas affected and desertified sites



Data from the Ministry of Environment - MMA indicate that an area of 181,000 km^2 in the semi-arid region is being seriously affected by the desertification process, with the generation of diffuse impacts, comprising different degradation levels of soil, vegetation, and water resources, which are concentrated in small areas with an intense degradation of resources and extensive damage. The areas that are mostly affected, called desertified sites, were firstly identified in four cities: Gilbués, Iraçuba, Seridó and Cabrobó, totaling 18,743.5 km^2.

Desertification causes three kinds of interrelated impacts: environmental, social, and economic. Environmental impacts include the destruction of fauna and flora, a significant reduction in the availability of water resources (silting of rivers and reservoirs) and physical and chemical soil losses. These environmental impacts generate a considerable loss of productive capacity, causing social changes, such as migration, which break up families and have serious impacts on urban centers to where people move in search of better living conditions. The economic consequences of such impacts are also extensive. According to the methodology adopted by the UN, damages caused by desertification total US$ 250 per hectare in irrigated areas, US$ 40 per hectare in non-irrigated cropland and US$ 7 per hectare in pasture areas. According to the MMA, economic losses from desertification may reach US$ 800 million a year, and the cost for recovering the areas most affected was estimated at US$ 2 billion for a period of 20 years.

Brazil, as established in the United Nations Convention to Combat Desertification, is preparing a National Plan to Combat Desertification in which legal, institutional, economic, financial and information instruments will be identified in order to make possible the adoption of policies and programs to combat the problem.

It should be noted that the areas in Brazil that are prone to serious degradation of soils, water resources, and vegetation and to decrease in the quality of life of the populations affected are not restricted to semi-arid or dry sub-humid regions. Land degradation processes have also been identified in other areas of the country, as in the State of Rio Grande do Sul (particularly in the city of Alegrete), and in the States of Paraná, São Paulo and Rondônia. A worrisome situation of degradation is found in the *cerrado* (savanna) region, where the soil is naturally weak, composed of quartz sand. Although the vegetation offsets the fragility of the ecosystem by maintaining a thin layer of fertile soil, frequent fires and cattle ranching, which consumes all sprouts, weakens the soil, and the productive layer of the soil gives way to sand. However, such areas do not fall within the concept of desertification as defined by the United Nations methodology.

4.4 Areas with High Urban Atmospheric Pollution

There is a wide range of anthropogenic sources of atmospheric pollution: industrial processes of extraction and transformation; processes of industrial heat generation; burning of residues; fuel transportation, storage and distribution; motor vehicles and other mobile sources; etc.

Air pollution causes respiratory diseases (asthma, bronchitis and lung emphysema) and physical discomfort (irritation of the eye, nose and throat, headaches, fatigue, cough), enhances cardio-respiratory diseases, and contributes to the development of lung cancer. Such health problems — which have been linked to atmospheric pollution by many epidemiological and toxicological studies, and also by the World Health Organization — have a high social cost, which includes expenses with health care, loss of working time and decreased productivity.

Moreover, atmospheric pollution causes materials (rubber, synthetic materials, leather, fabric, metal, etc.) to deteriorate, which results in economic losses. Agriculture activities are also affected in a variety of ways, such as by the decrease in plant resistance to diseases and pests and the accumulation of toxic pollutants in animals and transfer to other beings through the food chain.

Brazil, like the vast majority of developing countries, has high levels of urbanization. From 55.92% in the 70's, the proportion of the population living in urban areas reached 81.2% in 2000, while in the Southeast, the most developed region in the country, the figure was 90.5%.

This high — and usually chaotic — growth in the last decades has placed strong pressures in urban areas. This fact, together with the industrialization process, has meant extremely high rates of urban atmospheric pollution.

The most serious problem of atmospheric pollution found in Brazil is the emission of particulate material by industries and by the transport sector. The most harmful particles are those 2.5 $\mu g/m^3$ in size or less. However, available information only allows reporting on particle emissions of 10 $\mu g/m^3$ or larger.

A recent World Bank study, which mapped the main urban problems in Brazil, shows data on atmospheric pollution in big cities, placing emphasis on particulate materials released by four sources: diesel vehicles, gasoline vehicles, small industries (with less than 50 employees), and large industries (with more than 50 employees).

Table 4.4.1 - Municipalities with the Highest Emissions of 10 $\mu g/m^3$ Particulate Material (PM10)

Municipality (State)	Pop. (1000)	Total PM 10 (t.)	Transp. PM10 (t.)	Transp. % of total	Ind. PM10 (t.)	Lar. Ind. % of total	Sma. Ind. % of total
São Paulo (SP)	9,646	41,204	24,081	58	17,123	41	1
Rio de Janeiro (RJ)	5,481	16,684	9,727	58	6,957	41	1
Belo Horizonte (MG)	2,020	10,140	4,934	49	5,206	50	1
Curitiba (PR)	1,315	9,759	6,053	62	3,706	36	2
Porto Alegre (RS)	1,263	6,107	4,694	77	1,413	21	2
Salvador (BA)	2,075	6,104	4,796	79	1,308	19	2
Brasília (DF)	1,601	6,089	3,628	60	2,461	39	1
Volta Redonda (RJ)	220	5,833	390	6	5,443	93	1
Manaus (AM)	1,012	5,480	3,680	67	1,800	32	1
Campo Grande (MS)	526	4,603	3,964	86	639	13	1
Recife (PE)	1,298	4,542	2,048	45	2,494	52	3
Itapeva (SP)	82	4,515	112	2	4,403	97	1
Cubatão (SP)	91	4,406	238	6	4,168	90	4
Sete Lagoas (MG)	144	4,316	334	8	3,982	92	1
Guarulhos (SP)	788	4,228	2,020	48	2,208	50	2

Source: World Bank, 1998
Note: PM - Particulate Material.

According to this World Bank study, the cost of each life saved by reducing particulate emissions in metropolitan areas of big cities ranges from US$ 10,000 to US$ 25,000 for industry and from US$ 50,000 to US$ 85,000 for diesel vehicles.

4.5 Regions with Fragile Ecosystems

Fragile ecosystems include deserts, semi-arid lands, mountains, wetlands, small islands and some coastal areas, which are important because they contain unique characteristics and resources. Since islands and coastal areas, as well as semi-arid lands, have already been covered in this report, this section will focus on mountains, which received special attention in Agenda 21, in its Chapter 13, as fragile ecosystems.

The Brazilian territory consists of very old and extensively eroded geological structures. The country has low altitudes, with 93% of Brazilian territory having less than 900 meters of altitude. There are no great mountain ranges in Brazil, and the largest mountains in the country are located in national parks[3], as shown in the table below.

Table 4.5.1 - Mountains of Brazil with altitudes above 2,600 meters

NAME	LOCATION	STATE	ALTITUDE
Pico da Neblina	Pico da Neblina National Park	Amazonas	3,014m
Pico 31 de Março	Pico da Neblina National Park	Amazonas	2,992m
Pico da Bandeira	Caparaó National Park	Espírito Santo/Minas Gerais	2,890m
Pico das Agulhas Negras	Itatiaia National Park	Minas Gerais/Rio de Janeiro	2,787m
Pico do Cristal	Caparaó National Park	Minas Gerais	2,780m
Pedra da Mina	Serra Fina	Minas Gerais/São Paulo	2,770m
Monte Roraima	Monte Roraima National Park	Roraima	2,727m
Morro do Couto	Itatiaia National Park	Rio de Janeiro	2,680m
Pedra do Sino de Itatiaia	Itatiaia National Park	Minas Gerais	2,670m
Pico dos Três Estados	Serra Fina	Minas Gerais/Rio de Janeiro/ São Paulo	2,665m
Pedra do Altar	Itatiaia National Park	Minas Gerais/Rio de Janeiro	2,665m
Morro da Cruz do Negro	Caparaó National Park	Espírito Santo	2,658m
Pedra Roxa	Caparaó National Park	Espírito Santo	2,649m
Pico do Tesouro	Caparaó National Park	Espírito Santo	2,620m
Pico do Maromba	Itatiaia National Park	Rio de Janeiro	2,619m
Morro do Massena	Itatiaia National Park	Minas Gerais/Rio de Janeiro	2,609m
Pico da Cabeça de Touro	Serra Fina	São Paulo	2,600m

Source: IBGE, 1996b.

Special attention has been given in Brazil to the conservation of the Coastal Mountains (Serra do Mar), a mountainous system that extends from the State of Espírito Santo to the south of the State of Santa Catarina. The Coastal Mountains contain the main remaining areas of the Atlantic Forest (Mata Atlântica), which has been reduced to less than 5% of its initial area, and once covered the entire coast of eastern Brazil, from the States of Rio Grande do Norte to Rio Grande do Sul.

Furthermore, paragraph 4 of Article 225 of the Brazilian Federal Constitution declares "the Brazilian Amazonian Forest, the Atlantic Forest, the Coastal Mountains, the *Pantanal* and the Coastal Zone to be national heritage areas, with their use being subject to the law, under conditions that ensure environmental preservation, including the use of their natural resources".

[3] On August 22, 2002, a presidential decree created the Tumucumaque Mountains National Park, in the northwest of Amapá, at the border with the French Guiana, covering 3.8 million hectares of continuous and practically untouched Amazon forest.

4.6 External Dependency on Oil and Oil Products

In 1938, the National Petroleum Council - CNP was created, whose main activity was to "outline and implement the country's oil policy, control supply, and carry out research on oil and gas". In 1954, Brazil's national oil company, Petrobras, was created, with the main objective of carrying out research and investments to increase exploration of this energy source in Brazil, as well as to increase oil exploration and production.

The creation of these institutions, along with other measures, had the basic effect of developing the oil industry, mainly in the areas of exploration and production, so that exogenous factors would not interfere in the country's economic stability, since oil and oil products were and still are one of the main energy sources.

This effort had the result of reducing the external dependency of the country, which was further intensified by the effects of the oil price shocks of 1973 and 1979, when the Brazilian government, because of the increasing costs of imports, decided to implement an energy policy aimed at reducing foreign exchange spending. Thus, especially in the first half of the 1980s, large investments were made in the development of new energy sources to replace gasoline, diesel oil and fuel oil (particularly with alcohol from sugar cane, which will be analyzed later) and in research on domestic oil exploration, which resulted in large discoveries, especially in the Campos Basin.

All this effort resulted in a reduction of external dependency on oil and oil products, as shown in Table 4.6.1 for the 1990s.

Table 4.6.1 - External Dependency on Oil and Oil Products* - 1990 to 2000

Year	Oil	Oil Products				
		Gasoline	Diesel Oil	Fuel Oil	Naphtha	LPG
1990	46.27	-25.80	1.75	-17.28	2.71	23.97
1991	45.32	-15.50	6.80	-19.97	8.17	27.85
1992	46.68	-21.50	7.49	-18.36	16.37	27.58
1993	46.07	-37.83	13.14	-8.28	19.84	24.50
1994	46.92	-28.76	6.71	-7.26	27.27	25.76
1995	43.48	-6.29	13.83	-0.37	31.80	33.70
1996	40.31	0.72	14.12	-3.55	33.54	39.11
1997	40.30	-0.94	15.38	-13.66	38.72	42.04
1998	35.77	-6.31	15.56	-31.97	38.27	43.21
1999	30.70	-5.68	9.04	-26.34	22.25	41.48
2000	21.61	-12.83	9.93	-30.97	26.40	38.40

Degree of external dependency (%) = (1 production/total consumption) * 100
Source: MME, 2001

For oil, external dependency over the period of 1990 to 2000 fell 24.66 percentage points ending up in 2000 with an external dependency level of 21.61%. This means that the country produced 78.39% of what it consumes, which is a very positive figure for the Brazilian economy. For oil products the situation is different, as shown in Table 4.6.1.

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Brazilian Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases Not Controlled by the Montreal Protocol

Brazil's Initial National Communication

Part II

"The song of the sabiá
I'll go back,
I know now that I'll go back
I will lie in the shadow of a palm that's no longer there
And pick a flower that doesn't grow"

"The Song of the Sabiá"
Brazilian popular song, by Antônio Carlos Jobim and Chico Buarque

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1 INTRODUCTION

As a Party to the United Nations Framework Convention on Climate Change - UNFCCC, hereinafter referred to as the Convention, Brazil has committed itself to prepare and periodically update the National Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases not Controlled by the Montreal Protocol, hereinafter referred to as the Inventory.

The present Inventory has been developed according to the *Guidelines for the Preparation of Initial Communications by Parties not Included in Annex I to the Convention*, established by decision 10/CP.2 of the Second Conference of the Parties to the Convention, held in Geneva, in July 1996.

According to such Guidelines, data in the present Inventory are provided for the 1994 base year. Values for the years 1990 through 1993 are also presented.

The *IPCC Guidelines for National Greenhouse Gas Inventories*, prepared by the Intergovernmental Panel on Climate Change - IPCC in 1995, was the document used as a basic technical guidance. Whenever possible, the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, published in 1997, were used. Some of the estimates already take into account information published in the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*.

The IPCC methodology is largely based on research and methodologies developed by specialists from the developed countries, where emissions from burning of fossil fuels represent the largest share of emissions. As a result, important sectors to Brazil, such as agriculture and land-use change and forestry, are not developed in sufficient depth. For such sectors, default emission factors and even the methodology itself must be used with due caution, because they do not necessarily reflect the Brazilian reality. In many areas, there is no research in Brazil that allows an evaluation of the values suggested or the proposed methodology itself. Where research does exist, in some cases large discrepancies in values were found.

The lack of basic information required by the IPCC methodology was the main difficulty encountered during the development of this inventory, because in many areas there are no reliable statistical data, such as, for example, data on the country's vehicle fleet. In other cases, even when information was available, the fact that it had been obtained for other purposes required the need of an adaptation, with the consequent increase in the uncertainty of the results.

In spite of the limitations imposed by the lack of sufficient financial resources and by the scarce sources of information, efforts were undertaken to make this inventory as complete as possible, including the development of pioneering studies, such as, for example, studies about greenhouse gas emissions from the conversion of forests into agricultural land, from hydroelectric reservoirs, and from prescribed burning of the Brazilian savanna (*cerrado*).

1.1 Greenhouse Gases

Climate on Earth is regulated by the constant flow of solar energy that crosses the atmosphere as visible light. Part of this energy is reflected back into space by the Earth's surface as infrared radiation. Greenhouse gases present in the atmosphere absorb part of this outgoing infrared radiation. Many of them, such as water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3), exist naturally in the atmosphere and are essential for the maintenance of life on the planet, because without them the Earth would be, on average, around 30°C colder.

As a result of human (anthropogenic) activities in the biosphere, the concentration level of some of these gases, like CO_2, CH_4, and N_2O, has increased in the atmosphere. Other greenhouse gases also started to be emitted. These are chemical compounds produced only by man, such as chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).

As determined by the Convention, the Inventory should include only the anthropogenic emissions and removals of greenhouse gases. It should not include the CFCs and HCFCs, which deplete the ozone layer, because the emissions of such gases are already controlled by the Montreal Protocol.

The anthropogenic emissions and removals of the following gases were estimated in the present Inventory: CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. A few other gases, such as carbon monoxide (CO), nitrogen oxides (NO_x), and other non-methane volatile organic compounds (NMVOC), in spite of not being direct greenhouse gases, influence the chemical reactions that take place in the atmosphere. Therefore, information on the anthropogenic emissions of these gases is also included when available.

1.2 Sectors Inventoried

Different activity sectors produce anthropogenic greenhouse gases. The present Inventory is organized according to the structure suggested by the IPCC, covering the following sectors: energy, industrial processes, solvent and other product use, agriculture, land-use change and forestry, and waste.

Anthropogenic removals of greenhouse gases occur in the Land-Use Change and Forestry sector as a result of reforestation activities and abandonment of managed lands.

1.2.1 Energy Sector

In this sector, all anthropogenic emissions from energy production, transformation, and consumption are estimated. They include emissions resulting from fuel combustion and fugitive emissions in the chain of production, transformation, transmission, and consumption.

1.2.1.1 Fuel combustion

In this sector, estimations are made of CO_2 emissions from the oxidation of carbon when fuels are burnt for the generation of other forms of energy, such as electricity, or for end use consumption. Emissions of other greenhouse gases (CH_4, N_2O, CO, NO_x, and NMVOC) during the combustion process are also taken into account.

CO_2 emissions from biomass fuels (firewood, charcoal, alcohol, and bagasse) have not been included here. Fuels from a renewable source do not generate net emissions and the emissions associated with the non-renewable part are included in the Land-Use Change and Forestry sector.

Because of the basic information available, emissions are presented according to the structure defined in the National Energy Balance - BEN, which is similar but not identical to that suggested by the IPCC.

1.2.1.2 Fugitive emissions

This sector includes greenhouse gas emissions from coal mining, storage, processing, and transportation and from the extraction, transportation, and processing of oil and natural gas.

Coal mining and handling produces CH_4 and CO_2 emissions from spontaneous combustion in waste piles.

CH_4 emissions associated with oil and natural gas result from venting during extraction, transportation, and distribution, and during processing in refineries. CO_2 emissions from flaring in oil and natural gas extraction platforms and refinery units are also considered.

In spite of formally resulting from combustion, CO_2 emissions are reported as fugitive emissions because they are associated with a loss and not with the useful consumption of fuel.

1.2.2 Industrial Processes Sector

In this sector anthropogenic emissions are estimated for industrial production processes and not for fuel combustion because the latter are reported in the Energy sector.

Emissions were estimated for the mineral products industry, the chemical industry, the metallurgical industry, the pulp and paper industry, the food and beverage industry, and the production and use of HFCs and SF_6.

1.2.2.1 Mineral products industry

This sector includes emissions resulting from the production of cement and lime, as well as from the production and consumption of soda ash.

Cement production generates CO_2 emissions by the calcination of limestone ($CaCO_3$) during the production of clinker. In the lime production process, limestone and dolomite ($CaCO_3 \cdot MgCO_3$) are calcined, which also produces CO_2. The CO_2 emissions from the calcination of limestone that occur in smaller amounts in other industries were not estimated in this Inventory because of lack of information.

In the production of soda ash (Na_2CO_3) there may be CO_2 emissions, depending on the production process. As in Brazil the synthetic process is used, there are no CO_2 emissions in this phase. However, there are CO_2 emissions when soda ash is consumed in other industries, such as the glass industry.

1.2.2.2 Chemical industry

In this sector special attention was given to the estimation of CO_2 emissions from production of ammonia, N_2O and NO_x emissions from production of nitric acid, and N_2O, CO, and NO_x emissions from production of adipic acid.

During production of other chemicals, there can also be greenhouse gas emissions, especially NMVOC emissions from the petrochemical industry.

1.2.2.3 Metallurgical industry

This sector covers the steel and ferroalloy industries, where there are CO_2 emissions in the process of iron ore reduction, and the aluminum industry, where there are PFCs, CO_2, CO, and NO_x emissions.

In the steel and ferroalloy industries, CO_2 is emitted when carbon contained in the reducing agents combines with the oxygen present in the metal oxides. These reducing agents, such as coal coke, are also used as fuel for energy generation. Because of lack of information, it was not possible to separate the shares used for each purpose. Thus emissions associated with the production process (reduction) were reported together with the emissions resulting from combustion in the Energy sector.

In the aluminum industry, there are CO_2 emissions during the electrolysis process, when the oxygen of the aluminum oxide reacts with the carbon of the anode. During the same process, if the level of aluminum oxide in the production pot becomes too low, there can be a rapid increase in voltage (anodic effect). In this case, the fluoride contained in the electrolytic solution reacts with the carbon of the anode, producing perfluorocarbons (CF_4 and C_2F_6), which are greenhouse gases with a long residence time in the atmosphere. Depending on the technology used, there can also be CO and NO_x emissions.

1.2.2.4 Production and use of HFCs and SF_6

HFCs were developed in the 1980s and 90s as alternatives to CFCs and HCFCs, the use of which is being phased out because they deplete the ozone layer. HFCs do not contain chlorine and thus do not destroy the ozone layer but are greenhouse gases.

In the production and use of HFCs there may be fugitive emissions. During the production process of HCFCs there may also be the secondary production of HFCs and their consequent emission.

SF_6, another greenhouse gas produced only by men, is excellent for use in electrical equipment of high capacity and performance. Brazil does not produce SF_6. Thus the reported emissions of SF_6 are due only to leakages during the use of equipments containing this gas.

1.2.2.5 Other industries

The Pulp and Paper industry generates emissions during the chemical treatment to which the wood pulp is submitted in the production process. Such emissions depend on the type of raw material used and the quality of the product that is to be obtained.

In Brazil, eucalyptus is the major source of pulp, with the predominance of the sulfate process, during which CO, NO_x, and NMVOC emissions occur. Such emissions were estimated in this Inventory.

In the Food and Beverage industry, there are NMVOC emissions during many transformation processes of primary products, such as the production of sugar, animal feed, and beer. Emissions were estimated based on national production data, with the use of default emission factors. The processes of vegetable oil extraction are treated in the Solvent and Other Product Use sector.

1.2.3 Solvent and Other Product Use Sector

Solvent use, in general, favors evaporation of NMVOCs. Efforts were made in this Inventory to identify the most expressive sectors in terms of solvent use, despite the high level of uncertainty in the estimates.

The following activities have been analyzed: application in paint, degreasing of metals, dry-cleaning, foam processing, the printing industry, extraction of edible vegetable oils, and domestic use.

1.2.4 Agriculture Sector

Agriculture is an economic activity of great importance in Brazil. Because of the country's vast agricultural and grazing lands, it is one of the largest agricultural producers in the world.

Many are the processes that result in greenhouse gas emissions, which are described below.

1.2.4.1 Enteric fermentation

The enteric fermentation of ruminant herbivores, which is part of their digestive process, is one of the major sources of CH_4 emissions in the country. The intensity of the enteric fermentation depends on several factors, such as the category of animal, animal feed, the intensity of physical activity of the animal, and the different management practices. Among the many categories of animals, the cattle herds are the most important in terms of emissions, as Brazil is the second largest cattle producer in the world.

1.2.4.2 Manure management

Manure management systems may generate CH_4 and N_2O emissions. Anaerobic decomposition produces CH_4, especially when animal wastes are stored in liquid form.

1.2.4.3 Rice cultivation

When grown in flooded fields or floodplains, rice is an important source of CH_4 emissions. This is because of the anaerobic decomposition of the organic matter present in water. In Brazil, however, rice is mostly produced in non-flooded areas, which reduces the contribution of the sector to total CH_4 emissions.

1.2.4.4 Burning of agricultural residues

Because it is carried out in the field, burning of agricultural residues is an imperfect practice that produces CH_4, N_2O, NO_x, CO, and NMVOC emissions. CO_2 emissions are not considered net emissions because the same amount of gas that is emitted is necessarily absorbed during growth of the plant through photosynthesis.

In Brazil, the practice of burning agricultural residues takes place mainly in the sugar cane and cotton crops.

1.2.4.5 N_2O emissions from agricultural soils

N_2O emissions from agricultural soils result from the use of nitrogen fertilizers, both synthetic and of animal origin, and from manure deposition in pasture. The latter is not considered fertilizer application because it is not intentional. However, it is the most important process in Brazil because of the predominance of extensive livestock production.

Crop residues left in the field, and the process of nitrogen biological fixation in soybean crops are also sources of N_2O emissions.

Also included in this sector is the cultivation of organic soils, which increases the mineralization of organic matter and releases N_2O.

1.2.4.6 Prescribed burning of savannas

Areas of native *cerrado* (Brazilian savanna) burn during the dry season for several reasons, including anthropogenic influence. Like the burning of agricultural residues, such a combustion is imperfect, also generating greenhouse gas emissions. CO_2 emissions are not considered here because the burnt areas regenerate in the wet season. This Inventory presents a methodology to estimate emissions resulting from the prescribed burning of the *cerrado*. However, because of the lack of data for the period studied in this Inventory, estimates for non-CO_2 gas emissions were not included in it.

1.2.5 Land-Use Change and Forestry Sector

1.2.5.1 Changes in forest and other woody biomass stocks

In this sector, CO_2 emissions and removals from changes in the quantity of biomass stored in Brazilian planted forests are analyzed. This Inventory considers only forests planted for economic purposes and to produce timber for the pulp and paper, and steel industries. Because of lack of available information, forests planted for other reasons were not considered.

Changes in carbon stocks in native forests that are not a result of land-use change activities were not accounted for in this Inventory, even though preliminary results in the scientific literature indicate a CO_2 removal from the atmosphere, particularly in the Amazonian forest, which is the greatest forest carbon reservoir in Brazil. The reason for not including such removals is that they are not considered to be anthropogenic, even though many areas in the Amazonian forest are considered to be managed. This procedure is consistent with the definition of climate change for the purposes of the Convention. According to the Convention, in its Article 1, paragraph 2, "climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Other stock changes correspond to carbon flows from the atmosphere to the biosphere. Such flows, both to the terrestrial biosphere and to the oceans, are indirectly influenced by (global) human action, because they increase as a result of the increase in CO_2 concentration in the atmosphere (CO_2 fertilization), as well as by nitrogen deposition. The methodology used, objectively analyzing land-use change, is better and does not require the simple declaration that an area is managed or not.

However, it should be noted that emissions resulting from the deforestation activity, with or without the conversion of the area for other uses, and those resulting from the regeneration of forests by abandonment of managed lands are accounted for in the next section.

1.2.5.2 Forest and grassland conversion and abandonment of managed lands

Conversion of native vegetation areas for other uses results in the decrease in carbon stored in the terrestrial biosphere, with the consequent emission of CO_2 through time. The IPCC methodology establishes, though, that such a change in carbon stock should be accounted for as CO_2 emissions in the year of the conversion.

CO_2 removals from the regeneration of native vegetation areas resulting from the abandonment of managed lands are also estimated. This Inventory also includes removals from deforestation areas abandoned after clearing, even without conversion for other uses.

Other greenhouse gas emissions from biomass combustion in converted lands (CH_4, N_2O, CO, and NO_x) are also accounted for.

1.2.5.3 Carbon change in soils from land-use change, liming, and cultivation of organic soils

Land-use changes, especially when native forests are converted into agricultural or grazing areas and vice versa, alter the carbon content of the soil. Such an alteration depends on the soil type and the land use practices. Such a change in carbon stocks is associated with CO_2 emissions and removals.

Application of limestone to agricultural soils in order to correct acidness and enhance soil fertility also causes CO_2 emissions.

The conversion of organic soils for agricultural uses is generally followed by artificial drainage, cultivation, and liming, which results in rapid oxidation of the organic matter and stabilization of the soil, as well as CO_2 emissions.

1.2.5.4 Hydroelectric reservoirs

Building of reservoirs creates an environment where anaerobic decomposition of biomass occurs, with the consequent emission of CH_4. It is still difficult to evaluate the importance of this source because of the lack of significant research. The IPCC has not developed a methodology to estimate such emissions.

In order to increase knowledge on this issue, a pioneering research was developed, which included the measurement of emissions from several Brazilian reservoirs. Emissions occur both by bubbles and molecular diffusion. CO_2 emissions were also measured, even though such emissions are already accounted for in the section regarding forest conversion.

However, the great variability of the results observed did not allow estimates of CH_4 emissions to be incorporated into this Inventory.

1.2.6 Waste Sector

1.2.6.1 Solid waste disposal

Disposal of solid waste creates anaerobic conditions that generate CH_4. The emission potential increases depending on the control conditions in landfills and the depth of the dumps. Waste incineration, on its turn, like all forms of combustion, generates emissions of several greenhouse gases, but this activity is much reduced in Brazil.

1.2.6.2 Sewage treatment

Effluents with a high degree of organic content have a great CH_4 emission potential, especially domestic and commercial sewage, effluents from the food and beverage industry, and from the pulp and paper industry. The other industries also contribute to such emissions, but in a smaller degree.

In the case of domestic sewage, because of the nitrogen content in human food, there are also N_2O emissions.

2 SUMMARY OF ANTHROPOGENIC GREENHOUSE GAS EMISSIONS AND REMOVALS - BY GAS

In 1994, net anthropogenic greenhouse gas emissions were estimated at 1,030 Tg CO_2; 13.2 Tg CH_4; 550 Gg N_2O; 0.345 Gg CF_4; 0.035 Gg C_2F_6; 0.0018 Gg SF_6; 0.16 Gg HFC-23; and 0.12 Gg HFC-134a. Between 1990 and 1994, total CO_2, CH_4, and N_2O emissions increased by 5%, 6%, and 12% respectively. Gas emissions with indirect effects on climate change were also assessed. In 1994, such emissions were estimated at 2.3 Tg NO_x; 31.4 Tg CO; and 2.47 Tg NMVOC.

2.1 Carbon Dioxide Emissions

CO_2 emissions result from many activities. In developed countries, the main source of carbon dioxide emissions is the energy use of fossil fuels. Other important emission sources in these countries are the industrial processes of cement, lime, soda ash, ammonia, and aluminum production, as well as waste incineration.

Differently from industrialized countries, the greatest share of estimated net CO_2 emissions in Brazil comes from land-use change, particularly the conversion of forests for agricultural use. Because of the large share of renewable energy in the Brazilian energy matrix, by means of hydroelectric power generation, use of ethanol in transportation, and sugar cane bagasse and charcoal in industry, the share of CO_2 emissions from the use of fossil fuels in Brazil is relatively small. Moreover, it should be noted that the Brazilian energy consumption is still modest when compared to that in industrialized countries.

Table 2.1.1 and Figures 2.1 and 2.2 summarize CO_2 emissions and removals in Brazil by sector.

The Energy sector comprises emissions from fossil fuel combustion and fugitive emissions. The latter include flaring of gas in platforms and refineries, and the spontaneous combustion of coal in deposits and waste piles. It is important to note that CO_2 emissions from the reduction process in steel plants were aggregated to emissions from combustion and considered in the Energy sector, because it was not possible to separate such emissions.

In 1994, CO_2 emissions in the Energy sector represented 23% of total CO_2 emissions, having increased by 16% in relation to emissions in 1990. The Transport subsector alone was responsible for 40% of CO_2 emissions in the Energy sector in 1994 and 9% of total CO_2 emissions.

Except for the steel plants, emissions from industrial processes accounted for only 1.6% of total emissions, with the production of cement and lime representing the greatest share (80%). In the 1990-1994 period, emissions from industrial processes did not vary significantly.

The Land-Use Change and Forestry sector was responsible for the greatest share of CO_2 emissions (75%). Conversion of forests for other uses, particularly agricultural use, accounted for the greatest share of total CO_2 emissions, having been included the CO_2 removals from regeneration in abandoned managed lands and change in soil carbon stocks.

Table 2.1.1 - CO_2 emissions and removals

Sector	1990	1994	Share 1994	Variation 90/94
	(Gg)		(%)	
Energy	**203,353**	**236,505**	**23.0**	**16**
Fossil Fuel Combustion	197,972	231,408	22.5	17
Energy Industries	22,914	25,602	2.5	12
Manufacturing Industries	61,260	74,066	7.2	21
Iron and Steel	28,744	37,887	3.7	32
Chemicals	8,552	9,038	0.9	6
Other Industry	23,964	27,141	2.6	13
Transport	82,020	94,324	9.2	15
Civil Aviation	5,818	6,204	0.6	7
Road Transportation	71,150	83,302	8.1	17
Other Transportation	5,051	4,818	0.5	- 5
Residential	13,750	15,176	1.5	10
Agriculture	9,998	12,516	1.2	25
Other	8,030	9,723	0.9	21
Fugitive Emissions	5,381	5,096	0.5	- 5
Coal Mining	1,653	1,355	0.1	- 18
Oil and Natural Gas	3,728	3,741	0.4	0
Industrial Processes	**16,949**	**16,870**	**1.6**	**- 0**
Cement Production	10,220	9,340	0.9	- 9
Lime Production	3,740	4,150	0.4	11
Ammonia Production	1,297	1,301	0.1	0
Aluminum Production	1,510	1,892	0.2	25
Other Industries	182	187	0.0	3
Land-Use Change and Forestry	**758,281**	**776,331**	**75.4**	**2**
Changes in Forest and Other Woody Biomass Stocks	-45,051	-46,885	- 4.6	- 4
Forest and Grassland Conversion	882,477	951,873	92.4	8
Abandonment of Managed Lands	-189,378	-204,270	- 19.8	- 8
Emissions and Removals from Soils	110,233	75,613	7.5	- 31
TOTAL	**978,583**	**1,029,706**	**100**	**5**

Figure 2.1 - CO_2 emissions by sector - 1990

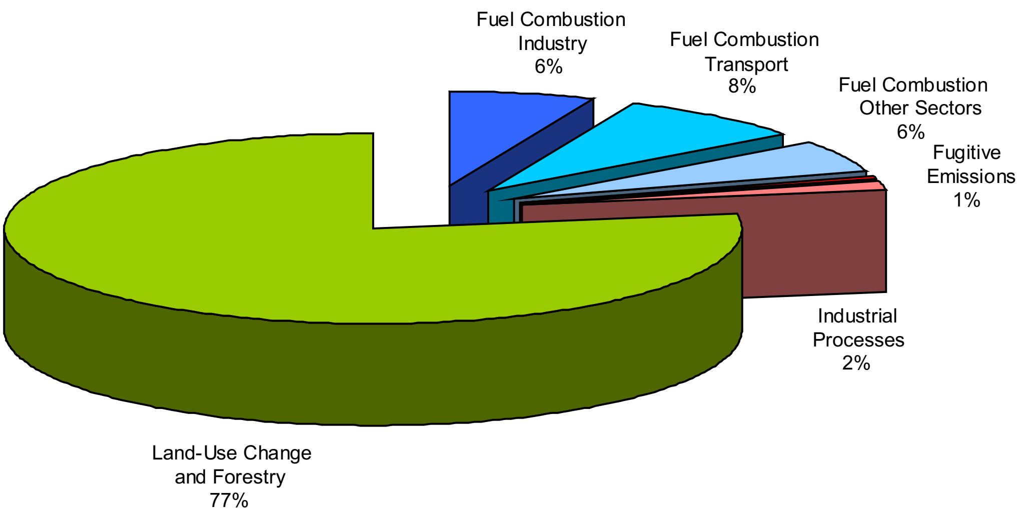
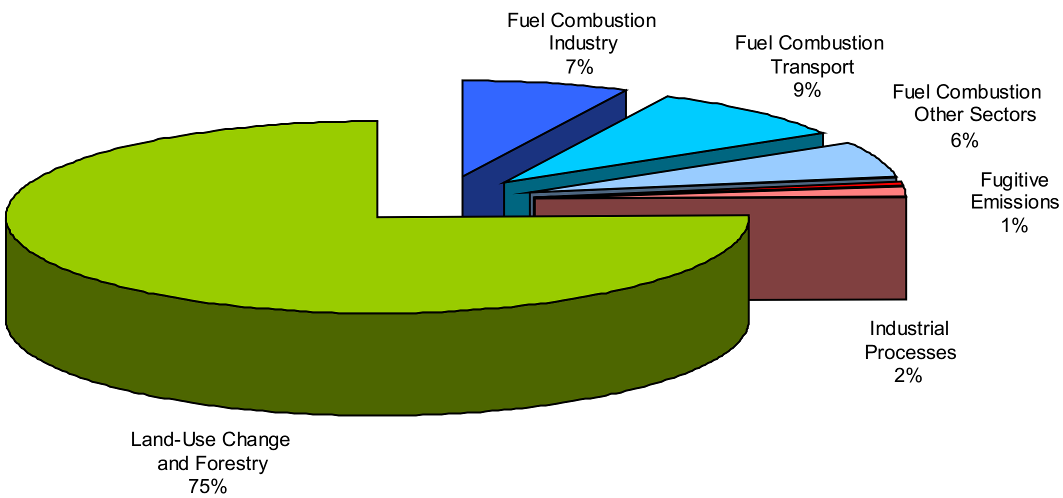


Figure 2.2 - CO_2 emissions by sector - 1994



2.2 Methane Emissions

CH_4 emissions result from many activities, including landfills, wastewater treatment, oil and natural gas production and processing systems, agricultural activities, coal mining, fossil fuel combustion, forest conversion for other uses, and some industrial processes.

In Brazil, the Agriculture sector contributes the most to CH_4 emissions (77% in 1994), where the main emission source is enteric fermentation (eructation), almost all of which from the cattle herd, which is the second largest in the world. Annual CH_4 emissions associated with enteric fermentation were estimated at 9.4 Tg, 92% of total CH_4 emissions in the Agriculture sector. The remaining 8% resulted from manure management, irrigated rice cultivation, and field burning of agricultural residues. Emissions in the sector increased by 7% in the 1990-1994 period, largely because of the increase in the non-dairy cattle herd.

In the Energy sector, CH_4 emissions occur as a result of the imperfect combustion of fuels and also because of CH_4 leakage during the processes of natural gas production and transport, and coal mining. CH_4 emissions in the Energy sector represented, in 1994, 3% of total CH_4 emissions, having decreased by 9% in relation to 1990 emissions.

In the Industrial Processes sector, CH_4 emissions occur during petrochemical production, but contribute little to Brazilian emissions.

Emissions in the Waste sector represented 6% of total CH_4 emissions in 1994, while solid waste disposal was responsible for 84% of this value. In the 1990-1994 period, CH_4 emissions in the Waste sector increased by 9%.

In the Land-Use Change and Forestry sector, CH_4 emissions are caused by biomass burning in the deforestation areas. Such emissions represented 14% of total CH_4 emissions in 1994.

Table 2.2.1 and Figures 2.3 and 2.4 summarize CH_4 emissions.

Table 2.2.1 - CH_4 emissions

Sector	1990	1994	Share 1994	Variation 90/94
	(Gg)		(%)	
Energy	**439**	**401**	**3.0**	**- 9**
Fuel Combustion	332	293	2.2	- 12
Energy Industries	172	150	1.1	- 13
Manufacturing Industries	58	55	0.4	- 4
Iron and Steel	40	37	0.3	- 8
Other Industry	18	19	0.1	5
Road Transportation	10	9	0.1	- 5
Residential	77	65	0.5	- 16
Other	15	13	0.1	- 15
Fugitive Emissions	107	108	0.8	1
Coal Mining	59	53	0.4	- 10
Oil and Natural Gas	47	54	0.4	15
Industrial Processes (Chemical Industry)	**3**	**3**	**0.0**	**8**
Agriculture	**9,506**	**10,161**	**77.1**	**7**
Enteric Fermentation	8,807	9,377	71.2	6
Cattle	8,391	8,962	68.0	7
Dairy	1,200	1,257	9.5	5
Non-Dairy	7,191	7,705	58.5	7
Other Animals	416	415	3.2	-
Manure Management	338	368	2.8	9
Cattle	242	259	2.0	7
Dairy	59	61	0.5	3
Non-Dairy	183	198	1.5	8
Poultry	48	61	0.5	27
Other Animals	48	48	0.4	1
Rice Cultivation	240	283	2.1	18
Field Burning of Agricultural Residues	121	133	1.0	10
Land-Use Change and Forestry	**1,615**	**1,805**	**13.7**	**12**
Waste	**737**	**803**	**6.1**	**9**
Solid Waste Disposal on Land	618	677	5.1	10
Wastewater Handling	119	126	1.0	6
Industrial	79	83	0.6	5
Domestic and Commercial	39	43	0.3	10
TOTAL	**12,299**	**13,173**	**100**	**7**

Figure 2.3 - CH_4 emissions by sector - 1990

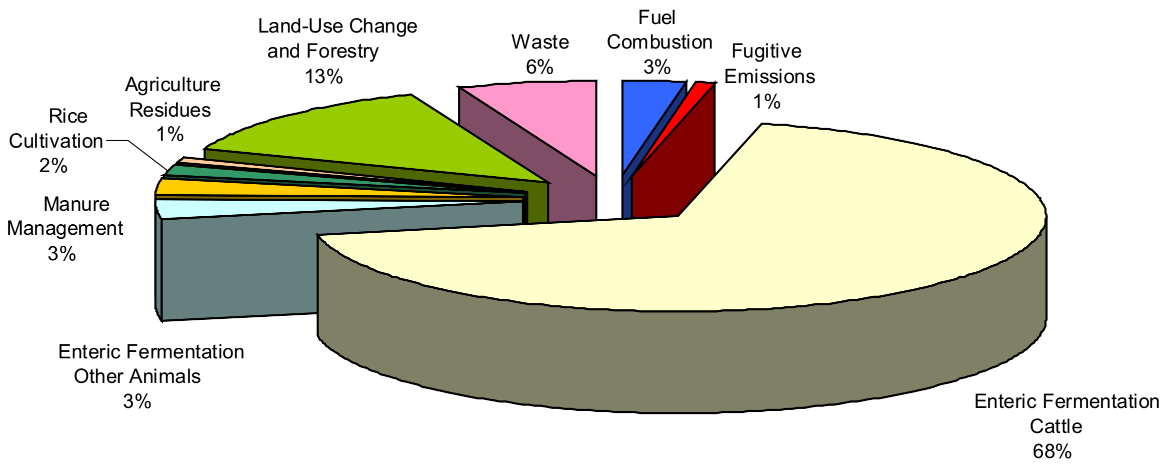
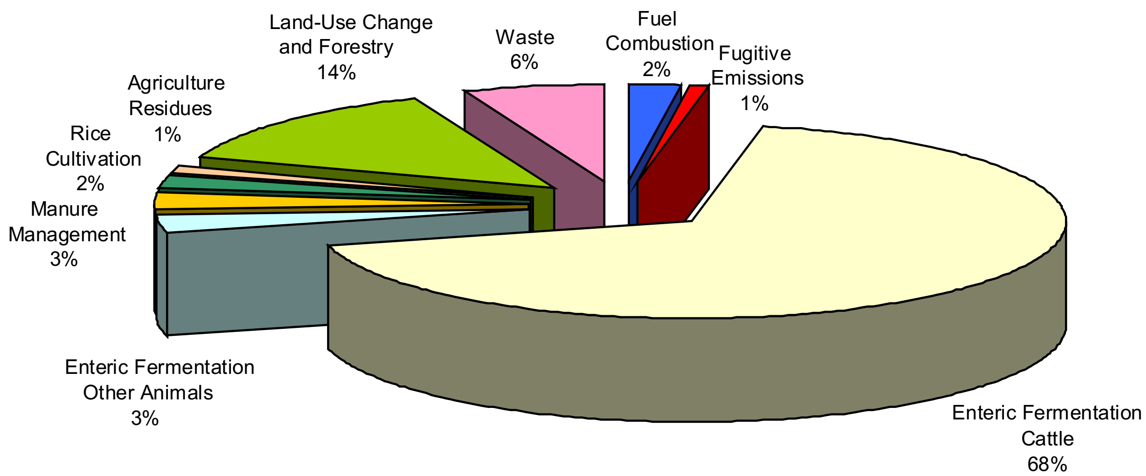


Figure 2.4 - CH_4 emissions by sector - 1994



2.3 Nitrous Oxide Emissions

N_2O emissions result from various activities, including agricultural practices, industrial processes, fossil fuel combustion, and forest conversion for other uses.

In Brazil, N_2O emissions occur mainly in the Agriculture sector (92% in 1994), either from manure deposition in pasture or, in a smaller scale, from fertilizer application to agricultural soils. N_2O emissions in the sector grew by 12% between 1990 and 1994.

N_2O emissions in the Energy sector represented only 1.6% of total N_2O emissions in 1994. Such emissions were due to imperfect fuel combustion.

In the Industrial Processes sector, N_2O emissions occur during the production of nitric acid and adipic acid, but accounted for only 2.5% of total N_2O emissions in 1994.

In the Waste sector, N_2O emissions occur during the process of domestic wastewater treatment, but contributed only 2.2% to total N_2O emissions in 1994.

In the Land-Use Change and Forestry sector, N_2O emissions occur as a result of biomass burning in the deforestation areas. Such emissions represented 2.3% of total N_2O emissions in 1994.

Table 2.3.1 and Figures 2.5 and 2.6 summarize N_2O emissions.

Table 2.3.1 - N_2O emissions

Sector	1990	1994	Share 1994	Variation 90/94
	(Gg)		(%)	
Energy (Fuel Combustion)	**8**	**9**	**1.6**	**11**
Manufacturing Industries	3	4	0.7	14
Other Sectors	5	5	0.9	9
Industrial Processes (Chemical Industry)	**8**	**14**	**2.5**	**61**
Nitric Acid Production	0	1	0.1	38
Adipic Acid Production	8	13	2.4	63
Agriculture	**451**	**503**	**91.5**	**12**
Manure Management	19	20	3.7	7
Cattle	13	13	2.4	5
Other Animals	6	7	1.2	11
Agricultural Soils	426	476	86.6	12
Grazing Animals	207	219	39.7	6
Synthetic Fertilizers	14	21	3.8	51
Animal Waste Fertilizer	12	13	2.4	12
Biological Fixation	21	26	4.8	25
Agricultural Residues	36	43	7.8	19
Organic Soils	16	22	4.1	38
Indirect Emissions	120	132	24.0	10
Field Burning of Agricultural Residues	6	7	1.2	9
Land-Use Change and Forestry	**11**	**12**	**2.3**	**12**
Waste (Domestic and Commercial Wastewater)	**12**	**12**	**2.2**	**6**
TOTAL	**490**	**550**	**100**	**12**

Figure 2.5 - N_2O emissions by sector - 1990

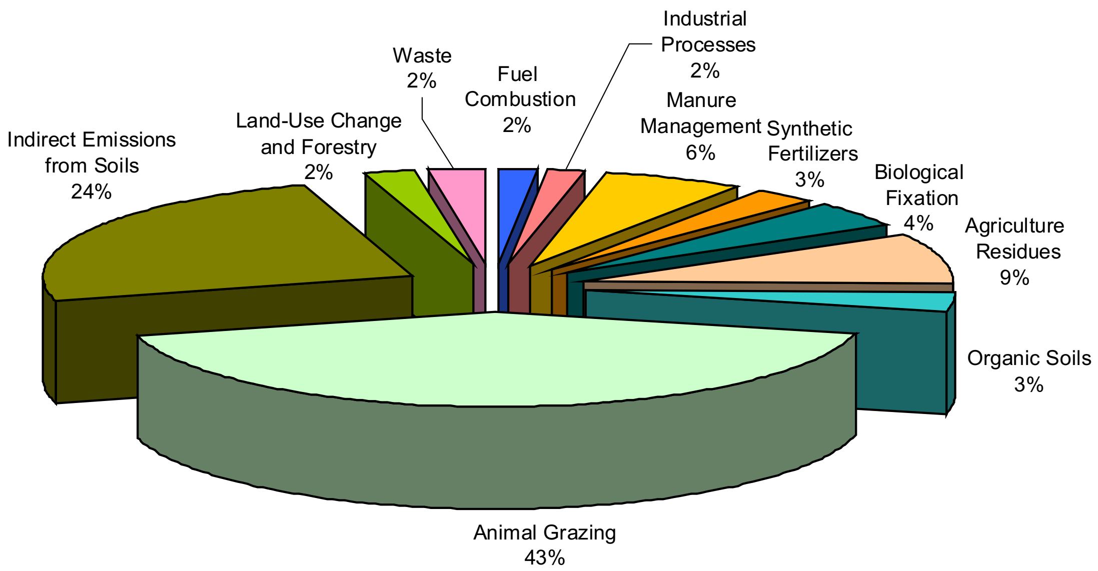
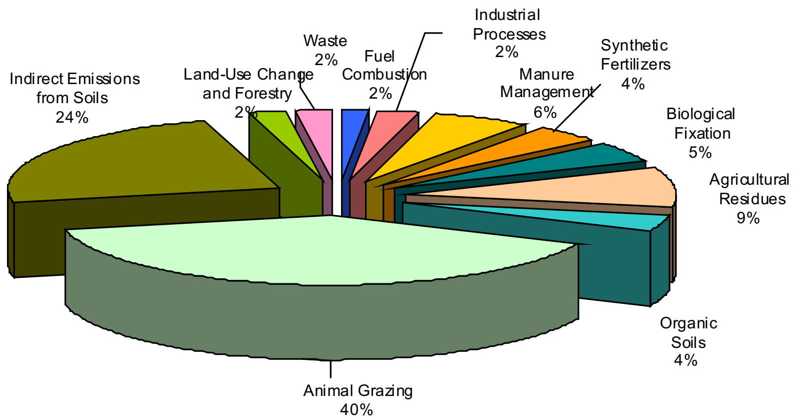


Figure 2.6 - N_2O emissions by sector - 1994



2.4 Hydrofluorocarbons, Perfluorocarbons and Sulphur Hexafluoride Emissions

HFCs, PFCs, and SF_6 are not originally present in nature but synthesized only by human activities.

Brazil does not produce HFCs, and imports of 125 t of HFC-134a in 1994 were registered for use in the refrigeration sector. Use in other possible applications, such as foam production or fire extinguishers, was not observed. Moreover, as a result of HCFC-22 production, HFC-23 emissions occur, which were estimated at 157 t in 1994, an increase of 30% in relation to 1990.

PFC emissions (CF_4 and C_2F_6) occur during the production process of aluminum. They result from the anodic effect that takes place when the amount of aluminum oxide decreases in the process pots. PFC emissions were estimated at 345 t CF_4 and 35 t C_2F_6 in 1994, an increase of 19% in relation to 1990.

SF_6 is used as insulator in large electrical equipment. Sulphur hexafluoride emissions result from leakages from equipment, especially during maintenance or when equipment is discarded. SF_6 emissions were estimated at 1.8 tonnes a year in the 1990-1994 period.

Table 2.4.1 to Table 2.4.5 summarize HFC, PFC, and SF_6 emissions.

Table 2.4.1 - HFC-23 emissions

Sector	1990	1994	Share 1994	Variation 90/94
	(t)		(%)	
Industrial Processes	**120**	**157**	**100**	**30**
HFC-23 Emissions from HCFC-22 Production	120	157	100	30
TOTAL	**120**	**157**	**100**	**30**

Table 2.4.2 - HFC-134a emissions

Sector	1990	1994	Share 1994
	(t)		(%)
Industrial Processes	**-**	**125**	**100**
Consumption in Refrigeration Equipment	-	125	100
TOTAL	**-**	**125**	**100**

Table 2.4.3 - CF_4 emissions

Sector	1990	1994	Share 1994	Variation 90/94
	(t)		(%)	
Industrial Processes	**290**	**345**	**100**	**19**
Aluminum Production	290	345	100	19
TOTAL	**290**	**345**	**100**	**19**

Table 2.4.4 - C_2F_6 emissions

Sector	1990	1994	Share 1994	Variation 90/94
	(t)		(%)	
Industrial Processes	**29**	**35**	**100**	**19**
Aluminum Production	29	35	100	19
TOTAL	**29**	**35**	**100**	**19**

Table 2.4.5 - SF_6 emissions

Sector	1990	1994	Share 1994
	(t)		(%)
Industrial Processes	**1.8**	**1.8**	**100**
Consumption in Electrical Equipment	1.8	1.8	100
TOTAL	**1.8**	**1.8**	**100**

2.5 Indirect Greenhouse Gases

Several gases influence the chemical reactions that occur in the troposphere and thus play an indirect role in increasing the radiative effect. Such gases include CO, NO_x, and NMVOC. Emissions of these gases result mainly from human activities.

The great majority of CO emissions (98%) results from imperfect combustion in the Energy, Agriculture, and Land-Use Change and Forestry sectors. The remaining emissions result from the production processes of aluminum and chemical products, such as ammonia and adipic acid. CO emissions increased by 1% between 1990 and 1994.

Almost all NO_x emissions result from imperfect combustion, either of fuels in the Energy sector, residues in the Agriculture sector, or biomass in areas being deforested. A small share of NO_x emissions occurs in the Industrial Processes sector as a result of the production of nitric acid and aluminum. NO_x emissions grew by 11% between 1990 and 1994.

Most NMVOC emissions are also a result of imperfect combustion of fuels (65% in 1994), but a significant share results from solvent production and use (21% in 1994) or from the food and beverage industry (12% in 1994).

Table 2.5.1, Table 2.5.2, and Table 2.5.3 present CO, NO_x, and NMVOC emissions, respectively.

Table 2.5.1 - CO emissions

Sector	1990	1994	Share 1994	Variation 90/94
	(Gg)		(%)	
Energy (Fuel Combustion)	**13,880**	**12,266**	**39.1**	**- 12**
Energy Industries	1,640	1,551	4.9	- 5
Manufacturing Industries	1,765	1,833	5.8	4
Iron and Steel	842	790	2.5	- 6
Food and Beverage	461	629	2.0	36
Other Industries	462	414	1.3	- 10
Transport	6,368	5,406	17.2	- 15
Road Transportation	6,262	5,301	16.9	- 15
Other	106	105	0.3	- 1
Residential	3,567	3,013	9.6	- 16
Other Sectors	540	463	1.5	- 14
Industrial Processes	**367**	**510**	**1.6**	**39**
Chemical Industry	1	1	0.0	63
Aluminum Industry	346	480	1.5	39
Pulp and Paper	20	29	0.1	43
Agriculture (Field Burning of Residues)	**2,542**	**2,787**	**8.9**	**10**
Sugar Cane	2,455	2,729	8.7	11
Cotton	87	57	0.3	- 34
Land-Use Change and Forestry	**14,132**	**15,797**	**50.4**	**12**
TOTAL	**30,921**	**31,360**	**100**	**1**

Table 2.5.2 - NO_x emissions

Sector	1990 (Gg)	1994 (Gg)	Share 1994 (%)	Variation 90/94 (%)
Energy (Fuel Combustion)	**1,448**	**1,601**	**69.6**	**11**
Energy Industries	215	235	10.2	9
Manufacturing Industries	297	347	15.1	17
Iron and Steel	94	113	4.9	21
Other Industry	203	233	10.1	15
Transport	869	956	41.5	10
Road Transportation	750	838	36.4	12
Other Transport	119	117	5.1	- 1
Residential	54	48	2.1	- 11
Other Sectors	14	16	0.7	17
Industrial Processes	**8**	**11**	**0.5**	**39**
Agriculture (Field Burning of Residues)	**219**	**239**	**10.4**	**9**
Sugar Cane	208	232	10.1	11
Cotton	10	7	0.3	- 34
Land-Use Change and Forestry	**401**	**449**	**19.5**	**12**
TOTAL	**2,076**	**2,300**	**100**	**11**

Table 2.5.3 - NMVOC emissions

Sector	1990 (Gg)	1994 (Gg)	Share 1994 (%)	Variation 90/94 (%)
Energy (Fuel Combustion)	**1,892**	**1,596**	**64.5**	**- 16**
Energy Industries	342	298	12.1	- 13
Manufacturing Industries	51	55	2.2	7
Iron and Steel	24	23	0.9	- 1
Food and Beverage	14	19	0.8	34
Other Industry	14	13	0.5	- 7
Transport	1,232	1,017	41.1	- 17
Road Transportation	1,214	999	40.4	- 18
Other	18	18	0.7	- 2
Residential	206	175	7.1	- 15
Other Sectors	59	51	2.0	- 15
Industrial Processes	**347**	**358**	**14.5**	**3**
Chemical Industry	27	31	1.2	15
Pulp and Paper	13	19	0.8	43
Food and Beverage	307	308	12.4	0
Solvent and Other Product Use	**357**	**521**	**21.1**	**46**
TOTAL	**2,595**	**2,474**	**100**	**- 5**

What is the share of Brazil in producing climate change?

A more precise formulation of this question is:

What is the fraction of the increase in global mean surface temperature resulting from overall emissions of greenhouse gases not controlled by the Montreal Protocol that results from the emissions in Brazil of greenhouse gases not controlled by the Montreal Protocol?

In order to answer this question, it will be necessary to wait for the SBSTA to complete its analysis of the "Scientific and Methodological Aspects of the Brazilian Proposal", as requested by the Third Conference of the Parties in Kyoto.

The scientific aspects are ever-evolving. They could be taken into account, nevertheless, by conventionally considering the knowledge as contained in the IPCC Third Assessment Report, on the grounds that such knowledge has been properly reviewed by the scientific community and by Governments, and then to review the estimate, if necessary, when a new IPCC assessment becomes available.

The methodological aspects are associated with the consideration of the known non-linearities and the influence of other radiatively active substances not included in the Convention, notably the aerosols and the chlorofluorocarbons. These have not yet been properly considered by the SBSTA.

In the case of Brazil, the greatest difficulty stems from the consideration of emissions from land-use change. Such emissions in the period 1990-1994 are relatively very important in Brazil, as can be seen in this Inventory. For the relevant previous period, however, there is no consistency between the estimates of global emissions and the national emissions reported by Parties in the LULUCF sector, mostly due to the difficulties in factoring out the direct human effect from other effects that influence emissions. The estimates of past emissions in Brazil from land-use change also suffer from similar problems.

The option of aggregating the reported emissions to produce carbon dioxide equivalent with the use of the Global Warming Potential (GWP) for a time horizon of 100 years has not been adopted by Brazil. The GWP is based on the relative importance of greenhouse gases, relative to carbon dioxide, in producing an amount of energy (per unit area) a number of years after a pulse of emission. This variable does not represent adequately the relative contribution of different greenhouse gases to climate change. Climate change, whether it is measured in terms of the increase in global mean surface temperature, mean sea-level rise or any statistics of meteorological elements related to damages, is not proportional to energy, except for very short periods of time. The use of the GWP would thus be conducive to inadequate mitigation policies. In addition, its use wrongly overemphasizes the importance of short-lived greenhouse gases, and that of methane in particular.

Anthropogenic Greenhouse Gas Emissions and Removals - By Sector

Energy

3 ANTHROPOGENIC GREENHOUSE GAS EMISSIONS AND REMOVALS - BY SECTOR

3.1 Energy

3.1.1 Characteristics of the Brazilian energy matrix

The Brazilian energy matrix is characterized by the high share of renewable sources, as it can be seen in Table 3.1.1. In 1994, hydroelectricity accounted for 93% of electrical energy consumption. Ethanol from sugar cane also plays an important role, as a result of the National Alcohol Program - Proalcool, a governmental program to stimulate the production of hydrous ethanol for automotive use and anhydrous ethanol to be added to gasoline. In addition to ethanol, sugar cane also produces bagasse, which is used mainly in boilers in the industrial sector.

As a consequence of this development policy, in 1994 the primary sources of fossil origin represented only 40% of the gross domestic supply of energy. Of these sources, oil contributed the most, followed by metallurgical coal, almost all of which was imported for use in the steel sector. Brazilian steam coal has low calorific power, and high ash content. These characteristics, for economical reasons, restrict its use to areas close to where it is extracted. It is used primarily in thermoelectric generation.

Table 3.1.1 - Gross domestic supply of energy by source

Source	1990 (Mtoe[a])	1994 (Mtoe)	Share 1994 (%)	Variation 90/94 (%)
Energy – Fossil Origin	**71.6**	**83.3**	**39.5**	**16**
Oil	57.9	67.1	31.8	16
Natural Gas	4.2	5.0	2.3	18
Steam and Coking Coal	9.5	11.2	5.3	18
Energy – Non-Fossil Origin	**115.7**	**127.5**	**60.5**	**10**
Uranium - U_3O_8	0.6	0.0	0.0	-
Hydro[b]	67.6	79.6	37.8	18
Firewood	28.2	24.5	11.6	-13
Sugar Cane Products	17.9	21.3	10.1	19
Other Primary	1.4	2.0	1.0	49
GROSS DOMESTIC SUPPLY	**187.3**	**210.8**	**100**	**13**

Source: MME, 1998.
[a] toe (1 tonne of oil equivalent) = 45.22 GJ (based on the average higher calorific power of oil consumed in Brazil).
[b] Conversion factor of hydraulic energy and electricity to toe: 1 MWh = 0.29 toe[1].

[1] The BEN 1998 adopts for the conversion of hydraulic energy and electricity into tonnes of oil equivalent the principle of "equivalence in the production", which establishes the quantity of crude oil necessary to generate 1MWh in a thermopower plant (1MWh = 0.29 toe). Most countries adopt the principle of "equivalence in the consumption" based on the first law of thermodynamics (1MWh = 0.086 toe). The convention adopted in Brazil overestimates the gross domestic supply of hydraulic energy, electricity, and of nuclear energy, as well as the final consumption of electricity, and it can distort comparisons with other countries.

Trends in the final consumption of energy can be seen in Table 3.1.2.

Table 3.1.2 - Final consumption of energy by source and sector

Source	1990 (ktoe[a])	1994 (ktoe)	Share 1994 (%)	Variation 90/94 (%)
Final Consumption by Source				
Firewood	15,441	13,592	7.5	-12
Bagasse	11,061	14,281	7.9	29
Diesel Oil	20,298	23,185	13.0	14
Fuel Oil	9,448	10,241	5.7	8
Gasoline	7,336	9,102	5.1	24
Coal Coke	5,030	6,591	3.7	31
Electricity[b]	63,121	72,440	40.0	15
Ethanol	5,700	6,467	3.6	13
Other	22,267	24,162	13.0	9
Final Consumption by Sector				
Energy Sector	13,181	14,625	8.1	11
Residential	27,730	29,052	16.0	5
Commercial	7,774	9,036	5.0	16
Public	5,426	6,837	3.8	26
Agriculture	7,259	8,234	4.6	13
Transport	32,311	37,068	21.0	15
Industrial	65,718	75,209	42.0	14
Other	303	0	0.0	-100
TOTAL	**159,702**	**180,061**	**100**	**13**

Source: MME, 1998.

[a] toe (1 tonne of oil equivalent) = 45.22 GJ (based on the average higher calorific power of oil consumed in Brazil).

[B] Conversion factor of hydraulic energy and electricity to toe: 1 MWh = 0.29 toe.

The most outstanding trends in the 1990-1994 period were the decrease in the use of firewood in the final consumption, and the increase in the use of electricity, bagasse, gasoline, and coal coke. An above-average increase in the energy consumption by the services, industrial, and transport sectors was verified. Such a change in the structure of final energy consumption over the period is a consequence of the accelerated process of industrialization and urbanization. A great part of the increase in energy consumption in industry refers to electricity. As the expansion of energy generation was primarily based on hydroelectricity, the increase in consumption did not represent an equivalent increase in greenhouse gas emissions.

In the following section, greenhouse gas emissions are estimated for energy production, transformation, distribution, and consumption, divided in two subsections: emissions from fuel combustion and fugitive emissions.

3.1.2 Emissions from fuel combustion

The combustion process generates mainly CO_2 from the oxidation of carbon contained in fuels, releasing energy. This process is, however, imperfect and, as a consequence, CH_4, CO, and NMVOC are also produced. As a secondary effect, there is also the generation of N_2O and NO_x.

3.1.2.1 CO_2 emissions from fossil fuel combustion

Brazilian CO_2 emissions from fuel combustion were estimated using two IPCC methodologies (IPCC, 1997): the reference or top-down approach, according to which CO_2 emissions are estimated based on fuel supply; and the sectoral or bottom-up approach, which estimates CO_2 emissions based on the final energy consumption in each sector. Only the CO_2 emissions from fossil fuels are considered in the Energy sector, since emissions resulting from non-renewable biomass burning are considered in the Land-Use Change and Forestry sector.

Emission estimates are based on production and consumption data by energy source obtained in the Brazilian Energy Balance (MME, 1998), published annually by the Ministry of Mines and Energy.

Top-Down

The use of a top-down methodology allows the estimation of CO_2 emissions using only data for the amount of energy supplied to the country. It involves an accounting of the domestic production of primary fuels, the net imports of primary and secondary fuels, and the internal variation of stocks of these fuels. The methodology presumes that, once introduced into the national economy in a given year, the carbon contained in a fuel is either released into the atmosphere or retained in some form (e.g. through an increase in the stock of fuel, incorporation in non-energy products or partially non-oxidized storage). The great advantage of the top-down methodology, however, is that it does not require detailed information on the energy flow through transportation centers as well as final consumption.

Table 3.1.3 shows the CO_2 emissions estimated using the top-down methodology for the 1990-1994 period.

Table 3.1.3 - CO_2 emissions from fossil fuels (*top-down*) - 1990 to 1994

Sector	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Oil and Oil Products	157,831	162,473	167,163	173,792	182,657	77.2	16
Coal and Coal Products	37,517	43,325	42,263	43,740	45,043	19.0	20
Natural Gas	6,927	6,730	7,303	8,036	8,308	3.5	20
Other Fossil Sources	636	692	736	801	589	0.3	- 7
TOTAL	**202,911**	**213,220**	**217,465**	**226,369**	**236,598**	**100**	**17**

Total CO_2 emissions from fossil fuel combustion grew from 203 Mt CO_2 in 1990 to 237 Mt CO_2 in 1994, which represents an increase of 17%, that is, an average annual increase of 4%.

It was identified the predominance of emissions from oil products (77% in 1994). In second place are emissions from coal and coal products (19% in 1994), which are mainly from imported metallurgical coal and coal coke. Coke, besides having an emission factor around 25% greater than that of oil, has been replacing charcoal from renewable origin.

Natural gas emissions, although they have grown throughout the period, contribute little to total emissions (4% in 1994).

Bottom-Up

CO_2 emissions depend on the carbon content of fuels and can be estimated at a high level of aggregation, such as that proposed in the top-down methodology. However, the IPCC methodology (IPCC, 1997) recommends the estimation of CO_2 emissions at a more disaggregated level, which would also be adopted to estimate emissions of other greenhouse gases[2]. CO_2 emissions from fuel combustion were thus estimated for the various sectors of the economy. Table 3.1.4 and Table 3.1.5 show emissions by fuel and by activity sector for the 1990-1994 period.

CO_2 emissions in 1994 were estimated at 231 Mt. Emissions grew by 17% in the 1990-1994 period, while energy consumption grew by 13%. It can be concluded that there was an increase in the carbon intensity of Brazil's energy system.

Table 3.1.4 shows CO_2 emissions from fossil fuel consumption by fuel.

Table 3.1.4 - CO_2 emissions from fossil fuels, by fuel - 1990 to 1994

Fuel	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Gasoline	21,620	23,406	23,288	24,494	26,825	11.6	24
Aviation Kerosene	5,677	5,960	5,616	5,920	6,054	2.6	7
Lighting Kerosene	568	550	480	413	364	0.2	-36
Diesel Oil	65,680	68,336	70,163	72,109	75,067	32.4	14
Fuel Oil	32,869	31,089	33,270	35,392	36,366	15.7	11
LPG	14,445	14,773	15,540	15,701	16,012	6.9	11
Naphtha	2,982	2,903	3,166	3,270	3,693	1.6	24
Lubricants	1,067	1,026	853	937	978	0.4	-8
Petroleum Coke	1,574	1,685	1,552	1,664	2,183	0.9	39
Steam Coal	7,634	9,498	8,052	7,129	7,650	3.3	0
Metallurgical Coal	-	-	-	685	1,031	0.4	-
Tar	660	840	996	1,021	918	0.4	39
Coal Coke	22,904	27,458	27,840	29,439	30,012	13.0	31
Natural Gas	6,363	6,374	6,974	7,725	7,945	3.4	25
Refinery Gas	4,126	4,623	4,748	4,948	5,302	2.3	28
Other Secondary Petroleum Products	2,894	2,738	3,222	3,209	3,911	1.7	35
Piped Gas	566	568	507	468	302	0.1	-47
Coke Oven Gas	5,711	6,062	6,176	6,417	6,211	2.7	9
Other Primary Fossil Fuels	630	685	729	795	585	0.3	-7
TOTAL	**197,972**	**208,573**	**213,170**	**221,734**	**231,408**	**100**	**17**

[2] Other greenhouse gases, known generically as non-CO_2 gases, are: CO, CH_4, NO_x, N_2O, and NMVOC.

Diesel oil is the fuel responsible for the greatest share of CO_2 emissions (32% in 1994). However, the 14% increase in the 1990-1994 period is inferior to the 17% average increase in total emissions from fuels. The second fuel that contributed the most to CO_2 emissions was fuel oil (16% in 1994), but at an equally low growth rate of 11%. Follow in a decreasing order: coal coke (13% share in 1994), gasoline (12%), LPG (7%), and natural gas (3.4%). Most of these fuels had a significant increase in the period: coal coke (31%), gasoline (24%), and natural gas (25%).

Table 3.1.5 shows CO_2 emissions from fossil fuels by sector.

Table 3.1.5 - CO_2 emissions from fossil fuels by sector - 1990 to 1994

Sector	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Energy Sector	**22,914**	**22,704**	**24,886**	**25,119**	**25,602**	**11.1**	**12**
Public Electricity	5,999	6,889	7,551	6,626	7,242	3.1	21
Autoproducers	3,076	3,231	4,146	4,263	3,607	1.6	17
Consumption in Energy Sector	13,839	12,584	13,189	14,229	14,753	6.4	7
Non-Energy Consumption	**5,482**	**5,438**	**5,423**	**5,614**	**6,204**	**2.7**	**13**
Residential	**13,750**	**14,122**	**14,633**	**15,168**	**15,176**	**6.6**	**10**
Commercial	**2,046**	**1,899**	**1,952**	**1,526**	**1,557**	**0.7**	**-24**
Public	**502**	**520**	**499**	**878**	**1,962**	**0.8**	**291**
Agriculture	**9,998**	**10,425**	**10,729**	**11,854**	**12,516**	**5.4**	**25**
Transport	**82,020**	**86,052**	**86,760**	**89,989**	**94,324**	**40.8**	**15**
Aviation	5,818	6,089	5,728	6,047	6,204	2.7	7
Road	71,150	75,052	75,923	78,338	83,302	36.0	17
Railways	1,614	1,611	1,657	1,682	1,260	0.5	-22
Navigation	3,437	3,300	3,452	3,922	3,558	1.5	4
Industrial	**61,260**	**67,412**	**68,289**	**71,587**	**74,066**	**32.0**	**21**
Cement	5,628	6,384	4,999	5,011	4,940	2.1	-12
Pig Iron and Steel	28,536	33,343	33,925	36,055	37,606	16.3	32
Ferroalloys	208	155	246	264	281	0.1	35
Mining and Pelletization	2,405	2,384	2,637	2,791	3,215	1.4	34
Non-Ferrous Metals	3,085	3,194	3,213	4,092	3,860	1.7	25
Chemicals	8,552	8,733	8,990	8,504	9,038	3.9	6
Food and Beverage	3,201	3,214	3,514	3,594	3,615	1.6	13
Textiles	1,599	1,523	1,497	1,583	1,332	0.6	-17
Pulp and Paper	2,445	2,710	3,098	2,885	2,936	1.3	20
Brick Making	1,680	1,775	2,220	2,465	2,501	1.1	49
Others	3,921	3,997	3,950	4,344	4,741	2.0	21
TOTAL	**197,972**	**208,573**	**213,170**	**221,734**	**231,408**	**100**	**17**

The sector that contributed the most to emissions in 1994 was the transport sector (41%), where the road transport alone accounted for 36% of emissions. The industrial sector contributed with 32% of the emissions. The industrial subsector that contributed the most to CO_2 emissions was that of pig iron and steel, with 16% of total emissions. It should be noted that emissions from the industrial sector grew by 21% in the 1990-1994 period, a value above the national average. Of the less significant sectors, the agriculture and public sectors had high emission growth rates in the period, 25% and 291% respectively, while the commercial sector had a drop of 24% in emissions[3].

Table 3.1.6 compares the CO_2 emission estimates obtained with the use of the two different methodologies. The values found with the use of the top-down methodology are around 2% higher than those obtained with the use of the bottom-up methodology. Such a difference was expected because estimates made with the bottom-up methodology do not take into account energy losses in transformation and distribution, which results in a lower estimate.

Table 3.1.6 - CO_2 emissions from fossil fuels estimated with the use of the top-down and bottom-up methodologies

		1990	1991	1992	1993	1994
Reference Methodology (Gg)	(A)	202,911	213,220	217,465	226,369	236,598
Bottom-Up Methodology (Gg)	(B)	197,972	208,573	213,170	221,734	231,408
Difference	**((A-B) / B)**	**2.5%**	**2.2%**	**2.0%**	**2.1%**	**2.2%**

3.1.2.2 Emissions of other greenhouse gases from fuel combustion

The other greenhouse gases considered are: CH_4, N_2O, CO, NO_x, and NMVOC. These gases are referred to generically as non-CO_2 gases, and their emissions were estimated for all fuels, including biomass fuels.

In order to apply the bottom-up methodology, the end uses of the energy sources must be known, as well as the characteristics of the equipment used. Data referring to end use were obtained from the Useful Energy Balance (MME, 1993), published by the Ministry of Mines and Energy.

Preference was given to the use of emission factors from the detailed approach (Tier 2) of the IPCC methodology (IPCC, 1997). Where adequate factors were not available, Tier 2 emission factors from the previous version of IPCC methodology were used (IPCC, 1995). When there was no information available, emission factors from the simplified approach (Tier 1) of the IPCC methodology (IPCC, 1997) were used. For gasoline and ethanol consumed in the road transport mode, emission factors for the national light vehicle fleet were used, calculated from data obtained at CETESB (CETESB, 1994).

Table 3.1.7 shows the emissions of other greenhouse gases from fuel combustion in the 1990-1994 period.

Table 3.1.7 - Emissions of other gases from fuel combustion - 1990 to 1994

Gas	1990	1991	1992 (Gg)	1993	1994	Variation 90/94 (%)
CH_4	332	306	290	290	293	-12
N_2O	7.9	8.1	8.1	8.1	8.7	10
CO	13,880	13,668	13,016	12,362	12,266	-12
NO_X	1,448	1,500	1,524	1,559	1,601	11
NMVOC	1,892	1,841	1,714	1,639	1,596	-16

In 1994, 12,266 Gg CO; 293 Gg CH_4; 1,601 Gg NO_x; 8.7 Gg N_2O; and 1,596 Gg NMVOC were emitted. In spite of the increase in fuel consumption, in the 1990-1994 period CH_4, CO, and NMVOC emissions declined significantly because of two main reasons: technological improvement in road transport vehicles and reduction in firewood consumption.

A more detailed analysis of the values above is made below. For each gas, tables are presented with emissions by fuel and sector, for the 1990-1994 period. Each of these tables also presents the share of emissions in 1994 and the corresponding growth rate in the period.

Methane

In 1994, Brazil emitted 293 Gg CH_4 from fuel combustion. Emissions declined by 12% over the period of 1990-1994.

Table 3.1.8 shows that biomass fuels are the main sources of CH_4 emissions (96% in 1994). However, these emissions dropped by 12% over the period. Emissions from fossil fuels, which were responsible for only 4% of emissions, dropped by 1%. The main fuel in terms of CH_4 emissions is firewood (73%), followed by charcoal (15%), and bagasse (6.5%). Of these, bagasse is the only fuel that had an increase in CH_4 emissions.

[3] These data must be interpreted in the light of the energy structure in Brazil. The increase in energy consumption in the commercial sector was exclusively due to electricity, while the consumption of fossil fuels declined. In the public and agriculture sectors, in addition to an increase in electricity consumption, there was also an increase in the consumption of fossil fuels.

Table 3.1.8 - CH_4 emissions by fuel - 1990 to 1994

Fuel	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
			Fossil Fuels				
Total Fossil Fuels	**12**	**12**	**12**	**12**	**12**	**4.1**	**-1**
Gasoline	5.0	4.9	4.5	4.1	3.8	1.3	-24
Aviation Kerosene	0.04	0.04	0.04	0.04	0.04	0.0	7
Lighting Kerosene	0.06	0.05	0.05	0.04	0.03	0.0	-38
Diesel Oil	5.0	5.2	5.4	5.6	5.8	2.0	15
Fuel Oil	0.87	0.85	0.91	0.95	0.93	0.3	8
LPG	0.26	0.26	0.28	0.28	0.29	0.1	12
Petroleum Coke	0.02	0.02	0.02	0.02	0.03	0.0	52
Steam Coal	0.08	0.10	0.09	0.07	0.08	0.0	-3
Metallurgical Coal	-	-	-	0.01	0.01	0.0	-
Tar	0.01	0.01	0.01	0.01	0.01	0.0	54
Coal Coke	0.22	0.26	0.26	0.28	0.28	0.1	31
Natural Gas	0.11	0.12	0.14	0.20	0.23	0.1	105
Refinery Gas	0.03	0.04	0.04	0.04	0.04	0.0	26
Other Secondary Petroleum Products	0.05	0.05	0.05	0.06	0.07	0.0	31
Piped Gas	0.04	0.04	0.04	0.03	0.02	0.0	-40
Coke Oven Gas	0.07	0.08	0.09	0.09	0.07	0.0	2
Other Primary Fossil Fuels	0.01	0.01	0.01	0.01	0.01	0.0	-7
			Biomass				
Total Biomass	**320**	**294**	**278**	**278**	**281**	**95.9**	**-12**
Firewood	251	230	217	215	215	73.4	-14
Charcoal	51	45	42	44	45	15.4	-13
Bagasse	15	16	17	16	19	6.5	29
Plant Residues	0.73	0.76	0.89	0.88	0.76	0.3	4
Black Liquor	0.10	0.11	0.13	0.15	0.16	0.1	64
Ethanol	1.7	1.8	1.8	1.7	1.8	0.6	4
TOTAL	**332**	**306**	**290**	**290**	**293**	**100**	**-12**

In terms of sectoral emissions in 1994 (Table 3.1.9), the Energy sector had the highest emissions of methane (51%) because of the share of Charcoal Production (48%), followed by the residential sector (22%) and the industrial sector (19%). The sectors with the highest rates of growth of emissions in the period were the public sector (48%) and the food and beverage industry (41%).

Taking into account the three variables — equipment, fuel, and sector — firewood for charcoal production is identified as the principal emission source, with 48% of methane emissions from fuel combustion in 1994. Following are firewood for furnaces in the residential sector (21%) and the charcoal burnt in blast furnaces in the pig iron and steel industry (11%).

The reduction of methane emissions is significantly influenced by the reduction in emissions from firewood, which fell 14% in the 1990-1994 period.

Table 3.1.9 - CH_4 emissions by sector - 1990 to 1994

Sector	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Energy Sector	**172**	**153**	**141**	**148**	**150**	**51.3**	**-13**
Public Electricity	0.11	0.12	0.15	0.13	0.14	0.0	24
Autoproducers	0.92	1.0	1.1	1.1	1.0	0.4	12
Charcoal Production	163	143	131	138	140	47.6	-14
Consumption Energy Sector	8.7	10	9.2	8.9	10	3.3	12
Residential	**77**	**76**	**76**	**67**	**65**	**22.1**	**-16**
Commercial	**1.7**	**1.6**	**1.6**	**1.5**	**1.5**	**0.5**	**-12**
Public Sector	**0.07**	**0.07**	**0.06**	**0.06**	**0.10**	**0.0**	**48**
Agriculture	**13**	**13**	**12**	**11**	**11**	**3.9**	**-11**
Transport	**10**	**11**	**10**	**10**	**10**	**3.4**	**-6**
Aviation	0.04	0.04	0.04	0.04	0.04	0.0	7
Road	10	10	9.7	9.5	9.5	3.2	-6
Railways	0.11	0.11	0.11	0.11	0.09	0.0	-22
Navigation	0.23	0.22	0.23	0.26	0.23	0.1	3
Industrial	**58**	**52**	**50**	**53**	**55**	**18.9**	**-4**
Cement	3.0	2.2	1.8	2.0	2.3	0.8	-25
Pig Iron and Steel	37	31	29	32	33	11.2	-11
Ferroalloys	3.0	4.1	3.5	4.2	3.7	1.3	21
Mining and Pelletization	0.31	0.33	0.29	0.06	0.06	0.0	-80
Non-Ferrous Metals	2.2	1.8	1.8	1.0	1.1	0.4	-49
Chemicals	0.75	0.72	0.68	0.69	0.72	0.2	-4
Food and Beverage	7.3	7.3	8.6	8.5	10.3	3.5	41
Textiles	0.20	0.19	0.14	0.15	0.13	0.0	-33
Pulp and Paper	1.1	1.1	1.3	1.3	1.3	0.4	17
Brick Making	2.2	2.1	1.9	2.0	2.1	0.7	-7
Others	0.89	0.88	0.66	0.71	0.75	0.3	-16
TOTAL	**332**	**306**	**290**	**290**	**293**	**100**	**-12**

Nitrous Oxide

In 1994, Brazil emitted 8.7 Gg of N_2O from fuel combustion. There was an increase of 10% between 1990 and 1994.

Table 3.1.10 - N_2O emissions by fuel - 1990 to 1994

Fuel	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Fossil Fuels							
Total Fossil Fuels	**1.8**	**2.0**	**2.0**	**2.2**	**2.4**	**27.0**	**30**
Gasoline	0.44	0.52	0.53	0.60	0.74	8.5	70
Aviation Kerosene	0.16	0.17	0.16	0.17	0.17	2.0	7
Lighting Kerosene	0.00	0.00	0.00	0.00	0.00	0.0	-36
Diesel Oil	0.54	0.56	0.57	0.59	0.61	7.0	14
Fuel Oil	0.19	0.17	0.19	0.20	0.21	2.4	11
LPG	0.02	0.02	0.02	0.03	0.03	0.3	11
Petroleum Coke	0.02	0.02	0.02	0.02	0.03	0.3	38
Steam Coal	0.09	0.12	0.10	0.08	0.09	1.0	-3
Metallurgical Coal	-	-	-	0.01	0.02	0.2	-
Tar	0.00	0.00	0.01	0.01	0.01	0.1	62
Coal Coke	0.30	0.36	0.37	0.39	0.40	4.6	31
Natural Gas	0.01	0.01	0.01	0.01	0.01	0.1	35
Refinery Gas	0.01	0.01	0.01	0.01	0.01	0.1	28
Other Secondary Petroleum Products	0.02	0.02	0.02	0.02	0.02	0.3	33
Piped Gas	0.00	0.00	0.00	0.00	0.00	0.0	-46
Coke Oven Gas	0.01	0.01	0.01	0.01	0.01	0.1	9
Other Primary Fossil Fuels	0.00	0.00	0.00	0.00	0.00	0.0	-7
Biomass							
Total Biomass	**6.1**	**6.1**	**6.0**	**5.9**	**6.3**	**73.0**	**4**
Firewood	2.7	2.6	2.5	2.4	2.4	27.2	-12
Charcoal	0.94	0.82	0.75	0.81	0.82	9.4	-13
Bagasse	2.0	2.1	2.2	2.2	2.5	29.1	29
Plant Residues	0.10	0.10	0.12	0.12	0.10	1.2	4
Black Liquor	0.02	0.03	0.03	0.04	0.04	0.4	65
Ethanol	0.37	0.41	0.39	0.43	0.48	5.6	32
TOTAL	**7.9**	**8.1**	**8.1**	**8.1**	**8.7**	**100**	**10**

Table 3.1.10 shows that biomass fuels are the main sources of N_2O emissions (73% in 1994). However, they had a relatively low growth (4% over the period) compared to the increase in emissions from fossil sources (30%). The main fuel in terms of N_2O emissions in 1994 was bagasse (29%), followed by firewood (27%), charcoal (9.4%), gasoline (8.5%), diesel oil (7.0%), and coal coke (4.6%). These fuels show diverse trends. Some have high growth rates gasoline (70%), bagasse (29%), diesel oil (14%), and coal coke (31%); while others declined significantly firewood (-12%) and charcoal (-13%).

Table 3.1.11 - N_2O emissions by sector - 1990 to 1994

Sector	1990	1991	1992 (Gg)	1993	1994	Share 1994 (%)	Variation 90/94 (%)
Energy Sector	**1.4**	**1.5**	**1.5**	**1.4**	**1.5**	**17.5**	**12**
Public Electricity	0.05	0.05	0.06	0.05	0.05	0.6	17
Autoproducers	0.13	0.14	0.15	0.16	0.15	1.7	13
Consumption Energy Sector	1.2	1.3	1.2	1.2	1.3	15.2	12
Residential	**1.4**	**1.4**	**1.4**	**1.2**	**1.2**	**13.7**	**-15**
Commercial	**0.03**	**0.03**	**0.03**	**0.03**	**0.02**	**0.3**	**-13**
Public Sector	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.1**	**209**
Agriculture	**0.46**	**0.46**	**0.42**	**0.43**	**0.43**	**4.9**	**-8**
Transport	**1.4**	**1.6**	**1.5**	**1.7**	**1.9**	**21.7**	**35**
Aviation	0.16	0.17	0.16	0.17	0.18	2.0	7
Road	1.2	1.3	1.3	1.5	1.7	19.3	40
Railways	0.01	0.01	0.01	0.01	0.01	0.1	-23
Navigation	0.03	0.03	0.03	0.03	0.03	0.3	3
Industrial	**3.2**	**3.2**	**3.2**	**3.3**	**3.6**	**41.7**	**12**
Cement	0.12	0.12	0.09	0.09	0.10	1.1	-22
Pig Iron and Steel	1.0	0.99	0.95	1.0	1.1	12.3	3
Ferroalloys	0.06	0.08	0.07	0.09	0.08	0.9	23
Mining and Pelletization	0.03	0.03	0.03	0.02	0.03	0.3	9
Non-Ferrous Metals	0.08	0.07	0.07	0.07	0.07	0.8	-13
Chemicals	0.09	0.09	0.09	0.09	0.09	1.1	0
Food and Beverage	1.1	1.1	1.3	1.3	1.5	17.2	35
Textiles	0.03	0.03	0.02	0.02	0.02	0.3	-31
Pulp and Paper	0.23	0.22	0.25	0.25	0.27	3.1	17
Brick Making	0.29	0.27	0.25	0.27	0.28	3.2	-3.2
Others	0.14	0.14	0.12	0.12	0.13	1.5	-11
TOTAL	**7.9**	**8.1**	**8.1**	**8.1**	**8.7**	**100**	**10**

In terms of sectoral emissions in 1994 (Table 3.1.11), the industrial sector was responsible for the majority of N_2O emissions (42%), with the subsectors of food and beverages (17%) and pig iron and steel (12%) being the most important, followed by the transport sector (22%), the energy sector (18%) and the residential sector (14%). The sectors that had the highest emissions also had high growth rates in the 1990-1994 period. The only exceptions are the pig iron and steel industry, with a slight increase (3%), and the residential sector (-15%).

N_2O emissions are not concentrated in only one use, fuel or sector. Taking into account the three variables — equipment, fuel, and sector — it was found that N_2O emissions from boilers using bagasse in the energy sector (15%) and in the food and beverages subsector (14%), and from firewood burnt in furnaces in the residential sector (13%) are the main sources. Other important emission sources are road transportation — gasoline (8.5%), ethanol (5.6%), and diesel (5.2%) — and charcoal fired furnaces in the pig iron and steel industry (7.5%).

Carbon Monoxide

In 1994, Brazil emitted 12,266 Gg of carbon monoxide (CO) from fuel combustion, which represented a 12% reduction in the 1990-1994 period.

Table 3.1.12 - CO emissions by fuel - 1990 to 1994

Fuel	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Fossil Fuels							
Total Fossil Fuels	**5,156**	**5,095**	**4,707**	**4,419**	**4,224**	**34.4**	**-18**
Gasoline	4,316	4,217	3,810	3,493	3,274	26.7	-24
Aviation Kerosene	8.0	8.4	7.9	8.4	8.6	0.1	7
Lighting Kerosene	0.27	0.26	0.22	0.19	0.17	0.0	-35
Diesel Oil	715	745	761	776	801	6.5	12
Fuel Oil	50	46	49	57	54	0.4	9
LPG	2.8	2.9	3.1	3.2	3.4	0.0	20
Petroleum Coke	1.2	1.3	1.2	1.3	1.6	0.0	42
Steam Coal	4.1	5.2	4.0	3.4	3.7	0.0	-9
Metallurgical Coal	-	-	-	0.58	0.88	0.0	-
Tar	0.40	0.54	0.73	0.74	0.67	0.0	69
Coal Coke	46	55	55	59	60	0.5	31
Natural Gas	5.8	5.7	6.4	7.5	7.9	0.1	36
Refinery Gas	2.7	3.1	3.2	3.3	3.5	0.0	29
Other Secondary Petroleum Products	0.43	0.39	0.47	0.52	0.61	0.0	43
Piped Gas	0.26	0.25	0.21	0.19	0.10	0.0	-60
Coke Oven Gas	3.9	4.1	4.1	4.3	4.3	0.0	9
Other Primary Fossil Fuels	0.19	0.22	0.22	0.22	0.18	0.0	-6
Biomass							
Total Biomass	**8,723**	**8,573**	**8,309**	**7,943**	**8,042**	**65.6**	**-8**
Firewood	5,384	5,209	5,055	4,681	4,612	37.6	-14
Charcoal	1,118	992	911	957	967	7.9	-13
Bagasse	842	903	953	931	1,085	8.8	29
Plant Residues	65	66	78	75	68	0.6	5
Black Liquor	4.6	5.1	6.1	7.1	7.5	0.1	63
Ethanol	1,311	1,398	1,306	1,292	1,302	10.6	-1
TOTAL	**13,880**	**13,668**	**13,016**	**12,362**	**12,266**	**100**	**-12**

Table 3.1.12 shows that biomass fuels were the main sources of CO emissions (66% in 1994). The main fuel in terms of carbon monoxide emissions was firewood (38%), followed by gasoline (27%) and ethanol (11%). The reduction of biomass emissions in the period resulted from the reduction in firewood consumption, the emissions of which were reduced by 14% in the 1990-1994 period. The main fossil fuel emission reductions are due to the reductions in gasoline emissions (-24%). Gasoline emission reductions, in spite of the increase in consumption, are due to technological changes that were introduced in the Brazilian light vehicle fleet, pushing down the average emission factors during the period.

Table 3.1.13 - CO emissions by sector - 1990 to 1994

Sector	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Energy Sector	**1,640**	**1,568**	**1,467**	**1,494**	**1,551**	**12.6**	**-5**
Public Electricity	7.4	7.6	10	8.5	9.1	0.1	23
Autoproducers	52	55	58	61	57	0.5	10
Charcoal Production	1,084	951	873	919	930	7.6	-14
Consumption Energy Sector	496	555	526	506	554	4.5	12
Residential	**3,567**	**3,545**	**3,537**	**3,103**	**3,013**	**24.6**	**-16**
Commercial	**18**	**18**	**20**	**19**	**19**	**0.2**	**6**
Public Sector	**1.1**	**1.1**	**1.0**	**1.1**	**1.4**	**0.0**	**29**
Agriculture	**521**	**507**	**462**	**450**	**443**	**3.6**	**-15**
Transport	**6,368**	**6,383**	**5,898**	**5,593**	**5,406**	**44.1**	**-15**
Aviation	39	37	32	36	41	0.3	6
Road	6,262	6,281	5,797	5,483	5,301	43.2	-15
Railways	22	22	23	23	17	0.1	-21
Navigation	45	44	46	52	47	0.4	3
Industrial	**1,764**	**1,645**	**1,632**	**1,702**	**1,832**	**14.9**	**3.8**
Cement	68	53	43	46	52	0.4	-23
Pig Iron and Steel	781	676	635	693	716	5.8	-8
Ferroalloys	61	82	70	85	74	0.6	21
Mining and Pelletization	9.2	10	9.1	4.6	5.2	0.0	-44
Non-Ferrous Metals	48	39	40	25	27	0.2	-44
Chemicals	26	25	22	23	24	0.2	-6
Food and Beverage	461	463	530	528	629	5.1	37
Textiles	12	11	7.3	7.7	7.7	0.1	-33
Pulp and Paper	95	92	107	105	111	0.9	16
Brick Making	146	138	125	136	138	1.1	-6
Others	58	57	44	46	49	0.4	-16
TOTAL	**13,880**	**13,668**	**13,016**	**12,362**	**12,266**	**100**	**-12**

In terms of sectoral emissions (Table 3.1.13), transport had the highest emissions of CO (44%), and the road subsector alone accounted for 43% of emissions, followed by the residential sector with 25%.

Taking into account all the information, the gasoline consumed in road transportation was the principal source of CO emissions (26%), followed by firewood burnt in furnaces of the residential sector (23%) and ethanol for road transportation (11%).

Nitrogen Oxides

In 1994, Brazil emitted 1,601 Gg of NO_x through fuel combustion, and the emissions grew by 11% between 1990 and 1994.

Table 3.1.14 - NO_x emissions by fuel - 1990 to 1994

Fuel	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Fossil Fuels							
Total Fossil Fuels	**1,199**	**1,246**	**1,277**	**1,313**	**1,347**	**84.1**	**12**
Gasoline	118	130	128	128	131	8.1	10
Aviation Kerosene	24	25	24	25	26	1.6	7
Lighting Kerosene	1.5	1.4	1.3	1.1	1.0	0.1	-32
Diesel Oil	634	659	680	682	698	43.6	10
Fuel Oil	171	157	169	188	188	11.7	10
LPG	16	17	19	20	22	1.4	37
Petroleum Coke	7.9	8.7	8.2	8.8	11	0.7	35
Steam Coal	54	67	59	53	56	3.5	3
Metallurgical Coal	-	-	-	3.9	5.9	0.4	-
Tar	2.8	3.7	5.0	5.1	4.6	0.3	65
Coal Coke	7.6	9.1	9.2	10	10	0.6	31
Natural Gas	74	73	80	90	92	5.8	25
Refinery Gas	27	31	32	33	35	2.2	30
Other Secondary Petroleum Products	6.1	5.6	6.7	7.3	8.7	0.5	42
Piped Gas	1.9	1.8	1.4	1.1	0.4	0.0	-78
Coke Oven Gas	51	53	53	55	56	3.5	10
Other Primary Fossil Fuels	2.0	2.3	2.4	2.5	1.9	0.1	-6
Biomass							
Total Biomass	**248**	**253**	**247**	**245**	**255**	**15.9**	**3**
Firewood	77	75	72	68	67	4.2	-12
Charcoal	26	23	21	22	22	1.4	-13
Bagasse	34	36	38	37	43	2.7	29
Plant Residues	2.0	2.0	2.4	2.3	2.1	0.1	5
Black Liquor	11	12	15	17	18	1.1	66
Ethanol	100	105	99	99	101	6.3	2
TOTAL	**1,448**	**1,500**	**1,524**	**1,559**	**1,601**	**100**	**11**

Table 3.1.14 shows that, in contrast with CH_4 and CO, fossil fuels are the main sources of NO_x emissions (84% in 1994), with a relatively high growth rate (12%) in the 1990-1994 period. The main fuel in terms of NO_x emissions is diesel oil (44%), followed by fuel oil (12%), gasoline (8%), ethanol (6%), and natural gas (6%). Consumption of all these fuels increased significantly in the period: diesel oil (10%), fuel oil (10%), gasoline (10%), ethanol (2%), and natural gas (25%).

Table 3.1.15 - NO_x emissions by sector - 1990 to 1994

Sector	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Energy Sector	**215**	**219**	**236**	**231**	**235**	**14.7**	**9**
Public Electricity	61	68	76	67	72	4.5	18
Autoproducers	18	19	22	22	22	1.4	23
Charcoal Production	2.7	2.4	2.2	2.3	2.3	0.1	-14
Consumption Energy Sector	133	130	136	139	139	8.7	4
Residential	**54**	**54**	**54**	**49**	**48**	**3.0**	**-11**
Commercial	**4.0**	**3.8**	**3.8**	**3.7**	**3.9**	**0.2**	**-3**
Public Sector	**1.0**	**0.9**	**0.9**	**1.7**	**4.0**	**0.2**	**316**
Agriculture	**8.5**	**8.3**	**7.8**	**7.7**	**7.9**	**0.5**	**-7**
Transport	**869**	**908**	**912**	**938**	**956**	**59.7**	**10**
Aviation	25	26	24	26	26	1.6	7
Road	750	790	792	807	838	52.3	12
Railways	26	26	27	28	21	1.3	-21
Navigation	68	66	68	78	70	4.4	3
Industrial	**297**	**306**	**310**	**328**	**347**	**21.7**	**17**
Cement	38	41	34	33	33	2.1	-14
Pig Iron and Steel	92	93	94	102	110	6.9	21
Ferroalloys	2.6	2.8	2.8	3.7	3.4	0.2	31
Mining and Pelletization	10	10	11	11	12	0.8	21
Non-Ferrous Metals	16	17	17	19	19	1.2	19
Chemicals	36	37	39	39	41	2.6	16
Food and Beverage	33	33	36	36	40	2.5	22
Textiles	4.2	4.0	3.7	3.9	3.3	0.2	-21
Pulp and Paper	20	21	24	26	27	1.7	36
Brick Making	19	19	23	25	27	1.7	40
Others	27	27	26	29	31	1.9	15
TOTAL	**1,448**	**1,500**	**1,524**	**1,559**	**1,601**	**100**	**11**

In terms of sectoral emissions (Table 3.1.15), transport was responsible, in 1994, for the majority of NO_x emissions (60%), with 52% coming from the road mode, followed by the industrial sector (22%) and the energy sector (15%). The sectors with the highest emissions had high growth rates over the 1990-1994 period: transport (10%), industrial (17%), and energy (9%).

Taking into account the three variables — equipment, fuel, and sector — it was found that NO_x emissions are much more concentrated in the use of engines for road transportation: diesel oil (38%), gasoline (8%), and ethanol (6%).

Non-Methane Volatile Organic Compounds

In 1994, Brazil emitted 1,596 Gg NMVOC from fuel combustion. Emissions dropped by 16% between 1990 and 1994.

Table 3.1.16 - NMVOC emissions by fuel - 1990 to 1994

Fuel	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Fossil Fuels							
Total Fossil Fuels	**967**	**946**	**867**	**807**	**760**	**48**	**-21**
Gasoline	807	779	697	631	579	36.3	-28
Aviation Kerosene	4.0	4.2	4.0	4.2	4.3	0.3	7
Lighting Kerosene	0.04	0.04	0.03	0.03	0.03	0.0	-36
Diesel Oil	141	147	150	153	159	9.9	12
Fuel Oil	8.4	7.8	8.3	9.7	9.0	0.6	8
LPG	1.2	1.2	1.2	1.3	1.3	0.1	11
Petroleum Coke	0.08	0.08	0.08	0.08	0.11	0.0	39
Steam Coal	1.0	1.3	1.0	0.88	0.95	0.1	-8
Metallurgical Coal	-	-	-	0.15	0.22	0.0	-
Tar	0.03	0.04	0.05	0.05	0.05	0.0	53
Coal Coke	3.5	4.1	4.2	4.4	4.5	0.3	31
Natural Gas	0.45	0.45	0.50	0.57	0.58	0.0	29
Refinery Gas	0.31	0.35	0.36	0.37	0.40	0.0	28
Other Secondary Petroleum Products	0.14	0.13	0.16	0.17	0.20	0.0	45
Piped Gas	0.05	0.05	0.05	0.04	0.03	0.0	-47
Coke Oven Gas	0.27	0.28	0.29	0.30	0.29	0.0	9
Other Primary Fossil Fuels	0.04	0.05	0.05	0.06	0.04	0.0	-7
Biomass							
Total Biomass	**924**	**896**	**847**	**832**	**836**	**52**	**-10**
Firewood	598	555	526	513	511	32	-14
Charcoal	26	23	21	22	22	1.4	-13
Bagasse	25	26	28	27	32	2.0	29
Plant Residues	1.2	1.3	1.5	1.5	1.3	0.1	4
Black Liquor	0.28	0.31	0.37	0.42	0.46	0.0	66
Ethanol	275	290	270	267	269	17	-2
TOTAL	**1,892**	**1,841**	**1,714**	**1,639**	**1,596**	**100**	**-16**

Table 3.1.16 shows that emissions are well distributed between fossil fuels (48%) and biomass sources (52%) and that emissions from both sources declined over the 1990-1994 period: fossil sources (-21%) and biomass sources (-10%).

The main fuel in terms of NMVOC emissions in 1994 was gasoline (36%), followed by firewood (32%), and ethanol (17%). The sharp reduction in emissions over the period is due to the decline in emissions from gasoline in the road transportation sector because of the technological changes that were introduced in the Brazilian road fleet.

Table 3.1.17 - NMVOC emissions by sector - 1990 to 1994

Sector	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Energy Sector	**342**	**304**	**280**	**294**	**298**	**18.7**	**-13**
Public Electricity	0.35	0.40	0.45	0.39	0.43	0.0	22
Autoproducers	1.7	1.8	2.0	2.1	2.0	0.1	13
Charcoal Production	325	285	262	276	279	17.5	-14
Consumption Energy Sector	15	17	16	15	17	1.1	12
Residential	**206**	**205**	**206**	**180**	**175**	**11.0**	**-15**
Commercial	**3.3**	**3.1**	**3.0**	**2.9**	**2.7**	**0.2**	**-19**
Public Sector	**0.10**	**0.10**	**0.07**	**0.10**	**0.17**	**0.0**	**71**
Agriculture	**56**	**54**	**50**	**49**	**48**	**3.0**	**-14**
Transport	**1,232**	**1,225**	**1,127**	**1,063**	**1,017**	**63.7**	**-17**
Aviation	4.6	4.8	4.5	4.7	4.9	0.3	7
Road	1,214	1,207	1,109	1,043	999	62.6	-18
Railways	4.4	4.4	4.5	4.6	3.4	0.2	-21
Navigation	9.1	8.7	9.1	10	9.4	0.6	3
Industrial	**51**	**49**	**49**	**51**	**55**	**3.4**	**7**
Cement	2.2	2.0	1.5	1.5	1.7	0.1	-25
Pig Iron and Steel	22	20	19	21	21	1.3	-3
Ferroalloys	1.5	2.1	1.8	2.2	1.9	0.1	22
Mining and Pelletization	0.3	0.36	0.36	0.24	0.28	0.0	-18
Non-Ferrous Metals	1.4	1.1	1.1	0.86	0.89	0.1	-34
Chemicals	1.3	1.3	1.3	1.3	1.3	0.1	-1
Food and Beverage	14	14	16	16	19	1.2	35
Textiles	0.45	0.43	0.32	0.33	0.32	0.0	-29
Pulp and Paper	2.8	2.7	3.1	3.1	3.3	0.2	17
Brick Making	3.6	3.5	3.2	3.4	3.5	0.2	-3
Others	1.8	1.8	1.5	1.6	1.6	0.1	-11
TOTAL	**1,892**	**1,841**	**1,714**	**1,639**	**1,596**	**100**	**-16**

In terms of sectoral emissions in 1994 (Table 3.1.17), the transport sector had the highest emissions of NMVOC (64%), with the road mode predominating (63%), followed by the energy sector (19%), led by charcoal production (17%), and the residential sector (11%). The three highest emitting sectors reduced their NMVOC emissions during the 1990-1994 period.

Taking into account the three variables — equipment, fuel, and sector — the principal sources of NMVOC emissions are gasoline vehicles (36%), firewood consumed in charcoal production (17%), ethanol powered road vehicles (17%), wood furnaces in the residential sector (11%), and diesel oil powered road vehicles (10%).

3.1.3 Fugitive emissions

3.1.3.1 Fugitive emissions from coal mining

This section presents the estimates of greenhouse gas emissions from the coal industry for the 1990-1994 period.

The estimates include fugitive emissions of CH_4 from surface and underground mines as well as CO_2 emissions from coal deposits and waste piles.

Coal originates from burial and decomposition of vegetable matter. After being buried and compacted in deposits basins these materials gradually undergo an enrichment in the carbon content. The degree of carbonification, among other characteristics of these fuels, is defined by external factors, such as pressure, temperature, tectonics, and time of exposure.

The coal formation process involves the generation of CH_4, which is released to the atmosphere in the mining process. The quantity of CH_4 emissions during mining is primarily a function of coal characteristics, depth, gas content, and mining method. CO_2 emissions can also occur as a consequence of coal burning in deposits and waste piles.

The characteristics of Brazilian coal are very different from most coals of other countries. Brazilian coal has low calorific power and high ash content. Consumption though is only feasible close to coal production areas. Coal production in Brazil concentrates on the three Southern states: Paraná, Santa Catarina, and Rio Grande do Sul.

Two types of coal are produced in Brazil: the steam coal, used industrially in the generation of steam and energy, and coking coal that is used in the steel industry. Most of the metallurgical coking coal used in the country is imported.

Total coal production in 1994, according to the Brazilian Coal Industry Extraction Union - SNIEC, amounted to 9.7 million tonnes, with 59% of the coal production coming from underground mines and 41% from surface mines, as shown in Table 3.1.18.

Table 3.1.18 - Production of run-of-mine coal - 1990 to 1994

Type of Mine	1990	1991	1992	1993	1994	Share	Variation 90/94
			(10^3 t)			(%)	(%)
Underground Mines	6,341	7,142	5,923	6,112	5,671	59	-10.6
Surface Mines	3,912	3,479	3,502	3,470	4,021	41	2.8
TOTAL	**10,253**	**10,621**	**9,425**	**9,583**	**9,692**	**100**	**-5.5**

Source: DNPM, 1995.

Methane emissions

This Inventory used the IPCC Tier 2 approach "Basin Specific Method", based on information obtained from production data and emission factors assessed by specialists, by mine.

Total CH_4 emissions in 1990 were estimated to be 59 Gg, decreasing to 53 Gg in 1994, as shown in Table 3.1.19. Underground mining accounted for 89% of this total, while surface mines were responsible for 2% of the emissions and post-mining activities for 9%. The drop in emissions (10%) in the 1990-1994 period was due mainly to the reduction in underground mining activity (-11%). During this period, a maximum of emissions was verified in 1991.

Table 3.1.19 - CH_4 emissions from coal mines - 1990 to 1994

Type of Mine	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
			Mining				
Underground Mines	52.8	60.4	49.7	50.9	47.3	88.9	- 10.4
Surface Mines	0.98	0.83	0.87	0.87	1.0	1.9	2.0
Total	**53.8**	**61.2**	**50.5**	**51.8**	**48.3**	**90.8**	**-10.2**
			Post-Mining				
Underground Mines	5.44	6.29	5.13	5.23	4.85	9.1	-10.8
Surface Mines	0.07	0.06	0.06	0.06	0.07	0.1	-
Total	**5.51**	**6.35**	**5.20**	**5.29**	**4.92**	**9.2**	**-10.7**
TOTAL EMISSIONS	**59.3**	**67.6**	**55.7**	**57.1**	**53.2**	**100**	**-10.3**

Carbon dioxide emissions

The carbon contained in coal can be converted into CO_2 emissions from spontaneous combustion in storage and tailings piles. It is considered in this Inventory that all the run-of-mine coal extracted was processed, producing washed coal and tailings. For the estimation of CO_2 emissions from spontaneous combustion in tailings piles, the quantity of tailings was estimated by the company records for mass balance and average carbon content of the run-of-mine and washed coal. In this estimation, the run-of-mine was considered as a product, not remaining in the mine but rather being immediately beneficiated or sold. It was also assumed that all carbon content in run-of-mine was transferred to the washed coal and tailings. The losses in the process were considered to be tailings. To estimate CO_2 emissions, an oxidation fraction of 50% for waste piles was used.

Carbon dioxide emissions from coal deposits and waste piles were estimated at 1,653 Gg in 1990, declining to 1,355 Gg in 1994.

Table 3.1.20 - CO_2 emissions from coal mines - 1990 to 1994

CO_2	1990	1991	1992 (Gg)	1993	1994	Variation 90/94 (%)
TOTAL	**1,653**	**1,690**	**1,338**	**1,350**	**1,355**	**-18**

3.1.3.2 Fugitive emissions from oil and natural gas

This category includes emissions from the production, processing, transport, and consumption of oil and natural gas, and non-productive combustion. It excludes the use of oil, natural gas, and their products for energy supply to the domestic market, energy production processes, and transportation, which are considered fuel combustion and accounted for in section 3.1.2. It includes, however, emissions resulting from combustion of natural gas during flaring operations.

Table 3.1.21 shows emissions estimated with the use of IPCC emission factors. CH_4 emissions include those released during oil and natural gas production (venting), transportation, refining, and storage. CO_2 emissions are those related with flaring activities.

Table 3.1.21 - Fugitive emissions from oil and natural gas - 1990 to 1994

Fugitive Emissions	1990	1991	1992 (Gg)	1993	1994	Variation 90/94 (%)
			CO_2			
TOTAL CO_2	**3,728**	**3,647**	**3,223**	**3,593**	**3,741**	**0.3**
			CH_4			
Transportation	**2.87**	**2.76**	**2.91**	**3.05**	**2.82**	**- 1.7**
Refineries/Storage	**1.98**	**1.92**	**1.98**	**1.99**	**2.13**	**7.6**
Venting and Flaring	**42.61**	**43.98**	**46.65**	**48.92**	**49.51**	**16.2**
Oil	6.53	6.46	6.52	6.67	6.92	6.0
Natural Gas	2.71	3.04	2.98	3.28	4.31	59.0
Gas and Oil Combined	33.37	34.48	37.15	38.97	38.28	14.7
TOTAL CH_4	**47.46**	**48.66**	**51.54**	**53.96**	**54.46**	**14.7**

Industrial Processes

3.2 Industrial Processes

The industrial sector is responsible for a part of CO_2 emissions from fossil fuel combustion. In addition to such emissions, which are included in section 3.1.2, referring to the Energy sector, some industries generate greenhouse gases as a byproduct of their production processes.

The principal industrial processes in terms of CO_2 emissions in Brazil are cement production, lime production, aluminum production, and ammonia production. N_2O emissions occur mainly in the adipic acid production process. During aluminum production, PFC emissions (CF_4 and C_2F_6) can also occur. HFC emissions occur during HFC use in the refrigeration sector and in the production of HCFC-22. During aluminum production, there are also CO emissions. The main NO_x emitting process is the pulp and paper production. The food and beverage subsector is responsible for the great majority of NMVOC emissions from industrial processes.

3.2.1 Mineral products

3.2.1.1 Cement production

In 1994, Brazil ranked eleventh in cement production in the world, with 1.9% of global production. Cement is produced in many states of Brazil. In 1994, the state of Minas Gerais was the largest producer (24%), the state of São Paulo held second place (20%), followed by Paraná (9%) and Rio de Janeiro (8%).

Portland cement is basically a mixture of clinker and gypsum. Clinker is produced through the calcination of limestone, a process that generates CO_2 emissions. In 1994, cement production amounted to 25 million tonnes and clinker production, 18 million tonnes. Table 3.2.1 shows data for the 1990-1994 period.

Table 3.2.1 - Cement production - 1990 to 1994

Product	1990	1991	1992	1993	1994	Variation 90/94
			(10^6 t)			(%)
Clinker	20.16	21.46	17.75	18.41	18.41	- 8.7
Cement	25.85	27.49	23.90	24.84	25.23	- 2.4

Source: National Association of Cement Producers - SNIC.

Around 90% of Brazilian cement is mixed with other components, which results in a much lower clinker content in cement (73%), as compared to the world average. IPCC default value for clinker content is 98%.

For this reason, CO_2 emissions in the cement industry were estimated based on clinker production rather than cement production. IPCC default value of 0.5071 t CO_2/t clinker was used, and a total of 9.3 Tg CO_2 in 1994 was obtained, as shown in Table 3.2.2.

Table 3.2.2 - Emissions from cement production - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CO_2	10,224	10,881	9,000	9,334	9,337	-8.7

3.2.1.2 Lime production

Lime production process consists in the thermal decomposition (calcination) of the calcium carbonate contained in limestone ($CaCO_3$) and dolomite ($CaCO_3 \cdot MgCO_3$), with the production of calcitic or quicklime (CaO) and dolomitic lime (CaO·MgO), as well as CO_2 emissions.

In 1994, Brazil was the seventh largest producer of lime in the world. Table 3.2.3 shows the production of lime and hydrated lime ($Ca(OH)_2$ or $Ca(OH)_2 \cdot Mg(OH)_2$) for the 1990-1994 period.

Table 3.2.3 - Lime production

Product	1990	1991	1992	1993	1994	Variation 90/94
			(10^6 t)			(%)
Lime	3.47	3.45	3.77	4.05	3.90	12
Hydrated Lime	1.43	1.55	1.47	1.58	1.52	7
Total	**4.90**	**5.00**	**5.24**	**5.63**	**5.42**	**11**

Sources: DNPM, 1995 and 1997;
Brazilian Association of Lime Producers - ABRACAL.

CO_2 emissions resulting from the lime production process were estimated at 3.7 Tg in 1990 and 4.2 Tg in 1994, an increase of 11% in the period, as shown in Table 3.2.4.

Table 3.2.4 - Emissions from lime production - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CO_2	3,743	3,807	4,009	4,312	4,152	10.9

3.2.1.3 Production and consumption of soda ash

Soda ash (sodium carbonate, Na_2CO_3) is consumed in a wide variety of industries, including the manufacture of glass, soaps, and detergents, pulp and paper production, and water treatment. Carbon dioxide is emitted in the use of soda ash, and can be emitted during its production, depending on the industrial process used to produce it.

Four different processes can be used commercially to produce soda ash. Three of them are referred to as natural processes and use trona as the basic raw material. The forth, called the Solvay process, is classified as a synthetic process. The natural processes are the only ones that are known to produce CO_2 emissions during soda ash production. All Brazilian production is carried out using the synthetic process, and thus no net emissions are produced.

Carbon dioxide is also emitted when soda ash is consumed in industry. Data on Brazilian soda ash production, imports, and exports are presented in Table 3.2.5. Soda ash consumption totaled 439 thousand tonnes in 1990, reaching 451 thousand tonnes in 1994.

Table 3.2.5 - Data on soda ash consumption - 1990 to 1994

	1990	1991	1992	1993	1994	Variation 90/94
			(10^3 t)			(%)
Production	195.89	207.61	220.60	231.39	219.47	12
Imports	242.79	253.61	179.78	218.95	231.83	- 5
Exports	0.00	0.00	0.00	0.01	0.26	-
Net Consumption	438.68	461.22	400.38	450.33	451.04	3

Source: ABIQUIM, 1997.

Estimations of CO_2 emissions were based on the IPCC default emission factor and totaled 182 Gg in 1990, reaching 187 Gg in 1994, as shown in Table 3.2.6.

Table 3.2.6 - Emissions from soda ash consumption - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CO_2	182.1	191.4	162.3	186.9	187.2	2.8

3.2.2 Chemical industry

3.2.2.1 Ammonia production

Ammonia (NH_3) is produced by catalytic steam reforming of natural gas. The manufacture process produces CO_2 emissions, which depends on the quantity and composition of the natural gas used in the process. Such emissions can also be estimated based on total ammonia production.

After a significant drop of 12% in 1991, ammonia production reached 1990 levels in 1993, totaling 1.2 million tonnes in 1994, as shown in Table 3.2.7.

Table 3.2.7 - Ammonia production - 1990 to 1994

Product	1990	1991	1992	1993	1994	Variation 90/94
			(10^3 t)			(%)
Ammonia	1,153	1,012	1,038	1,153	1,157	0.4

Source: ABIQUIM, 1995 and 1997.

In the assessment of emissions, a country-specific factor of 1.125 t CO_2/t ammonia was used, related to the technology used, according to the Brazilian Chemical Industry Association - ABIQUIM. Emissions in 1994 were estimated at 1.3 Tg CO_2, as shown in Table 3.2.8.

Table 3.2.8 - Emissions from ammonia production - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CO_2	1,297	1,139	1,168	1,298	1,301	0.4

3.2.2.2 Nitric acid production

Nitric acid is used as a raw material mainly in the manufacture of nitrogenous-based fertilizers. It may also be used in the production of adipic acid and explosives, for metal etching, and in the processing of ferrous metals.

The production of nitric acid generates N_2O as a by-product of the high temperature catalytic oxidation of ammonia. There can also be NO_x emissions besides those from combustion.

Nitric acid production totaled 554 thousand tonnes in 1994, with an increase of 43% in relation to 1990, as shown in Table 3.2.9.

Table 3.2.9 - Nitric acid production - 1990 to 1994

Product	1990	1991	1992	1993	1994	Variation 90/94
			(10^3 t)			(%)
Nitric Acid	386.89	404.82	398.61	416.79	554.26	43

Source: ABIQUIM, 1995 and 1997.

In order to estimate N_2O and NO_x emissions, country-specific emission factors were used: 1 kg N_2O and 1.75 kg NO_x per tonne of nitric acid produced, respectively, according to the technologies employed. These values were obtained from ABIQUIM. Emissions were estimated at 0.55 Gg N_2O and 0.97 Gg NO_x in 1994, as shown in Table 3.2.10.

Table 3.2.10 - Emissions from nitric acid production - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
N_2O	0.39	0.40	0.40	0.42	0.55	43
NO_x	0.68	0.71	0.70	0.73	0.97	43

3.2.2.3 Adipic acid production

Adipic acid is used in the manufacture of a large number of products including synthetic fibers, coatings, plastics, urethane foams, elastomers and synthetic lubricants. One of the stages of adipic acid production involves an oxidation by nitric acid, which generates N_2O as a by-product. Adipc acid production also results in the emissions of CO and NO_x.

In 1994, adipic acid production totaled 52 thousand tonnes, an increase of 62% in relation to 1990, as shown in Table 3.2.11.

Table 3.2.11 - Adipic acid production - 1990 to 1994

Product	1990	1991	1992	1993	1994	Variation 90/94
			(10^3 t)			(%)
Adipic Acid	31,95	41,68	38,54	51,26	51,82	62

Source: ABIQUIM, 1995 and 1997.

N_2O, CO, and NO_x emissions were estimated with the use of country-specific emission factors: 250 kg N_2O, 16 kg CO, and 5 kg NO_x per tonne of nitric acid produced, respectively, according to the technologies employed. These values were obtained from ABIQUIM. Emissions were estimated at 13 Gg N_2O, 0.83 Gg CO, and 0.26 Gg NO_x in 1994, as shown in Table 3.2.12.

Table 3.2.12 - Emissions from adipic acid production - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
N_2O	7.99	10.42	9.64	12.82	12.96	62
CO	0.51	0.67	0.62	0.82	0.83	62
NO_x	0.16	0.21	0.19	0.26	0.26	62

3.2.2.4 Production of other chemicals

Production of other chemicals may result in greenhouse gas emissions, especially of NMVOC. Such emissions depend directly on industrial processes and operating conditions.

Table 3.2.13 shows the annual production of other chemicals in the 1990-1994 period.

Table 3.2.13 - Production of other chemicals - 1990 to 1994

Product	1990	1991	1992	1993	1994	Variation 90/94
			(t)			(%)
Acrylonitrile Butadiene Styrene (ABS)	27,000	26,300	28,300	32,000	32,100	19
Acrylonitrile	78,000	63,470	74,159	74,258	76,522	-2
Phthalic anhydride	65,645	77,364	77,210	76,037	91,390	39
Styrene Butadiene Rubber (SBR)	184,692	188,639	196,400	191,623	209,409	13
Caprolactam	42,059	47,193	41,699	50,824	50,838	21
Monomer Vinyl Chloride (MVC)	480,415	331,897	333,782	381,824	409,757	-15
Dichloroethane	538,183	369,538	420,540	495,139	499,934	-7
Styrene	306,217	279,963	253,605	223,413	261,613	-15
Ethylene	1,499,714	1,448,812	1,505,573	1,709,460	1,895,754	26
Ethylbenzene	441,007	314,440	286,812	237,793	345,514	-22
Formaldehyde	177,391	194,594	206,421	244,942	261,775	48
Carbon black	178,395	182,567	186,422	197,248	204,301	15
Polyvinyl chloride (PVC)	504,330	500,264	488,940	510,794	593,413	18
Polystyrene	134,332	154,718	136,572	163,356	153,641	14
HDPE Polyethylene	322,219	339,233	311,100	429,565	478,549	49
LDPE Polyethylene	626,028	585,374	570,475	609,139	609,248	-3
LLDPE Polyethylene	-	-	-	103,610	133,433	-
Polypropylene	303,841	356,319	374,992	478,288	521,540	72
Propylene	793,544	779,224	826,543	974,982	1,086,330	37

Source: ABIQUIM, 1995 and 1997.

IPCC default emission factors were used for other chemical products, with the exceptions indicated in Table 3.2.14. The corresponding Brazilian emissions are shown in Table 3.2.15.

Table 3.2.14 - Emission factors for other chemical products - 1990 to 1994

Product	CH_4	N_2O	NO_X	NMVOC
	(kg/t)			
Acrylonitrile Butadiene Styrene (ABS)				27.2
Acrylonitrile				1
Phthalic anhydride *				1.3
Styrene Butadiene Rubber (SBR)**				5.8
Caprolactam **		0.35		
Monomer Vinyl Chloride (MVC)**				8.5
Dichloroethane				2.2
Styrene	4			18
Ethylene	1			1.4
Ethylbenzene				2
Formaldehyde				5
Carbon black **			0.14	
Polyvinyl chloride (PVC)*				1.5
Polystyrene *				3.3
HDPE Polyethylene				6.4
LDPE Polyethylene				3
LLDPE Polyethylene				2
Polypropylene				12
Propylene				1.4

* Source: CORINAIR, 1996.
** Source: GRUMAN *et al,* 2002.

Table 3.2.15 - Total emissions from production of other chemicals - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CH_4	2.73	2.57	2.52	2.60	2.94	8
N_2O	0.015	0.017	0.015	0.018	0.018	20
NO_x	0.025	0.026	0.026	0.028	0.029	16
NMVOC	26.5	24.8	24.7	27.8	30.6	15

3.2.3 Metallurgical industry

3.2.3.1 Iron and steel production

In 1994 Brazil was in eighth place in the global ranking with a production of 25.7 million tonnes, which represented around 4% of the global steel production, as shown in Table 3.2.16.

Table 3.2.16 - Raw steel production

	1970	1980	1990	1994	Variation 90/94
		(10^6 t)			(%)
Global	595.4	715.6	770.5	725.2	-6
Latin America	13.2	28.9	38.2	46.0	20
Brazil	5.4	15.3	20.6	25.7	25
Brazilian share of global	1%	2%	3%	4%	
Brazilian share of Latin America	41%	53%	54%	56%	
Ranking of Brazil in the world	18th	10 th	9 th	8 th	

Sources: International Iron & Steel Institute - IISI;
Latin American Iron and Steel Institute - ILAFA;
Brazilian Iron and Steel Institute - IBS.

In Latin America, Brazil is the largest producer of steel (56% of production in 1994).

The Brazilian industry has 11 integrated and 15 semi-integrated plants, administered by 15 companies. Around 80% of the Brazilian raw steel production comes from the integrated plants.

The steel plant uses mainly metallurgical coke and charcoal to generate energy and as reducing agent for the iron ore (the latter in the case of integrated plants, where around 70% of pig iron production uses coke as a reducing agent and the remaining uses charcoal). Later, some of the carbon is incorporated into the products and the major part is emitted to the atmosphere in the form of CO_2.

To estimate CO_2 emissions, it is important to distinguish between the fuel consumed in the chemical process and the fuel necessary to generate energy.

According to the International Iron and Steel Institute - IISI, the pig iron production process (coke oven, sintering/pelletization, and blast furnace) consumes 60-70% of the total energy consumed in integrated plants, principally due to the use of coke as a reducing agent in the transformation of iron ore into pig iron.

Along with metallurgical coke and charcoal, other fuels, such as diesel oil, fuel oil, LPG, and natural gas, may be used both for combustion and iron ore reduction in the steel production process.

The semi-integrated plants do not have the reduction phase, and as a result, consume carbon principally for energy uses.

In this Inventory, information on fuel consumption was obtained from the Brazilian Energy Balance (MME, 1998), so it was not possible to distinguish between emissions from combustion and emissions from iron ore reduction. For this reason, total emissions were estimated in the Energy sector (section 3.1).

3.2.3.2 Ferroalloy production

Ferroalloy is a term used to describe concentrated alloys of iron and one or more metals, such as silicon, manganese, chromium, molybdenum, vanadium, and tungsten. Such alloys are used to deoxidize and alter the physical properties of steel. Ferroalloy plants produce concentrated compounds that are sent to steel production plants to be incorporated in alloy steels. Ferroalloy production involves a metallurgical reduction process wich results in CO_2 emissions.

In ferroalloys production, raw ore, coke, and slag are melted together at a high temperature. During fusing of the ferroalloys, the reduction reaction occurs at high temperatures. Carbon captures the oxygen from the metal oxides to form CO_2, while the minerals are reduced to basic molten metals. As a result, the component metals combine in the solution.

The most accurate methodology is to estimate emissions based on the amounts of reducing agent used. The emissions can also be estimated based on production volume. The IPCC suggests default values assuming the use of only fossil carbon.

Data on Brazilian production by type of alloy are shown in Table 3.2.17.

Table 3.2.17 - Ferroalloys production

Type of Alloy	1990	1991	1992	1993	1994	Variation 90/94
			(10³ t)			(%)
Ferro-silicon (50% Si)	5.47	5.49	4.62	5.34	3.06	-44
Ferro-silicon (75% Si)	223.94	185.38	239.22	233.53	195.45	-13
Metallic silicon	131.61	106.00	93.73	90.38	90.02	-32
Manganese-based ferroalloys	170.50	169.10	178.94	201.52	199.67	17
Manganese silicon	216.78	272.05	300.00	284.15	248.16	14
Ferrochromium	83.75	82.22	91.10	83.89	77.16	-8
Ferrochromium-silicon	4.97	4.52	6.76	4.13	7.74	56
Other	102.25	110.52	104.18	117.23	115.11	13
TOTAL	**939.28**	**935.28**	**1,018.55**	**1,020.16**	**936.35**	**- 0.3**

Source: ABRAFE, 1996.

In Brazil, ferroalloys production uses predominantly charcoal, as shown in Table 3.2.18.

Table 3.2.18 - Brazilian production of ferroalloys using charcoal - 1990 to 1994

	1990	1991	1992	1993	1994	Variation 90/94
			(10³ t)			(%)
Total production	939.28	935.28	1,018.55	1,020.16	936.35	-0.3
Production using charcoal	911.10	907.22	998.18	999.76	908.26	-0.3
Share of production using charcoal	97%	97%	98%	98%	97%	

Sources: ABRAFE, 1996; ABRACAVE, 1996.

Based on this information, it is possible to estimate the fraction of ferroalloys production that uses coal and coke, and thus emits CO_2 that must be accounted for. In this Inventory, however, because it was not possible to separate combustion emissions from iron ore reduction emissions, all emissions were estimated jointly in the Energy sector (section 3.1).

3.2.3.3 Aluminum production

Brazil has the world's third largest reserve of bauxite. This fact, along with its extensive hydroelectric potential, favorable geographic conditions, and the Brazilian industrial tradition in the area of metallurgy, places Brazil in sixth place in terms of primary aluminum production in the world. In 1994, 1.2 million tonnes of primary aluminum were produced, representing 6% of the world production. Table 3.2.19 shows data on production, imports, and exports of aluminum in Brazil.

Table 3.2.19 - Production, imports, and exports of aluminum - 1990 to 1994

Production, imports and exports of aluminum		1990	1991	1992	1993	1994	Variation 90/94
				(10³ t)			(%)
Primary aluminum production (by technology)	Soderberg	378.9	407.4	409.3	385.5	384.7	2
	Prebaked Anode	551.7	732.2	784.0	786.5	799.9	45
	Total	930.6	1,139.6	1,193.3	1,172.0	1,184.7	27
Imports (primary metals, alloys, and manufactured goods)		16.1	19.6	19.7	32.6	55.0	242
Exports (primary metals, alloys, and manufactured goods)		639.4	829.5	872.6	873.0	876.1	37

Source: Brazilian Aluminum Association - ABAL.

Primary aluminum is produced through a process of electrolytic reduction. The reaction occurs in a carbon container, which acts as a cathode and contains the electrolytic solution. The carbon anode is partially submerged in the solution and consumed during the process.

Electrolysis of aluminum oxide produces molten aluminum, which is deposited on the cathode, and oxygen, which is deposited on the anode and reacts with the carbon to produce CO_2. Some CO_2 is also formed as the anode reacts with other sources of oxygen (especially air). The primary aluminum production process can use two principal types of technology, Soderberg and Prebake Anode, with the difference being the type of anode used.

The methodology recommended by the IPCC to estimate CO_2 emissions resulting from aluminum production consists of multiplying the amount of aluminum produced by an emission factor corresponding to the technology used: 1.8 t CO_2/t Al, for the Soderberg technology, and 1.5 t CO_2/t Al, for the Prebaked Anode technology.

The aluminum industry emits mainly PFC gases, which are produced occasionally when it is not possible to adequately control the ratio between substances in the electrolytic cell, during primary aluminum production. This is an undesirable situation also for industry, because it causes a drop in productivity.

In primary aluminum production, the alumina (Al_2O_3) is dissolved in molten fluoride, consisting principally of cryolite (Na_3AlF_6). When an electrolytic cell for producing aluminum is operating normally, measurements show that there is no production of PFCs. But if the aluminum oxide contained in the solution is much diluted, below 1.5%, there is a rapid increase in voltage (the "anode effect") and the solution comes to participate in the reaction, reacting with the carbon to produce PFCs, and the following reactions occur:

$$Na_3AlF_6 + \tfrac{3}{4}C \longrightarrow Al + 3NaF + \tfrac{3}{4}CF_4$$

$$Na_3AlF_6 + C \longrightarrow Al + 3NaF + \tfrac{1}{2}C_2F_6$$

Therefore, PFC emissions during the anode effect depend on its frequency and duration.

Since emissions of CF_4 and C_2F_6 vary depending on the type of technology used, the emission factors must be chosen according to the technology and applied to Brazilian production of primary aluminum.

CF_4 and C_2F_6 emissions were reported by the companies themselves and were estimated using the Tabereaux methodology or the Fourier transform infrared spectrometer method. The emission factors were estimated by the companies as of 1994 and are shown in Table 3.2.20. Emissions for the years 1990 through 1993 were estimated using the 1994 emission factors.

Table 3.2.20 - Emission factors of PFCs for Brazil in 1994

Technology	CF_4	C_2F_6
	(kg/t aluminum produced)	
Soderberg	0.46	0.046
Prebaked Anode	0.21	0.021

Source: Brazilian Aluminum Association - ABAL.

The aluminum production also generates emissions of CO and NO_x, which can be estimated using emission factors provided by the IPCC.

The emissions from anode baking only occur in the Prebaked Anode process, where the anodes are prepared in advance.

CO_2 emissions from aluminum production were estimated at 1.9 Tg in 1994. PFC emissions were estimated at 0.34 Gg CF_4 and 0.034 Gg C_2F_6. Table 3.2.21 presents the emission estimates for the 1990 to 1994 period.

Table 3.2.21 - Total emissions from aluminum production - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CO_2	1,510	1,832	1,913	1,874	1,892	25
CF_4	0.290	0.341	0.352	0.342	0.345	19
C_2F_6	0.029	0.034	0.035	0.034	0.034	19
NO_X	2.00	2.45	2.57	2.52	2.55	28
CO	346	447	475	473	480	39

3.2.4 Pulp and paper

The Pulp and Paper sector is made up of 220 companies that operate 255 industrial units located in 16 Brazilian states.

The sector has 1.4 million hectares of its own planted forests, mainly Eucalyptus (62%) and Pinus (35%). Pulp is produced exclusively from wood from planted forests.

The preparation of chemical pulp for paper and other ends involves the separation of the fibers from other wood component, especially lignin, which gives the wood rigidity.

Some types of wood, such as pine and araucaria, have long fibers (3-5 mm), while eucalyptus wood has shorter and thinner fibers (0.8-1.2 mm). The first are called conifers or softwood, while the second are known as broadleaf or hardwoods.

There are many processes for preparation of wood pulp, ranging from purely mechanical to chemical, where wood is treated with chemical products, pressure and heat (higher than 150ºC) to dissolve the lignin. Only the chemical processes generate greenhouse gas emissions.

Pulp and paper production has three principal phases: pulping, bleaching, and paper production. The type of pulping and the amount of bleaching used depend on the nature of the raw material and the desired quality of the final product. Kraft pulping is the most widely used.

The most widely used process in Brazil is Sulfate, a variation of the Kraft process. It uses the same chemical products as Kraft but larger amounts of sulfide and soda, and cooking is carried for a longer period and at higher temperatures. It is considered the most suitable for obtaining chemical pulps from eucalyptus. During this process there are emissions of CO, NO_x, and NMVOC.

Table 3.2.22 shows the Brazilian pulp production for each year in the 1990-1994 period, by type of production process.

Table 3.2.22 - Brazilian pulp production by type of production process

Type of pulp/chemical process	1990	1991	1992	1993	1994
			(t)		
Chemical Pulp	**3,843,747**	**4,275,509**	**4,795,270**	**4,958,204**	**5,342,744**
Sulfate	3,593,547	4,018,086	4,512,600	4,723,283	5,127,981
Soda	218,989	225,286	252,447	210,287	188,304
Sulfite	22,386	22,153	21,956	16,448	19,331
Lime	8,825	9,984	8,267	8,186	7,128
Semi-Chemical Pulp	**70,941**	**71,011**	**75,297**	**51,984**	**33,527**
Neutral Sulfite	10,281	12,759	10,498	10,196	3,522
Soda	45,083	40,856	48,377	28,898	27,225
Lime	15,577	17,396	16,422	12,890	2,780
High Yield Pulp	**436,455**	**431,596**	**431,777**	**460,742**	**452,599**
Mechanical	338,161	331,146	312,714	316,185	307,663
Chemo-Mechanical	6,748	5,526	7,676	8,772	6,415
Thermo- Mechanical	88,564	93,465	80,560	82,452	89,722
Chemo-Thermo-Mechanical	2,982	1,459	30,827	53,333	48,799
TOTAL	**4,351,143**	**4,778,116**	**5,302,344**	**5,470,930**	**5,828,870**

Source: Brazilian Pulp and Paper Association - BRACELPA.

In this Inventory, the emission factors provided by the IPCC for the Kraft process were used for the Sulfate process, which is responsible for 88% of the production in 1994. There is no information available about emissions from the other processes. The greenhouse gas emissions in the sector are presented in Table 3.2.23.

Table 3.2.24 - Brazilian food production - 1990 to 1994

Product	1990	1991	1992	1993	1994	Variation 90/94
			(10^3 t)			(%)
Meat, fish, and poultry	7,010	7,635	7,981	8,511	8,821	26
Sugar	9,342	9,607	10,647	10,164	10,372	11
Margarines and solid fats for cooking	356	336	314	304	366	3
Cakes, biscuits, and breakfast cereals	580	676	600	665	742	28
Breads	3,548	3,612	3,587	3,587	3,712	5
Animal feed	8,258	8,613	8,639	8,998	9,832	19
Coffee roasting	394	408	427	437	446	13

Source: Brazilian Food Industry Association - ABIA.

Table 3.2.23 - Emissions from pulp production in Brazil - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CO	20.12	22.50	25.27	26.45	28.72	43
NO_x	5.39	6.03	6.77	7.08	7.69	43
NMVOC	13.30	14.87	16.70	17.48	18.97	43

3.2.5 Food and beverage

In the industrial process of food and in the production of beverages there may be emissions of NMVOC. The IPCC provides emission factors for some subsectors. Because there was no additional information, such factors were used in this Inventory. Table 3.2.24 shows the Brazilian production for the food and beverage industries in the 1990-1994 period. Processes of vegetable oil extraction are included in the Solvent and Other Product Use sector (section 3.3).

In the production of alcoholic beverages there are emissions of NMVOC during the use of cereals and fruits in the fermentation process. To estimate such emissions, default emission factors provided by IPCC were also used. Table 3.2.25 presents the Brazilian production of beverages for the 1990-1994 period.

Table 3.2.25 - Brazilian production of beverages - 1990 to 1994

Product	1990	1991	1992	1993	1994	Variation 90/94
			(10^6 l)			(%)
Wine	309	293	277	261	245	-21
Beer	5,499	5,786	4,966	5,145	6,088	11
Distillates (*cachaça*)	1,125	1,080	1,035	1,080	1,035	-8

Sources: Brazilian Food Industry Association - ABIA;
Brazilian Wine and Grape Growers Union - UVIBRA;
Brazilian Beverage Association - ABRABE.

Emissions from the food and beverages sector are presented in Table 3.2.26 for the 1990-1994 period.

Table 3.2.26 - Emissions of NMVOC from production of food and beverages - 1990 to 1994

Sector	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
Food Industry	136.52	140.13	150.17	145.83	150.54	10
Beverage Industry	170.92	164.26	157.21	164.01	157.58	-8
Total	**307.44**	**304.39**	**307.38**	**309.84**	**308.12**	**0**

3.2.6 Emissions related to the production of hydrofluorocarbons

In Brazil, in the 1990-1994 period, there was no production of HFCs, but there were emissions of HFC-23 as a byproduct of the production of HCFC-22. Emissions were estimated with the use of the IPCC default emission factors, as shown in Table 3.2.27.

Table 3.2.27 - Emissions of HFC-23 from the production of HCFC-22 - 1990 to 1994

Product/by-product	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
Production of HCFC-22	3.01	3.44	4.09	4.31	3.92	30
Emissions of HFC-23	0.120	0.138	0.164	0.172	0.157	30

3.2.7 Emissions related to the consumption of hydrofluorocarbons

In refrigeration and air conditioning, HFCs are used as one of the principal alternatives to CFCs as refrigerant fluids. This was practically the only sector where HFCs were used in the 1990-1994 period.

In the plastic foam manufacturing industry, HFCs may be used as expansion agents both for rigid foams (insulation) and for flexible foams (structural), as substitutes for CFCs. However, in Brazil, between 1990 and 1994, there was no significant use of HFCs and thus no emissions in this sector. HFCs could also be used to replace CFCs for specific fire extinguishers, which, however, were not available in Brazil.

The IPCC methodology to estimate emissions from refrigerant fluids requires information such as inventory of equipment by type and amount of gas used and estimation of equipment losses, which to date are not available in Brazil. As the use of HFC in Brazil was very limited in the period, the simplified Tier 1 methodology was used, which allows an estimate of the potential emissions, according to the formula below:

Potential Emissions = Production + Imports - Exports - Destruction

In the Brazilian refrigeration and air conditioning sector, only in 1994 HFC started to be consumed significantly, with imports of 125 t of HFC-134a. There is no record of HFC production, exports or destruction in the 1990-1994 period.

Table 3.2.28 shows the estimates of emissions in HFC consumption.

Table 3.2.28 - Emissions in HFC consumption - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(t)			(%)
HFC-134a	-	-	-	-	125	-

3.2.8 Emissions related to the consumption of sulphur hexafluoride

SF_6, in view of its excellent properties as an inert insulator, being non-toxic, refrigerant, nonflammable, thermally stable, possessing a high dielectric strength and self-regeneration power, enabled the development of electrical equipment of high capacity and performance, in addition to being more compact, lighter and safer. Among the electrical equipment developed to be used with SF_6, the most important are circuit breakers and gas-insulated substations, which use only around 10% of the physical space of corresponding conventional substations.

In Brazil, there is no production of SF_6 but there are emissions because of leakage in SF_6 gas-insulated substations. A research carried out in the 1991-1993 period concluded that to a total amount of 207,553 kg installed, around 1,800 kg/year were released into the atmosphere because of leakage in those substations. As there is no other information available, this value was considered the annual emission estimate for the 1990-1994 period.

Table 3.2.29 shows the emission estimates for SF_6 consumption.

Table 3.2.29 - Emissions in SF_6 consumption - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(t)			(%)
SF_6	1.8	1.8	1.8	1.8	1.8	-

Solvent and Other Product Use

3.3 Solvent and Other Product Use

This section presents the emission series for NMVOC from the use of solvents in Brazil, for the period (1990-1994). In some sectors, emissions could also include CH_4, thus represented as VOCs (volatile organic compounds).

According to the CORINAIR (1996) methodology, the following activities are analyzed: application in paint, degreasing of metals, dry-cleaning, processing of polystyrene and polyurethane foams, printing industry, extraction of edible vegetable oils, domestic use, aeration of asphalt, and wood preservation.

It is worth to note two obstacles in the production of estimates: the reliability of statistical data, particularly with the required levels of disaggregation of information, and the lack of adequate emission factors for NMVOCs and the activities included in this sector.

Thus, to address a specific activity that could be relevant to Brazil, even in the absence of statistical information, this Inventory, as a first approximation, relied on per capita emission factors observed in a set of countries, applied to the economically active population of Brazil.

The data on domestic sales and imports of chemical products were taken from the ABIQUIM Yearbook (1995 and 1997). Table 3.3.1 shows the emissions of NMVOC and VOC from the different activities for the 1990-1994 period.

Table 3.3.2 - Brazilian automobile production - 1990 to 1994

Category	1990	1991	1992	1993	1994	Variation 90/94
	(1,000 vehicles)					(%)
Automobiles	**663.1**	**705.3**	**815.9**	**1,100.3**	**1,248.8**	**88**
Passenger	267.5	292.9	338.3	391.6	366.8	37
Mixed Use	395.6	412.4	477.6	708.7	882.0	123
Light commercial vehicles	**184.8**	**182.7**	**201.6**	**224.4**	**251.0**	**36**
Pickups/Mixed Use	17.3	12.0	16.1	25.5	39.0	125
Utility	1.8	1.7	0.4	0.3	0.2	-89
Cargo Pickups	165.7	169.0	185.1	198.6	211.8	28
Heavy commercial vehicles	**66.6**	**72.3**	**56.3**	**66.8**	**81.5**	**22**
Trucks	51.6	49.3	32.0	47.9	64.1	24
Buses	15.0	23.0	24.3	18.9	17.4	16

Source: ANFAVEA, 1997.

Table 3.3.3 shows the emission factors for painting of cars used in this Inventory.

Table 3.3.3 - Emission factors correlated to painted area

Type of automobile	Painted surface (m^2)	NMVOC emission factor (g/m^2)
Small car	65	203
Large car	117	277
Truck	171.5	120
Van	120	120
Bus	271.5	500

Source: CORINAIR, 1996.

Table 3.3.1 - Emissions of NMVOC and VOC by activity - 1990 to 1994

Gas Class	Activity	1990	1991	1992	1993	1994	Variation 90/94
		(Gg)					(%)
NMVOC	Application of paint	253.34	271.98	296.39	355.51	396.12	56
	Degreasing of metals	12.70	15.22	13.75	11.61	15.76	24
	Dry-cleaning	0.61	0.73	0.66	0.55	0.75	24
	Processing of foams	0.56	0.60	0.69	0.65	0.88	55
	Printing industry	39.76	42.07	44.31	46.62	47.67	20
VOC	Extraction of edible vegetable oils	13.67	11.56	13.06	14.85	16.59	21
	Domestic use	36.35	38.46	40.51	42.62	43.58	20
NMVOC + VOC	**TOTAL EMISSIONS**	**356.99**	**380.62**	**409.37**	**472.41**	**521.35**	**46**

3.3.1 Application in paint

This activity is disaggregated into four sub-activities: automobile production; building construction; domestic use; and other industrial applications.

3.3.1.1 Automobile production

The Brazilian automobile industry accounts for a significant share of the GNP and is an extensive user of paints.

The activity covers coating, including corrosion protection. The Brazilian automobile production statistics used to estimate emissions are presented in Table 3.3.2.

In order to make Table 3.3.2 and Table 3.3.3 compatible, passenger automobiles were considered small cars; mixed use automobiles were considered large cars; and all light commercial vehicles were considered vans. Table 3.3.5 shows NMVOC emissions for this sub-activity.

3.3.1.2 Construction and buildings

This sub-activity refers to the use of paints in construction uses by construction companies and professional painters. For estimating amounts of NMVOC emissions in this sub-activity, an average per capita emission factor of 1.2 kg/capita/year was used, along with the economically active population (EAP) in Brazil in the period 1990-1994. Table

3.3.5 presents estimates of NMVOC emissions from this sub-activity.

3.3.1.3 Domestic use

This sub-activity covers the use of paints in construction uses by individual consumers.

Similar to the previous sub-activity, the average emission factor of 0.73 kg/person/year, along with the values of economically active population (EAP), were used. Table 3.3.5 shows the NMVOC emissions for this sub-activity.

3.3.1.4 Other industrial applications

This sub-activity covers the use of paints in ship construction, in manufacture of metallic items, wood products, and production of plastic items.

To estimate emissions from this sub-activity, it was used the ratio between the contribution of this sub-activity to total NMVOC emissions and that of the sub-activity of automobile production in 28 countries. This ratio is presented in Table 3.3.4.

Table 3.3.4 - Ratio between NMVOC emissions from "Other Industrial Applications" and those from "Automobile Industry" in 28 countries

Sub-activity	Contribution to total NMVOC emissions
A – Automobile production	0.6 %
B – Other industrial applications	3.3 %
Ratio factor (B / A)	**5.5**

Table 3.3.5 shows the total emissions of NMVOC in the use of solvents in paints for the 1990-1994 period.

Table 3.3.5 - Emissions of NMVOC - application in paints - 1990 to 1994

Population / Emissions by sub-activity		1990	1991	1992	1993	1994	Variation 90/94 (%)
EAP (10^6 inhab.)		**56.8**	**60.1**	**63.3**	**66.6**	**68.1**	**20**
Emissions (Gg)	Automobile production	22.11	24.00	26.80	34.92	40.72	84
	Construction and buildings	68.16	72.12	75.96	79.92	81.72	20
	Domestic use	41.46	43.87	46.21	48.62	49.71	20
	Other industrial applications	121.61	131.99	147.42	192.05	223.96	84
	TOTAL EMISSIONS	**253.34**	**271.98**	**296.39**	**355.51**	**396.11**	**56**

3.3.2 Degreasing of metals

This activity involves removing dirt caused by agents such as grease, fats, oils, waxes, carbon deposits, on metals, plastics, fiberglass, printed circuits, and other surfaces, using principally chlorinated solvents.

Tetrachloroethylene (also called perchloroethylene - PERC), methylene chloride, trichloroethylene, 1,1,1-trichloroethane, and trichlorotrifluoroethane are indicated as the chlorinated chemicals most often used in this activity. Only imports of PERC were identified in the period 1990-1994.

Two of the products above were identified as being produced domestically (ABIQUIM, 1995 and 1997):

- 1,1,1-trichloroethane, produced until 1991, had its production discontinued as a result of the Montreal Protocol. It was not possible to obtain the destination of the product in the domestic market;
- perchloroethylene, regularly produced in Brazil, having 93% of its sales going to metal degreasing.

Thus, the estimate of NMVOC emissions for this activity was based on Brazilian consumption of perchloroethylene, according to Table 3.3.6. Considering that metal degreasing represents 93% of sales of PERC (ABIQUIM, 1997) and using the default emission factor of 1.0 kg of NMVOC/1.0 kg of solvent used (CORINAIR, 1996), the emission estimates presented in Table 3.3.1 were obtained.

Table 3.3.6 - Brazilian consumption of perchloroethylene - 1990 to 1994

	1990	1991	1992	1993	1994	Variation 90/94
			(10^3 t)			(%)
Domestic sales	13.66	15.35	14.30	11.26	11.63	-15
Imports	-	1.02	0.49	1.22	5.32	-
TOTAL CONSUMPTION	**13.66**	**16.37**	**14.79**	**12.48**	**16.95**	**24**

Source: ABIQUIM, 1995 and 1997.

3.3.3 Dry-cleaning

This activity involves cleaning of a variety of materials such as furs, leathers, textile, and fiber products, using principally chlorinated solvents. The principal solvent used in dry-cleaning is perchloroethylene. In order to quantify the use of this solvent in Brazil, it was used the same market share as in Europe, where PERC accounts for 90% of total solvent consumption under this activity (CORINAIR, 1996), because this input is produced locally. It was also considered that 4% of consumption of PERC went to drycleaners (ABIQUIM, 1997) and the emission factor used was 100% of the solvent used. Table 3.3.7 shows the consumption of solvents in dry-cleaning in the 1990-1994 period, resulting in the NMVOC emissions shown in Table 3.3.1.

Table 3.3.7 - Consumption of solvents - dry-cleaning - 1990 to 1994

	1990	1991	1992	1993	1994	Variation 90/94
			(10^3 t)			(%)
Total consumption of PERC	13.66	16.37	14.79	12.48	16.95	24
Consumption of PERC in drycleaners (4%)	0.55	0.65	0.59	0.50	0.68	24
Total consumption of solvents in drycleaners	0.61	0.73	0.66	0.55	0.75	24

Source: ABIQUIM, 1995 and 1997.

3.3.4 Processing of polystyrene foams

Production of foams occurs through the use of a blowing agent, which is pentane in the case of polystyrene foam, used principally in the insulation and packaging sectors. In flexible foams, water is used as a blowing agent.

According to CORINAIR (1996), 6% of the blowing agent is incorporated into foams before expansion. Thus, to quantify emissions of NMVOC in these activities, EPS foam production presented in Table 3.3.8 was used. NMVOC emissions are shown in Table 3.3.1.

Table 3.3.8 - EPS production - 1990 to 1994

Product	1990	1991	1992	1993	1994	Variation 90/94
			(10^3 t)			(%)
EPS	9.39	10.01	11.43	10.86	14.59	55

Source: ABIQUIM, 1995 and 1997.

3.3.5 Printing industry

The methodology proposed for quantification of NMVOC emissions in this activity requires historical series of ink consumption in the printing, publishing, packaging, and other sectors. As was done in other sectors, the average per capita emission factors from other countries associated with the economically active population were used.

An average emission factor of 0.7 kg/person/year was used. The NMVOC emissions for this activity are presented in Table 3.3.1

3.3.6 Extraction of edible vegetable oils

This activity involves the extraction, through solvents, of edible oils from oilseeds and grains. While in other countries solvents can sometimes be used in drying of residues from crushing of seeds/grains, this procedure is not used in Brazil.

According to the methodology (CORINAIR, 1996), the emission factor that indicates the release of VOC to the atmosphere is located within a broad range, going from 0.85 to 19 kg VOC/t of seeds/grains crushed. It is reasonable to suppose that such factors depend on variables such as technology, efficiency in emission controls, and the type of seed/grain processed. Since Brazil has a modern soybean processing industry, with an important exporting arm and modern technologies, the lower end of the range was adopted (0.85 kg VOC/t of seed/grain crushed).

Table 3.3.9 presents, for the period 1990-1994, data on the industry of edible oils contained in oilseeds/ grains. The corresponding VOC emissions are shown in Table 3.3.1.

Table 3.3.9 - Data on the industry of edible vegetable oils - 1990 to 1994

Product	1990	1991	1992	1993	1994	Variation 90/94
			(10^3 t)			(%)
Soybean production	20,444	15,757	19,456	22,780	24,813	21
Crushed soybean	15,435	13,057	14,756	16,771	18,736	21
Total grains/seeds crushed[1]	16,078	13,601	15,371	17,470	19,517	21

Source: Brazilian Association of Vegetable Oil Industries - ABIOVE.
[1] Soybean is considered to account for 96% of the total seeds/grains crushed.

3.3.7 Domestic use

This activity covers the following product categories: cosmetics and bath products (aerosols of all types, perfumes, aftershave lotions, deodorants, nail polish removers), home cleaning products (aerosols of all types, cleaners, disinfectants, waxes, and polishes), construction (adhesives for carpets and tiles, solvents, paint removers, adhesives for construction), and automotive (aerosols of all types, brake fluids, waxes, and polishes).

The methodology for quantifying emissions in this sector recommends the adoption of an average emission factor of 2,566 g VOC/person/year. This factor is derived from the average emission factors of selected countries. It should be noted that the simple transposition of this average factor (coming from highly developed economies) to Brazil could result in an overestimate of emissions, even if correlated with the economically active population. Brazilian experts' analysis, taking into account the GDP per capita, led to the use of a figure of 640 g VOC/person/year. The estimated values for VOC are presented in Table 3.3.1.

Agriculture

3.4 Agriculture

Agriculture is an economic activity of great importance in Brazil. Because of the country's vast agricultural and grazing lands, it is one of the largest agricultural producers in the world. According to data from FAO, in 1994, Brazil ranked first in sugar cane production, with 27% of total production in the world, and ranked second in soybean production, with 18% of the global total. It also had the second largest bovine herd in the world, with 12% of the global total.

In this sector, greenhouse gas emissions are produced by different processes. Enteric fermentation in ruminants is one of the most important methane emission sources in the country (83%) while manure management is responsible for emissions of CH_4 and N_2O.

Flooded rice, which is also one of the principal sources of CH_4 emissions in the world, is not a very expressive source in Brazil, because a great share of rice is produced in non-flooded areas.

The imperfect field burning of agricultural residues produces emissions of CH_4, N_2O, NO_x, CO, and NMVOC. In Brazil, this practice occurs in the sugar cane and cotton crops.

N_2O emissions from agricultural soils result mainly from animal waste deposition in pasture and from soil fertilization practices. The latter include the use of synthetic fertilizers and manure management products. The process of biological nitrogen fixation, which occurs in the soybean crop, and the use of organic soils for cultivation also generate N_2O emissions.

Finally, emissions result from the imperfect combustion that occurs during the prescribed burning of the native *cerrado*.

3.4.1 Livestock

In 1994, total cattle herd reached 158 million heads, a value 7% above that in 1990. Of this total, non-dairy cattle represented 87%, and dairy cattle, 13%. The country also has expressive herds of swine, sheep, and poultry, as shown in Table 3.4.1.

In the cattle production activity, there are various processes that generate greenhouse gas emissions. The production of CH_4 is part of the digestive process of the ruminant herbivores (enteric fermentation); the manure management produces both CH_4 and N_2O emissions; use of manure as fertilizers and manure deposition by grazing animals also produce N_2O.

Estimates of emissions from enteric fermentation and animal waste management are presented below. N_2O emissions from manure addition to the soil, intentionally or by grazing livestock, are analyzed jointly with emissions from other types of fertilizers in section 3.4.4.

3.4.1.1 Enteric fermentation

The production of CH_4 is part of the normal digestive process of the ruminant animals and occurs in smaller amounts in other herbivores. The intensity of methane emissions depends on the animal category, the type and amount of ingested food, the degree of digestibility of the digested mass, and the intensity of physical activity of the animal, according to the different production practices.

The estimation of emissions requires good knowledge of such parameters, which are fundamental to estimate emission factors. In Brazil, because of the large size of the territory and the great dispersion of activities, with different practices and types of animal feed, these parameters vary a lot. Unfortunately, there is still limited research in Brazil in this area. Even so, efforts were made, with the contribution of Brazilian specialists, to obtain emission factors for cattle that better represented the characteristics of livestock production in Brazil and its regional differences. The values obtained are consistently higher than the IPCC (1997) default values, as shown in Table 3.4.2.

Table 3.4.1 - Animal populations - 1990 to 1994

Type of animal	1990	1991	1992	1993	1994	Variation 90/94
			(million animals)			(%)
Dairy cattle	19.2	20.0	20.5	20.1	20.1	5
Non-dairy cattle	128.3	132.2	133.8	135.3	138.2	8
Donkeys	1.3	1.4	1.4	1.3	1.3	- 2
Buffalo	1.4	1.4	1.4	1.5	1.6	12
Goats	11.9	12.2	12.2	10.6	10.9	- 9
Horses	6.2	6.2	6.3	6.3	6.4	4
Mules	2.0	2.0	2.0	2.0	2.0	- 2
Sheep	20.0	20.1	20.0	18.0	18.5	- 8
Swine	33.7	34.3	34.5	34.3	35.1	4
Poultry	549.2	597.0	642.1	657.3	683.5	24

Source: IBGE, 1990, 1991, 1992a, 1993, 1994.

Table 3.4.2 - CH_4 emission factors for enteric fermentation - 1990 to 1994

Category of animal	Sub-population	Region	Emission factor used (kg/head/year)	IPCC emission factor (kg/head/year)
Dairy cattle		North	59	57
		Northeast	61	
		Center-West	61	
		Southeast	65	
		South	62	
Non-dairy cattle	Adult females	North	65	58
		Northeast	73	
		Center-West	67	
		Southeast	67	
		South	65	
	Adult males	North	62	57
		Northeast	73	
		Center-West	64	
		Southeast	64	
		South	66	
	Young cattle	North	47	42
		Northeast	56	
		Center-West	48	
		Southeast	48	
		South	50	

Source: Brazilian Agricultural Research Corporation - EMBRAPA.

IPCC default emission factors were used for the other categories of animals, because there was no other information available, which increases the level of uncertainty in the estimates.

Methane emissions from enteric fermentation in 1994 were estimated at 9.4 Tg, an increase of 6% in relation to emissions in 1990. Non-dairy cattle were responsible for 82% of this total, contributing with 7.7 Tg.

Table 3.4.3 - CH_4 emission from enteric fermentation - 1990 to 1994

Category of animal	1990 (Gg)	1991 (Gg)	1992 (Gg)	1993 (Gg)	1994 (Gg)	Share 1994 (%)	Variation 90/94 (%)
Dairy cattle	1,200	1,249	1,281	1,259	1,257	13.4	5
Non-dairy cattle	7,191	7,403	7,491	7,549	7,705	82.2	7
Buffaloes	77	79	78	82	86	0.9	12
Sheep	100	101	100	90	92	1.0	-8
Goats	60	61	61	53	54	0.6	-10
Horses	111	112	114	114	115	1.2	4
Mules and donkeys	34	34	34	33	33	0.4	-3
Swine	34	34	35	34	35	0.4	3
TOTAL	**8,807**	**9,073**	**9,193**	**9,215**	**9,377**	**100.0**	**6**

3.4.1.2 Manure management

When the organic material from animal wastes decomposes under anaerobic conditions, methanogenic bacteria can produce considerable amounts of CH_4. Anaerobic conditions are created when the residues are stored in liquid form (in lagoons, ponds, or tanks).

In Brazil, because most livestock production is on range-land, the anaerobic treatment ponds from intensive animal production in confinement systems contribute only a limited fraction. Even for confined cattle the utilization of waste treatment facilities is restricted. Animal wastes produced by the cattle herds are deposited in the fields as solid material. The parameters relative to management systems are presented in Table 3.4.4.

Table 3.4.5 - CH_4 emission factors for animal waste management

Category of animal	Sub-population	Region / State	Emission factor used – Climate – Temperate (kg/head/year)	Emission factor used – Climate – Hot (kg/head/year)	IPCC emission factor – Climate – Temperate (kg/head/year)	IPCC emission factor – Climate – Hot (kg/head/year)
Dairy cattle		South	1	-	1	-
		Other regions	3	5	1	2
Non-dairy cattle	Adult females	South	1	-	1	-
		Other regions	2	2	1	1
	Adult males	Northeast	2	3	1	1
		South	2	-	1	-
		Other regions	2	2	1	1
	Young cattle	South	1	-	1	-
		Other regions	1	2	1	1
Swine		North	-	0.4	-	2
		Northeast	1	1	1	2
		South and São Paulo	0.5	-	1	-
		Other states	1	-	1	-

Source: Brazilian Agricultural Research Corporation - EMBRAPA.

CH_4 emissions from manure management in 1994 were estimated at 368 Gg, a 9% increase in relation to 1990 emissions. Non-dairy cattle were the category that contributed the most, with emissions estimated at 198 Gg (54%). Table 3.4.6 presents the estimates of CH_4 emissions for the 1990-1994 period.

Table 3.4.4 - Manure management systems

Category of animal	Region/State	Pasture (%)	Solid storage (%)	Liquid system (%)	Anaerobic lagoon (%)	Daily spread (%)	Other (%)
Dairy cattle	South	75	-	-	-	20	5
	Other regions	45	20	3	1	20	11
Non-dairy cattle	South	75	-	-	-	20	5
	Other regions	97	3	-	-	-	-
Sheep	All regions	100	-	-	-	-	-
Swine	South and São Paulo	-	-	-	-	10	90
	Southeast and Center-West					5	95
	Other regions	-	-	-	-	-	100
Poultry	All regions	-	20	-	-	80	-
Other	All regions	99	-	-	-	-	1

Source: Brazilian Agricultural Research Corporation - EMBRAPA.

CH_4 emissions were estimated using the methodologies provided by the IPCC (1997). For cattle and swine the detailed methodology was used, which takes into account national parameters on food consumption, digestibility, and management systems, obtained with the help of Brazilian specialists.

Table 3.4.5 shows the resulting emission factors for cattle and swine and compares them with the IPCC default values.

For other animal categories the simplified methodology was used, with IPCC default emission factors.

Table 3.4.6 - CH_4 emissions from animal waste management - 1990 to 1994

Category of animal	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Dairy cattle	59.3	62.2	63.8	61.6	61.1	16.6	3
Non-dairy cattle	183	189	191	193	198	53.8	8
Buffaloes	2.4	2.4	2.4	2.5	2.7	0.7	12
Sheep	3.5	3.5	3.4	3.1	3.2	0.9	-9
Goats	2.3	2.4	2.4	2.1	2.1	0.6	-9
Horses	10.8	10.9	11.1	11.1	11.2	3.0	4
Mules and donkeys	3.5	3.5	3.6	3.4	3.4	0.9	-3
Swine	25.1	25.4	25.4	24.8	25.4	6.9	1
Poultry	48.4	53.3	57.8	59.2	61.3	16.7	27
TOTAL	**338**	**353**	**361**	**361**	**368**	**100**	**9**

Manure management may also produce N_2O emissions during handling, depending on the system used. After handling, manure is occasionally used as fertilizer, as in the daily spread system. In this case, only the emissions that occur before the manure is added to soils are reported here, including basically emissions from animals in confinement regime. N_2O emissions occurring after manure is added to soils, including manure from grazing animals, are esti-mated in section 3.4.4, which reports the emissions from nitrogen addition to agricultural soils.

N_2O emissions were estimated using the methodology provi-ded by the IPCC (1997), considering the share of various systems used for each category of animal. As there was no information available on specific emission factors for Brazil, the IPCC default values were used.

N_2O emissions from manure management were estimated at 20 Gg in 1994, an increase of 7% in relation to 1990, as shown in Table 3.4.7. It can be seen that dairy cattle contributes the most to emissions, since non-dairy cattle is maintained mainly in pasture regime.

Table 3.4.7 - N_2O emissions from manure management - 1990 to 1994

Category of animal	1990	1991	1992	1993	1994	Share 1994	Variation 90/94
			(Gg)			(%)	
Dairy cattle	8.3	8.7	8.9	8.7	8.6	42.6	4
Non-dairy cattle	4.3	4.5	4.5	4.6	4.7	23.3	8
Swine	4.0	4.1	4.1	4.1	4.2	20.8	4
Poultry	2.1	2.3	2.4	2.5	2.6	12.9	24
Other	0.1	0.1	0.1	0.1	0.1	0.5	-3
TOTAL	**18.8**	**19.6**	**20.1**	**19.9**	**20.2**	**100**	**7**

3.4.2 Rice cultivation

Anaerobic decomposition of organic material in irrigated or flooded rice fields is an important source of CH_4. This process does not occur, however, when rice is cultivated in uplands.

Contrary to most countries, where upland rice answers for only 15% of the cultivated area, in Brazil upland rice represents the greatest part of the area cultivated (67% in 1994). This is the most commonly used growing practice in the Northeast and Center West regions. Even though irrigated rice covers a smaller cultivation area, it answers for the greatest part of production (55%), which is concentrated in the South region (68%). Rice is also grown, at a smaller scale, in floodplains in the state of Minas Gerais.

In 1994, Brazil had a total area of 1.5 million hectares of flooded rice or rice grown in floodplains, which represented an increase of 17% in relation to 1990, as shown in Table 3.4.8.

Table 3.4.8 - Harvested area of rice - 1990 to 1994

Harvested area		1990	1991	1992	1993	1994	Variation 90/94
				(10^3 ha)			(%)
Continuously flooded		1,077	1,142	1,220	1,305	1,305	21
Intermittently flooded	Single aeration	-	1	0.4	0.1	0.1	-
	Multiple aeration	20	17	17	15	14	-30
Floodplain	Drought prone	30	32	31	31	29	-3
	Flood prone	132	134	133	129	119	-10
TOTAL		**1,258**	**1,326**	**1,402**	**1,480**	**1,468**	**17**

Source: Brazilian Agricultural Research Corporation - EMBRAPA.

Studies carried out in several countries have shown the influence of various factors on CH_4 emissions in rice paddies, including temperature, solar radiation, organic amendment, type of cultivar, and soil type. There are still no experimental data in Brazil on which to base methane emission factors in flooded rice fields under the different regional and climatic conditions in the country. For this reason, the IPCC default emission factors were used.

Methane emissions were estimated at 283 Gg in 1994, with an increase of 18% in relation to 1990, as shown in Table 3.4.9.

Table 3.4.9 - CH_4 emissions from rice cultivation - 1990 to 1994

Cultivation regime		1990	1991	1992	1993	1994	Share 1994	Variation 90/94
				(Gg)			(%)	
Continuously flooded		215	228	244	261	261	92.2	21
Intermittently flooded	Single aeration	-	0.10	0.04	0.01	0.01	0.0	-
	Multiple aeration	0.78	0.68	0.68	0.60	0.57	0.2	-27
Floodplain	Drought prone	2.4	2.6	2.5	2.4	2.3	0.8	-4
	Flood prone	21	21	21	21	19	6.7	-10
TOTAL		240	253	269	285	283	100	18

3.4.3 Field burning of agricultural residues

Although burning residues liberates a large amount of CO_2, this is not considered a net emission because the same amount of CO_2 is necessarily absorbed during growth of the plant through photosynthesis. However, during the combustion process, other gases besides CO_2 are produced. The emissions of these gases depend on the type of biomass and on the conditions under which burning takes place. In the phase of burning with flames, the gases N_2O and NO_x are generated, and the gases CO and CH_4 are formed under burning where smoke is predominant.

The principal Brazilian crops that involve burning of residues are sugar cane and herbaceous cotton, but the latter at a smaller scale. Emissions from burning of residues in 1994 were estimated at 133 Gg CH_4; 6.6 Gg N_2O; 2,787 Gg CO; and 239 Gg NO_x, as shown in Table 3.4.10.

Table 3.4.10 - Emissions from field burning of agricultural residues - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
Sugar cane						
CH_4	117	116	121	109	130	11
N_2O	5.8	5.7	6.0	5.4	6.4	11
CO	2,455	2,438	2,537	2,285	2,730	11
NO_X	208	207	215	194	232	11
Herbaceous cotton						
CH_4	4.2	4.7	4.3	2.6	2.7	-35
N_2O	0.3	0.3	0.3	0.2	0.2	-35
CO	88	98	91	55	57	-35
NO_X	10.5	11.7	10.9	6.5	6.8	-35
Total						
CH_4	121	121	125	111	133	10
N_2O	6.1	6.1	6.3	5.5	6.6	10
CO	2,543	2,536	2,628	2,340	2,787	10
NO_X	219	219	226	201	239	10

3.4.3.1 Sugar cane

Sugar cane has a high photosynthetic efficiency, with excellent growth at temperatures between 20 and 35ºC. Sugar cane is cultivated on a wide range of soil types in Brazil and is very tolerant of acidity and alkalinity. This is why sugar cane cultivation has always had a great importance to the national economy, mainly for the production of sugar. The role of sugar cane increased significantly with governmental incentives to the production of ethanol, by means of the implementation of the Proalcool program, which expanded sugar cane cultivation to all Brazilian states, especially São Paulo, Alagoas, and Pernambuco.

The practice of burning sugar cane prior to harvest is widespread in Brazil, being used to improve the yield from manual harvest (with an increase of up to 10 times), to avoid problems from poisonous animals, which are very common in the plantations, and to help prepare the land for the next planting.

The average annual harvested area of sugar cane in the 1990-1994 period totaled 4.3 million hectares. Greenhouse gas emissions from burning of sugar cane residues in 1994 were estimated at 130 Gg CH_4; 6.4 Gg N_2O; 2,730 Gg CO; and 232 Gg NO_x.

3.4.3.2 Herbaceous cotton

Cotton cultivation is distributed over seventeen Brazilian states under a wide range of environmental conditions. The average harvested area of herbaceous cotton for the period of 1990-1994 was 1.3 million hectares. Along with herbaceous cotton, arboreal cotton is also grown in Brazil. This variety is perennial, and there is no burning of residues.

Cotton harvesting in Brazil is generally manual. After harvest, plant remains are burnt to eliminate pests (boll weevil, pink bollworm) and fungal diseases. The eradication of plant remains requires that all parts of the plant be incinerated, including the roots. However, this practice has not been widely adopted in Brazil. Although some states have laws requiring farmers to burn residues, the growing mechanization of cultivation has replaced this practice by incorporation of the residues from the harvest into the soil and by adoption of other measures for control of pests and diseases.

In the Northeast region, where the practice of burning is also recommended as a measure to control the boll weevil, most producers do not do it, but rather use the plant remains for animal feed, especially the husks, which are rich in proteins. For purposes of estimating greenhouse gas emissions, cotton production in the Northeast region of Brazil was not included in the emission estimations.

Greenhouse gas emissions in 1994 were estimated at 2.7 Gg CH_4; 0.2 Gg N_2O; 57 Gg CO; and 6.8 Gg NO_x.

3.4.4 N_2O emissions from agricultural soils

The use of nitrogen fertilizers has been singled out as the major cause of the rise in global N_2O emissions from agricultural soils. However, in Brazil the main source of emissions is manure from grazing animals. N_2O emissions also occur from use of manure as agricultural fertilizer, biological nitrogen fixation, nitrogen from crop residues, and atmospheric deposition of NO_x and NH_3.

Emissions of N_2O from agricultural soils were subdivided into three categories, according to the IPCC:

- N_2O emissions from grazing animals;
- other direct sources of N_2O emissions, including the use of synthetic fertilizers, manure used as fertilizers, biological nitrogen fixation, and crop residues; and
- indirect sources of N_2O emissions from nitrogen used in agriculture, including volatilization and subsequent atmospheric deposition of NO_x and NH_3 from fertilizer application, and leaching and runoff of fertilizer nitrogen.

Table 3.4.11 shows the estimates of N_2O emissions from agricultural soils in the 1990-1994 period.

Table 3.4.11 - N_2O emissions from agricultural soils - 1990 to 1994

Types of emission	1990	1991	1992 (Gg)	1993	1994	Share 1994 (%)	Variation 90 / 94 (%)
Grazing animals	**207.1**	**213.2**	**215.7**	**214.6**	**218.5**	**46**	**6**
Dairy cattle	20.8	21.7	22.2	21.9	21.9	5	5
Non-dairy cattle	150.2	155.0	156.9	158.8	162.1	34	8
Donkeys	1.7	1.7	1.7	1.6	1.6	0	- 6
Mules	2.5	2.5	2.5	2.5	2.5	1	0
Buffaloes	1.7	1.8	1.8	1.9	2.0	0	18
Goats	14.8	15.1	15.1	13.2	13.5	3	- 9
Horses	7.7	7.8	7.9	7.9	7.9	2	3
Sheep	7.6	7.6	7.5	6.8	7.0	1	- 8
Other direct emissions	**98.8**	**96.1**	**107.3**	**114.6**	**125.7**	**26**	**27**
Synthetic fertilizers	13.8	13.8	15.3	17.9	20.8	4	51
Animal manure	11.6	12.1	12.6	12.7	13.0	3	12
Dairy cattle	4.2	4.4	4.5	4.4	4.4	1	5
Non-dairy cattle	2.8	2.8	2.8	2.9	2.9	1	4
Swine	0.4	0.4	0.4	0.4	0.5	0	25
Poultry	4.1	4.5	4.8	5.0	5.2	1	27
Biological fixation	21.1	15.8	20.3	23.9	26.4	6	25
Crop residues	36.1	35.1	38.8	38.3	43.1	9	19
Organic soils	16.3	19.3	20.3	21.9	22.5	5	38
Indirect emissions	**119.8**	**123.2**	**125.9**	**127.5**	**131.8**	**28**	**10**
Deposition of NO_x and NH_3	24.2	25.0	25.4	25.6	26.3	6	9
Leaching	95.5	98.2	100.5	101.9	105.5	22	10
TOTAL	**425.7**	**432.4**	**448.9**	**456.7**	**476.0**	**100**	**12**

3.4.4.1 N_2O emissions from grazing animals

Manure from grazing animals is the most important source of N_2O emissions from agricultural soils in Brazil, because of the large livestock herd and the predominance of extensive livestock production in the country. Table 3.4.4 indicates the contribution of the manure management systems in Brazil, showing that 75% of the bovine cattle in the South region are under a grazing regime, as well as 97% of the non-dairy cattle and 45% of the dairy cattle in the other regions. The same regime is used for almost all other animal categories, except for swine and poultry.

N_2O emissions were estimated with the use of the IPCC default emission factors for the amount of nitrogen contained in animal manure and for the N_2O emission factor per amount of nitrogen applied to soils. N_2O emissions from grazing animals represented 46% of N_2O emissions from agricultural soils in 1994 (of which 34% is related to non-dairy cattle and 5% to dairy cattle), an increase of 6% in relation to the estimated value for 1990, as shown in Table 3.4.11.

3.4.4.2 N_2O emissions from other direct sources

Use of synthetic fertilizers

The main nitrogen fertilizers used in Brazil are urea, ammonia, anhydrous ammonia nitrate, and ammonium sulfate. Total consumption of synthetic nitrogen fertilizers in Brazil in 1994 was 1.17 million tonnes, with an increase of 51% in relation to consumption in 1990. Part of this nitrogen is incorporated into plants and into the soil, part of it volatilizes as NO_x and NH_3, and another part is released as N_2O. Because of the lack of specific studies on emission factors for the management and climate conditions in Brazil, the IPCC default emission factors were used. Direct N_2O emissions from synthetic fertilizer use represented 4% of N_2O emissions from agricultural soils in 1994, as shown in Table 3.4.11.

Use of manure as fertilizers

There is scarce information in Brazil about the use, as organic fertilizers, of residues and effluents resulting from livestock confinement. Based on the experience of Brazilian specialists that have good knowledge of the different practices employed in each region, the daily spread system was considered to be the only system where animal manure is used as fertilizer. The IPCC default values were used for N_2O emission factors. Direct N_2O emissions from use of manure as fertilizers accounted for 3% of N_2O emissions from agricultural soils in 1994, as shown in Table 3.4.11.

Biological nitrogen fixation

Biological nitrogen fixation is the process through which atmospheric N_2 is reduced to ammoniacal forms of nitrogen by living organisms that incorporate them into the biosphere.

In Brazil, the practice of inoculation with specific bacteria for N_2 fixation is routinely employed only in soybean crops, and there is no information available on its application in other cultures. In 1994, the Brazilian area planted with soybeans covered 11.5 million hectares, without a significant increase in relation to 1990. Soybean production in 1994 was of 24.9 million tonnes, an increase of 25% in relation to production in 1990. To estimate N_2O emissions, an 89.8% content of dry matter was adopted, as well as the IPCC default emission factor. This factor was calculated from the amount of nitrogen contained in the plant, as an approximation to the amount of nitrogen fixed by the crop, assuming a fixed relation between the production and the amount of residues. This relation was subsequently revised by the IPCC but without reevaluating the consistency of the relation between the amount of nitrogen fixed and the total nitrogen contained in the biomass. This reevaluation should also be made to avoid double counting, since the crop residues are also considered in the item below. Specific research concerning practices and conditions of this crop in Brazil are thus necessary. Direct N_2O emissions from biological nitrogen fixation represent 6% of N_2O emissions from agricultural soils in 1994, as shown in Table 3.4.11.

Crop residues

The nitrogen contained in crop residues and incorporated into the soils is also a source of N_2O emissions. To estimate such emissions, the annual production and the amount of dry matter per type of crop were used, and a total of 155 million tonnes of dry matter was estimated in 1994. The main crops were sugar cane, corn, soybean, rice, and manioc. In the absence of better information, the IPCC default emissions factors were used for the nitrogen contained in residues and for the part of the residues remaining in the field. Direct N_2O emissions from crop residues represented 9% of N_2O emissions from agricultural soils in 1994, as shown in Table 3.4.11.

High organic content soils

There is no soil information available in compatible scales to allow the determination of the area of organic soils cultivated every year in Brazil. For this reason, this area was estimated using the available knowledge about the production systems of major crops in Brazil. It is known that floodplain rice, palm tree, and jute are almost exclusively cultivated in floodplains, and in the Northern region of the country. Corn is also mainly cultivated in floodplains. The sum of the areas occupied by these crops was used as an estimate of the cultivated area of organic soil, even though these crops are not grown exclusively on organic soils and small areas of other crops are sometimes cultivated in soils of this kind. Uncertainty associated with this estimate is thus high, tending to overestimate the results. A value of 2.1 million hectares was estimated in 1994, an increase of 38% in relation to 1990. Direct N_2O emissions from cultivation of organic soils represented 5% of N_2O emissions from agricultural soils in 1994, as shown in Table 3.4.11.

3.4.4.3 N_2O emissions from indirect sources

Atmospheric deposition of NO_x and NH_3

Part of the nitrogen contained in synthetic fertilizers and animal manure used as fertilizers volatilizes as NO_x and NH_3. This part is not taken into account in the estimates of emissions from direct sources. However, part of these gases is deposited again into the terrestrial surface and if such a deposition occurs on agricultural soils it may result in additional emissions of N_2O. It is impossible to determine the area where such a deposition would occur as it could also be into the oceans. NO_x and NH_3 deposition into agricultural soils could also result from other sources such as combustion. Therefore, uncertainty about this share of emissions is very high. The criterion adopted was to consider the total deposition relative to the gases volatilized from agricultural soils. The IPCC default emission factors were used. N_2O emissions from atmospheric deposition of NO_x and NH_3 in 1994 represented 6% of N_2O emissions from agricultural soils, an increase of 9% in relation to the value estimated in 1990, as presented in Table 3.4.11.

Nitrogen leaching and surface runoff

Part of the nitrogen applied to agricultural soils in the form of synthetic fertilizers or animal manure is subject to leaching and runoff, flowing to rivers and the sea. In such environments there are also emissions of N_2O, which are classified as indirect emissions from the application of fertilizers. Uncertainty about N_2O emission factors from nitrogen leaching is very high, and there is no assessment about the values that would be more appropriate to Brazilian conditions. The IPCC default emission factors were used. In 1994, N_2O emissions from leaching and runoff of nitrogen applied to soils as fertilizer represented 22% of N_2O emissions from agricultural soils, an increase of 10% in relation to the value estimated for 1990, as shown in Table 3.4.11.

3.4.5 Prescribed burning of the *Cerrado*

Areas of native *cerrado* burn during the dry season because of several reasons, including anthropogenic influence (stimulus to the growth of new grassy vegetation and pest control). Such burnings are characterized by the regeneration of vegetation, in the affected areas, during the wet season. Their net emissions of CO_2 are null, but they release other gases such as CH_4, N_2O, CO, and NO_x.

The IPCC considers that even the burns in *cerrado* areas that were not subject to anthropogenic influence also result from an anthropogenic action. Studies carried out in Brazil about the recurrence of burns and dating of carbonized residues suggest that the periodical burning of *cerrado* areas already occurred before any anthropogenic influence. Thus it is necessary to promote a broad debate about this issue under the IPCC, which may result opportunely in the revision of the current criterion.

To estimate greenhouse gas emissions from anthropogenic burning of the *cerrado*, it is necessary to estimate a series of parameters, including the area burnt, the efficiency of the burning, the types of vegetation physiognomy affected, the biomass densities of such physiognomies, and the fraction of the biomass burnt. Of these, biomass density subject to burning and the fraction of biomass really burnt are known by means of studies carried out in Brazil (MIRANDA *et al.*, 1996). However, the estimates of the burnt area per type of vegetation affected were not reliable and were estimated again with the use of a methodology combined with remote sensing data.

In spite of their low spatial resolution, images from meteorological satellites are used to detect fires. Brazil was the first country in the world to implement an operational system for fire detection, based on images of the sensor Advanced High Resolution Radiometer (AVHRR) onboard the polar orbit satellite National Oceanographic and Atmospheric Administration (NOAA). Traditionally, these low resolution satellites have demonstrated their potential to monitor fire activity because of their daily coverage of the terrestrial globe. A thermal band sensitive to surface temperatures provides important data for monitoring. Nonetheless, these are not the most adequate instruments to quantify burnt areas. High resolution sensors such as the TM-Landsat 5 and the HRV/SPOT are more appropriate for this type of application. However, they have important limitations related to low temporal resolution (revisit frequency of the satellite) — 16 days for the TM-Landsat 5; 26 days for some SPOT sensors — and to the use of an optical system that does not allow images to be acquired from surface below the clouds. In this case, because of the fast regeneration of the vegetation in some *cerrado* areas affected by burning, the non-availability of useful images (without clouds or with a low cloud incidence) may lead to the non-identification of some areas affected by burning, and a consequent underestimation of the burnt area. It is practically impossible to obtain, for each *cerrado* scene, a temporal series with useful images during all the dry season (April to November, when burns are more frequent). Recent studies (LOMBARDI, 2003) indicate that the permanence time of burnt scars varies according to the type of vegetation physiognomy affected, ranging from a few days to a few months.

To try to solve this problem, and considering the size of the Brazilian *cerrado*, which covers approximately 2.0 million km^2, a methodology was developed to combine the estimates of burnt areas made with the TM-Landsat 5 data with the daily hot spots provided by the AVHRR/NOAA.

The densities of biomass in the different *cerrado* vegetation physiognomies, the fraction burnt, and the distribution of the different types of *cerrado* physiognomies were obtained from research institutions in Brazil.

The methodology was developed and tested with the use of information and satellite imagery available for 1999. To estimate the total *cerrado* area burnt that was not subject to anthropogenic activity, a statistical sampling plan was developed with the use of the grid of the TM-Landsat 5 over the *cerrado* area as the sampling universe. TM-Landsat 5 scenes from the June/July period were selected as samples, according to a stratification design, by area of the *cerrado* and degree of human intervention. The area burnt in June/July (for the non-anthropogenic *cerrado* only) from the sampled images was estimated at 12,522 km^2. Extrapolating these results for the entire *cerrado*, the value of 25,787 km^2 with a standard deviation of 5,678 km^2 for June/July period was obtained.

In order to extrapolate the results to the entire burning season (June-November) in all Brazilian *cerrado*, data from AVHRR were used. AVHRR data for the year 1999 indicated that 15% of the hot spots detected in the Brazilian non-anthropogenic *cerrado* were concentrated in the June/July period. Assuming that there is a correlation between the area burnt observed in AVHRR data and TM-Landsat 5 data, and applying a correction factor for dates, the total area burnt in the *cerrado* was estimated at 197,602 km^2. Discriminating by vegetation type, the results are as follows: 16,401 km^2 in *Campo Limpo/Sujo* (8.3%); 20,748 km^2 in *Cerradão* (10.5%); 131,206 km^2 in *Cerrado Stricto Sensu* (66.4%); and 29,245 km^2 in *Parque de Cerrado* (14.8%).

The biomass densities (fine fuel) from the different vegetation physiognomies of the Brazilian Cerrado were estimated as ranging from 7.2 t/ha (*Campo Sujo/Campo Limpo* physiognomy) to 9.4 t/ha (*Cerrado Sensu Stricto*).

These data, once incorporated into the IPCC methodology, produced the following estimates of non-CO_2 gas emissions in 1999: 306 Gg CH_4; 3.8 Gg N_2O; 8,036 Gg CO; and 137.3 Gg NO_x.

The occurrence of burns was particularly high in 1999, as the number of hot spots detected by the NOAA-12 satellite in 1999 was three times the number of hot spots detected in 1996. The occurrence of burns is extremely variable from one year to another; therefore, it is not possible to use these results to estimate emissions for the 1990-1994 period. However, the values presented, in addition to illustrating a methodology that may be applied in future inventories, indicate the order of magnitude of non-CO_2 gas emissions resulting from *cerrado* burning. This study was carried out for 1999 because of the availability of data (satellite imagery) produced for other works. It was not carried out for the 1990-1994 period because of lack of financial resources.

Land-Use Change and Forestry

3.5 Land-Use Change and Forestry

This sector comprises four categories: (1) Changes in Forest and Other Woody Biomass Stocks; (2) Forest Conversion to Other Uses; (3) Abandonment of Managed Lands; and (4) CO_2 Emissions and Removals from Soils.

In the category Changes in Forest and Other Woody Biomass Stocks only the changes in stocks of planted forests were considered, based on data reported by the Brazilian Association of Renewable Forests - ABRACAVE and by the National Pulp and Paper Manufacturers Association - ANFPC.

For the categories Forest Conversion to Other Uses and Abandonment of Managed Lands, an objective approach with satellite data was used. Except for Atlantic Forest, the analysis of satellite images included changes in surface cover resulting both from forest conversion to other uses and changes resulting from sustainable forest management practices.

Thus, the emissions reported in this Inventory under the category Forest Conversion to Other Uses include emissions from deforestation, in addition to those that should be included in the category Changes in Forest and Other Woody Biomass Stocks. Similarly, the category Abandonment of Managed Lands includes removals resulting from regrowth of abandoned deforested areas and converted areas, as well as areas under sustainable management.

The methodology used in this Inventory may lead to an overestimation of CO_2 emissions in Brazil because of the following factors: instantaneous accounting as CO_2 emissions of all carbon stored in the converted area, rather than distributing it over time, according to the destination of the biomass (use in metallurgy and energy, pulp and paper, furniture, civil construction and architecture industries, as well as burning and decomposition of forest residues in the converted area); and (2) accounting of CO_2 emissions that occur in other countries, because of Brazilian exports of timber and wood products.

Moreover, as mentioned above, the consideration of regrowth was based on objective data from satellite observation. Hence, it does not take into consideration if the regrowth results from a declared practice of sustainable management or from abandonment of agricultural activity.

3.5.1 Changes in the stocks of planted forests

Forests are planted in Brazil for different uses, but especially to meet industrial needs, with the main objective of producing timber for the pulp and paper, steel, timber, laminate, and ply board industries, as well as firewood for energy purposes. Such forests are planted for specific uses, following a management plan (i.e. felling, clear-cutting, and rotation), which influences the quantity and quality of timber. Plantations for other uses, on their turn, do not follow a management plan as they focus on environmental protection and recovery, such as, for instance, slope protection, windbreaks, protection of water sources, recovery of degraded areas, etc.

To estimate changes in stocks of planted forests between 1990 and 1994, only forests planted for industrial use were considered. Non-industrial forests were not considered because they do not have a significant variation in carbon stock over time, as they are not subject to felling or rotation.

To estimate annual stock changes in the 1990-1994 period, estimations were made first for the quantity of carbon fixed each year. This calculation required information on the area covered by forests for industrial use, the species planted, the type of management system, the annual rate of dry matter production, and the fraction of carbon contained in the dry matter.

With regard to the area of planted forests in Brazil, available data are conflicting, and only a few institutions have a historical record with reliable data on forest areas planted each year by their associated companies, such as the Brazilian Association of Renewable Forests - ABRACAVE and the National Pulp and Paper Manufacturers Association - ANFPC. *Pinus* and *Eucalyptus* account for more than 80% of plantations. The areas of planted forests shown in Table 3.5.1 were based on reports relative to the 1969-1994 period (ANFPC, 1994) and (FARIA, 1997).

Table 3.5.1 - Area of planted forests - 1969 to 1994

Year	*Eucalyptus*	*Pinus*
	(10^3 ha)	
1969	35.0	-
1970	49.0	11.6
1971	64.8	11.4
1972	73.4	13.9
1973	77.1	12.1
1974	99.1	21.2
1975	160.5	25.3
1976	217.1	24.6
1977	235.3	27.7
1978	287.3	19.2
1979	295.1	21.0
1980	263.2	24.6
1981	509.7	19.8
1982	232.1	23.6
1983	171.2	21.7
1984	209.5	22.6
1985	233.6	19.9
1986	210.9	24.5
1987	249.9	29.5
1988	290.0	25.0
1989	303.4	24.8
1990	434.5	22.9
1991	277.1	14.8
1992	244.1	13.5
1993	886.3	17.8
1994	282.0	18.7

Sources: ANFPC, 1994; Faria, 1997.

The management systems, on their turn, comprise a set of activities carried out over a given number of years, going from planting until final timber harvest. These systems may differ between species and even for the same species. The system used for *Pinus* forests, for instance, generally differs from that for *Eucalyptus* forests. To estimate stock changes for the *Pinus* forests the management system adopted consisted of three selective cuts (at the ages of 8, 12, and 16 years old), with the final cut at 20 years of age. With regard to the *Eucalyptus* forests, the management system considers a rotation of 21 years and three clear-cuttings.

In planted forests, the variable of the greatest economic interest is the production of timber, represented by the volume of the trunk per unit of area (m^3/ha). This production varies over time and is influenced by the type of management system. It therefore becomes necessary to have a different approach for each genus. The production estimates used in this Inventory were obtained from the available scientific publications and through consultations with Brazilian specialists. Average annual production by hectare for the *Pinus* genus was estimated at 26.25 m^3 with bark; for the *Eucalyptus* genus, it was estimated at 28.33 m^3 with bark.

As the density of the timber (mass-volume ratio) may vary between genera and species (the values found in scientific literature for the basic density of *Eucalyptus* timber are slightly superior to those found for the *Pinus* genus), average values for the density of timber with bark were estimated for each genus. For *Pinus*, the average value was estimated at 0.385 t/m^3 and for *Eucalyptus* it was estimated at 0.425 t/m^3.

Annual rates of dry matter production vary from one genus to another and are represented mainly by the quantity of dry matter in the trunk. Annual rates are obtained by multiplying the basic density figures and the timber production each year. Average annual rates for the *Pinus* and *Eucalyptus* genera were estimated at 10.1 t/ha and 12.0 t/ha, respectively.

There are few Brazilian publications that give a quantification of the below-ground production of planted forests, and they are basically about the *Eucalyptus* genus. According to data available in literature, the average value of 35% was adopted for the relation between root production and trunk production with bark for both genera.

The quantity of carbon in the dry matter, according to the literature, is around 50%. This figure was adopted for the carbon/dry matter ratio for all parts of the tree (trunk, crown, and roots) for the *Pinus* and *Eucalyptus* genera.

Based on these data, annual changes in carbon stocks in planted forests were estimated for the 1990-1994 period, and an annual estimate of carbon stored until the end of each year in the period was obtained for each genus. This was done by adding the carbon stock remaining from plantations with different ages (1 to 21 years for *Eucalyptus* and 1 to 20 years for *Pinus*) for each year in the period.

Table 3.5.2 shows the annual estimates of changes in carbon stocks in planted forests in the 1990-1994 period. According to the results presented, the average annual estimate for changes in stocks of forests planted for industrial use was 11 Tg C a year, which corresponds to an average annual removal of 41.1 Tg CO_2 from the atmosphere.

Table 3.5.2 - Changes in carbon stocks of planted forests

Year	*Eucalyptus*	*Pinus*	Total	Annual Change	
		(Gg C)		(Gg C)	(Gg CO_2)
1989	95,938	19,121	115,058	-	-
1990	107,314	20,031	127,345	12,287	45,051
1991	117,597	20,975	138,572	11,227	41,167
1992	125,700	21,695	147,394	8,822	32,348
1993	135,540	22,744	158,284	10,890	39,931
1994	148,004	23,067	171,071	12,787	46,885

3.5.2 Forest conversion and abandonment of managed lands

This section of the Inventory addresses the emissions and removals resulting from forest conversion to agricultural or other uses, as well as removals from abandonment of managed lands. Forest conversion to other uses characterizes deforestation and is generally done by clearing of shrubs and subsequent felling of trees, followed by the partial removal of timber for commercial use or use as firewood, burning and/or decomposition of forest residues.

Data on deforestation or regrowth areas were obtained through analysis of Landsat satellite images. The Landsat satellite sensor (TM) has an appropriate spatial resolution (30 meters) for this application. However, the analysis of the satellite imagery does not provide information on the new use of the deforested land. Deforestation data in Brazil consider as deforestation all areas identified in the satellite images as having a spectral pattern of exposed soil (independent of the final use of the deforested land). Thus, emissions resulting from cuts in managed lands are also included in this category because of the difficulty to discriminate areas under forest management from other forest areas.

3.5.2.1 Net CO_2 emissions

The IPCC methodology indicates the estimation of changes in biomass stocks that have occurred between the Inventory year and the previous 10 years. According to the IPCC Guidelines, CO_2 emissions from changes in aboveground carbon stocks resulting from conversion of forests could be accounted for as immediate emissions in the conversion year. Emissions from aboveground biomass degradation, on their turn, could be distributed over a 10-year period. The IPCC also includes estimation of emissions from changes in carbon stocks in soils, which are considered in section 3.5.3.

The methodology used in this Inventory to estimate net CO_2 emissions followed, in general, the IPCC default methodology. However, a few adaptations were made because of the non-availability of data, limitation of financial resources, and level of uncertainty. Thus, changes in carbon stocks were estimated based on the areas of gross deforestation in 1988 and 1994 (that is, 6 years instead of the 10 years suggested in the IPCC methodology). It was also considered that the net CO_2 emissions from forest conversion occurred in the same year of the conversion, independently of the fate of the biomass in the converted area: commercial use of the wood, burning, or decomposition of forest residues. This represents a methodological simplification. The IPCC suggests methodological alternatives in which, for example, emissions resulting from decomposition of forest debris may be distributed over a 10-year period rather than being accounted for as immediate emissions.

The Inventory estimated the net CO_2 emissions, including both CO_2 emissions and removals.

To estimate CO_2 emissions from deforestation (with or without conversion to other uses), a more comprehensive methodology was used for biomes with greater biomass content, such as, for instance, the Amazonian Forest, the *Pantanal*, and the Atlantic Forest, which comprise 64% of the national territory and concentrate the largest carbon stock in the country's vegetation. In such cases, estimates of the deforestation areas were made based on all useful images of the Landsat satellite that cover these biomes (281 scenes) and not on a sampling approach. In total, 324 scenes were analyzed. Estimates of removals, on their turn, were made based on sampling of almost all biomes considered (except for the *Pantanal* and the Atlantic Forest, which comprise 26% of the national territory and all corresponding scenes available were used). A total of 172 Landsat scenes were analyzed (representing 22% of the Amazonian Forest; 26% of the *Cerrado*; 30% of the *Caatinga*; 88% of the Atlantic Forest, and 100% of the *Pantanal*). Regrowth in deforestation areas (with or without conversion) was considered as removal. The relation between the number of images analyzed to estimate emissions and that to estimate removals leads to the conclusion that estimates of CO_2 emissions are more precise than the estimates of removals.

To estimate the net CO_2 emissions from forest conversion, a project was developed based on remote sensing technologies and geographic information systems, aimed at developing a database, by biome, including the following data: a) spatial distribution of deforestation areas at two different times (1988 and 1994); b) spatial distribution of regrowth areas at these two times; c) spatial distribution of forest physiognomies; and d) spatial distribution of biomass densities by type of vegetation.

The Brazilian territory was divided into six regions: Amazonian Forest, *Cerrado*, *Caatinga*, *Pantanal*, Atlantic Forest, and *Pampas*. The *Pampas* area, located in the extreme Southern part of Brazil, was not included in this Inventory because of the grassland features of the area and the stable balance of the forest remnants.

With regard to data on the deforestation area, this Inventory took into account the important database available from large scale projects, such as the Gross Deforestation Monitoring Project in Legal Amazonia (PRODES), carried out every year since 1988 by FUNCATE for the National Institute for Space Research (INPE), and the monitoring system of the Atlantic Forest remnants, developed by the non-governmental organization SOS Mata Atlântica jointly with INPE. For regrowth areas, data were available only for the Atlantic Forest, since the PRODES project estimates only the gross deforestation, that is, the increase in deforestation area over time, without considering regrowth areas or areas under regeneration. For areas not included in monitoring projects, a sampling approach was used to estimate deforestation and regrowth, using scenes from the TM/Landsat 5 sensor grid.

Because of the large number of TM sensor scenes covering the five biomes of interest, and considering that the anthropogenic change in vegetation cover is distributed unevenly over the territory, a sampling approach was adopted for the estimation of regrowth in the Amazonian Forest, deforestation and regrowth in the *Cerrado*, and deforestation in the *Caatinga*, with a stratification by degree of anthropogenic activity (percentage of deforestation area in the image). A complete analysis of all scenes was made to estimate deforestation in Amazonia and deforestation and regrowth in *Pantanal*.

It was not possible to estimate regrowth areas in the *Caatinga* due to difficulties to discriminate such areas in the satellite images, as a result of the seasonal variation of the vegetative cycle.

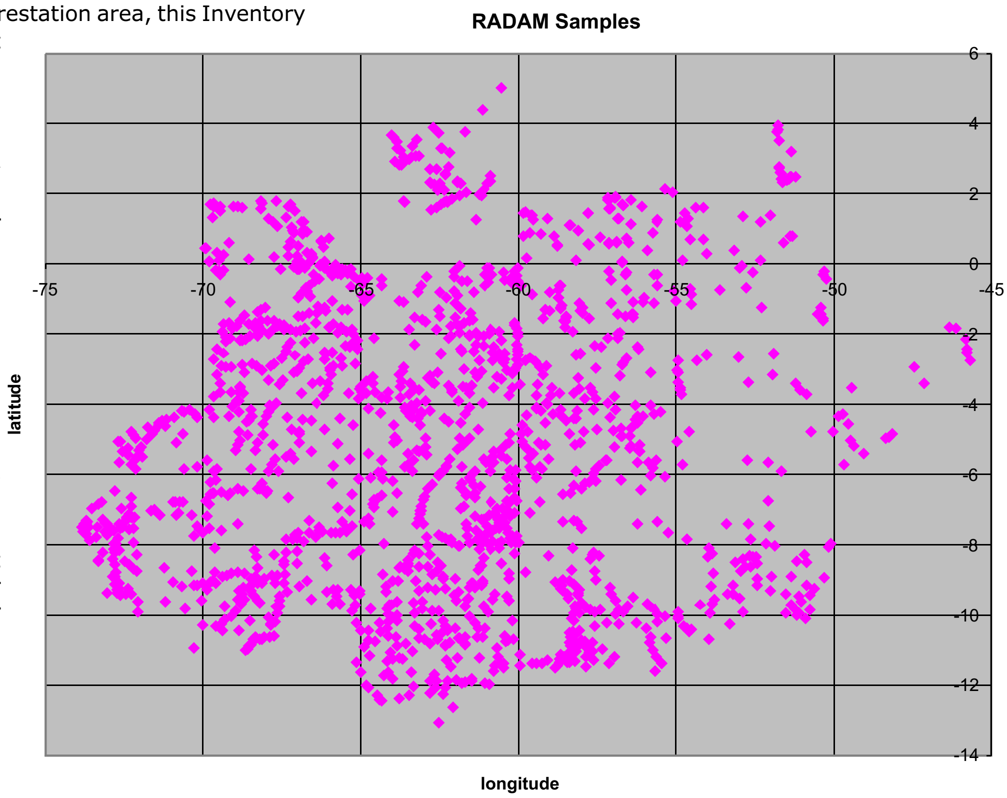
The methodology used for each biome is described below.

Amazonia

To estimate net emissions in the Amazonian biome, the necessary data included information on deforestation area, regrowth area, and biomass density for the different vegetation physiognomies. Information on the area of gross deforestation was obtained by means of the analysis of 196 of the 229 images of the TM/Landsat 5 sensor covering the Legal Amazonia.

Regrowth data were estimated through visual analysis of a set of 44 sample scenes of the TM/Landsat 5, which were extrapolated to the rest of the biome. The spatial distribution of the different forest physiognomies and their biomass contents were obtained from the RADAMBRASIL Project (PROJETO RADAMBRASIL, 1973-1983). The project collected data of circumference at breast height (CBH) and height of trees in sampling units in Amazonia (Figure 3.1). The circumference data were used to estimate the biomass and the carbon content in the different vegetation physiognomies.

Figure 3.1 - Distribution of the RADAMBRASIL Project samples



The biomass estimates were made using the following allometric equations (HIGUCHI *et al*., 1998):

$\ln P = -1.754 + 2.766 \ln D$ for $5 \text{ cm} \leq D < 20 \text{ cm}$; and

$\ln P = -0.151 + 2.170 \ln D$ for $D \geq 20 \text{ cm}$.

Where

P is the aboveground biomass of the tree (kg); and

D is the diameter at breast height of the tree (cm).

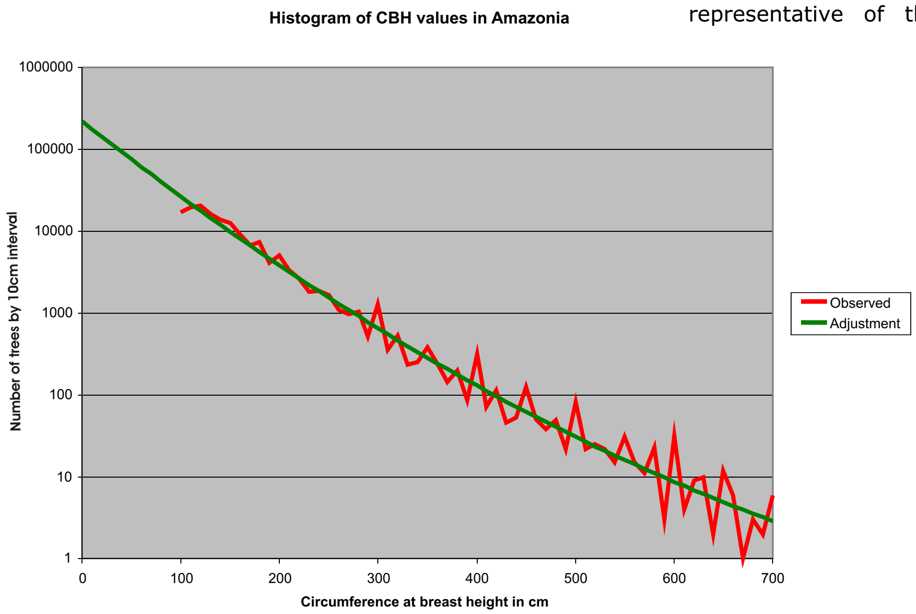
The conversion of biomass into carbon content, C, was based on the following relation (HIGUCHI *et al*., 1998):

C (kg) = 0.2859 P

For each sampling unit, the carbon of all trees was added and divided by the unit area, resulting in the estimate of the carbon density of the sample.

Since the RADAMBRASIL Project collected data only in trees with circumference greater than 100 cm, a correction factor of 1.316 was applied to the carbon density values, to include trees with smaller circumference (MEIRA FILHO, 2000). This factor is based on the extrapolation of the histogram of circumferences of trees sampled by the RADAMBRASIL Project (Figure 3.2).

Figure 3.2 - Histogram of circumference at breast height values in Amazonia



The RADAMBRASIL Project did not consider palm trees and lianas in the sampling units. Such an omission was compensated in the carbon density estimates with the use of data from the literature (HIGUCHI, 2004) that indicated additional mean values of 2% for palm trees and 1% for lianas. This correction was incorporated into the 1.316 correction factor, resulting in a global factor of 1.35.

The consideration of the carbon contained in belowground biomass (roots) is complex and was not included in this Inventory. Such a complexity was recognized by the IPCC, which addressed this issue in the section "Refinements in Calculations" (IPCC, 1997), as it recognizes that the dynamics of fluxes is not known and the application of simple models may generate unreliable results. The IPCC points out that the consideration of roots should be included when the fate of the carbon contained in the roots can be identified. Such a fate depends, however, on the amount of carbon that will be or not be incorporated into the soil after the forest is cleared, as a result of new land use and management practices. Data in the Brazilian scientific literature (HIGUCHI, 2004) indicate a ratio of 0.21 between the amount of biomass in the roots and the aboveground biomass for the areas studied in Amazonia. This value is below the lower limit (0.23) provided by the IPCC (1997).

To estimate CO_2 removals from regrowth in deforestation areas, an annual carbon removal rate of 4.5 tC/ha (HOUGHTON *et al.*, 2000) was considered for the vegetation physiognomies with carbon densities above 93 tC/ha; and of 3.7 tC/ha (adapted from ALVES *et al.*, 1997) for vegetation physiognomies with carbon densities below that value. For the conversion of dry biomass density to carbon density, a constant factor of 0.48 (CARVALHO *et al.*, 1995) was used. The IPCC default value is 0.50 tC per tonne of dry matter.

Cerrado

To estimate net emissions from the *Cerrado* biome, the deforestation areas and regrowth areas by abandonment of managed lands were identified in sample images of the TM/Landsat 5 sensor. Of the 103 images that cover such biome, 27 were analyzed and selected by stratified sampling according to the degree of anthropogenic activity.

Estimates of the average carbon density in the different vegetation physiognomies were obtained from the Brazilian scientific literature (FUNCATE, 2004). The calculated carbon values by type of vegetation were considered to be representative of the original stocks, under primary vegetation conditions and without significant disturbance.

From the data presented in Table 3.5.3 it can be concluded that the average carbon content adopted for deforestation was 45.4 tC/ha; and for regrowth, 53.0 tC/ha. It was considered, for the purpose of extrapolating the deforestation and regrowth data for the whole biome, that deforestation and regrowth in the non-sampled scenes would be proportional to those observed in the sampled scenes for each degree of anthropogenic activity considered.

In the estimation of net emissions, it was assumed that regrowth, when identified through analysis of satellite images, has restored the carbon density back to its original levels.

Caatinga

Estimates of net emissions from the *Caatinga* biome were obtained based on the same procedure used for the *Cerrado* biome. CO_2 removals from regrowth areas could not be estimated because of the difficulty to discriminate such areas in the satellite images, as a result of the seasonal variation of the vegetative cycle. Of the 53 scenes considered in the *Caatinga* biome, 16 were selected by sampling and analyzed, and the results obtained were extrapolated to the entire area. An average biomass value was assigned to each phytophysiognomic class, using data from the Brazilian scientific literature (SAMPAIO, 1997).

To extrapolate the deforestation data to all biome, it was considered that for each degree of anthropogenic activity considered, deforestation in the non-sampled scenes was proportional to that observed in the sampled scenes.

From data shown in Table 3.5.3 it can be concluded that the average carbon content adopted for deforestation was 24.9 tC/ha.

Pantanal

TM/Landsat 5 images were also used to estimate deforestation and regrowth areas in the *Pantanal* biome. All 15 scenes covering the *Pantanal* biome were considered. Homogeneous cover classes were grouped, according to information from specialists. An average aboveground biomass density value was associated to each grouped class based on literature data (GOODLAND, 1971; DELITTI, 1984; CESAR *et al*., 1988, quoted by DELITTI & MEGURO, 1997).

In the estimation of net emissions, it was assumed that regrowth, when identified through analysis of satellite images, has restored the carbon density back to its original levels.

From data shown in Table 3.5.3 it can be concluded that the average carbon content adopted for deforestation was 63.0 tC/ha; and for regrowth, 49.7 tC/ha.

Atlantic Forest

To estimate CO_2 emissions and removals by the Atlantic Forest biome, data were obtained from the Atlantic Forest Remnants and Associated Ecosystems project, developed by the SOS Mata Atlântica Foundation and INPE, comprising the 1990-1995 period. From the 80 scenes associated with the Atlantic Forest biome, 70 TM/Landsat 5 scenes were considered. The biome was divided into three vegetation classes: *mata*, *restinga*, and mangrove. Deforestation and regrowth areas during that timeframe were obtained for each one of them.

The average biomass values attributed to each of these classes were obtained from the Brazilian scientific literature (DELITTI & BURGER, 1997); (SILVA, 1999). The carbon densities used were:

- *Mata*: 123.6 tC/ha for deforestation and annual removal of 2.40 t C/ha by regrowth;
- *Restinga*: 61.8 tC/ha for deforestation and 1.44 t C/ha by regrowth; and
- Mangrove: 31.4 tC/ha, both for deforestation and regrowth.

Table 3.5.3 presents the emissions by sources and removals by sinks associated with land-use change in Brazil by biome, as estimated in this Inventory for the 1988-1994 period.

Table 3.5.3 - Net emissions from forest conversion and abandonment of managed lands by biome - 1988 to 1994

Biome	Deforestation: Area in the period (1988 - 1994)	Deforestation: Gross Annual Emissions	Regrowth: Total Area	Regrowth: Annual Removal	Net Annual Emissions		
	(10^3 km^2)	(Tg C/year)	(10^3 km^2)	(Tg C/year)	(Tg C/year)	(Tg CO_2/year)	(%)
Amazonia - sampled scenes to estimate regrowth	39.2	66.9	36.0	15.1	51.8	189.9	
Amazonia - other scenes	52.9	84.9	46.3	19.8	65.1	238.8	
Amazonia	**92.1**	**151.7**	**82.3**	**34.9**	**116.9**	**428.6**	**59**
Cerrado - sampled scenes	28.6	22.5	6.6	5.1	17.3	63.6	
Cerrado - other scenes	60.1	44.7	11.1	10.5	34.1	125.1	
Cerrado	**88.7**	**67.1**	**17.7**	**15.7**	**51.5**	**188.7**	**26**
Atlantic Forest*	**4.6**	**11.8**	**2.0**	**0.5**	**11.3**	**41.3**	**6**
Caatinga - sampled scenes	11.3	5.2	-	-	5.2	19.2	
Caatinga - other scenes	12.6	4.7	-	-	4.7	17.3	
Caatinga	**24.0**	**10.0**	**-**	**-**	**10.0**	**36.5**	**5**
Pantanal	**9.8**	**10.3**	**3.4**	**2.8**	**7.5**	**27.4**	**4**
TOTAL	**219.2**	**250.9**	**105.5**	**53.8**	**197.1**	**722.5**	**100**

* 1990-1995 period.

The methodology used allows to obtain only average net annual emission in the studied period. To estimate the variation in annual emissions, even as an approximation, the annual estimates of gross deforestation in Amazonia, obtained from the PRODES project, were used, assuming a perfect correlation between these values and those for net emissions in all biomes. The results are presented in Table 3.5.4.

Table 3.5.4 - Net emissions from forest conversion and abandonment of managed lands - 1990 to 1994

	1990	1991	1992	1993	1994	Variation 90/94
			Tg CO_2			(%)
Gross deforestation	882.5	711.2	880.9	951.9	951.9	8
Regrowth	189.4	152.6	189.0	204.3	204.3	8
Net emissions	**693.1**	**558.6**	**691.9**	**747.6**	**747.6**	**8**

CO_2 EMISSIONS FROM SELECTIVE LOGGING ACTIVITIES

In addition to the emissions that result from deforestation, others result from selective logging activities. The areas affected by these can be later subject to deforestation, or abandoned. The latter results in natural regrowth and consequent reposition of the carbon stock. Selective logging occurs in Amazonia in different ways: from the exploitation by private companies with good infrastructure, as in Paragominas, to manual exploitation, as in Tailândia, along the PA150 road. An evaluation of the selective logging activities in Amazonia was carried out at the National Institute for Space Research - INPE by Krug *et al.* (2001), using TM-Landsat 5 scenes at the scale 1:250,000, covering all the areas affected by selective logging activities identified through visual analysis. The observation of all the 229 scenes that cover the Brazilian Amazonia led to the identification of 26 such scenes, which presented varying degrees of selective logging intensity. These scenes were observed for each year in the period 1988 to 1998, indicating an annual mean increment of 1,561 km^2, with a standard deviation of 713 km^2. Several estimates of the area affected by selective logging in the Brazilian Amazonia can be found in the literature, with values ranging from 3,000 to 19,000 km^2. There are several reasons for such discrepancies: some authors generate their estimates from non-objective inferences (such as questionnaires), distinct from those obtained through use of satellite imagery; hypothesis about the permanence of selective logging scars in the images; the addition of a buffer area around the selective logged areas identified in the images, to account for damage caused by selective logging, amongst others. Considering that satellite images present limitations in the identification of low intensity (or low impact) selective logged areas, the mean area in the study by Krug *et al.* (2001) was increased by a factor of 2.56. Presently, several initiatives are being carried out to diminish the uncertainties associated with the estimates of the area affected by selective logging using orbital data. However, despite their uncertainties, these data allow the regular monitoring of an area as large as Amazonia, with its 3,500,000 km^2 of primary forest. For the purposes of estimating the CO_2 emissions, an area of 4,000 km^2 annually affected by selective logging activities was assumed. Several experiments are being conducted in the Brazilian Amazonia as part of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), to estimate fluxes in areas affected by selective logging. These fluxes, however, depend on the intensity of the logging and/or their impact in the area logged. Ideally, the areas identified in the images should be stratified by classes of intensity and/or impact of logging. Although this stratification has not been conducted, results from the study by Krug *et al*. (2001) indicated that 15% of the areas subject to selective logging in the period 1988 to 1998 were subsequently deforested, and that 38% of them were in advanced stage of regeneration (spectral response in the Landsat images similar to that of the primary forest). The remaining areas (47%) still presented scars associated with the logging activities. The CO_2 emissions in the areas of selective logging later deforested have not been accounted for, since they are included in the PRODES project, at the appropriate time. According to Fearnside (1994), care needs to be taken when using estimates of biomass in the computation of greenhouse gas emissions, to avoid double counting of the carbon affected by selective logging. This would occur if the biomass of the forest, before the selective logging, would be used in a calculation that computed the carbon emissions resulting from selective logging, when the same biomass value would be used for the deforestation. Hence, the same carbon would be accounted twice: through the deforestation, and through the selective logging products when they decompose. The emissions in the areas of selective logging abandoned for regrowth have not been included as well, since the CO_2 emitted is reincorporated into the forest during the regeneration process. It was assumed that the 47% remaining areas were subject to medium intensity selective logging. According to Uhl *et al*. (1991), considerable damage occurs during the logging process. The largest part of this damage (55%) concentrates in the canopy openings that result from tree fellings. Their results also illustrated that there is an ample natural regeneration of the wood species after selective logging, due the light abundance and nutrients, in the form of material in decomposition in such areas. However, the most abundant species that originate from regeneration are not necessarily the same as those extracted during the logging process. The net emissions of CO_2 that result from selective logging activities depend on the intensity and/or impact of the exploitation. Presently, there are no reliable data in the literature to represent this heterogeneity. However, preliminary results from LBA, based on flux tower data in an area of selective logging of low impact indicated an annual net emission of approximately 2 tC/ha. They also indicate that the emissions associated with selective logging activities are larger in the year of cut, and less intense in the following years. Taking into account these preliminary results, and considering the lack of observational data in areas of medium impact, a net emission of 10 tC/ha was assumed to estimate the CO_2 emissions from selective logging. It was also assumed that emissions resulted from selective logging activity in the following 3 years, with a net annual emission of 1 tC/ha. These assumptions led to an annual estimate of 2.4 Tg C resulting from selective logging. Due to the need of more elaborated analyses, CO_2 emissions from selective logging have not been included in this Inventory.

3.5.2.2 Emissions of other greenhouse gases from burning in the deforestation area

The methodology used to estimate CO_2 emissions took into account the immediate emission of all the carbon contained in the existing biomass of the deforestation area, regardless of its fate. To estimate the emissions of other greenhouse gases, only the share of biomass that was actually burnt in the area was considered. Thus, the timber used for commercial purposes (furniture and construction) and the firewood used for energy generation elsewhere was subtracted from the total biomass cleared. Non-CO_2 greenhouse gas emissions from firewood combustion outside the deforestation area were accounted for in the Energy sector (section 3.1.2.2).

To estimate the amount of timber removed for commercial uses, except that used as firewood, statistical data from IBGE were used. A study carried out to estimate the percentage of harvested wood (RODRIGUES *et al.*, 2004) showed a large variation depending on the studied area and resulted in an average value of 4% of total biomass contained in the deforestation area. This value is considered to be underestimated since it only takes into account the timber that was commercially registered. Based on personal communication with experts from the National Institute of Research in Amazonia - INPA, the total figure of 6% was adopted for the quantity of removed timber.

To estimate the share of biomass cleared for use as firewood, information on the consumption of firewood in the different sectors, including charcoal production, were obtained from the Brazilian Energy Balance (MME, 1998). The values estimated for firewood consumption include both timber from native forests and timber from reforestation areas. The criterion adopted was that all timber originated from native forests except that used for industrial purposes and in charcoal production. For almost all industrial sectors it was considered that 50% of the timber originated from native forests and 50% from reforestation areas. For the pulp and paper, cement, and metallurgical sectors, the criterion adopted is that all timber comes from reforestation. For charcoal production a variable composition over time was used, according to the information obtained from consumption of charcoal from reforestation (Part III, Table 1.8.1). This analysis leads to an estimate that 9% of total biomass contained in the deforestation area was used as firewood.

To estimate the emissions of CH_4, N_2O, CO, and NO_x, the IPCC methodology was used. For the fraction of biomass effectively burnt (burning efficiency), the value of 0.5 was adopted (CARVALHO *et al.*, 2001). The IPCC default values were adopted for the emission factors and the N/C relation.

Table 3.5.5 presents the emissions of these gases for the 1988-1994 period.

Table 3.5.5 - Non-CO_2 greenhouse gas emissions from biomass burning in forest conversion areas - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CH_4	1,615	1,283	1,638	1,793	1,805	12
N_2O	11.1	8.8	11.3	12.3	12.4	12
CO	14,132	11,230	14,331	15,693	15,797	12
NO_X	401	319	407	446	449	12

3.5.3 CO_2 emissions and removals by soils

Net CO_2 emissions from soils are mainly associated to changes in the amount of carbon stored. Release of CO_2 can also originate from inorganic sources such as lime use to improve soil fertility. In native ecosystems, climate and soil conditions are the primary determinants of the carbon balance, because they control the rates of production and decomposition. However, in agricultural systems, the type of land use and management alter both the entrance of organic matter and the rate of decomposition through production of residues, selection of cultivars, fertilization, harvest techniques, soil tillage practices, and waste management.

Invariably, the destruction of native vegetation followed by cultivation leads to the reduction of soil carbon (DETWILLER, 1986; BROWN & LUGO, 1990; SCHLESINGER, 1986). Several reviews of the literature mention losses between 20% and 40%, or more (DETWILLER, 1986; SCHLESINGER, 1986). However, studies have shown that under well managed pasture conditions, carbon stocks can achieve the same levels or even higher than those found under native forests (NEPSTAD *et al.*, 1991; CERRI *et al.*, 1991; MORAES *et al.*, 1995; and NEILL *et al.*, 1997). Nevertheless, these conditions are not found in Brazil, where existing estimates show that more than 50% of pasture is degraded or with productivity declining considerably (MACEDO, 1995; SPAIN *et al.*, 1996; FEARNSIDE & BARBOSA, 1998; VEIGA & SERRÃO, 1987).

The methodology used to estimate CO_2 emissions and removals by soils resulting from land-use changes was that suggested by the IPCC (1997), which covers the following processes: i) CO_2 emissions and removals by mineral soils resulting from changes in land use and management practices; ii) CO_2 emissions from reaction of neutralization of lime used in agriculture; iii) CO_2 emissions from use of organic soils because of the rapid oxidation of organic matter. Table 3.5.6 presents the estimates of emissions and removals for each of the processes.

Table 3.5.6 - CO_2 emissions and removals by soils - 1990 to 1994

Subsector	1990	1991	1992	1993	1994	Variation 90 - 94
			(Gg CO_2)			
Change in land use and management practices	93,259	83,887	74,514	65,142	55,769	-40
Lime use	5,103	4,719	6,780	8,650	8,991	76
Organic soils	11,871	12,168	12,041	11,686	10,853	-9
TOTAL	**110,233**	**100,744**	**93,335**	**85,478**	**75,613**	**-31**

3.5.3.1 CO_2 emissions and removals by mineral soils resulting from changes in land use and management practices

To estimate CO_2 emissions from soils resulting from land-use change, two sources of data were necessary: i) representative carbon stocks of soil (under primary vegetation conditions); ii) land-use changes in a period of 20 years. Data on representative carbon stocks had to be estimated because they were not available.

Estimation of the original carbon stock of soil under native vegetation

The methodology adopted for calculating the representative carbon stocks consisted of the following stages: i) preparation of the Soil-Vegetation Associations (SVA) map for Brazil; ii) organization of a database of soil profiles, containing information such as carbon concentration, type of soil, and native vegetation; iii) calculation of individual carbon stocks (profile by profile); iv) estimate of values for representative soil carbon under native vegetation for each SVA category.

The ASV map, based on an assumption that there is a direct relation between climate, vegetation, and soil carbon stocks, is an adaptation of the methodology proposed by the IPCC (1997), which includes a soil-climate associations map. This soil-vegetation associations map was prepared in three stages: i) stratification of the original soil map into six great soil groups, according to some characteristics recommended by the IPCC (1997), such as type of clay (high or low activity), soils texture and drainage; ii) stratification of the vegetation map of Brazil into 15 great categories, according to the typology of vegetation and/or geographic location; iii) combination of the soil and vegetation map, resulting in 75 categories (of the 90 possible).

The database of soil profiles was prepared using information already published in national and regional inventories. Most information about soil profiles came from descriptions defined in the project RADAMBRASIL (MME, 1973-1983; IBGE, 1986-1987) and the soil descriptions of EMBRAPA at a state scale (EMBRAPA/SNLCS, 1978-1980). The following information was considered for each soil profile: location (geographic coordinates or corresponding city), type of soil, type of vegetation or use, horizons analyzed, carbon concentration (Walkley-Black type methods, WALKLEY & BLACK, 1934), apparent soil density (ASD), and clay content (pipette method - DAY, 1965). In total, 3,969 soil profiles were incorporated into the database.

The representative carbon stock (RCS) of each horizon was estimated through the product of the following variables: apparent soil density (ASD); carbon concentration; and thickness of each pedogenetic horizon (i.e. horizons A, B, and C) to 30 cm of depth. Where there was no record of ASD, the models developed by Bernoux *et al*. (1998) were applied for the determination of ASD in soils of Amazonia.

The RCS values ranged from 1.51 kg C/m^2 (Sandy Soils under Steppe vegetation in the Northeast region) to 41.8 kg C/m^2 (Other Soils, in the Atlantic Forest). More than 75% of the area of all soil-vegetation categories had RCS values of between 3 and 6 kg C/m^2 and 41% were between 4 and 5 kg C/m^2.

The carbon potential in the upper layer (0-30 cm) of native soils was obtained through the combination of the RCS table and the Soil-Vegetation Associations map. The results show that 36.4 ± 3.4 Pg of carbon were originally stored in 8,456,931 km².

The estimated original carbon stocks of soils in the 0-30 cm layer are presented in Table 3.5.7 for each region. Values range from 31.7 t C/ha (Northeast region) to 60.5 t C/ha (South region).

Table 3.5.7 - Representative carbon stock (RCS) in soil for the upper 30 cm layer

Region	Total area (km^2)	Area of land use (km^2)	Total carbon (0-30 cm)[1] (Tg C)	RCS (t C/ha)
North	3,869,638	3,822,534	17,789	46.5
Northeast	1,561,178	1,540,743	4,886	31.7
Southeast	927,297	923,105	3,725	40.4
South	577,214	559,661	3,388	60.5
Center West	1,612,077	1,610,888	6,591	40.9
BRAZIL	**8,547,404**	**8,456,931**	**36,378**	**43.0**

Sources: Cerri *et al.*, 2002; [1]Bernoux *et al*., 2001.

CO_2 emissions

CO_2 emissions from land-use changes resulting from changes in carbon stocks were based on the difference over a 20-year period. The carbon stock in a given year was obtained by multiplying the representative carbon stock by the area occupied with each class of land use and the impact factor.

The impact factor represents the changes in carbon stock (mainly losses) as a function of land-use change and management practices, according to the IPCC (1997) methodology. The impact factor is obtained by multiplying the base factor by the tillage factor and the input factor. To summarize, the base factor represents the loss of soil carbon resulting from the conversion of forest to agricultural use; the tillage factor represents the loss of carbon resulting from soil management (i.e. plowing and harrowing); and the input factor represents the amount of organic matter that is incorporated into the soil. Table 3.5.8 presents the coefficients used for the impact factors.

Table 3.5.8 - Factors used for the different categories of land use

Category of land use [1]	Base factor (a)	Tillage factor (b)	Imput factor (c)	Impact factor (a x b x c)
Crops[2]: PC/TC/FL	0.6	0.9	0.8	0.432
Pastures[3]: NP/PP	0.9	NA[4]	NA	0.9
Forests[5]: NF/PF	1.0	NA	NA	1.0
Others[5]: UU/US/Other	1.0	NA	NA	1.0

[1] Meaning of the abbreviations: PC - permanent crop; TC - temporary crop; FL - fallow land; NP - natural pasture; PP - planted pasture; NF - native forest; PF - planted forest; UU - unused productive land; US - unsuitable land; Other - area not used by rural establishments;

[2] The tillage factor refers to the full level (i.e. with plowing and harrowing) and the input factor to a low level of input (i.e. soil management without incorporation of organic matter);

[3] Assuming 50% of the pastures are not improved (MACEDO, 1995; SPAIN *et al*., 1996), with an associated base factor of 0.7, and 50% of pasture improved, with a base factor of 1.1;

[4] Not applicable;

[5] Basic reference value = 1.0.

Annual emissions from soils resulting from land-use changes were estimated at 93.3 Tg CO_2 and 55.8 Tg CO_2 for the 20-year period ending in 1990, and at 55.8 Tg CO_2 for the period ending in 1994. Table 3.5.9 shows the results by region.

Table 3.5.9 - Net CO_2 emissions by mineral soils from land use change and management practices - 1990-1994

State/region	1990	1991	1992 (Gg CO_2)	1993	1994
North	22,517	21,721	20,925	20,129	19,332
Northeast	21,433	19,507	17,582	15,657	13,731
Southeast	6,749	4,672	2,595	517	-1,560
South	11,835	8,901	5,966	3,031	97
Center West	30,725	29,086	27,447	25,808	24,169
BRAZIL	**93,259**	**83,887**	**74,514**	**65,142**	**55,769**

Note: positive values represent net carbon emissions and negative values represent uptakes.

3.5.3.2 Emissions from liming agricultural soils

CO_2 emissions from liming agricultural soils to ameliorate soil acidification can be estimated based on the composition and amount of the lime applied annually in the country (IPCC, 1997). Information on annual agricultural lime sales in Brazil in the 1990-1994 period was provided by the Brazilian Association of Agricultural Lime Producers - ABRACAL. Because of the lack of more detailed data about the composition of lime sold in the country, it was assumed that the lime consumed in Brazil is composed primarily of calcium carbonate. Corresponding emissions were obtained using an emission factor of 0.44 t CO_2/t $CaCO_3$.

The annual emissions resulting from the use of lime were estimated at 5.10 Tg CO_2 and 8.99 Tg CO_2 for the years 1990 and 1994, respectively. Table 3.5.10 presents the estimations by region.

Table 3.5.10 - Annual CO_2 emissions from the use of lime in agriculture - 1990 to 1994

State/ region	1990	1991	1992 (Gg CO_2)	1993	1994	Variation 90 - 94 (%)
North	0	0	0	3	3	-
Northeast	81	97	210	257	505	520
Southeast	1,666	1,795	2,301	2,654	3,097	86
South	2,255	1,428	2,570	3,186	3,243	44
Center West	1,101	1,399	1,698	2,549	2,144	95
BRAZIL	**5,103**	**4,719**	**6,780**	**8,650**	**8,991**	**76**

3.5.3.3 CO_2 emissions from organic soils

Conversion of organic soils to agriculture is normally accompanied by artificial drainage, cultivation and liming, resulting in rapid oxidation of organic matter and soil subsidence. Because of lack of specific information for the Brazilian conditions, the IPCC default emission factor for tropical systems was used, that is, 20 tonnes of carbon per hectare/year in croplands. Only the floodplains used for rice cultivation were considered, as they were identified as the only ones where there is drainage, which is a necessary condition for CO_2 emissions.

Annual CO_2 emissions from the cultivation of organic soils were estimated at 11.9 Tg for 1990 and 10.9 Tg for 1994. Table 3.5.11 shows the area of organic soil cultivation and the corresponding CO_2 emissions.

Table 3.5.11 - CO_2 emissions from organic soils - 1990 to 1994

	1990	1991	1992	1993	1994
Cultivated organic soils (ha)	161,883	165,922	164,191	159,361	147,998
CO_2 Emissions (Gg)	11,871	12,168	12,041	11,686	10,853

3.5.4 Carbon dioxide and methane emissions from Brazilian hydroelectric reservoirs

Estimates of CO_2 emissions from flooded biomass in reservoirs are included in the estimation of CO_2 emissions from forest conversion, reported in section 3.5.2 of the present Inventory. The IPCC methodological guidelines used in this Inventory do not consider the estimation of CH_4 emissions from reservoirs. In Brazil, except for the studies by COPPE/UFRJ for Eletrobrás in 1992-1993 (in the reservoirs of Samuel, Tucuruí, and Balbina), there were no reports of *in loco* scientific studies to determine the total emissions of greenhouse gases (bubbles and molecular diffusion), through a program of systematic sampling. A specific study was then carried out with measurements of emissions from reservoirs, aiming at the development of a methodology to estimate methane emissions from hydroelectric reservoirs in the country and to be used in the present Inventory. Because of the limited availability of financial resources, the number of reservoirs studied had to be restricted.

The criterion adopted for the selection of reservoirs included the identification of parameters that could explain the variations in the measurements of gases. Such parameters include: geographic latitude; meteorological conditions; age of the reservoir (time since flooding); presence of anthropogenic activity; preservation of environmental conditions; and time of water residence.

To estimate the emissions, seven reservoirs were selected, which were located at different latitudes and had different biomes and ages since flooding. Measurements were made at three different meteorological conditions in the reservoirs of Miranda, Barra Bonita, Segredo, Três Marias, Xingó, Samuel, and Tucuruí. Additional data from measurements carried out in the reservoirs of Itaipu (Itaipu Binational) and Serra da Mesa were used. The measurement methodologies used were essentially the same for all cases.

The latitudes involved ranged from 2° S to 25° S e vegetation types included equatorial rainforest, subtemperate forest, Atlantic forest, *cerrado*, and *caatinga* (semi-arid), which includes the principal Brazilian ecosystems. The ages since flooding of the hydroelectric reservoirs range from one to twenty years, which gives the study good temporal representation. Table 3.5.12 below provides a brief description of the reservoirs studied.

Table 3.5.12 - Summary of the characteristics of the hydroelectric reservoirs studied and referenced

Station	Latitude	Biome	Capacity (MW)	Area of reservoir (km²)	Density of generating capacity (W/m²)
Miranda	18º55' S	*Cerrado*	390	51	7.71
Três Marias	18º13' S	*Cerrado*	396	1,040	0.38
Barra Bonita	22º31' S	Atlantic Forest	141	312	0.45
Segredo	25º47' S	Atlantic Forest	1,260	82	15.37
Xingó	9º37' S	*Caatinga*	3,000	60	50.00
Samuel	8º45' S	Amazonia	216	559	0.39
Tucuruí	3º45' S	Amazonia	4,240	2,430	1.74
Serra da Mesa*	13º50' S	*Cerrado*	1,275	1,784	0.71
Itaipu*	25º26' S	Atlantic Forest	12,600	1,549	8.13

* Reservoirs studied in parallel surveys.
SOURCE: ANEEL, 2000.

Methane emissions in each of the reservoirs selected, whether through bubbles or diffusive exchange between water and atmosphere, were assessed by sampling, with subsequent extrapolation of results to obtain a value for the reservoir. A great variability was found in the intensity of emissions, linked to the influence of various factors, including temperature, depth at the point of measurement, wind regime, sunlight, physical and chemical parameters of water, the composition of the biosphere, and the operational regime of the reservoir. Table 3.5.13 shows the emission estimates for each of the reservoirs studied.

Table 3.5.13 - Summary of methane emissions from the hydroelectric reservoirs studied and referenced

Hydroelectric dam	Bubbles	Diffusion	Total
	kg CH_4/km²/day		
Miranda	23.8	130.3	154.1
Três Marias	164.5	31.8	196.3
Barra Bonita	3.9	17.0	20.9
Segredo	1.8	7.0	8.8
Xingó	10.8	29.3	40.1
Samuel	16.5	87.6	104.1
Tucuruí	7.8	101.6	109.4
Serra da Mesa*			51.1
Itaipu*			20.8

* Measurements made in other studies.

An important observation was the low correlation between emissions and the age of the reservoir, which could be related to the fact that emissions result not only from the decomposition of the preexisting stock of terrestrial biomass, but also from the organic matter from the upstream drainage basin (i.e. carbon from biomass and soil, and any sewage effluent and residual waters) and from the organic material produced internally in the reservoir (i.e. production of phytoplankton). This fact suggests a greater difficulty in separation of anthropogenic emissions from flooding of reservoirs from emissions that would occur even in the absence of the dam. Because of these factors, the results obtained have a high level of uncertainty and need to be improved by the further development of existing studies.

For these reasons, it was not possible to estimate anthropogenic CH_4 emissions from reservoirs in this Inventory. Based on the measurement methodologies developed in this work, and on the experience of analyzing the results, a new study is under way seeking to obtain a greater number of measurements and reduce the uncertainties of results. There are also plans for a study of emissions prior to the construction of the Belo Monte hydroelectric station, to allow a comparison of emissions to be measured after construction, with the objective of identifying the anthropogenic component of emissions.

Comparison was also made between emissions from hydroelectric plants and thermoelectric equivalents. Keeping in mind that the estimated values for hydroelectric plants include emissions that are not totally anthropogenic and that there is probably double counting of methane emissions from sewages, especially domestic wastewater released into the reservoirs, the hydroelectric plants studied in general had lower emissions than equivalent thermoelectric plants. Hydroelectric facilities with greater power densities (capacity/area flooded - W/m^2), such as Itaipu, Segredo, Xingó and Miranda, had the best performance, much better than thermoelectric plants with the most modern technology natural gas with combined cycle, with 50% efficiency. On the other hand, some hydroelectric stations, with low power density, such as Samuel (and also Balbina, which was studied previously) perform only slightly above or even worse than their thermoelectric equivalent plants.

Waste

3.6 Waste

Disposal of solid waste and treatment of domestic or industrial wastewater can produce greenhouse gas emissions. CH_4 emissions result both from solid waste disposal and anaerobic handling of sewage and wastewaters. N_2O emissions also occur as a result of domestic wastewater treatment. Waste incineration, like all combustion, generates greenhouse gas emissions, depending on waste composition, but this activity is much reduced in Brazil.

The methodology introduced by the IPCC (1997) lead to the assessment of statistical data for the definition of the characteristics of the population and the industrial park in Brazil. It is necessary to know the total urban population, along with the conditions of effluent treatment and waste disposal. That implies determining the volume of waste generated, its organic matter content, and the nature of sanitation facilities, such as landfills or open dumps and anaerobic sewage treatment, in a given year. Much of these data is not available for all the country or has very high uncertainties.

In 1990, Brazil's population was 150 million people, which represented a population density of 17.6 inhabitants/km^2. This density, however, varied a lot among regions: the North, with 5% of the population, had 1.9 inhabitants/km^2; the Northeast, 28.2 inhabitants/km^2 or 29% of the population; the Southeast, with 44% or 70.4 inhabitants/km^2; the South, with 16% or 41.6 inhabitants/km^2; and the Center West, with 6% or 5.9 inhabitants/km^2.

Brazil has had an urbanization rate much higher than world average. According to IBGE (1997), in the 1991-1996 period, 78% of the population lived in urban areas.

This trend towards urbanization affects the choice of treatment and collection systems for solid and liquid wastes. The disorganized populational growth and development of huge unplanned cities make handling wastes more difficult.

3.6.1 Solid waste disposal

Waste deposits, landfills, and dumps generate CH_4 under certain conditions. This generation varies from place to place, as a function of factors such as amount of wastes, deposit age, presence of anaerobic environment, acidity, and structural and handling conditions. The better the control conditions in the landfills and the deeper the dumps, that is, the best the sanitation conditions, the greater the CH_4 emission potential.

According to the IPCC methodology (IPCC, 1997), CH_4 emissions can be estimated based on the country's urban population, solid waste generation rate, waste destination, and waste composition.

Urban population in the 1990-1994 period was estimated based on national censuses for 1980, 1991, and 1996 (IBGE, 1997a).

Studies by the Environmental Sanitation Technology Company (CETESB, 1992) that were based on a great number of municipalities in the state of São Paulo verified that daily waste generation per inhabitant in a city ranges from 0.4 to 0.7 kg/inhabitant, depending on the town's size, with an average daily rate estimated at 0.5 kg/inhabitant. This value was adopted in this Inventory. Based on the National Home Sample Survey (IBGE, 1997b), it was estimated that 85% of the solid waste generated was collected.

Solid waste disposal and treatment were distributed in the following way: 76% were deposited in open dumps, 22% in sanitary landfills, and 2% had other destinations, such as composting plants and incineration. The general conditions for solid waste disposal are inadequate in Brazil and there is no detailed assessment of such conditions or the average waste composition. Thus, in this Inventory, the IPCC default values were adopted for methane correction factor (0.6), degradable organic carbon (0.12), fraction of degradable organic carbon dissimilated (0.77), and fraction of methane in landfill gas (0.5).

CH_4 emissions from solid waste disposal were estimated at 0.68 Tg in 1994, growing by 10% in relation to emissions in 1990, as shown in Table 3.6.1.

Table 3.6.1 - CH_4 emissions from solid waste disposal - 1990 to 1994

	1990	1991	1992	1993	1994	Variation 90/94
Urban population (10^6 inhabitants)	107.8	111.0	113.3	115.7	118.1	10%
CH_4 emissions (Gg)	618	636	650	663	677	10%

3.6.2 Wastewater treatment

Effluents with high organic matter content, such as domestic wastewater and the effluents from the food and beverage and pulp and paper industries, have a great CH_4 emission potential. Domestic wastewater is also a source of N_2O emissions because of the nitrogen content in human food.

3.6.2.1 Domestic and commercial wastewater

A great variety of systems is used for wastewater treatment in Brazil. In spite of this, a huge amount of wastewater is released directly into rivers and the ocean without treatment. According to sanitation data from the National Survey on Basic Sanitation (IBGE, 1992b), from the 4,425 municipal districts of the country, 2,091 (47%) had sewage collection and from these, only 345 (8%) had some kind of collective treatment.

Among the various options for collective biological treatment, the most used in Brazil are stabilization ponds and variants of the activated sludge process; especially those that use delayed aeration and biological filters.

CH_4 emissions were estimated based on the amount of organic matter present in the effluents, expressed in terms of Biochemical Oxygen Demand (BOD_5), which represents the amount of oxygen consumed by microorganisms in five days in the biochemical oxidation of the organic matter.

For daily organic load generation the value of 0.05 kg BOD_5/inhabitant was used. Taking into account the assessment of the fraction of wastewater treated and the type of treatment, the emission factor of 0.02 kg CH_4/kg BOD_5 was used.

CH_4 emissions from domestic and commercial wastewater handling were estimated at 43 Gg in 1994, an increase of 10% in relation to the value estimated for 1990, as it can be seen in Table 3.6.2.

N_2O emissions were estimated based on the per capita protein intake in each state of Brazil, based on a study by Galeazzi *et al*. (1997), which identifies values ranging from 70.3 to 116.8 g/day/person, depending on the region. The IPCC default factors were used for the nitrogen content and subsequent N_2O emission. Emissions were estimated at 12.3 Gg N_2O in 1994, an increase of 6% in relation to 1990.

Table 3.6.2 - Emissions from domestic and commercial wastewater handling - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CH_4	39.3	40.5	41.4	42.2	43.1	10
N_2O	11.6	11.8	11.9	12.1	12.3	6

3.6.2.2 Industrial Wastewater

Industrial effluents from different sectors, such as food, beverages, chemical, metalwork, textile, leather, and pulp and paper, have been treated traditionally by means of lagoons or by activated sludge and biological filters. In the last years, however, there has been a strong tendency to use anaerobic reactors because they require small areas and do not consume energy for aeration.

To estimate CH_4 emissions, data on industrial production and the organic load emission factor were used for each of the industrial subsectors.

Table 3.6.3 shows the values estimated for the organic load generated by the sectors that most contribute to emissions from industrial wastewater.

Table 3.6.3 - Annual organic load by industrial sector

Sector	1990	1994
	(10^3 t BOD_5)	
Food and beverages	1,022	1,051
Pulp and paper	278	341
Oil/Petrochemical	231	244
Textiles	127	96
Tanning	61	65
Chemical	36	43
Other	6	8
TOTAL	**1,762**	**1,848**

Source: Environmental Sanitation Technology Company - CETESB.

As it was not possible to obtain information on the fraction of wastewater treated and methane emission factors for each type of industry, the IPCC default values were used (IPCC, 1997).

Emissions from industrial wastewater were estimated at 83 Gg CH_4 in 1994, an increase of 5% in relation to the value estimated for 1990, as shown in Table 3.6.4.

Table 3.6.4 - Emissions from industrial wastewater handling - 1990 to 1994

Gas	1990	1991	1992	1993	1994	Variation 90/94
			(Gg)			(%)
CH_4	79.3	79.3	81.2	81.6	83.2	5

4 UNCERTAINTY IN THE ESTIMATES

The estimates of anthropogenic greenhouse gas emissions and removals presented in this Inventory are subject to several sources of uncertainty, ranging from lack of accuracy in the basic data to insufficient knowledge of the processes that originated the greenhouse gas emissions and removals.

The IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000) acknowledges that uncertainty in the estimates cannot be totally eliminated and that the main objective should be producing neither over nor underestimates (accurate estimates), while seeking to increase the accuracy of the estimates as far as practicable.

Following such recommendations, in the production of the estimates presented in this Inventory efforts were made to ensure that the estimates did not contain any biases. However, this objective could not be completely achieved for some activities, either because it was not possible to make estimations for some subsectors or because of the default parameters used in the absence of adequate values for the national circumstances. Theses cases were indicated in the previous sections.

The accuracy of estimates varied depending on the characteristics of each sector, the data available and the resources that were invested in the determination of emission factors that were more adequate to Brazilian conditions. Emphasis was thus placed on the most relevant sectors in terms of greenhouse gas emissions.

In this Inventory, it was not possible to make a detailed analysis of the uncertainties in the estimates, since this would require a considerable effort to analyze the accuracy and precision of the basic information used. Even so, a general evaluation of the accuracy of the Inventory was carried out, based on the judgment/knowledge of specialists in the specific areas. The objective was simply to identify the sectors of the Inventory that would require more investment in the future.

The precision associated with the activity data and the emission factors as well as the emission or removal estimates are expressed as ± x %, meaning the limits of a 95% confidence interval for the value presented.

4.1 Uncertainty in CO_2 Emissions and Removals Estimates

Table 4.1.1 shows the results of the uncertainty analysis for CO_2 emissions and removals estimates.

Table 4.1.1 - Accuracy of CO_2 Emissions and Removals Estimates

Sector	Uncertainty (%)
Energy	**5**
Fossil Fuel Combustion	5
Fugitive Emissions	60
Coal Mining	50
Oil and Natural Gas	80
Industrial Processes	**7**
Cement Production	10
Lime Production	20
Ammonia Production	10
Aluminum Production	5
Other Industries	10
Land-Use Change and Forestry	**39**
Changes in Forest and Biomass Stocks	30
Forest and Grassland Conversion	30
Abandonment of Managed Lands	40
Emissions and Removals from Soils	50
TOTAL	**29**

4.2 Uncertainty in CH_4 Emissions Estimates

Table 4.2.1 shows the results of the uncertainty analysis for CH_4 emissions estimates.

Table 4.2.1 - Accuracy of CH_4 Emissions Estimates

Sector	Uncertainty (%)
Energy	**28**
Fossil Fuel Combustion	30
Fugitive Emissions	64
Coal Mining	80
Oil and Natural Gas	100
Industrial Processes (Chemical Industry)	**10**
Agriculture	**46**
Enteric Fermentation	50
Manure Management	60
Rice Cultivation	50
Field Burning of Agricultural Residues	50
Waste	**51**
Solid Wastes	60
Wastewater Handling	49
Industrial	70
Domestic and Commercial	50
TOTAL	**41**

4.3 Uncertainty in N_2O Emissions Estimates

Table 4.3.1 shows the results of the uncertainty analysis for N_2O emissions estimates.

Table 4.3.1 - Accuracy of N_2O Emissions Estimates

Sector	Uncertainty (%)
Energy (Fuel Combustion)	**50**
Industrial Processes (Chemical Industry)	**10**
Agriculture	**57**
Manure Management	60
Agricultural Soils	60
Grazing Animals	100
Other Direct Sources	100
Indirect Sources	100
Field Burning of Agricultural Residues	50
Waste (Domestic Wastewater Handling)	**50**
TOTAL	**53**

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Description of Steps Taken or Envisaged to Implement the United Nations Framework Convention on Climate Change in Brazil

Brazil's Initial National Communication

Part III

"And who knows, then
Rio will be
Some underwater city
The divers will come
Explore your house
Your room, your things
Your soul hideouts".

"Futuros Amantes"
(Brazilian popular song, by Chico Buarque)

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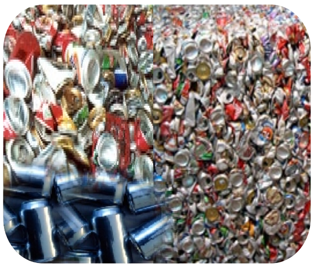
Programs And Activities Related to Sustainable Development



1 PROGRAMS AND ACTIVITIES RELATED TO SUSTAINABLE DEVELOPMENT

Some of the programs and activities related to sustainable development involve the use of renewable energies and energy conservation/efficiency, which are responsible for the fact that Brazil has a "clean" energy matrix, with very low greenhouse gas emissions in the energy sector. These programs contribute to the stabilization of greenhouse gas concentrations in the atmosphere and at the same time contribute to sustainable development over the long term.

One of the main programs related to sustainable development is the National Alcohol Program - Proalcool, developed to reduce the need for foreign currency during the oil price shocks. From 1975 to 2000, around 5.6 million vehicles running on hydrated alcohol were produced. In addition, Proalcool allowed the substitution of all previously pure gasoline with up to 25%[1] anhydrous alcohol, for a fleet of more than 10 million gasoline-fueled vehicles, thereby avoiding carbon dioxide emission in the order of 400 million tonnes over this period. This also offset imports of 550 million barrels of oil, and reduced the demand for foreign currency by around 11.5 billion dollars[2].

Other important programs seek to reduce energy waste, and indirectly contribute to avoiding further greenhouse gas emissions. These programs include the National Electrical Energy Conservation Program - PROCEL, created in 1985; and the National Program for the Rational Use of Natural Gas and Oil Products - CONPET, created in 1991. The objective of these programs is to reduce losses and eliminate waste in energy production and use, and encourage the adoption of more energy efficient technologies, and they also contribute to delaying the need for investments in new electrical stations and oil refineries.

In 2000, Brazil produced 322 TWh from generating stations connected to the public grid, and more than 90% of this production was from hydroelectric sources. Because of this, the Brazilian electrical sector has special characteristics, not only as one of the world's largest producers of hydroelectric energy, but also because of the predominance of hydroelectricity in electrical generation.

Thus, CO_2 emissions from the Brazilian electrical sector are among the lowest in the world in relation to population and GDP. However, emissions have been growing in recent years. But this trend can be modified and even reversed with the programs and activities related to sustainable development (new renewable energy sources and use of charcoal), addressed in this section.

1.1 The National Alcohol Program

1.1.1 History of Alcohol as Fuel

Even after several centuries of growing sugar cane, only in the 20th century did Brazil discovered in alcohol an attractive energy option. Between 1905 and the late 1960s, there were several attempts by the sugar and alcohol industry to promote alcohol as a fuel. But in the mid-1970s, with the fall in international sugar prices and rising oil prices, the basis for a stronger role for fuel alcohol was created.

The "oil shocks" of the 1970s, especially the second, in 1979, had a great impact on the economy of Brazil. To reduce distortions in the Brazilian trade balance caused by the sharp rise in oil prices, the Federal Government decided to implement an energy policy whose objective was to reduce the balance of payments deficit. One of the key elements of this policy was support for alternative energy sources to replace imported oil, as well as energy efficiency, mainly through the following programs:

- Oil Production Program;
- Thermal Electric Program;
- Efficiency in Energy Use Program - Conserve;
- National Alcohol Program - Proalcool.

In Brazil, in terms of fuel alcohol specifically, one of the most significant measures was the introduction of ethanol as a stand-alone fuel. Annual end use energy consumption of ethanol grew from 580 million liters in 1975 to 10.6 billion liters in 2000, peaking with a production of 15.5 billion liters in 1997.

In 2000, ethanol was used as a fuel in two ways: blended with gasoline, with a content of around 22%[3] of anhydrous alcohol, forming a "gasohol"[4] mixture; and as pure alcohol, in the form of hydrated alcohol, used in vehicles with engines designed for the exclusive use of hydrated alcohol as a fuel.

Ethanol has proven a good automotive fuel, with a higher octane rating than gasoline. Furthermore, it contains no sulfur, thus avoiding emissions of sulfur compounds and the contamination of catalytic converters, and it has a lower vapor pressure than gasoline, which results in less emission through evaporation.

1.1.2 Development of the National Alcohol Program

Proalcool was created on November 14, 1975 by Decree no. 76.593, with the objective of stimulating ethanol production to meet the needs of domestic and international markets, as well as automotive fuels policy. The decree states that production of ethanol from sugar cane, manioc or any other raw material should be encouraged through the expansion of supply of raw materials.

Sugar cane has the highest return for farmers per hectare planted. The production cost for sugar in Brazil is one of the lowest in the world, which allows Brazilian producers to compete on highly favorable conditions on the international market. However, this market is volatile and prices fluctuate widely. Global production of sugar in 2000 was 131 million tonnes, with around 13% coming from Brazil (FAO Statistical Database).

The production process for sugar and alcohol differ only in terms of the use of treated and cooked juice, which can then be fermented for alcohol production, or processed for crystallization of sugar.

The decision to produce ethanol from sugar cane, aside from the cost of sugar production, is also based on political and economical reasons, involving additional investments. This decision was taken in 1975, when the Federal Government decided to encourage production of alcohol to replace pure gasoline, in order to reduce oil imports, which were placing a heavy burden on the balance of payments. At this time, the price of sugar on the international market did not provide adequate return for Brazilian exports, which contributed to the implementation of the alternative fuel program.

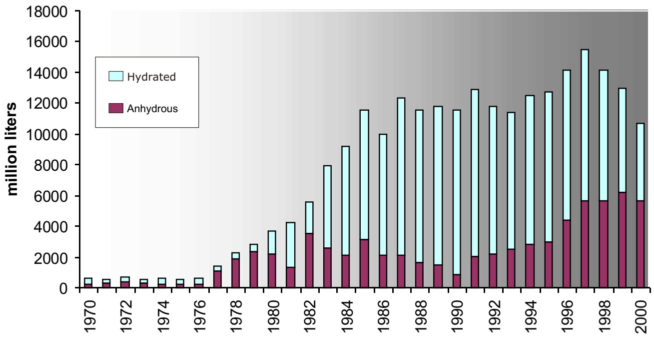
[1] According to data from the National Energy Balance (MME, 2000) from 1975 to 2000, the anhydrous alcohol content in the mixture (gasoline/anhydrous alcohol) over the period ranged from a minimum of 1.1% (in 1975) to a maximum of 25% (in 1999).
[2] Given the replacement of 1 liter of gasoline by 1 liter of anhydrous alcohol or by 1.25 liters of hydrated alcohol; 5% of the energy consumed in refining; the average prince of "Brent" oil (British Petroleum - BP); and the percentage of oil imports. Given also the emission factor of 0.63 kg of C per liter of gasoline (IPCC, 1997).
[3] See footnotes 1 and 6.
[4] In Brazil, what is usually called gasoline is a mixture of pure gasoline and anhydrous alcohol, known internationally as "gasohol".

To briefly summarize, Proalcool involved the following key phases:

Initial Phase (1975 to 1979)

The effort was directed mainly at the production of anhydrous alcohol for mixture with gasoline. In this phase, the main effort was made by the connected distilleries. Alcohol production grew from 600 million liters per year (1975-1976) to 3.4 billion liters per year (1979-1980) (Figure 1.1). The first cars fueled by ethanol alone were produced in 1978.

Figure 1.1 - Evolution of Ethanol Production - 1970 to 2000

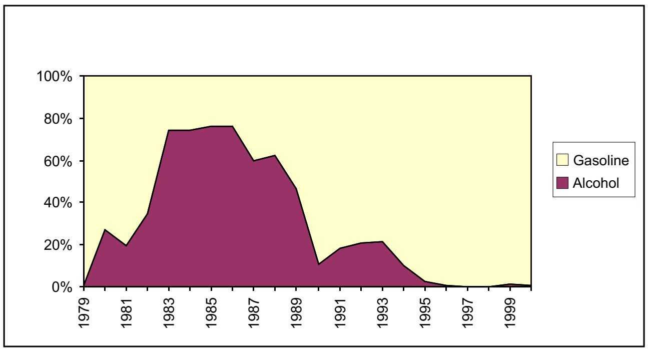


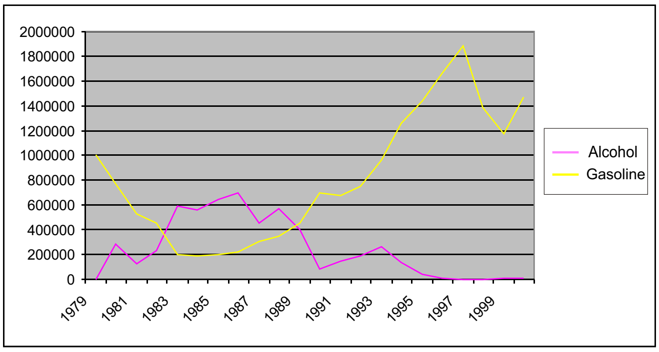
Source: National Energy Balance - BEN, 1986/1990/2001.

Expansion Phase (1980 to 1986)

The second oil shock (1979-80) tripled the price per barrel of oil, and oil imports came to represent 46% of all Brazilian imports in 1980. The government then decided to adopt measures for the full implementation of PROACOOL. Bodies such as the National Alcohol Council - CNAL and the National Alcohol Executive Commission - CENAL were created to facilitate the program. Alcohol production reached a peak of 12.3 billion liters in 1986 and 1987 (Figure 1.1), exceeding by 15% the government's initial goal of 10.7 billion liters/year for the end of this phase. The proportion of ethanol powered cars in the total of Otto cycle cars (passenger and mixed use) manufactured in Brazil increased from 0.46% in 1979 to 26.8% in 1980, and reached the ceiling of 76.1% in 1986 (Figure 1.2).

Figure 1.2 - Production of Light Vehicles





Source: National Association of Automotive Vehicle Manufacturers, 2001.

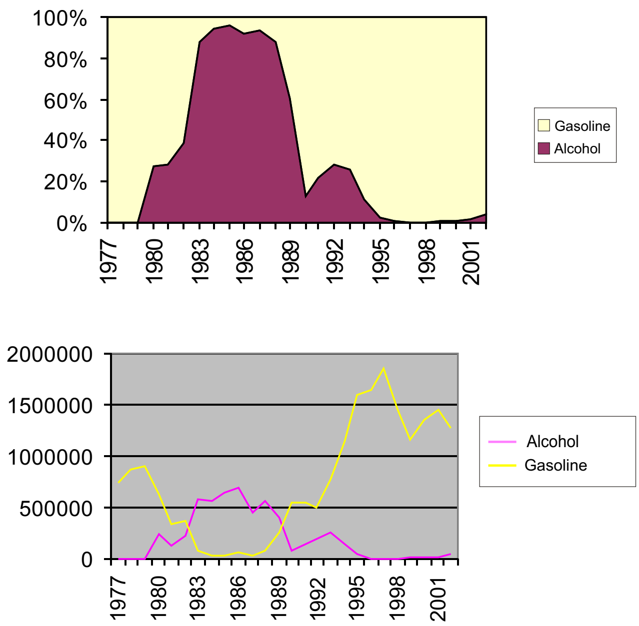
Stagnation Phase (1986 to 1995)

The year 1986 marked a new shift in the international oil market. The price per barrel of crude oil dropped from US$ 30-40 to a low of US$ 12-20. This new period, which some observers called the "oil countershock", dealt a blow to efforts to replace fossil fuels and to promote energy efficiency around the world. In Brazilian energy policy, this wave began to have an effect in 1988, coinciding with a period of scarce public resources to subsidize programs to stimulate alternative energy sources, resulting in a significant decrease in investments in domestic energy production projects.

The supply of ethanol could not keep with the growth in demand. In 1985, sales of ethanol-fueled cars exceeded 95% of total sales of Otto cycle vehicles for the domestic market. From that point on, the low prices of ethanol set by the Government, in the context of the sudden drop in international oil prices, brought an end to the increase in domestic alcohol production. However, maintaining ethanol low prices relative to gasoline, and lower taxes on ethanol fueled vehicles than on those using gasoline, continued being attractive to consumers. This combination of discouraging ethanol production and encouraging demand generated a supply crisis in the period between harvests in 1989-1990. In the period prior to the supply crisis, both production of alcohol, as noted above, and production and export of sugar, whose prices at the time were set by the Government, were discouraged. Annual ethanol production remained virtually constant, around 12 billion liters in the period 1985 to 1990.

Despite its temporary nature, the crisis of ethanol supply at the end of the 1980s damaged the credibility of Proalcool, which together with the reduction of incentives for the use of ethanol, caused in the coming years a significant drop in demand, and thus in sales of ethanol-fueled automobiles (Figure 1.3).

Figure 1.3 - Sales of Light Vehicles



Source: National Association of Automotive Vehicle Manufacturers, 2001.

Other factors should be mentioned that also contributed to the drop in production of ethanol fueled vehicles. At the end of the 1980s and the beginning of the 1990s, the international price of the oil barrel declined significantly. This situation, which persisted for the next ten years, combined with the increasing trend on the part of the automobile industry to standardize production of (gasoline-fueled) models and engines globally. In the early 1990s, Brazil also liberalized imports of automotive vehicles (manufactured with exclusively gasoline or diesel engines) and introduced an incentive policy for vehicles with 1,000 cubic centimeters engine ("popular car"), which until 1992 benefited only gasoline fueled vehicles.

The ethanol supply crisis obliged the country to at times import ethanol and methanol[5] to ensure market supply over the 1990s.

Redefinition Phase (from 1996)

The markets for fuel alcohol, both anhydrous and hydrated, are now free in all phases — production, distribution and resale — with the prices set by supply and demand. Currently, the question is how Brazil, without the role of government in the sector, will find modern market mechanisms that can ensure the supply of the different sectors, without breaking international trade rules. With a view to directing policies for the sugar and alcohol sector, the Interministerial Sugar and Alcohol Council - CIMA was created by decree on August 21, 1997.

According to the National Association of Automotive Vehicle Manufacturers (ANFAVEA, 2000), production of vehicles fueled by ethanol remained at around 1% of the total between 1998 and 2000. Incentives given to the use of hydrated alcohol in some classes of light vehicles, such as official cars and taxi, has led to a debate between experts in the economic area, opposed to incentives, and from the environmental areas, favorable to ethanol incentives. On May 28, 1998, Provisional Measure no. 1662 established a minimum percentage of 22% of anydric alcohol added to gasoline, which could reach 24%[6]. The producers and research centers have also tested the addition of ethanol to diesel fuel.

There are currently no incentives for ethanol, as a fuel. There is a regional incentive that compensates the higher production costs in the Northeast region in the agricultural stage[7], relative to the more efficient states, and a freight subsidy for producers located further from the consumption centers[8] (i.e., for those in Mato Grosso and Mato Grosso do Sul). This incentive, however, is temporary, because it sought only to provide a period of adjustment for those producers that faced a natural market disadvantage. All the government measures involving products from the sugar and alcohol sector are compatible with the commitments assumed by Brazil under the World Trade Organization - WTO.

1.1.3 Economic Aspects of Proalcool

Ethanol Production Costs

The cost of ethanol production is directly linked to the productivity of sugar cane cultivation and to the industrial yield of the process of ethanol production. In the last few decades, the development and implementation of new techniques and technologies in the sugar and alcohol sector were largely responsible for the reduction in costs of production. It is believed that from 1976 to 2000, the costs of production of fuel alcohol in Brazil fell from approximately 90 US$/bep to 45 US$/bep, which corresponds to an average rate of cost reduction of 2% a 3% per year.

The productivity gains in the sugar and alcohol sector came from three distinct phases:

- starting in 1975, search for greater industrial productivity;
- from 1981-1982 onwards, the pursuit of greater efficiency in conversion of sucrose to the final product, as well as through cost reductions;
- from 1985, integrated management of agricultural and industrial production, where planning and control of sugar cane production is integrated with industrial production.

To increase effectiveness of technological development programs, the sector has focused its efforts on the agricultural sector, because this stage involves around 61% of the costs of ethanol production.

Stages of Production

In sugar cane production (agricultural phase)

The average productivity of Brazilian sugar cane increased from 50-60 tonnes per hectare in 1975 to 75-85 tonnes per hectare in 1996, as a result of various factors:

- varieties of sugar cane selected — the Cooperative of Producers of Sugar Cane, Sugar and Alcohol of the State of São Paulo Ltd. — Copersucar[9] has the world's largest research program on genetic improvement of sugar cane and accounts for approximately 60% of sugar cane production in Brazil;

[5] MEG Mixture - 60% of hydrated alcohol, 34% of methanol and 6% of gasoline.
[6] This provisional measure was regulated by Law no. 10,203, of February 26, 2001.
[7] Ministry of Finance Administrative Directive no. 275/98 and CIMA resolution no. 5, from September 10, 1998.
[8] National Petroleum Agency - ANP Administrative Directive no. 138/98.
[9] Copersucar is a private cooperative made up of more than 100 members, including rural producers, agricultural units and sugar plants and alcohol distilleries. In the 2001-02 harvest it was responsible for a production of 54 million tonnes of sugar cane; 3.5 million tonnes of sugar, and 2.4 billion liters of alcohol, for a 20-25% share of Brazil's sugar cane industry.

- agriculture technology - leading developments are the principle of management of agricultural production with the use of soil maps, use of satellite images for identifying varieties, and general improvement of management;

- reduction of fuel consumption in harvest - the mechanization of harvest and the transport of more tonnes of sugar cane per trip provide a reduction of 50% in fuel consumption in harvest between 1991 and 1996;

- harvest of raw sugar cane - sales of machinery for harvest of raw sugar cane;

- management of agricultural residues - utilization of the waste product *vinhoto*, and dry cleaning of sugar cane, without the need for washing, thereby avoiding losses of 1% to 2% of sugar that is carried off by the water during washing of the cane;

- reduction of demand for artificial fertilizers - use of *vinhoto* as organic manure, rich in phosphorus and potassium.

In ethanol production (industrial phase)

There have been significant technological advances, resulting in an increase in average productivity in the conversion of sugar cane into ethanol from 75 liters/t in 1985 to around 85 liters/t in 1996, because of various factors:

- extraction of sugar cane juice - the extraction rate of juice from sugar cane grinding has risen from 92% to 97%. Also, with small changes in equipment and the operational system, it was possible to raise grinding capacity by 45%;

- treatment and fermentation of juice - first, biological control and then continuous fermentation (more than a 230% increase in productivity since 1975);

- distillation - increased capacity according to the alcoholic content of the mixture, because of improvements in equipment;

- improvements in the area of energy - in the production of sugar and alcohol, from 1980 to 1995, the percentage of plants self-sufficient in electricity, because of the utilization of bagasse in boilers, rose from 60% to 95%. Some plants already sell their surplus electricity to the grid. In São Paulo, there is already 300 MW available for the electrical system.

Ethanol Prices

Alcohol prices in Brazil are set by the free market. Given the importance of the sector, and its characteristics, the activities of production, distribution and sales of fuels are regulated by the National Petroleum Agency - ANP.

The percentage difference between the values attributed to ethanol and gasohol (gasoline mixed with anhydrous alcohol) between 1980 and 1997 indicates that there were distinct phases of government energy policies:

- 1980 to 1983 - strong stimulus to ethanol - pressured by a crisis in the balance of payments and the high prices for imported oil, ethanol prices in this period were around 40-45% lower than for gasoline.

- 1984 to 1988 - moderate stimulus to fuel ethanol - domestic interest in controlling inflation and reducing prices of imported oil from 1985 onwards resulted in ethanol prices in this period being on average 35% lower than gasoline.

- 1989 to 1996 - weak government stimulus to the program - due to the crisis of alcohol shortage in the late 1980s, combined with low international oil prices, the price differential for consumers between hydrated alcohol and gasoline fell to less than 20%, using the price of gasoline as a reference.

- 1997 to present day in more recent years, with the rise in international oil prices, the price difference for consumers between hydrated alcohol and gasoline again increased[10]. There is no policy set for hydrated alcohol fuel, although several authorities have come out in support of the resumption of this option. There has been discussion of restoring incentives for alcohol-fueled cars[11], and rising international oil prices, as well as exchange rates, tends to favor the use of alcohol.

During the 1980s, ethanol, along with allowing the reduction of imports of oil and its products, contributed to Brazilian export. But after 1989, there was a period of net imports of ethanol, because of the domestic supply crisis. In recent years, the pendulum swung back to net exports, and there is a clear trend towards Brazil becoming a significant exporter of this product, because of the comparative advantages of production in the country and the adoption of programs for use of fuel alcohol in several countries as a strategy to achieve environmental improvements and emissions reductions.

1.1.4 Proalcool's Externalities

Proalcool is a governmental program that goes beyond specific issues to include policies related to energy, industry, agriculture, transport, international trade, social welfare, labor and the environment. Therefore, for a more rigorous evaluation of the program, experts have pointed out the need to take into account the various externalities in the agricultural, industrial and energy fields, in order to distinguish more clearly the socioeconomic and environmental impacts of production and consumption of sugar cane and ethanol.

Environmental

Elimination of tetraethyl lead from gasoline - Brazil was the first country in the world to completely eliminate tetraethyl lead from fuels in 1992, but starting in 1989 around 99% of oil refined in the country was lead-free. This achievement was possible thanks to the use of alcohol as a gasoline additive.

Reduction of atmospheric pollution in urban centers - according to the Environmental Sanitation Technology Company of the State of São Paulo - CETESB, if Brazil's entire fleet of cars were fueled by alcohol, air pollution in the large centers would be reduced by 20-40%. Carbon monoxide (CO) emissions were significantly reduced: before 1980, when gasoline was the only fuel in use, CO emissions were above 50g/km driven, but the emissions dropped to less than 1g/km by 2000, because of the technological changes introduced in the period, which has also resulted in

[10] In the 2000-2002 period, the difference was between 35% and 50%, being 50% in 2002.

[11] Law no. 10,336, of December 19, 2001 created the "Contribution for Intervening in the Economic Domain" - CIDE, applied to imports and sales of oil and oil products, natural gas and its products, and ethyl alcohol fuel. The revenue collected from the CIDE will be allocated, in the form of budgetary law, to payment of subsidies to the prices or transport of fuel alcohol, natural gas and its products, and oil products; to financing of environmental projects related to the oil and gas industry; and to financing of transportation infrastructure programs.

significant reductions of emissions of other gases (see Table 7.5.4).

Another factor of concern in the large urban centers is the significant emissions of SO_x, as a result of burning of gasoline and diesel fuel, which is still a concern with the increase in fleet size (CETESB, 1993 and 2001), even though levels dropped from, respectively, 0.22 g/km and 2.72 g/km in 1992 to, 0.16 g/km and 0.43 g/km in 2000, as the result of reductions of sulfur content in these fuels. Combustion of ethanol does not emit SO_x, which is one more environmental advantage of this fuel. However, ethanol combustion produces slightly more aldehydes than does gasoline.

Reduction of greenhouse gases - in terms of the risks of global climate change, the final balance is highly positive, as a function of the process of photosynthesis in which sugar cane absorbs the same amount of carbon dioxide as is released in the burning of alcohol and bagasse. However, there are emissions of greenhouse gases in agricultural production (because of the use of fertilizers and burning for harvest) and in transport of sugar cane from the field to the plant. As a result, the net reduction in CO_2 emissions is in the order of 2.46 t CO_2 equivalent per m^3 of ethanol consumed.

The avoided CO_2 emissions with substitution of gasoline correspond to an average reduction of 4 M t C/year in the 1980s and 6.2 M t C/year in the 1990s. The CO_2 reduction with substitution of gasoline in the period 1975-2000 was around 110 M t C/year[12].

Table 1.1.1 - CO_2 Equivalent Flows in Production and Consumption of Ethanol in Brazil

Gases	Flow (tCO_2/m^3 ethanol)
CO_2 avoided*	**-2.71**
(substitution of gasoline)	-2.44
(substitution of fuel oil)	-0.27
CO_2 liberated** (sugar cane/ethanol prod.)	**0.25**
Total Net	**-2.46**

Source: Macedo, 1997.
Notes:
* Average reduced CO_2 from substitution of gasoline, both by anhydrous or hydrated alcohol and replacement of fuel oil by sugar cane bagasse.
** CO_2 equivalent from agricultural and industrial stages of production of sugar cane and ethanol[13].
In contrast with Brazilian ethanol, produced from sugar cane and using sugar cane bagasse as a source of energy in its industrial production process, production of alcohol from grains (especially corn) uses large energy inputs from fossil fuels to its production. This results in reductions of only 30 to 36% in CO_2 emission in vehicles running on E85 fuel (85% ethanol and 15% gasoline) and of only 2.4 to 2.9% in vehicles with E10 fuel (10% ethanol and 90% gasoline). These reductions are very modest compared to the negligible net emissions for alcohol produced from sugar cane in Brazil.

In the burning of sugar cane leaves for harvest[14], CO_2 is liberated, but experts do not consider this to be a net emission, because the carbon emitted was previously absorbed by the plant during its growth. However, other gases are produced in the combustion process (N_2O and NO_x are generated in the phase of burning with flames, while CO and CH_4 are formed under burning conditions where smoke is predominant). In Brazil, there is legislation calling for the gradual elimination of burning of sugar cane for harvest, which results in increased yield of raw sugar cane and an effort to develop technology for mechanical cutting of this raw sugar cane, which could be further encouraged by the greater economic value of the tips and straw for production of electrical energy.

Water and soil pollution - discharge of *vinhoto* into rivers, waterways, soils and water tables was extremely critical at the beginning of Proalcool. Today, this waste product from ethanol production has become an economic and environmental asset for sugar cane producers, because it is now returned to the soil as fertilizer, in controlled amounts to avoid contamination of the water tables.

Energy

Extremely positive energy balance - one of the great advantages of Proalcool is the fact that ethanol production consumes much less energy than it produces. Research shows that in crops in the State of São Paulo, the ratio of energy produced (ethanol and excess bagasse) to energy consumed (fossil fuels and electricity acquired) ranges between 9 and 11.2.

Potential for cogeneration[15] with use of ethanol by-products - the use of excess bagasse from ethanol production and perhaps also sugar cane straw represents a vast potential for renewable cogeneration of electrical energy (see section 1.4.3.2). Currently around 93% of bagasse is consumed as a fuel to provide all the electrical, mechanical and thermal energy required for sugar cane processing. With the use of high pressure boilers and turbines, using only bagasse during the harvest (cogeneration), it is possible to generate up to 50 kWh in surplus electricity per tonne of sugar cane. The leaf straw and tips are not used so far, since in most cases (around 85%) sugar cane is still burned before harvest. With the trend towards harvesting without burning (which could reach 55 to 60%) and with the use of 50 to 80% of the available straw, the plant could generate surpluses of more than 100 kWh/tonne of sugar cane with conventional technology (high pressure boilers and turbines) or more than 250 kWh/tonne of sugar cane with more advanced technologies, such as biomass gasification and gas turbines. In these two cases, the energy would be generated year around, with a hybrid of cogeneration and pure thermal generation.

A plant processing 3 million tonnes of sugar cane per year could provide 70 MW of electricity to the Brazilian electrical system, with the use of bagasse in boilers of 80 to 100 kgf/cm^2 of steam. Given that current Brazil produces 300 million tonnes of sugar cane, there is a cogeneration potential of 7000 MW, or half the installed capacity of the Itaipu generating station (12,600 MW).

Economic

Important fiscal contribution - in the 1996-97 harvest, the sugar and alcohol sector was responsible for the circulation of US$ 10.5 billion per year, which corresponds to around US$ 2.8 billion/year in state, federal and municipal taxes from this sector alone[16].

Declining costs of production of sugar cane products - in constant values, the costs of ethanol production dropped by an average 2.85% annually between 1976 and 1996. It is estimated that the cost has dropped by an average of 2% per year between 1996 and 2000.

[12] See footnote 2.
[13] During the industrial and agricultural phases of ethanol production, greenhouse gases are emitted such as CO_2, CH_4 and N_2O, in the order of 250 kg of CO_2 equivalent per m^3 of ethanol produced.
[14] Sugar cane has abundant foliage with cutting edges and is planted with such close spacing that at harvest time it is very difficult to penetrate the plantation.
[15] Energy cogeneration is defined as the process of combined production of useful heat and mechanical energy, generally totally or partially converted to electrical energy, from chemical energy provided by one or more fuels (see section 1.4.3).
[16] In the 2001-2002 harvest, the sugar and alcohol sector had revenues of 7.1 billion dollars of revenue and paid one billion dollars in taxes (the average exchange rate in this period was R$ 2.45 to one dollar).

Sugar from Brazil, for its part, has one of the lowest costs of production in the world, which allows producers to compete on favorable terms on the international market.

Social

Job creation and wages - the sugar and alcohol industry is one of largest creators of employment in the Brazilian economy and is responsible for around one million jobs, half of which can be attributed to alcohol and the other half to sugar.

Keeping workers in rural areas - along with the high employment levels in the sugar cane agro-industry, these jobs are in rural areas, which reduces rural-urban migration and avoids adding to the growth of the large Brazilian cities.

Improvement in health conditions - the reduction in air pollution associated with the greater use of ethanol also reduces public costs on health care, especially in the large cities.

Strategic

Alternative to oil - the growing consumption of oil in the world, along with the concentration of oil reserves in the countries of the Persian Gulf, suggest a growing trend towards instability in future hydrocarbon prices. In 2000, Brazil produced domestically 78% of the gross domestic oil supply. Given current production levels, ethanol from sugar cane cannot replace all consumption of oil in Brazil, but should form part of the energy options for dealing with unstable oil supplies.

Technological

Development of technology for ethanol fueled cars - Brazilian automotive engineering has made a significant technological effort to adapt Otto cycle vehicles to use ethanol in the diverse climatic conditions of the country. In addition, new materials and coatings were used to avoid corrosion caused by ethanol.

Technical progress in sugar and alcohol production - the efforts of universities and public and private research centers have led to significant scientific and technological advances in this area. Since 1975, the productivity of sugar cane increased from 50-60 tonnes to 75-85 tonnes per hectare, sugar production increased from 90-100 kg to 120-140 kg per tonne of sugar cane processed, and ethanol production rose from 60 liters to 80 liters per tonne of sugar cane. The improvements in sugar cane production led to more intensive use of biotechnologies and soil conservation techniques, as well as improvements in production environments and systems.

Soil quality - at first, sugar cane cultivated year after year in the same land could be expected to result in declining productivity over time. However, the reverse proved to be the case: after decades of harvests the productivity of Brazilian sugar cane has increased continuously. Much of the increased productivity could be attributed to better preparation of the soil, to development of superior varieties of sugar cane and to recycling of nutrients (*vinhoto*).

1.2 Energy Conservation Programs

1.2.1 Energy Conservation in Brazil

There is a great potential for energy savings in Brazil both on the energy supply side and on the demand side.

The relation between energy savings and reduction of emissions is not linear, that is, a given reduction of energy consumption does not necessarily lead to a proportional reduction in greenhouse gases. This results to a great extent from the dominance of hydro energy in electrical generation. However, if the role of fossil fuel fired thermal plants in generation increases, then energy savings will have a proportionally greater effect on emissions.

1.2.2 Government Programs for Energy Conservation

The most common measure of energy intensity is the amount of energy used per unit of GDP. In Brazil (MME, 1998), in 1994, this index was 0.27 toe[17]/US$ 1,000.

Conservation measures in Brazil were carried out by the Federal Government as a way to avoid crises caused externally, particularly from oil price increases and higher interest rates that affect generation, bringing risks of rationing.

In response to the oil shocks of 1973 and 1979, when imported oil supplied approximately 70% of Brazil's primary energy consumption, a strategy was formulated centered on the reformulation of energy supply policy: intensification of oil exploration, increasing hydroelectric capacity, use of domestic coal, and replacement of gasoline by ethanol for the transport sector (see section 1.1.1).

In the early 1980s, the program Conserve was implemented, administered by the National Economic and Social Development Bank - BNDES. This program financed projects for rationalization of energy use in industries, mobilizing a broad government effort, and generated significant results.

In the mid-1980s, the National Electrical Energy Conservation Program - PROCEL was created, and in the 1990s, the National Program for the Rational Use of Natural Gas and Oil Products - CONPET, which has achieved impressive results.

Annual investments in research and development and in energy efficiency, on the part of those holding concessions, permissions and authorizations from the electrical sector are currently regulated by Law no. 9991, of July 24, 2000, which obliges holders of concessions and permissions for public services of electricity distribution to allocate annually at least 0.75% of their net operational revenue in research and development in the electrical sector, and at least 0.25% in end use efficiency programs. Until December 31, 2005, the minimum investment will be 0.5%, both for research and development and for energy efficiency programs in energy supply and end use.

Companies holding concessions for generation and those authorized for independent production, as well as concession-holders for public services of transmission of

[17] Given that 1 MWh = 0.086 toe (tonnes of oil equivalent) and 1 toe = 10,000 Mcal, in accordance with the methodology adopted by the IEA/OECD.

[18] As provided for in Law no. 9991, some resolutions and procedures manuals were already published by ANEEL. The most recent resolutions are Resolution no. 502, from November 27, 2001, for R&D, and Resolution no. 394, from September 18, 2001, for energy efficiency. It is estimated that the resources invested in the period of 2000-2001 in energy efficiency resulted in a reduction in consumption of around 4.1 GWh/year and an avoided demand of around 154 MW.

[19] On October 17, 2001, Law no. 10,295 was sanctioned, creating the National Policy for Conservation and Rational use of Energy, seeking the efficient allocation of energy resources and environmental preservation. According to this law, the Executive Branch of Government will establish maximum levels of specific consumption of energy, or minimum energy efficiencies, for energy consuming machines and appliances manufactured or sold in Brazil, based on relevant technical indicators, which the manufacturers and importers of these machines and appliances will be required to obey. The law also requires the Executive to develop mechanisms to promote energy efficiency in buildings constructed in

electricity, are required to invest annually at least 1% of their net operational revenue in research and development in the electrical sector[18].

Other measures for conservation and rational use of energy, as well as for energy[19] efficiency, are being studied.

1.2.2.1 Conserve

The program Conserve, created under the Ministry of Industry and Commerce - MIC (currently the Ministry of Development, Industry and Foreign Trade - MDIC) in 1981, was the first significant effort in terms of energy conservation in Brazil, and aimed at meeting the objectives of Administrative Directive MIC/GM46, which addressed the promotion of energy conservation in industry, in the development of more energy efficient products and processes, and encouraging the replacement of imported oil by domestic alternative sources. The program Conserve is presented here only as an indication of Brazil's accumulated experience in energy efficiency measures over the last two decades.

The reduction of oil imports, which jumped to the top of governmental priorities after the consecutive oil price shocks, also affected fuel oil supplies to industries. Along with a policy of price increases starting in the 1980s, the National Petroleum Council - CNP imposed linear cuts of 10% on fuel oil supply and 5% on diesel supply to industry and implanted a system of supply controls through fuel quotas until 1983. The unpopularity generated in the business community with the adoption of these measures led the Federal Government to offer support to conservation and the replacement of fuel oil used in industry, through the program Conserve.

Conserve offered the possibility of carrying out energy diagnostics in industrial facilities, free of charge, in order to identify the energy conservation potential in each case. The structure of Conserve was complemented by a fund to support transfers, in the form of very favorable loans, to nationally owned companies to support the energy conservation efforts identified through the diagnostic.

The most positive results of Conserve, along with promoting energy conservation in industry, was the strengthening of national capacity for surveying industrial energy conservation opportunities. The program served as a catalyst and channel for the competence built up by the state research and technological centers for joint action with the private sector.

In terms of energy savings, in the period 1981-1985 there was a reduction from 9.5 million toe to 5.3 million toe in consumption of fuel oil in the industrial sector; a reduction of 44%. These results, while significant, were not obtained only through the Conserve program. Indications are that around 18% of the reductions resulted from these actions. Much of the reduction in fuel oil consumption resulted from the slowdown in industrial activity at the beginning of the 1980s, because of the economic recession in Brazil. However, the outcome of Conserve is very satisfactory for a program aimed at conservation of oil products.

A critical analysis of the program should address two questions: the underutilization of the resources allocated and the predominance of a focus on replacement of energy sources, to the detriment of the original purpose of energy conservation.

In terms of the first question, approximately half the resources available through Conserve went unused, and fewer than 200 companies submitted requests for these resources, while around 80 effectively made use of them.

It is clear that this underutilization of resources was not just a result of bureaucratic delays in Conserve's approval process. Other external factors should also be considered, such as Brazil's economic recession in the period 1981-1985, which reduced the level of industrial activity and investments in the sector, moving energy conservation to the back burner, as well as the absence of clear signals on the part of the authorities in regards to economic policy, and especially energy policy.

In terms of the second question raised, Table 1.2.1 shows that most of the operations approved under Conserve between 1981 and 1985, by the BNDES system, were for energy switching (79%), with energy savings through conservation accounting for only the other 21%.

Table 1.2.1 - Total Savings of Oil Products in the period 1981-1985

Sectors	Conservation	Replacement	Total
		(10^3 toe)	
Pulp and Paper	155.1	165.8	320.9
Iron and Steel	146.7	486.8	633.5
Cement	0.4	498.6	499.0
Petrochemicals	26.6	93.3	119.9
Energy	42.0	7.4	49.4
Metallurgy	2.1	13.9	16.0
Mining	-	8.6	8.6
Agroindustry	1.0	88.8	89.8
Construction Material	-	18.0	18.0
Total	**373.9**	**1,381.2**	**1,755.1**

Source: Piccinini, 1994.

Thus, the original purpose of Conserve was subverted, since in practice it became a set of efforts and measures oriented to the replacement of oil products, with probable losses in efficiency, and ignoring the core energy conservation program.

In 1981, with the economic recession of that time and the resulting reduction in demand for electricity, there was excess generating capacity in the country. Thus, in order to reduce the idle generating capacity in the electrical sector, the Guaranteed Energy for a Specified Time - EGTD[20] was created, aimed at the industrial sector, which was suffering from high prices for oil products. This rate was provided to companies willing to replace oil products with electricity, at prices 30% lower than normal.

Therefore, the intensification of electrical energy use in the industrial sector, which was already encouraged by Conserve, was reinforced through the application of the EGTD rate. This exercised a strong influence on the performance of Conserve, to the extent that it increased the distortion of the fundamental purpose of the program, allowing the alternative of replacement of oil products (in this case by electricity) at the expense of the original focus of the program.

In addition, the EGTD raised the level of underutilization of the resources of Conserve, to the extent that it constituted an alternative to this program, with reduced bureaucracy and faster implementation, thus presenting a more efficient “service” to the “public” (industrial sector). This resulted in the withdrawal of several applications already presented to the Conserve program.

[20] “Guaranteed Energy for a Specified Time” - EGTD, according to MME Administrative Directive no. 1169, from August 20, 1982, is understood as active energy, supplementary to firm energy from the interconnected grid, put at the disposal of specific industrial consumers, with a guaranteed minimum of supply for 3,000 or for 6,000 hours annually.

With the growing use of electricity for thermal uses in the industrial sector as a result of Conserve and EGDT, there was actually transference of responsibility for energy conservation to the electrical sector, since the growth in electricity demand for thermal purposes in industry began to put pressure on the available generating capacity.

Therefore, the strategic option in the face of the existing situation was to implement a conservation policy for electrical energy use, which culminated in the creation of PROCEL, in 1985, under the coordination of Brazilian Electric Power Company Utility- Eletrobrás.

1.2.2.2 PROCEL

The National Electrical Energy Conservation Program - PROCEL was created by the interministerial Administrative Directive no. 1877 of December 30, 1985, by a joint initiative of the Ministry of Mines and Energy - MME and the then Ministry of Industry and Commerce - MIC.

The objective of the program was to combat waste in the production and use of electrical energy, providing the same product or service at a lower consumption, through greater energy efficiency, thereby ensuring an overall reduction in costs and investments in new installations in the electrical system.

On July 18, 1991, through a presidential decree, PROCEL went from being a sectoral program to being a governmental program, with more wide-ranging goals and greater responsibilities. The program was no longer restricted to just the electrical sector, but came to be involved in all sectors of society directly or indirectly linked to the production and use of electrical energy.

From the time PROCEL was created until 1989, there was a more generalist focus on the issues addressed, with incentives for research and promotion of new technologies. Nevertheless, in 1989, the operational structure of PROCEL underwent reforms providing more flexibility for executive actions that would result in real energy savings.

However, in the 1990-1991 period, PROCEL stagnated to some extent and only in 1994 was the program revitalized, with the objective of expanding its capacity for linkages and coordination, as well as to decentralize its executive activities through a better organization of the conservation areas of the electrical energy concession-holders, supporting capacity-building of multipliers and strengthening the program's relations with the private sector.

The revitalization of PROCEL was motivated by the establishment of international contracts starting in 1993, in order to learn from international experience, along with cooperation with the United Nations Development Program - UNDP and the European Commission. The objective of the project is to ensure that PROCEL will be able to act as an electrical energy conservation body, in an autonomous and independent manner.

Other efforts towards the revitalization of the program included the promulgation of Law no. 8631, of March 4, 1993, which determined that part of the resources from the Global Reversion Fund - RGR[21] must be allocated to the conservation of electrical energy; the development of Eletrobrás' Priority Action Plan, which established a set of measures to stimulate conservation under the Ministry of Mines and Energy's - MME's National Campaign Against Waste; and the creation of the Committee for the Conservation and Rational Use of Electrical Energy of Eletrobrás System Companies - CONSEL.

With this new focus, PROCEL also became active in reducing losses from generation, transmission and distribution systems for electrical energy; and especially in the objective definition of the potential and priorities for electrical energy conservation in the short term, in order to promote the long term objectives of the program.

Between 1986 and 1992, several initiatives were identified, but concrete programs were established for only five lines of action over this period:

- Consumption labeling: aims at informing consumers of the level of electrical energy consumption of domestic appliances available on the market, to influence purchasing decisions and induce manufacturers to increase the energy efficiency of their equipment.
- Energy diagnostics, self-assessment and energy optimization: consists of an assessment of energy use and the conditions of the facilities of the consuming unit, allowing the identification of critical points and indicating the requirements of specific equipment.
- Research and technological development: accounts for around one third of PROCEL's resources, with the goal of enabling the entrance into the market of a growing range of more efficient end use equipment.
- Public lighting: through a joint effort of distribution concession-holders and PROCEL, incandescent lamps were replaced by mercury vapor and high-pressure sodium vapor lamps, which consume around 75% less energy than the incandescent lamps.
- Information, Education and Promotion programs: the objective is to enable a range of sectors of Brazilian society to have access to information regarding conservation of electrical energy. One such program is "PROCEL in Schools" (see section 4.2.1), as well as manuals and pamphlets giving advice on energy consumption.

Since 1994, PROCEL has been undertaking new activities, along with improving those mentioned above, working in the following areas:

- Marketing: seeking to strengthen the PROCEL trademark and promoting ideas for combating electricity waste to the market and the public. The main instruments used are the "Energy Savings Seal" and the "National Award for Combating Energy Waste".
- Residential Sector: normally carried out in partnership with the concession-holders, aims at combating waste with the use of efficient lighting and domestic appliances.
- Government buildings: seeks the optimization of energy spending in buildings used for public administration, through the use of efficient lighting and refrigeration and through orientation of staff in the rational use of resources.
- Municipal energy management: carried out through an agreement with municipalities, aims at optimizing municipal expenses on electrical energy.
- Leading edge management: involves actions using a range of means to reduce electricity demand in peak hours of systems.

[21] The RGR is a federal fund created with resources from concession-holders, proportional to their investments in installations and services. This fund is allocated to investments in electrical energy, with part going to energy efficiency projects.

- Reduction of losses in the electrical system: carried out by concession-holders to make their facilities more efficient. These actions could involve plants, substations, transmission lines and distribution networks.

- Training: aims at adequately preparing the human resources necessary for the objectives of combating energy waste in the long term. Accordingly, many courses, as well as seminars and conferences, have been offered to industrial and commercial consumers, concession-holder staff, public organizations, covering a range of issues, and involving universities, international experts and others.

- Technology research and development: to support programs to combat energy waste, in terms of databases and methodological tools.

- System for information, management and assessment of results: PROCEL has been improving its methods for analysis, implementation and evaluation of results of energy conservation programs.

Results

The quantitative results achieved by PROCEL have been estimated in terms of energy savings, expressed in GWh/year, and in demand reduction during peak hours of the system, expressed in MW removed or diverted from the peak.

These values for energy savings and demand reduction can also be translated as the electricity equivalent produced by a typical hydroelectric plant (equivalent plant), whose construction was avoided because of the implementation of energy conservation measures. Also considered is the avoided investment in construction of this plant and expansion of the electrical system, taking into account generation, transmission and distribution of energy to final consumers.

The indicators in Table 1.2.2 show the accumulated results of actions of PROCEL in the periods of 1986-1995 and 1996-1998:

Table 1.2.2 - Quantitative Results of PROCEL

Indicator	1986-1995	1996	1997	1998
Investments approved (R$ millions)	63.5	50	122	159
Investments already made (R$ millions)	47.3	19.6	40.6	50.4
Energy saved and additional generation (GWh)	1846	1970	1758	1,977
Equivalent plant (MW)	435	430	1758	1,977
Reduction of peak load (MW)	322	293	415	460
Avoided investment (R$ millions)	870	860	830	920

Source: ELETROBRAS/PROCEL, 1998.

In the period 1986-98, PROCEL enabled energy savings of around 7551 GWh, at a cost of less than R$ 395 million, compared with an avoided investment of R$ 3.48 billion in the construction of plants. In other words, for each R$ 1.00 invested in waste reduction, R$ 8.81 were saved.

Reluz

In the year 2000, the program Reluz was launched, with the goal of encouraging the installation of efficient public lighting systems and providing improvements in public safety throughout the country. The Federal Government, under the coordination of the Ministry of Mines and Energy - MME, with technical, financial, and administrative support of Eletrobrás, and in partnership with the National Electrical Energy Agency - ANEEL[22], intends to improve the efficiency of 9 million points of public lighting, reducing peak load by 580 MW and saving 2550 GWh per year of electrical energy.

Energy savings will reduce municipal expenses on lighting, reducing electrical bills and other costs, including for maintenance and stocks, with the payback period estimated at 3.3 years.

1.2.2.3 CONPET

The National Program for the Rational Use of Oil and Natural Gas Products - CONPET was created by a presidential decree on July 18, 1991, with the goal of developing and integrating actions related to the rationalization of the use of oil and natural gas products by reduction of losses and elimination of waste, using energy in a more rational and efficient manner, and developing more energy efficient technologies. All these measures are in accordance with the directives of the National Program for Rationalization of Energy Production and Use, created by Decree no. 99250, of May 11, 1990.

CONPET's goal is to obtain a gain in energy efficiency of 25% in the use of oil products and natural gas in the next 20 years, without affecting the level of activities of the diverse sectors of the national economy. CONPET has been carrying out projects in the transport, industrial, residential, commercial, agriculture and thermoelectric generation sectors.

Transport Sector

Setting energy efficiency indexes - a project developed under the Brazil - European Union - EU agreement, with participation from the private sector and government bodies linked to highway transport. The purpose is to develop a methodology to assess energy efficiency in bus and truck fleets, as well as to compare energy efficiency in the transport sectors of Brazil and Western European countries. The project also aims at developing demonstration and dissemination projects, through monitoring fuel consumption, vehicle maintenance, driver training, and new fuel saving technologies.

Urban passenger transport - development of a methodology for managing the use of diesel oil in bus companies, carried out in partnership with the Federation of Urban Passenger Transport of the State of Rio de Janeiro - Fetranspor (35 companies in the State of Rio de Janeiro are formally involved in the project). This involves demonstration

[22] According to Article 2 of Law no. 9427, from December 26, 1996, which created ANEEL, the objective of the Agency is to regulate and inspect the production, transmission, distribution and sale of electrical energy, in accordance with the policies and guidelines of the Federal Government. Article 3 holds that it is the responsibility of ANEEL to: "V - resolve, at the administrative level, the divergences between holders of concessions, permissions and authorizations, independent producers and self-producers, as well as between these agents and their consumers."

projects to validate the methodology and incentives to bus companies to adopt management practices and technologies aimed at reducing fuel consumption.

Highway freight transport (Project SIGA BEM) - pilot project with BR Distribuidora, first established in June 1994 at a Petrobras service station on the Fernão Dias Highway in Betim/MG, which in 2000 had 75 roadside service stations. The objective is to motivate truck drivers to save fuel, as well as monitor and analyze consumption in their vehicles. This involves dissemination of instructional material and adjustment and maintenance of vehicles to reduce fuel consumption, offered free of charge at the service sites.

Project Economizar - created in 1996 as an instrument for rational energy use, the priority objective of MME's energy policy, the project coordinates government efforts with the private sector, through supporting freight and passenger transport companies in the implementation of measures to improve the use of diesel oil and professional training for drivers and mechanics. The project operates in 21 states, with the participation of 14 regional entities (federations and unions), through which 111,000 assessments of 67,000 vehicles were conducted, resulting in reductions of up to 14% in the specific consumption of diesel oil in the fleets participating in the project. This resulted in fuel savings of around 144 million liters/year and 402 Gg/year of CO_2 not emitted to the atmosphere.

Energy Efficiency Label - created through a presidential decree on December 8, 1993, the objective is to recognize light vehicles that, already labeled, have the best energy performance in its class.

Industrial Sector

Establishment of energy efficiency indexes - Brazil-EU cooperation project for the development of indexes to assess industrial energy efficiency and to allow comparison with energy efficiency of industries of Western Europe.

Energy conservation in professional courses - training and dissemination of information about energy conservation and the rational use of fuel in the professional courses of the National Industrial Training Service - SENAI, including the development of teaching material for students and teachers.

Cogeneration - energy integration in Petrobras's industrial facilities using energy cogeneration systems.

Residential and Commercial Sector

Review of technical standards - project involving review of technical standards for testing the energy performance of domestic gas stoves and water heaters.

Green label of energy efficiency - created by a presidential decree to recognize domestic appliances with the best energy performance in its class.

1.2.2.4 Activities by state concession-holders

São Paulo

Energy conservation activities have been implemented in the State of São Paulo since 1985, by the Energy Application Agency - AAE and by the concession-holders São Paulo Electrical Company - CESP, São Paulo Electricity S.A. - Eletropaulo, São Paulo Power and Light Company - CPFL and São Paulo Gas Company - Comgas.

AAE receives funding and personnel from the three concession-holders in the State of São Paulo and coordinates the energy efficiency program in the state. The concession-holders participate in the programs implemented by AAE, but also carry out their own actions, generally through their distribution departments. Although several activities have been already implemented, a quantification of the results obtained from energy conservation efforts is not available.

State program for rational energy use - its purpose is to measure and monitor energy consumption in all public buildings and provide recommendations for controlling consumption.

Education of students in elementary and high schools about energy efficiency - program established at the end of the 1980s, to educate students and train professors to avoid the excessive use of energy.

Training of professionals in various areas in the efficient use of energy - several courses and meetings take place annually to train experts in marketing and personnel in industrial and commercial activities involved with energy management.

Encouraging activities of Energy Conservation Service Companies - ESCOs - it is widely accepted that ESCOs are important partners for dissemination of energy efficient technologies.

Minas Gerais

Minas Gerais Electrical Utility - CEMIG is a public concession-holder of the State of Minas Gerais that in recent years has taken an increased interest in energy efficiency. Most activities have taken place in a poor rural area where the installation of transmission lines is very expensive (Vale de Jequitinhonha). In this area, CEMIG offered subsidies for compact fluorescent lamps - CFLs and the installation of current limiters to avoid high residential consumption during peak hours. CEMIG was also a pioneer in the installation of seasonal meters in residences, to discourage consumption during peak hours through a surcharge on electricity consumed in these hours. This program, called "Yellow Tariff", is now being implemented by other concession-holders.

Other States

In the last few years the Ceará Electrical Company - COELCE has shown an interest in energy conservation activities and is involved in a large program to stimulate the use of compact fluorescent lamps. The North Region Eletric Power Company - Eletronorte became interested in energy efficiency because of the difficulty in providing electricity to the growing market in the city of Manaus. In the last years, the Bahia Electrical Company - COELBA and the Paraná Electrical Company - COPEL have been active in demonstration projects in the residential sector and in public lighting.

1.3 Contribution of Hydroelectric Generation to Reduction of Greenhouse Gas Emissions

1.3.1 Trends in Electricity Generation

Brazil is a country of continental dimensions, with eight large drainage basins: the Amazonas river basin; the Tocantins river basin; the South Atlantic basin - North and Northeast regions; the São Francisco river basin; the South Atlantic basin - East region; the Paraná river basin; the Paraguay river basin; and the South Atlantic basin - Southeast region.

The water production on Brazilian territory, understood as the average flow of rivers emptying into the ocean, is

168,790 m^3/s. If one includes the flow produced in the area of the Amazonian basin located on foreign territory, estimated at 89,000 m^3/s, total water availability reaches 257,790 m^3/s.

The hydroelectric potential of Brazil is currently assessed at 1,268 TWh/year (including 50% of the capacity of binational potential), of which only around 24% had been exploited in 2000.

The preference for the hydroelectric option predates the 1960s, when integrated planning and expansion of supply began at the regional and later national level. Although statistics on generation before 1950 are not available, the data on installed generating capacity are sufficient to indicate a historic predominance of hydroelectricity in Brazil, as shown below:

Table 1.3.1 - Brazil - Installed Generating 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
1997	54,889	62,972	87
1998	56,759	65,209	87
1999	58,997	69,153	85
2000	61,324	74,903	82

Source: MME, 2001.
*Includes 50% of Itaipu from 1994 onwards.

In the 1950s, large-scale state activities in the area of hydroelectric generation began, with the construction of plants on the São Francisco and Grande rivers. Activities on the São Francisco river began with the Paulo Alfonso I plant (180 MW) in the State of Bahia, followed by Três Marias (306 MW) in the State of Minas Gerais. The Grande river projects included the Furnas plant (1,312 MW), important because of its installed capacity and the capacity of other facilities downstream. Also significant was the construction of the Jupiá (1,414 MW) and Ilha Solteira (3,444 MW) plants on the Paraná river, begun in the 1960s, when exploitation of the Paranapanema and Iguaçu basins also began. The 1970s saw, along with the expansion in the São Francisco river and Paraná river basins (on Brazilian territory), the beginning of construction of Itaipu (12,600 MW), on its international stretch, as well as the exploitation of the potential in the Amazonia, with the Tucuruí plant (4,200 MW) on the Tocantins river.

The preference of the electrical sector for hydroelectricity, even before 1973 (the first oil shock), resulted from the competitive costs of this source of electrical energy, provided by natural conditions favorable to a wide range of projects, their relative proximity to consumer markets, relatively low discount rates (around 10% per year) and at the business level, access to credit at interest rates not exceeding 6% per year. These relative advantages offered by a range of projects prevailed even in the 1960s, when oil prices reached their lowest levels, accompanied by reduction of international transport costs. The impact of importing fuel and equipment (greater for thermal and especially coal plants) on the balance of payments was also a significant factor.

Beginning in the 1970s, there was a significant growth in hydroelectricity's share of the total electrical generation in Brazil. Various factors contributed to this:

- rising fuel prices, with the renewed pressure of imports on the balance of payments;
- reduction of the unit costs of transmission, making more distant sites from consumption centers viable;
- exploitation of hydrological diversities;
- longer useful lifetime for hydroelectric facilities;
- flood control;
- increase in costs of thermal plants, especially coal, because of the relatively low quality of Brazilian coal;
- increasing compliance with environmental restrictions;
- worsening of the oil shock in 1979, when all the importing countries sought to reduce their dependency on this fuel; and
- geopolitical factors that favorably influenced the decision to implement some projects, such as Itaipu and Tucuruí.

Brazil is one of the greatest hydroelectric producers in the world, and its energy matrix has as its defining characteristic an exceptional share of hydroelectricity in electrical energy generation. In the year 2000, 347.7 TWh of electricity were generated in Brazil. Of this production, 88.5% was generated from hydro power. Of the remainder, a significant amount was produced with biomass (around 3%) and nuclear energy (around 1.5%).

1.3.2 National Energy Balance 1970-2000

According to the Ministry of Mines and Energy - MME, electrical energy destined to meeting domestic demand (acquired by consumers, plus self-generation) was as follows:

Table 1.3.2 - Electrical Supply by Source and End Use Consumption (TWh)

Source	1970	1980	1990	1999	2000
			(TWh)		
Total Generation*	45.7	139.3	222.8	332.3	347.7
Hydroelectric Generation	39.8	128.9	206.7	292.9	307.6
Thermal Generation	5.9	10.4	16.1	39.4	40.1
Nuclear			2.2	4.0	5.0
Coal	1.4	2.6	2.8	7.4	6.4
Natural Gas			0.7	2.0	3.8
Oil	3.7	5.2	5.4	16.0	14.1
Others	0.8	2.6	5.0	10.0	10.8
Net Imports		-0.2	26.5	39.9	42.4
Gross Supply of Electricity	45.7	139.1	249.4	372.2	390.1
Losses, Distribution and Storage	6.1	16.4	31.7	57.5	58.5
End Use Consumption	39.6	122.7	217.7	314.7	331.6

Source: MME, 2001, except disaggregation for thermal generation in 2000 (normalized based on e&e Economia e Energia).
* Includes generating stations connected to the grid and self-generators.

The imports indicated in the Table 1.3.2 mainly come from the Paraguayan quota of the Itaipu hydroelectric plant. Because Paraguay does not use its entire quota, it cedes the right of purchase to Brazil. Almost all of these imports involve hydroelectricity produced at the country's border, from investments of predominantly Brazilian funds. The sources included under "other" are predominantly derived from biomass and are therefore renewable.

1.3.3 Impacts on Greenhouse Gas Emissions of Hypothetical Scenarios for Alternatives for Sources of Electricity Supply Between 1960 and 2000

To assess the impact on emissions of different alternatives for sources of electricity supply, the following hypothetical scenarios will be considered:

I - Starting in 1960, 30% of actual hydroelectric generation would be replaced by thermal energy, with 40% being coal and 60% fuel oil. There would be a greater share of imported coal, allowing lower levels of SO_2 than would have been the case with the domestic coal that has been used until now in thermal generation.

II - Starting in 1960, 75% of current hydroelectric generation would be replaced by thermal generation, again with 40% being coal and 60% fuel oil. Emission levels could be even further reduced if it were also assumed that nuclear energy had an increased share, reaching 10% of total generation in 2000. In this case, thermal generation would have the following distribution: 35% from coal, 52% from fuel oil and 13% from nuclear.

While in case I total CO_2 emissions would increase by 29%, in 2000, in case II this increase would reach between 62% and 71%, depending on whether the nuclear share increases or not. It is estimated that from 1960 to 2000, the additional CO_2 emitted would have been 1.6 x 10^9t, in case I, and 3.5 to 3.9 x 10^9 t, in case II. The emission levels as a function of population and GDP would have been as follows:

Table 1.3.3 - Comparison of Brazilian CO_2 Emissions with Population and GDP

Comparison with population	1970	2000
	t/person	
Observed	0.86	1.83
Case I	0.98	2.35
Case II	1.15	2.97* to 3.14
Comparison with GDP in 2000	**t/10^3 US$**	
Observed	0.37	0.40
Case I	0.42	0.51
Case II	0.49	0.64* to 0.68

Source: GDP (PPP).
*Because of the greater share (10%) of nuclear.

Table 1.3.3 shows that while CO_2 emissions per capita have increased as a function of industrialization and the expansion of the amount of transport in spite of energy conservation efforts, CO_2 emissions per unit of GDP remained at the same order of magnitude. However, if hydroelectric development had been significantly lower, according to the two scenarios formulated, the emission rate per unit of GDP would have been substantially higher and closer to those of industrialized countries, although still lower than other countries of Latin America.

Brazil's greenhouse gas emission levels resulting from the use of fossil fuels in electrical energy generation are among the lowest in the world, whether considered in per capita terms or in terms of GDP. The extensive use of a renewable source (hydroelectricity) also contributes to the sustainability of the country's development and to greater autonomy in energy supply.

Given the potential available under economically competitive conditions with other sources and the growing awareness of the urgent need to avoid environmental degradation, particular in terms of climate change, it is probable that energy and environmental policies in Brazil will seek to maintain a high share of hydro energy over the next two decades in meeting the growing demand for electricity. In order for this development to be carried out, appropriate financial conditions need to be provided, and the long term environmental and energy benefits need to be taken into account in comparisons with alternative sources for electrical generation.

1.4 Status and Prospects for New Sources of Renewable Energy in Brazil

New sources of renewable energy include "modern biomass use", small hydroelectric plants - SHPs, and wind, solar (including photovoltaic), tidal and geothermal energy. "Modern biomass use" excludes traditional uses of biomass, such as firewood, and includes the use of agricultural and forestry residues, as well as solid wastes, for the generation of electricity and production of heat and liquid fuels for transport.

Brazil still has a predominantly renewable energy matrix, which is not necessarily based on traditional energy sources such as wood, but on sources such as hydroelectricity and fuels such as ethanol. In remote areas, there is a pent-up demand that will lead to increased demand for solar photovoltaic energy, small scale wind systems and generation systems using vegetable oils. It is expected that the institutional and regulatory incentives introduced in recent years will reduce the space occupied by fossil fuels, in favor of local renewable sources.

Given that a substantial number of renewable energy projects registered with ANEEL have a good chance of being implemented[24], it is expected that a part of the trend outlined in MME's Ten-Year Plan for Expansion of the Electrical Sector could be reverted. It is expected that this matrix be diversified also through the inclusion of other forms of biomass, wind energy, and a greater role of small hydro plants. Over the next 10 years, it is expected that these sources will represent around 5% of Brazilian supply[25]. As well, small scale cogeneration units and renewable community or individual systems for remote areas could, in the same time frame, serve around 500,000 homes that are not likely to be connected to the national grid.

1.4.1 Recent History of Renewable Energy Sources

In Brazil, the use of new forms of renewable energy got a major boost after the UN Conference on Environment and Development, known as Rio 92. Since then, in accordance with ANEEL's data, more than 12 MW[26] of photovoltaic systems have been implemented and 21.4 MW of wind systems, which serve to demonstrate the technical viability of these alternatives, both in the case of solar photovoltaic energy for meeting energy needs in certain niches, and for feeding the electrical grid in areas with substantial wind potential, such as coastline in the Northeast. The use of energy from small hydroelectric projects and sugar cane bagasse, along with other forms of biomass that are already established in the country, have been consolidating and expanding because of the restructuring of the electrical sector and the incentives offered to these sources and to electricity cogeneration.

In April 1994, the Ministry of Mines and Energy - MME and the Ministry of Science and Technology - MCT called a "Meeting to Establish Guidelines for the Development of Solar and Wind Energy in Brazil", during which a range of actions were raised in order to identify mechanisms and propose changes in governmental policies that would enable promotion of these energy sources. The establishment of a Permanent Forum was recommended (established in October, 1994) to ensure the implementation of the guidelines and the creation of the Centers of Reference for the diverse technologies that emerged, such as the Center of Reference in Solar and Wind Energy - CRESESB, the Center of Reference in Biomass - CENBIO, and the Center of Reference in Small Hydroelectric Plants - CERPCH, established in 1994, 1996 and 1997, respectively. The private sector also organized and created, in November 1994, the Brazilian Association of Renewable Energy and Energy Efficiency Companies - ABEER, made up of representatives of companies operating in these sectors in Brazil.

Other initiatives in the use of solar photovoltaic energy that should be mentioned are being coordinated by various electrical concession-holders. CEMIG established a model where a tariff is charged to cover part of the costs of reaching isolated homes, with the remainder of the investment covered by a mandatory allocation of part of its profits to social programs. COPEL, in the State of Paraná, has been incorporating renewable solar systems as an option in its rural electrification program, while CESP, in the State of São Paulo, has implanted a pilot project in which a tariff is charged for services provided for residential solar systems.

In the area of wind energy, several states have begun wind measurements, such as Minas Gerais, Ceará, Bahia, Paraná and Santa Catarina, and are now in different stages of negotiation to implement wind energy projects connected to the grid. The most promising projects are located in the Sates of Ceará, which has 17.4 MW installed, and Paraná, with 2.5 MW.

In the area of small hydroelectric plants - SHPs, Brazil has extensive technical knowledge, production capacity and natural resources. According to the Center of Reference in Small Hydroelectric Plants - CERPCH, interest in building new plants has grown considerably in recent years, with an increasing number of annual applications. This growth is primarily due to the introduction of regulatory incentives, stimulating an extensive program by the private sector.

Introducing some of the incentives described above would have the natural consequence of reversing the history of waste of agricultural and forestry residues by means of the incorporation of technologies that are either already developed or in diverse stages of development, for the efficient use of biomass energy. Agricultural residues, excluding those of sugar cane, represent an energy potential in the order of 37.5 million toe annually, equivalent to 747,000 barrels of oil per day, which is practically unused.

1.4.2 Legal and Regulatory Framework

Law no. 9427, from December 26, 1996, which created the National Electrical Energy Agency - ANEEL, regulates the concession of public electrical services and contains other provisions, including calling for at least a 50% reduction in fees for the use of transmission and distribution systems; and free sale of energy to consumers of at least 500 kW; and the exemption from payment of financial compensation for the use of water resources for projects involving small hydroelectric plants - SHPs. Decree no. 2003, from September 10, 1996, defines and regulates independent and self-generation of electricity, which are important in generation of electricity from alternative and renewable energy sources.

On August 6, 1997, Law no. 9478, addressing national energy policy, was sanctioned. The law's provisions include guidelines for the rational use of energy sources, including alternative sources and technologies, through the economic utilization of the available inputs (Article 1, clause VIII, of this law).

Based on article 175 of the 1988 Federal Constitution — which deals with federal state and municipal public services and defines that concessions and permits must go through a public tendering process, and the subsequent ordinary laws — the Brazilian electrical sector began a process of restructuring. This restructuring is based mainly on the introduction of competition in both ends of the electrical production chain (generation and retailing, and free access in those areas, which until them were considered natural monopolies), as well as in transmission and distribution, thus providing greater transparency and opportunities, including for renewable energy sources.

Particularly important were the incentives provided by Law no. 9648[27], from May 27, 1998, to small hydro facilities, which were exempted from paying "royalties" to states and municipalities, had a reduction of 50% on transmission and

[24] It is expected that projects for new renewable sources of electricity authorized between 1998 and 2002, but which still have not started construction, generate around 6300 MW. Cf. ANEEL Generation Information Bank.

[25] In 2002, Brazil proposed the "Brazilian Energy Initiative" under the Global Sustainable Development Summit - Rio+10, in Johannesburg, South Africa, which called on countries to commit to increasing the share of new sources of renewable energy to 10% of their domestic energy supply.

[26] According to estimates of the Photovoltaics Systems Laboratory of the University of São Paulo.

distribution tariffs, and could sell energy directly to any consumer with more than 500 kW and were exempted from the public bidding process, requiring only an authorization from ANEEL. After this law was created, similar benefits were advocated for the other renewable sources.

ANEEL's Resolution no. 112, from May 18, 1999, established the requirements for obtaining the registration or authorization for the implantation, expansion or refitting of thermoelectric, wind, or photovoltaic generating stations, and of other alternative energy sources destined to selling energy under the form of independent production, exclusive use or the execution of a public service. This resolution was established by virtue of the need to modernize and complement the procedures contained in prior regulations, in order to facilitate the entrance of new generation sources, through simplifying rules and standardizing procedures. Among other provisions, it establishes the requirement of registration for plants with a generating capacity of up to 5 MW, and of authorization for plants with a capacity of greater than this capacity.

On July 2, 1999, the Ministry of Mines and Energy - MME, through Administrative Directive no. 227, determined that Eletrobrás should hold a public call for proposals to identify the surplus electricity available from cogeneration, with the objective of bringing it to the market in the short term. It also determined that Eletrobrás should establish appropriate mechanisms for the purchase, directly or through companies under its control, of surplus electricity produced by cogenerators duly authorized by ANEEL.

On August 11, 1999, ANEEL Resolution no. 245 established conditions and time frames for the subrogation to transferring benefits of the Fuel Consumption Account - CCC to projects involving replacement of thermoelectric generation using oil products in isolated electrical systems. The resolution allowed the use of funds from the CCC to wholly or partly replace existing uses, such as to meet new loads resulting from market expansion. The following were explicitly listed: hydroelectric projects with a capacity of more than 1000 kW and equal to or less than 30,000 kW, characterized as small hydroelectric plants; and other electrical generation projects using alternative renewable natural resources. The concept of Reference Energy was defined, which will be established for each project by ANEEL based on the market served, the existing repressed demand, and the long-term availability of energy from the project. Finally, the monthly amount of funds that could be directed to qualified recipients and the time frames for use of these benefits were defined.

Pursuant to the relevant legal provisions, especially those in Art. 11.4 of Law no. 9648 from 1998, and in light of the compatibility of SHPs and other alternative sources and technologies for electrical generation with the characteristics of small electrical isolated systems, ANEEL Resolution no. 245 sought to encourage forms of generation with lower cost and environmental impact, in order to encourage socioeconomic development and the reduction of regional inequalities[28].

ANEEL Resolution no. 261, from September 3, 1999, regulated the requirement of using resources of electrical concession-holders in activities to reduce electricity waste and for technological research and development in the electrical sector for the two years 1999-2000, along with establishing that at least 10% of the annual operational revenue must be used in technological research and development projects in the electrical sector. The resolution established that presentation of programs must follow the Manual for Development of the Annual Program of Research and Development of the Brazilian Electrical Sector, which includes renewable energy among the five lines of research, along with energy efficiency, electrical energy generation, environment and strategic research. This resolution however, especially in terms of the operational revenue, was profoundly altered by Law no. 9991, from July 24, 2000, which obliges companies holding concessions, permissions and authorizations from the electrical sector to invest a minimum of 0.75% of its net operational revenue in energy efficiency and technological research and development (see section 1.2.2).

Resolution no. 281, from October 1, 1999, established the general conditions for obtaining access, including use and connection, to electrical transmission and distribution systems. In terms of incentives to alternative sources, there is a reduction of at least 50% in charges for use of transmission and distribution systems by small hydroelectric plants - SHPs. There is also a complete exemption from these charges for projects that start up by December 31, 2003.

Resolution no. 21, from January 20, 2000, established the requirements for qualification of electricity cogeneration plants. These requirements include a minimum percentage of energy savings in relation to simple use of heat, and benefits small units with a capacity of less than 5 MW as well as those above 20 MW. Plants using fuels of more than 25% fossil origin need to have an electrical generation yield of at least 24%, 27% and 31% respectively for plants of up to 5 MW, 5 to 20 MW and more than 20 MW. Plants with renewable fuels must have an electrical generation yield of at least 14%, 17% and 21% respectively for the same capacity ranges, or 10% less than for fossil fuels. This regulatory mechanism was based on incentives policies for the rational use of energy resources, given that energy cogeneration contributes to rational energy use, since it enables a better use of fuels compared to generation of heat and electricity separately.

The regulatory (or official) rates - VN are set out in ANEEL Resolution no. 266, of August 13, 1998, which established the formulas for calculating costs of purchased energy to be considered in readjusting the rates charged by distributors. These formulas contain percentage ranges that progressively limit the ability to pass the price of energy

[27] Law no. 9648, from May 27, 1998, changed various laws in the electrical sector, and among other things, established incentives to alternative renewable energy sources that replace thermoelectric generation using oil products in isolated electrical systems. This law allows these sources to take advantage of the benefits of the allocation system of the Fuel Consumption Account - CCC for generation of electricity in isolated systems, as established in Law no. 8631, of March 4, 1993 (Art. 11.4). This provision is regulated by ANEEL Resolution no. 245, from August 11, 1999.

[28] This resolution was amended by changes made to Law no. 9,648 by Law no. 10,438/2002, which refers to the CCC. Law no. 10,438, from April 26, 2002, among other provisions, creates the Incentive Program for Alternative Sources of Electrical Energy - PROINFA, the Energy Development Account - CDE, addresses the universalization of electrical energy services and changes the legal provisions that affect the use of alternative sources and cogeneration of energy, as described below: a) extends to projects with a capacity of up to 30 MW, of wind generation, biomass generation and qualified cogeneration the benefit of at least a 50% reduction in charges for the use of transmission and distribution systems; b) extends to wind energy, solar and biomass the benefits of marketing their energy to consumers or groups of consumers with a load greater than or equal to 500 kW, in the interconnected electrical system; c) reduces to 50 kW the minimum load limit for marketing energy, when the consumer or group of consumers are located in an isolated electrical system; d) extends for another 20 years the proration system of the CCC in isolated systems, requiring, however, the establishment of mechanisms that encourage economic and energy efficiency, environmental protection and use of local energy resources; e) establishes new procedures and mechanisms for allocation of the resources of the Global Reversion Reserve - RGR, including the destination of resources for generation projects from alternative sources, especially small scale (up to 5 MW) for serving communities with isolated electrical systems. The development of PROINFA has proven very dynamic.

purchased on to the rates paid by final consumers. Within a range of 5% above or below the regulatory rates - VN, the full amount can be passed on. Outside of this range, the profits or losses resulting from the amounts of energy contracted become increasingly assumed by the distributor. An ANEEL measure from July of 1999 that establishes the regulatory rates in R$/MWh[29], as well as other benefits, makes possible new investments in expansion of the electrical supply (generation) through incentives to small hydroelectric projects, alternative sources and cogeneration. According to the text of the resolution, the regulatory rates established by ANEEL are differentiated by type of energy source and based on the costs of new generation projects, on bilateral projects for purchase of electrical energy and on the guidelines of the National Energy Policy. Each electricity purchase contract is linked to the regulatory rates in force at the time of signing the contract, as well as on the respective readjustment formula. These parameters remain constant for the respective contracts during the entire period they are in force. At the discretion of ANEEL, the regulatory rates can be revised annually or whenever there are relevant structural changes in the electrical production chain, and cease to exist when the market conditions so warrant. Thus, the transitory nature of the regulatory rates is directly related to the date the contract is signed and to market conditions. The definition of the regulatory rates will have no impact on current electricity rates authorized by ANEEL for the concession-holders. The final consumer will benefit the most from competition in the electrical sector.

1.4.3 Modern Use of Biomass and Cogeneration

Energy cogeneration is defined as the process of combined production of useful heat and mechanical energy, generally totally or partially converted to electrical energy, based on chemical energy provided by one or more fuels.

The use of biomass in electricity generation is a very efficient alternative. One of the positive aspects of the use of biomass to generate electricity is that this does not contribute to global warming, since the carbon emitted in the form of CO_2 is absorbed from the atmosphere during the process of plant growth (photosynthesis).

It is estimated that a considerable amount of energy can be obtained from plantations of trees, sugar cane, and other biomass sources. Many studies have shown that the energy generated by gasification of biomass could be favorably compared to that generated by hydro resources in Brazil in terms of costs and energy potential. Furthermore, biomass energy can also contribute to the decentralization of electricity generation.

According to ANEEL Generation Information Bank (www.aneel.gov.br), there are 30 cogeneration plants (electricity producers and independent producers) in operation in Brazil, for an installed potential of 414 MW, with 62% of the installed capacity located in the State of São Paulo.

Sugar cane bagasse and black liquor are among the most important sources of energy in the sugar and alcohol and pulp and paper industries, respectively, along with the several types of fossil fuels-based hybrid systems. The 2000-2009 Decennial Expansion Plan estimates the technical potential of cogeneration in these two sectors in 2009 to be 5,750 MW, with a commercial potential of slightly more than 2,800 MW. The current installed capacity in the sugar and alcohol sector is around 1150 MW, in accordance with the ANEEL Generation Information Bank. In the pulp and paper sector there is 718 MW of capacity in operation, and another 930 MW could be obtained in the pulp and paper sector.

Some limited efforts have been made to reduce consumption of diesel oil in isolated systems in the Amazonia. One such effort was carried out by the Rio Solimões Institutional Support Foundation - UNISOL, a body linked to the Federal University of Amazonas, through an agreement with ANEEL, to teach isolated communities in the Legal Amazonia to use solar energy and vegetable oil. The project calls for the development of a 115 kW system based on vegetable oil in the Extractive Reserve of Média Juruá in Carauari (State of Amazonas), which will benefit 2,500 people. The native oleaginous plants of the Amazonia (*andiroba*, *murumuru* and *buriti*, among others), are a natural substitute for diesel oil. ANEEL selected the Rio Preto and Médio Juruá reserves for the implementation of projects, because these areas are protected and monitored by the Brazilian Institute for the Environment and Renewable Natural Resources - IBAMA, and the populations are organized through extractivist cooperatives, which facilitates the implementation of the agreement.

In 1996, in the State of Rio Grande do Sul, the first thermoelectric plant using rice husks as a fuel was built. With an installed capacity of 2 MW, it cost around R$ 2 million. The energy generated is sufficient for the consumption of 3,000 families. The production will meet the entire demand of the industry, which processes 300,000 bags of rice in husks per month. The surplus energy is sold to the concessionaire operating in the region. The industry reports that the rice husks available in the state would be sufficient to supply 600 thermoelectric plants of the size of the one in São Gabriel, for a total of 1,200 MW.

The General Electrical Distribution Company - CGDE has announced the investment of US$ 64.5 million in the construction of 13 cogeneration plants. The units will have a total installed capacity of around 110 MW, around 8% of the current installed capacity of the State of Rio Grande do Sul. A company will be created for management of the project involving CGDE (80%), the State Electrical Energy Company - CEEE (10%), and the engineering firm Koblitz (10%). The projects will be submitted to the European Community Investment Partners, a European Union program for energy efficiency in Latin American countries. The three first units are in Dom Pedrito (6 MW), Capão do Leão (6 MW) and Piratini (10 MW). The fuel used in the first two will be rice husks, with wood wastes used in Piratini. Pelotas, Camaquã and Mostardas will be the next municipalities to receive plants.

In mid-1999, ANEEL authorized the city of São Paulo to install a 26.3 MW thermal generating station in the district of Sapopemba, in the west zone of the city, to generate electricity using garbage as a fuel (see section 1.4.4.6). The plant will be built by the Incineration and Electrical Energy Company - CIEL, which is being created for this end. All energy produced will be consumed exclusively by the city administration and any surplus can be used in public lighting.

Gas-fired micro-turbines for electrical generation in isolated systems will be the object of a research project, through an agreement signed in February 2000 between the Federal Engineering School of Itajubá - EFEI in the State of Minas Gerais and CEMIG. Different micro-turbines of up to 45 kW will be tested, fuelled by alcohol and gasified biomass, as well as natural gas. Dendê (African oil palm) oil, one of the vegetable fuels with the highest productivity per area planted, will also be considered.

[29] Type of Energy Source - Regulatory Rate (R$/MWh), updated by ANEEL Resolution no. 488, of August 29, 2002: competitive 72.35; coal-fired thermoelectric 74.86; small hydroelectric - SHP 79.29; thermoelectric using biomass and residues 89.86; windmills 112.21; solar photovoltaic 264.12. This resolution also establishes the Regulatory Rates for Natural Gas Fired Thermoelectric Plants. For more information see www.aneel.gov.br (1 US$ = R$ 2.3758).

1.4.3.1 Wood Gasification

The project "Brazilian Wood BIG-GT Demonstration Project/Integrated Wood Gasification and Electricity Generation System" (WBP/SIGAME) seeks to demonstrate the commercial viability of electricity generation from wood (forest biomass) by means of the use of gasification technology integrated with a gas turbine operating in combined cycle (BIG-GT technology - Biomass Integrated Gasification - Gas Turbine). This project is the result of the combined interests of a group of companies and Brazilian government bodies in the development of this technology, along with the environmental protection objectives of the Global Environmental Facility - GEF, of the United Nations. The objective of the project is to establish a replicable prototype, on a commercial scale, for generation of electricity, based on wood chip gasification, thereby avoiding CO_2 emissions from conventional thermal sources using fossil fuels.

1.4.3.2 Sugar cane bagasse

In Brazil, because of the vast production of sugar cane and the experience with using ethanol, studies have been undertaken of the technical and economic viability of more extensive use of sugar cane bagasse and straw in energy generation projects (see section 1.1.4).

The plants need little electrical and mechanical energy compared to thermal, in their processes. Also, until recently, the legislation made it practically impossible to sell surplus electricity. Thus, existing cogeneration systems convert only around 4%[30] of the energy from bagasse to electrical and mechanical energy, with most of the remainder used as thermal energy. This situation is changing, as a function of the possibility of selling excess electricity.

Analyses of conventional systems (steam) for energy generation in Brazilian plants and distilleries suggest the possibility of increasing the current levels of conversion of 4% to 16% or more, including the possibility of cogeneration throughout the year using residues (leaves and tips). The gasification/gas turbine technology - BIG/GT, still under development, could raise the rate of conversion of bagasse to electricity to above 27%. Furthermore, the energy generation potential could become a substantial fraction of the total revenue of Brazilian distilleries. An evaluation of the cogeneration potential for sugar cane bagasse can be seen in Table 1.4.1.

In July of 1997, the Copersucar Technology Center - CTC began implementation of a project, coordinated by MCT, aimed at developing technology for the entire electrical energy production cycle with advanced conversion systems (gasification/gas turbine) based on sugar cane biomass.

Project BRA/96/G31 involved an extensive program, including assessment of all stages of the process from sugar cane harvest to the energy produced, seeking to increase the efficiency of this technology. This program included plans to assess the availability, quality and cost of sugar cane straw for use in gasification systems; evaluate/develop agronomic regimes for sugar cane harvest without burning; test the atmospheric gasification process with bagasse and straw; integrate the BIG/GT process with a typical plant; and identify and evaluate the environmental impacts.

The assessments of impacts of the BIG-GT system on the atmosphere were concluded in March of 1998, and indicate that with the reduction of burning of sugar cane, there would be greater availability of biomass for energy, greater conversion efficiencies and lower emissions.

Project BRA/96/G31 showed a significant potential impact[31], with the possibility of a five-fold increase in surplus electrical generation at sugar/alcohol plants with the BIG/GT, and the residues could be used as a supplementary fuel to bagasse. The technology could be quickly and extensively replicated, given the size of the sugar-cane industry in Brazil and the world.

The analysis was based on the harvest of burned sugar cane (reference scenario) and identified a future scenario, depending on the harvest regime (3 scenarios/regime) (Table 1.4.2):

- Reference: 100% of sugar cane is burned before harvest; 10t (MS)/ha of straw collected; energy self-sufficiency.
- Future: 55% of sugar cane unburned, recovery of 100% or 50% of the straw in the unburned sugar cane, depending on the harvest regime.

Table 1.4.1 - Cogeneration in plants: conventional and with gasification

Scenarios	Consumption in process (kg. of steam /t. sugar cane) 500	340	Energy Surplus 80% Brazil[e]	Generating Capacity, Brazil Harvest [d]	Annual [d]
	Energy (kWh/t cane)		(TWh)	(GW)	
Cogeneration, steam 100% of bagasse[a]	57	69	13.6 - 16.6	3.1 - 3.8	
Cogeneration, steam Bagasse + 25% straw [a,b]	88	100	21.1 - 24.0		2.4 - 2.7
Cogeneration, steam Bagasse + 40% straw [a,b]	115	126	27.6 - 30.2		3.1 - 3.4
BIG - GT (partial) [a,c] Bagasse + 40% straw		167	40.0		4.6

Source: Macedo, 2001.

[a] Conventional cogeneration: steam cycles, condensation-extraction, 80 bars; using all the bagasse and in some cases complementing with straw. Gasification: cycles involving gasification of bagasse and use of gas turbines; technology not currently commercially available.
[b] Straw: not yet available; amounts increasing in coming years.
[c] BIG - GT partial: part of the bagasse is still burned in boilers, not gasified. Systems with total gasification could have greater efficiency.
[d] Operation only for harvest (4,400 h/year) and annual (8,760 h/year).
[e] 80%: assuming that 20% of the potential will not be used, for various reasons.
[f] Thermal energy, today ~500 kg steam/t cane (~330 kWh/t cane).

[30] Given electrical generation of 28 kWh/t of sugar cane (with 12 kWh/t sugar cane for electrical energy and 16 kWh/t sugar cane for mechanical energy) and 644 kWh/t sugar cane (thermal energy) from the use of 90% of the sugar cane bagasse (280 kg of bagasse/t cane).
[31] The project was assessed in May of 2002, and at that time 97% of the projected activities had been completed.

Table 1.4.2 - Differences in CO_2 emissions between future and reference scenarios

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

* whole sugar cane with straw, 100% transported to plant;
** sugar cane chopped (extractor disconnected), 100% of straw transported to plant;
*** sugar cane chopped (extractor connected), baled, 50% of straw transported to plant.

The last column of Table 1.4.2 presents the hypothetical reduction of CO_2 emissions that could be achieved in Brazil with the BIG-GT technology implemented, according to the scenarios adopted.

The scenarios took into account reductions in emissions of methane and other gases resulting from the reduction of burning of sugar cane[32] crops. Emission factors for burning of crop straw were measured in a wind tunnel specifically for sugar cane and the results differ from the general average values for burning of residues recommended by the Intergovernmental Panel on Climate Change - IPCC (1997) (which are around 4 to 5 times higher). IPCC values were used to estimate the reduction in emissions of CH_4, CO and NO_x with partial harvest (55%) of sugar cane without burning.

Table 1.4.3 - Reduction in emissions of CH_4, CO and NO_x from harvest of 55% of sugar cane without burning

Gases	Difference between situation of reference and future (t straw burned/t cane)	Emission factors (kg gas/t straw burned)		Impact on emissions (kg gas/t cane)	Impact on emission Brazil: 300 x 10^6 t cane /year (t gas/year)
CH_4	0.056 - 0.125 = -0.069	IPCC	2.83	-0.195	-58,500
		Tunnel	0.41	-0.028	-8,500
CO	0.056 - 0.125 = -0.069	IPCC	59.5	-4.10	-1,230,000
		Tunnel	25.48	-1.76	-527,000
NO_x	0.056 - 0.125 = -0.069	IPCC	4.37	-0.301	-90,000
		Tunnel	1.40	-0.097	-29,000

Source: Macedo, 1997 (table updated by author in 2002).

1.4.4 Other New Renewable Energy Sources

1.4.4.1 Small Hydroelectric Plants

According to ANEEL Generation Information Bank, there are 205 SHPs in operation in Brazil, for a total of 865.6 MW, 40 projects under construction (504.9 MW) and 82 projects authorized (construction not started), which, if built, will add another 1,323MW[33] to the system.

Measures have been taken to attract the private sector to hydroelectric plants. These include regulatory measures to facilitate the process, and a new financing policy that has already been implemented, with BNDES financing up to 80% of the costs. There are estimates that the remaining hydro potential that could be exploited by means of SHPs is in the order of 7,000 MW.

1.4.4.2 Solar photo- voltaic energy

The estimate of the Photovoltaic Systems Laboratory of the University of São Paulo - LSF/USP is that there are 12 MWp[34] installed in photovoltaic systems in Brazil, distributed among community systems, with most of the systems provided by the Energy Development Program of States and Municipalities - Prodeem, and residential systems sold directly by distributors, whether through direct sales or financed through existing lines of credit.

Prodeem (see section 1.5) has a potential market of around 100,000 communities in Brazil currently without electricity. From its creation in 1994 to 1999, the program cumulatively served 4,000 communities, benefiting more than 800,000 people.

Another source of financing that can be used in solar photovoltaic energy programs is the rural electrification program *Luz no Campo*, which intends to increase the coverage of rural electrification in Brazil from 57% to 67.5%. The goal of the government is to provide lighting to one million new rural properties and homes.

In the second half of the 1990s, the first experiences began to emerge involving connection of photovoltaic systems to the conventional distribution grids, with Brazil becoming part of an emerging global trend towards the increasing importance of this technological application[35].

The contribution of photovoltaic generation to the country's energy matrix, based on the 12 MWp installed and a capacity factor for isolated photovoltaic systems of 12% annually (annual production of 1,050 kWh/kWp), is around 12.6 GWh/year. It should be noted that systems connected to the grid operate with a higher capacity factor than isolated systems. In Brazil, capacity factors of between 15 and 19% (annual productivity of between 1,300 and 1,700 kWh/kWp) can be obtained with these systems.

[32] There is a single complete study using appropriate methodology, in a wind tunnel (Jenkins, 1994). The IPCC recommends using "general" values for emissions on burning of agricultural residues when there are no specific data. These values are higher than those measured for sugar cane according to the above mentioned study.
[33] Data from 2002.
[34] Data from 2002.
[35] By the end of 2001 there were 20 kW in systems connected to the public grid.

1.4.4.3 Solar Thermal Energy

Solar thermal technology is emerging as one of the potentially most interesting solutions for Brazil, because it comes from a source that is abundant, renewable and clean.

The *Gerahélio* project was submitted to GEF, with the goal of identifying the most appropriate solar technology and the size of a pre-commercial plant based on solar concentrators (in the order of 30 MW). The project was approved by GEF, which provided the approximately US$ 330,000 needed for its implementation.

This project is being developed with the cooperation of several Brazilian companies, including Eletrobrás, Petrobras, Chesf, and the São Francisco and Parnaíba Valleys Development Company - CODEVASF, under the guidance of the Ministry of Mines and Energy - MME. The technical management of the project is carried out by the Center for Electrical Energy Research - CEPEL, in partnership with the Brazilian Sustainable Development Foundation - FBDS which has been addressing the issue since 1994. The most likely site for the installation of the pre-commercial plant is the semi-arid Northeast region, in the State of Bahia.

In terms of the use of solar energy for domestic water heating (in individual houses and apartment buildings) and commercial applications (especially in hotels), the annual growth rate of at least 30% observed in recent years should be maintained.

1.4.4.4 Wind energy

Brazil has around 22 MW[36] of wind energy installed, which is very modest compared to the estimated potential. The recent "Atlas Brazilian Wind Potential", prepared by CEPEL with financing from the Ministry of Mines and Energy and Eletrobrás, shows an enormous natural potential, in the order of 143 GW, which could become an important alternative for diversification of Brazil's mix of electricity generation. Although not all this potential can be economically exploited, there is a huge space for growth in the use of wind energy in Brazil[37].

There are good opportunities for Brazil in the integration of the interconnected grid of the main blocs of generation on the North and Northeast coastal regions. The wind regimes mapped by different institutions in these regions complement the water regime, with stronger winds in the most unfavorable hydrological seasons, providing an ideal composition of generation. The most significant expected developments of wind energy in Brazil are in the States of Ceará, Rio Grande do Norte and Paraná.

Development of wind energy technology in Brazil takes place in universities, research centers and concession-holders, with a scientific and technological production that only gained recognition at the end of 1970s and throughout the 1980s. These activities intensified at the end of the 1990s, in an attempt to respond to the greater maturity achieved by wind energy technologies.

In 1996, the first Brazilian factory producing windmills was built. The plant was installed to produce large windmills and their components, both for export and to serve the domestic Brazilian market[38].

Certainly, the possibility of incentives and conditions such as a guarantee of purchasing on the part of concessionaires, and financing through BNDES and Eletrobrás, with the Global Reversal Reserve - RGR[39], will allow a rapid development of this source of energy.

1.4.4.5 Electricity generation from vegetable oils

Supplying electricity to isolated communities is a significant challenge to be faced by Brazilian society. Electrification of small isolated communities, however, faces great obstacles represented by the high cost of transmission lines and transport of diesel oil and by the low purchasing power of members of these communities.

For the North of the country, where only 2.6% of rural properties are provided with electrical energy (KALTNER, 1998) primarily due to the scattered small communities located far from the electricity generation centers and where the conventional electrical transmission lines are economically unviable the generation of electricity from vegetable oils is emerging as a local, viable and sustainable option in socioeconomic and environmental terms. Most importantly, this region is home to an enormous diversity of native oleaginous plants and favorable soil and climatic conditions for the cultivation of exotic species that are highly productive in oils, thus contributing to local employment and economic activities, and to improvement in housing, health and educational conditions. Thus, isolated efforts are being carried out by Brazilian companies and institutions in the use of vegetable oils for energy; and recently a national biofuels program is seeking to unify these various initiatives.

Brazilian Biofuels Program - Probiodiesel

Biodiesel fuels are obtained from mixing diesel and vegetable oil esters in different proportions.

In 1983, the Brazilian government, motivated by rising oil prices, mandated the implementation of a project (the National Program for Energy from Vegetable Oils - OVEG Project), which tested the use of biodiesel and fuel mixtures in vehicles running for more than one million kilometers. This initiative, coordinated by the Secretariat of Industrial Technology of MIC, had the participation of the automobile industry, autoparts manufacturers, producers of lubricants and fuels, vegetable oil producers and research institutes.

The technology feasibility of the use of the fuel was demonstrated, using existing distribution logistics. However, at that time, the costs of biodiesel were much higher than diesel, and for this reason the production of biodiesel was not implemented on a commercial scale.

From January to March of 1998, under the coordination of the Paraná Institute of Technology - TECPAR, a field experiment was carried out in Curitiba on the monitored use of biodiesel B20 - USA, a mixture of 20% soybean ester with the metropolitan diesel of the State of Paraná, for a fleet of twenty urban buses that operated normally with the new fuel.

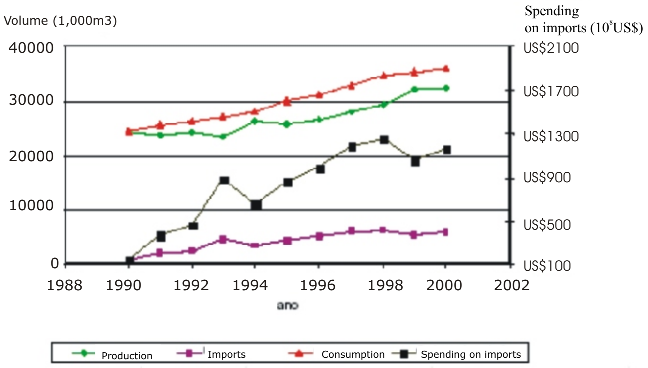
[36] Data for 2002, including the wind farms in Mucuripe (State of Ceará), with 2.4 MW of installed capacity, and Bom Jardim da Serra (State of Santa Catarina), with another 0.6 MW of installed capacity.
[37] The Electrical Energy Crisis Management Chamber - GCE, through Resolution no. 24, from July 5, 2001, created the Emergency Wind Energy Program - Proeólica, with the objective of enabling the installation of 1050 MW of wind generation capacity by December of 2003, integrated into the national interconnected electrical grid. The Incentive Program for Alternative Electrical Energy Sources - Proinfa, in accordance with Law no. 10,438, of April 2002, whose Article 3 establishes a goal for installation of 1100 MW of wind energy by 2006, guaranteeing the purchase by Eletrobrás, of energy produced by wind farms installed under the program for 15 years by wind farms installed under the program.
[38] In February of 2002, Wobben inaugurated its affiliate in the State of Ceará, in the Port Industrial Complex of Pecém. The production capacity of the Sorocaba and Pecém plants is planned to reach 600 MW per year as of 2003.
[39] See Law no. 10,438, from April 2002. See footnote 28.

Subsequently, the program Probioamazon, managed by the Ministry of Agrarian Development - MDA and the Ministry of Science and Technology - MCT, was implemented, with prospects for producing around 500,000 tonnes/year of palm oil (*dendê*) in the North Region, through production in settlements of the National Institute for Settlement and Agrarian Reform - INCRA.

Biodiesel emerges as an alternative for reducing dependency on oil products and has established a new market for oleaginous plant products. This also results in the reduction of the current dependency on imports of diesel oil, by around 6 million cubic meters per year, reducing the burden on the balance of payments and creating wealth in rural areas.

In the year 2000, the production of diesel vehicles in Brazil passed the barrier of 100,000 vehicles[40] per year. Diesel oil is currently the oil product with the highest consumption in Brazil. Given the production profile of Brazilian refineries, a growing fraction of this product has been imported, as shown in Figure 1.4.

Figure 1.4 - Production, demand, imports and spending on imports of diesel oil



Source: MME, 2001.

The mixture of vegetable esters with diesel oil in different proportions (or the use of pure ester) will allow a reduction in consumption of oil products, with the potential to reduce pollution emissions in urban transport systems. There is an immediate impact on the level of pollution in cities, with an improvement in the quality of life of their inhabitants.

MCT and Petrobras, through the National Science and Technology Plan for the Oil and Natural Gas Sector - CTPetro, support a project with the participation of the Federal Universities of Rio Grande do Sul and of Pelotas and the Regional University of Alto Uruguai, with the basic goal of refining and implementing the physical and chemical testing methods proposed by the American Society for Testing Materials - ASTM for Brazilian biodiesel, and to assess the properties of the mixtures of biodiesel and diesel mixtures in different proportions.

The Brazilian Biofuels Program - Probiodiesel will develop the technology for production and use of ethyl and methyl ester biodiesel. In the first phase, until 2003, tests were carried out on ethyl ester from soybean and ethanol, as well as methyl ester from soybean. In Phase II, by 2005, the production chains for biodiesel will be developed from other vegetable oils and/or residual oils. The potential of some oil plants found in Brazil are presented in Table 1.4.4.

Table 1.4.4 - Characteristics of some oil plants with potential energy uses

Species	Origin of Oil	Oil Content (%)	Cycle for Maximum Efficiency	Months to Harvest	Yield in Oil (t/ha)
Oil 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
Babaçu Palm (*Orbinya martiana*)	Nut	66	7 years	12	0.1-0.3
Sunflower (*Helianthus annus*)	Grain	38-48	Annual	3	0.5-1.9
Canola (*Brassica campestris*)	Grain	40-48	Annual	3	0.5-0.9
Castor Bean (*Ricinus communis*)	Grain	43-45	Annual	3	0.5-0.9
Peanut (*Arachis hypogeae*)	Grain	40-43	Annual	3	0.6-0.8
Soybean (*Glycine max*)	Grain	17	Annual	3	0.2-0.4
Cotton (*Gossypium hirsut*)	Grain	15	Annual	3	0.1-0.2

Source: Nogueira, 2000.

Probiodiesel's objective is to develop production technologies and a consumer market for biofuels; establish a national network of biodiesel, to unite and harmonize the activities of experts and entities responsible for the development of this economic sector; develop and approve specifications for the new fuel for Brazil; and attest to the technical, economic, social and environmental viability and competitiveness, based on laboratory, counter and field tests.

The main strategy is to develop the biofuel (methyl ester or ethyl ester) from production of oil crops (soybean, *dendê*, castor bean and babaçu palm) or domestic ethanol, thereby generating employment and income in the various regions of the country. Furthermore, it is intended to ensure greater autonomy in the supply of liquid fuels, contribute to improving Brazil's international contribution to global environmental issues, establish its position on the vanguard in the development of new markets for potential underutilized (agricultural) products, create significant alternative markets for Brazilian commodities (oil/gas, soybean and sugar/alcohol sectors) and byproducts (glycerin) with excess supply on the international market, and develop domestic technologies for production of fuels.

The development of Probiodiesel will allow the development of the technical and economic competitiveness of biodiesel, enabling environmental benefits and generating new business opportunities for agribusiness, assemblers and the autoparts sector.

Brazil, the world's second largest producer and exporter of soybean oil, could gradually become an important producer and consumer of biodiesel, and also has the opportunity to use other typical vegetable oils from the different regions of the country.

1.4.4.6 Biogas in sanitary landfills

Sanitary landfills are used for the final disposal of urban solid waste, mainly consisting of household waste. This consists of around 50% of moist organic material, which is mainly food waste, and thus can biologically decompose relatively

[40] Mainly trucks, light commercial vehicles and buses were produced, which together with the agricultural equipment and thermoelectric generation in isolated systems, accounted for a demand of approximately 37 million m^3 of diesel fuel in 2001.

rapidly. The other 50%, called dry waste, includes metals, glass and plastics (non-biodegradable waste), along with papers, cardboard, wood and rags, which are organic products consisting basically of cellulose, and thus subject to slower degradation. This composition, when confined in closed environments, starts a process of aerobic decomposition that lasts as long as there is oxygen in the air pockets in the waste (which exist in inverse proportion to the degree of compaction of the landfill waste) and then passes through successive stages dominated by facultative and anaerobic bacteria and fungi. Methane generation occurs a few days or weeks after the disposal of waste in the landfill, as soon as the oxygen has been consumed.

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

Sanitary landfills started having the technology implemented in 1979, as a result of the crises from the oil price shocks. In São Paulo, this was initially planned for the Bandeirantes and Sapopemba sanitary landfills. The main innovation, which was incorporated in the techniques of landfill operations, was the placement of convergent horizontal drains for the drainage wells, with the dual function of draining leachate to the bottom drains and gases for capture at the upper surface of the landfills. These horizontal drains are implanted in the surface of each new layer of waste of around five meters thick, and it is not uncommon to have from ten to twenty such layers, totaling from fifteen to thirty million tonnes of waste.

The anaerobic process that takes place in the sludge digesters of urban sewage treatment stations generate the same biogas of sanitary landfills, and its energy use is based on the same technological principles and the same equipment for energy capture in landfills. The capture of gas is simpler, however, since its generation occurs in confined environments, in contrast to landfills, which involve a suction operation in the interior of landfills with greater technical complexity. The disadvantage of this use is the still low percentage of sewage treated in Brazil.

Yet to be assessed is the potential for biogas generation from agro-industrial residues such as barley bagasse in beer production or the many forms of organic sludge. The industries do not necessarily need to invest in the construction of digestors, but can simply pump or transport it to idle sewage digestion facilities or create a "pool" of industries for extraction of the energy fraction of their sludges before the final disposal of digested sludges, which could be animal food, as occurs with the non-digested barley residues in breweries. Organic sludge can also be processed in dryers, resulting in pelletized powder, suitable for burning in furnaces or boilers for generating steam or thermoelectricity.

As leading edge technology the market is offering thermal destruction by means of plasma, at very high temperatures, with high efficiency of treatment of sludge and residues (including non-biodegradable) and high energy yield.

Industrial and sanitation companies are also trying to find viable ways to use the huge amount of sludge generated in their sewage and effluent treatment stations for energy production. Initial studies indicate the sustainability of these uses, and their environmental and economic attractiveness.

1.5 Energy Development Program for States and Municipalities - Prodeem

Created in December of 1994 by presidential decree, the Federal Government's Energy Development Program for States and Municipalities - Prodeem, is coordinated by the Ministry of Mines and Energy - MME through the National Department of Energy Development - DNDE.

Prodeem's objective is to provide electrical energy to isolated communities not reached by the conventional grid[41], with the energy coming from local renewable sources, thereby promoting the social and economic development of these areas.

Prodeem, with the name "Energies of Small Communities", is part of the Federal Government's Multi-Year Plan 2000-2003 - PPA. The program reflects a greater awareness on the part of bodies responsible for incorporating mechanisms that permit a greater knowledge of ecological and socio-productive systems of rural communities, and thus of the existing relations between these two systems, giving priority to the development of the energy potential currently available and under development (such as biomass, wind, solar, small hydro and wave power).

The activities of *Social Prodeem* are aimed at providing energy to schools, health clinics, community centers, water pumps, among others, through installing photovoltaic systems in these community facilities, either directly or through partnerships with state governments. There is also *Prodeem Market*, which takes a different approach, which is aimed at developing the latent market potential in rural communities. Its activities are directed at developing the basic conditions for implementation of self-sustaining management models compatible with the available human, technical, institutional and economic resources, through addressing both supply and demand of energy.

Prodeem has a great diversity of partners, including both public and private entities, at the federal, state and municipal levels. Its partners also include the Interamerican Development Bank - IBD, through the funds FUMIN and JSF, with support from UNDP[42]. This cooperation is focused primarily on developing business models and lines of micro-credit compatible with the objectives of *Prodeem Market*. In the coming years, it is expected that the cooperation requested from the Japanese agency JICA[43] will be forthcoming, aimed at the institutional strengthening of the program.

The great challenge for the program is to develop a management model that can coordinate all the agents imposed by the geopolitical diversity of Brazil, the widely dispersed remote communities, low purchasing power and consumption levels of users, the high cost of the installations, and the fact that legal and regulatory frameworks are still being developed, among other problems inherent to the process.

Therefore, Prodeem intends to benefit around 14 million Brazilians, most of them in rural areas and distributed over approximately 60,000 communities, three million rural

[41] In 1995, according to data from Eletrobrás, of the 5,835,779 rural properties in Brazil, only 1,604,247 of them, or 27.5% of the total, were electrified.
[42] The UNDP has made a grant to the program of around US$ 7 millions, along with various experts working directly on the problem.
[43] Two other significant sources of financing are in process US$ 300 millions requested from the Japan Bank for International Cooperation, and another for technical assistance, provided by the World Bank, which will be applied directly to supplying energy to communities.

properties, 58,000 public schools and 3,000 indigenous communities.

Prodeem has the following specific objectives:

Social Development: installation of micro-systems for energy production and use in needy communities that are not linked to the electrical grid, thus meeting basic needs.

Economic Development: use of renewable and decentralized electrical generation sources for supplying small producers, new settlements and isolated populations.

Complementing Energy Supply: complementary energy generation using decentralized renewable sources, to serve all consumers.

Technological and Industrial Base: promotion of technological development and production of alternative energy systems and the corresponding training of human resources for their installation, operation and maintenance. The technologies involved in the program include the use of photovoltaic panels, windmills and wind generators, small and micro hydro facilities, biomass fuels (alcohol, vegetable oils, and forestry and agricultural wastes), biodigesters and others.

1.6 Hydrogen Powered Collective Transport Program

Fuel cells have many advantages, such as high efficiency, modularity, clean and silent operation, rapid response to load, reliability, reduced maintenance and flexibility as to fuel used. More specifically, hydrogen powered fuel cells have zero emissions if the hydrogen is produced by electrolysis of water, and small amounts of liquid emissions if hydrogen is produced from biomass or ethanol. Brazil has especially attractive conditions in that it can obtain hydrogen from hydroelectric energy.

Hydroelectricity makes up a large part of primary energy sources in Brazil. While the seasonal storage of large excess amounts of hydro capacity in the rainy season (secondary energy) is not always possible, there is sufficient excess peak capacity in the daily cycle of electrical energy supply in the São Paulo Metropolitan Region to supply 12,000 fuel cell powered buses at an acceptable cost.

Research on the use of hydrogen as fuel has been carried out in several countries, focusing especially on its use in mass transport in large urban centers. Fuel cells are particularly advantageous in vehicles that operate most of the time stopping and starting, like urban buses. Fuel cells propulsion has been installed successfully in a range of urban buses and demonstrated in operation.

Hydrogen fueled buses have an energy yield of 45%, compared to 36% from the best diesel buses, and have very favorable characteristics for urban service, maintaining their high yield at low speeds, unlike thermal engines.

Buses play and will continue to play a fundamental role in urban transport in Brazil, which has a large fleet of urban buses. Buses are the dominant form of public transportation in metropolitan regions, which have grave problems of pollution and traffic congestion. Diesel fueled vehicles greatly contribute to polluting emissions, with diesel buses contributing a significant proportion of these emissions. Although the majority is low technology and low cost buses, around 10% of the fleet is higher technology buses with longer life, operated under better conditions. The replacement of these vehicles by fuel cell buses can be economically feasible. Their replacement by fuel cell powered buses could result in significant health gains, while creating a potential market of 500 fuel cell buses per year for 10 years, replacing only the more sophisticated diesel buses.

There should be no serious problems in implementing fuel cell buses in Brazil, since the country already has a large and modern infrastructure for manufacturing buses and trolley buses. The costs projected for the life cycle of fuel cell buses are entirely competitive with those of trolley buses, which they can complement because of their greater flexibility. They are in the same cost range as diesel buses, and are competitive if the environmental externalities of diesel fueled buses are taken into account.

In 1994, the project Environmental Strategy for Energy: Hydrogen Fuel Cells Buses for Brazil (ESE/HB) was implemented by the São Paulo Metropolitan Urban Transport Company, the Energy Application Agency of São Paulo and the University of São Paulo, with resources from the Global Environment Facility - GEF, managed by the United Nations Development Program - UNDP.

Phase I of the project, completely financed by GEF/UNDP, involved the assessment of the situation and prospects for sales of buses. This phase has been completed and culminated in a proposal presented to the GEF for Phase II.

Phase II of the project, to begin after approval of the proposal by the GEF, consists of the acquisition, operation and maintenance of eight hydrogen fuel cell buses, along with the hydrogen production and bus fuelling station, and with performance monitoring and evaluation of these buses.

Phase III will involve the beginning of industrial production in Brazil and a fleet of around 200 buses based in one garage. Phase IV will involve full scale production and development in São Paulo and other cities.

1.7 Recycling

Recycling is related to the reutilization of materials and wastes that are generally seen as garbage. Although recycling does not contribute directly to the reduction of greenhouse gas emissions, it results in lower production of inputs, and thus has an indirect effect on mitigation of global warming.

Given the economic, social and environmental advantages, recycling in Brazil has been expanding steadily, with increasing government incentives for these initiatives. There has been a great advance in Brazil in terms of recycling, as shown in the table below:

Table 1.7.1 - Recycling in Brazil

Material		Level of Recycling (%)
Aluminum		78
Glass containers		42
Paper	Office	22
	Corrugated	72
	Film	15
Plastic	Rigid	15
	PET	26
Steel cans		40
Tires		20
Long Life Carton Packaging		15
Used Lubricating Oil		18
Urban Compost*		1.5

Source: CEMPRE *site*.
* process of transformation of non-hazardous organic solid waste — vegetable and animal wastes — into a high quality and low price fertilizer.

The program *Brasil Joga Limpo* is one of the programs in the 2000-2003 Multi-year Plan - PPA. Its objectives include reducing solid waste generation, increasing the rate of appropriate collection and final disposal, recycling, reuse and treatment of solid wastes, as well as ensuring appropriate disposal techniques. The target public includes public and private companies, as well as organizations and institutions providing services whose activities generate wastes.

The program was designed because of the need to reduce the use of natural resources and waste in consumption of materials and energy, as well as to increase the reuse of materials recycling, while reducing the amount of waste going into sanitary landfills and thus increasing the landfill's lifetime. There is also a growing demand on the part of municipalities for actions aimed at urban sanitation, waste recycling and appropriate disposal of solid wastes.

1.8 Charcoal Industry

Charcoal is obtained from wood and firewood[44] in a process of controlled combustion, in ovens, which increases its concentration of carbon. This chemical process is called pyrolysis. Charcoal has a greater heating power than the original solid fuel: 3300 kcal/kg for commercial firewood, compared to 6800 kcal/kg for charcoal.

The majority of the wood processed in the transformation of coal used to be harvested from natural forests, contributing to deforestation. This practice has occurred in Brazil since the colonial period, being justified by both technological and social factors. In technological terms, the conversion of wood into charcoal — generally carried out in ovens made of clay bricks, simple to build, low cost and easy to operate — is very rudimentary, allowing production by small autonomous low-income producers. From the social point of view, the production of charcoal from native forests is one of the main sources of income for poor populations in rural areas, especially in the *cerrado* region.

Starting in the middle of the 20th century, concerns emerged about deforestation for charcoal production, because of the reduction of supply of raw material for industries and increased distances between the charcoal ovens (*carvoarias*) and their main consumers (steel plants). As a result, in the 1940s, some steel plants in the State of Minas Gerais began reforestation projects, ensuring part of the raw material necessary to production and thereby giving rise to tree plantations.

Reforestation projects[45] currently supply more than half of the needs of industries that use charcoal as a basic input, specifically for steel and cement production. The overall share of wood coming from planted forests that is used for charcoal production in industry has grown to 72% of the total in 2000 (Table 1.8.1).

Table 1.8.1 - Consumption of charcoal from reforested areas

Year	Charcoal Consumption (10^3 m^3)	Share from Reforestation	Charcoal from Reforestation (10^3 m^3)	Emissions Avoided (10^3 tC)
1990	33,636	34.0%	11,436	2,898
1991	29,224	42.3%	12,362	3,133
1992	26,828	38.9%	10,436	2,645
1993	28,840	43.5%	12,545	3,179
1994	29,432	54.0%	15,893	4,028
1995	27,352	52.0%	14,223	3,604
1996	25,344	70.0%	17,741	4,496
1997	24,256	75.0%	18,192	4,610
1998	21,924	67.4%	14,777	3,745
1999	22,240	70.0%	15,568	3,945
2000	22,600	71.7%	16,204	4,106

Source: MME, 2001 (consumption) and ABRACAVE, 2001 (reforestation).
Note: Emission factors used are 0.63 toe/t CV and 1,609 tC/toe.

Charcoal is consumed primarily in the metallurgy industry (mainly steel) and in the cement industry, with some use in other sectors (Table 1.8.2).

Table 1.8.2 - Consumption of charcoal in the main industrial sectors - 1,000 m^3

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Industrial	33636	29224	26828	28840	29432	27352	25344	24256	21924	22240	22600
Pig Iron and Steel	27040	22800	21256	23300	24048	22068	19144	20048	18388	18848	19184
Steel Alloys	2240	3020	2560	3100	2708	2360	3580	2400	2012	2256	2260
Cement	2168	1548	1272	1412	1604	1752	2260	1492	1260	952	968
Non-Ferrous and Other Metallurgy	1576	1264	1272	700	760	904	192	160	136	136	140
Mining and Pelletizing	212	220	192	20	16	0	0	0	0	0	0
Chemicals	200	180	164	176	184	148	80	40	32	0	0
Others	100	100	56	68	72	80	32	48	88	48	48
Brickmaking	80	72	44	52	32	36	48	60	0	0	0
Textiles	20	20	12	12	8	4	8	8	8	0	0

Source: MME, 2001.
Specific mass of charcoal: 250 kg/m^3 (MME, 2001).

There has been an overall reduction in charcoal consumption over the years analyzed. Particularly since 1994 there was a trend towards reduction in charcoal consumption because of its replacement by coal, largely resulting from the privatization process in the steel sector. With privatization, many companies integrated with charcoal production were shut down and the process shifted to imported coal. With lower costs, over the short and medium term the use of coal facilitates an increase in scale of production. However, the pig iron produced using charcoal had a higher quality, compensating the use of this raw material in the production of some higher-value iron and steel products. In recent years, use of coal in coking plants to obtain coke has increased, and there has been a return to fuel oil in the cement industry.

[44] By definition, "wood" is the woody part of the trunks and branches of trees. "Firewood" is the part of the branches, sticks or fragments of tree trunks destined as fuel.
[45] The main reforestation technology is that of planting short-rotation trees.

Brazil is one of the few countries that still uses charcoal in the metallurgy production process. Its use is concentrated in the iron and steel industry. In many countries, coal has replaced charcoal in steel making processes.

However, the development and diffusion of plantation technologies and the favorable climatic conditions in Brazil have provided a reduced period between planting and harvest, which makes the use of planted forests economical, providing gains for the industrial sector.

As a result, the share of charcoal produced from planted forests has increased in the total charcoal consumption in industry (see Table 1.8.1). Thus, because of the use of a renewable source of energy — charcoal from planted forests — emissions from an equivalent amount of coking coal were reduced by around 40 millions t C in the industrial sector in this period.

Programs and Activities Containing Measures That Contribute to Addressing Climate Change and its Adverse Effects

2 PROGRAMS AND ACTIVITIES CONTAINING MEASURES THAT CONTRIBUTE TO ADDRESSING CLIMATE CHANGE AND ITS ADVERSE EFFECTS

This section will analyze the replacement of fossil energy sources in Brazil with high carbon content per unit of energy generated by others with lower content, or which generate greenhouse gas emissions with lower global warming potential. Despite not being sustainable over the long term, the programs and activities analyzed here have the objective of helping to mitigate climate change and contribute to the ultimate objective of the UN Framework Convention on Climate Change, which is to contribute to the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Brazilian demand for electricity has grown much more quickly than that for primary energy or the economy of the country. This trend will likely continue for the coming years and will require new strategies for energy planning. Thus, an analysis of the current national electrical energy system is necessary to outline future prospects and their implications for greenhouse gas emissions.

The programs and activities analyzed here include the prospects for increasing the share of natural gas in Brazil's energy matrix and its impacts on greenhouse gas emissions, the reduction of fugitive methane emissions in oil and natural gas production in Brazil and in the distribution of natural gas in São Paulo; and the reduction of vehicular emissions in urban transport in São Paulo.

Methane gas generated in waste treatment can be used as an energy source or can be burned when not used, thus avoiding its release to the atmosphere and generating carbon dioxide emissions, with a lower global warming potential than methane. Given the predominantly organic nature of wastes in Brazil, this reduction is covered in section 1.4.4.6, as a new renewable source of energy.

This section also analyzes the development of nuclear energy in Brazil, which doesn't contribute directly to anthropogenic emissions of greenhouse gases, but does rely on a mineral resource and is thus exhaustible, and thus cannot be considered sustainable over the long term. Furthermore, the environmental impact of thermonuclear plants has also been strongly emphasized in recent decades, and is a leading concern of environmental movements. On the other hand, nuclear plants do not emit greenhouse gases, and thus could contribute to addressing climate change and its adverse effects.

2.1 The Brazilian Electrical Sector

According to ANEEL data, the electricity market in Brazil experienced a growth of around 4.5% per year, and should exceed 100,000 MW in 2008. Government planning for the medium term shows the need for investments of around US$ 6-7 billion per year in expansion of the Brazilian electricity matrix, to meet the demand of the Brazilian consumer market.

Over the last two decades, electricity consumption has grown much faster than the Gross Domestic Product - GDP, because of the population growth in urban areas and efforts to increase electricity supply and modernize the economy.

The Brazilian electrical system is distinguished by the long distances of transmission lines and a predominantly hydroelectric generation capacity. The consumer market (47.2 million customers) is concentrated in the South and Southeast regions, which are more industrialized. The North region is served largely by small generating stations, mostly diesel thermoelectric.

The classes of residential, commercial and rural consumption increased their shares considerably, while the industrial sector had a lower share of this growth, mainly because of the use of more efficient technologies in the end use of electricity, allied with measures to rationalize consumption implemented especially in the 1990s.

In recent years, the Brazilian energy sector has undergone significant institutional reforms with the objective of increasing energy efficiency and resolving supply problems to meet the growing demand for electricity.

Since the mid-1990s, new opportunities have emerged for the private sector, allowing generation for self-consumption — with or without the sale of excess electricity — and generation for sale. These rules allow sales to companies which supply public services, large consumers or business groups.

The entry of private capital in the electrical sector, previously primarily state-owned, brought profound changes in the old model. The investors started to build plants with lower generating capacity, based on new technologies, which could be built at lower costs and more rapidly than hydroelectric plants. This led to considerable changes in electricity generation sources.

Electricity generation in Brazil has very distinctive characteristics in the average global context, in terms of reliance on fossil fuel sources. Brazil has the privileged position, as mentioned above (see section 1.3) of having established, since the mid-20th century, a base of renewable hydroelectric energy sources. In 2000, the primary fossil fuel sources in thermal generation accounted for 6.9%; renewable thermal sources 3.1%; and nuclear 1.5%[46]. The remainder (88.5%) of the electricity was generated from hydro power.

Thermal sources of electrical generation in Brazil in recent decades have contributed less than 10% of the electricity generated. Thus, the primary fossil fuel sources in electrical generation in Brazil contribute much less to global atmospheric emissions (on a per capita basis) than the majority of industrialized countries.

However, the best hydroelectric opportunities in Brazil have probably already been exploited, especially in the Center-West, Southeast and South regions. The exhaustion of hydroelectricity potential in watersheds close to the large urban centers indicates that, if new large-scale hydro plants were built, they would be distant from these areas (there is a great electricity generation potential to be exploited in the North region, especially in the Amazonian basin), which would involve higher energy costs, because of the increase in transmission costs, and possibly environment restrictions.

In the short term, natural gas has become an important alternative for the necessary expansion of electricity generating capacity. The expectations of a rapid increase in the share of natural gas in the energy matrix conformed to a strategic governmental decision that, through Petrobras, it

[46] Disaggregation for thermal generation in 2000, normalized based on Patusco and e&e. Includes power stations connected to the grid and self-generators. See Table 1.3.2.

would invest in the construction of the Bolivia-Brazil gas pipeline. In this context, the Federal Government instituted the Priority Thermoelectric Generation Plan - PPT[47], by Decree no. 3,371, on February 24, 2000. Through Administrative Decree no. 43, of February 25, 2000, the Ministry of Mines and Energy defined 49 thermoelectric plants as part of PPT, for an anticipated total nominal capacity of around 16 GW.

According to the decree creating it, the thermal plants forming part of PPT have a guaranteed supply of natural gas for a period of up to twenty years, according to the rules established by the Ministry of Mines and Energy; a guarantee of application of the regulatory rate to the electrical energy distributor, for a period of up to twenty years, according to the National Electrical Energy Agency - ANEEL; and a guarantee from the Brazilian Development Bank - BNDES of access to the Program for Financial Support to Priority Investments in the Energy Sector.

With the development of energy applications for natural gas, combined with the private sector interest in thermoelectric generation and the creation of a consumer market, including urban distribution for domestic use, it is expected that the expansion of Brazilian reserves will match demand growth and become sustainable.

Although it has a greater impact on greenhouse gas emissions than hydroelectric facilities, the replacement of fossil fuels by others with lower carbon content is a technical measure for reduction of emissions from thermoelectric generation. Natural gas, for example, with better conversion efficiency than other fossil fuels, results in lower CO_2 emissions per unit of energy generated.

The typical technological profile of thermal generation projects will determine the rate of increase in carbon emissions from the Brazilian electrical sector. The best available technical options could ensure that the use of fossil fuels in electrical generation becomes a new and promising element in the diversification of the Brazilian energy matrix, while at the same time ensuring a reduced impact on the environment.

It should not be forgotten that the diversification of the Brazilian energy matrix, in order to meet a growing demand, should also involve a significant share of renewable energy sources, mainly biomass sources, as discussed above (see section 1.4), as well as nuclear energy (see section 2.5).

2.2 Prospects for Natural Gas in Brazil and its Role in Reducing Growth of Greenhouse Gas Emissions

2.2.1 Trajectory and Share of Natural Gas in the Brazilian Energy Matrix

Proven reserves of natural gas in Brazil grew sharply in the mid-1980s, with the discovery of highly promising areas for exploration in the Campos basin, on the north coast of the State of Rio de Janeiro. From 1980 to 1990, reserves jumped from 52,544 to 172,019 million m^3, as shown in Table 2.2.1, for an average annual growth of 12.5% in that period. In the 1990s, continuous exploration activities increased the total proven natural gas reserves at the rate of 2.5% per year, reaching 220,999 million m^3 in 2000.

Production of natural gas in Brazil grew at a similar rate, with a rate of growth of around 20% per year in the period from 1980-85, but only 7.8% per year in the 1990s. This production is strongly conditioned by oil production, because of the existence of associated gas and oil reserves, especially in the Campos basin, and the strong weight of basic oil products in energy demand from the wide range of activities that make up the national economy.

Table 2.2.1 - Proven Reserves and Production of Natural Gas in Brazil

Year	Proven Reserves (10^6 m^3)	Annual Production (10^6 m^3)	Reserves/ Production (years)
1980*	52,544	2,205	23.8
1985*	92,734	5,467	17.0
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	207,962	7,955	26.1
1996	223,764	9,156	24.4
1997	227,650	9,865	23.1
1998	225,944	10,833	20.9
1999	231,233	11,898	19.4
2000	220,999	13,328	16.6
Average annual increase from 1990 to 2000	2.5 % p.a.	7.8 % p.a.	-

Source: Petrobras, 1998 and ANP Administrative Directive no. 009, from January 21, 2000, to 1999 and 2000.
Note: The total amount of production includes gas re-injected, flared, and losses.
* Proven reserves from the years 1980 and 1985 were calculated using the Petrobras classification criteria until 1996, whose methodology was mainly based on the technical aspects of reserves. Data from the period of 1990-97 were obtained by means of the Society of Petroleum Engineers/World Petroleum Congress - SPE/WSP classification criteria, adopted by Petrobras in 1997, whose methodology places equal emphasis on technical and economic aspects, incorporating the guarantee of economic return as a parameter in the determination of reserves.

The ratio of proven reserves to production of natural gas in 2000 indicates a useful life of these reserves at current production levels of 16.6 years. Over the 1990s this level declined by an average of around 5% annually, explained in part by the recent priority given to natural gas as a high quality energy source, which brings pressure to increase production and for greater end use consumption.

The data for natural gas in Brazil is presented in Table 2.2.2. There was a high rate of flaring in 1991, which despite reductions achieved over the decade remained high in 2000. These losses are mainly due, as mentioned above, to the gas associated with oil, where the use of gas is determined by oil production, as occurs in the Campos basin, the main oil producing area in Brazil. It should be added that often the infrastructure for access to gas is expensive and makes its use unviable, or it is not technically possible.

An analysis by ANP showed a paradox in this context: while the initial expansion of natural gas in Brazil was supported by the growth in production of gas associated with oil, this association became an important limiting factor in its

[47] Since the launch, the PPT has changed: it began with 49 plants, grew to 55 in 2001, and in February of 2002 had 38. Plans for plants were removed from the PPT because they did not advance in the schedule established by the National Electrical Energy Agency - ANEEL and did not meet the requirements set by the Electrical Energy Crisis Management Chamber - GCE. The schedule for implementation of the plants included in the original PPT was frustrated largely by the impasse generated by the exchange rate risks associated with the price of natural gas, which was quoted in dollars, while the contracts signed for electricity purchases were in Brazilian Reais.

expansion. Of all the gas produced, more than three quarters are associated, and only 19.1% in 2000 of Brazilian gas has a non-associated origin. This profile, highly dependent on oil production, explains the high rate of non-utilization of gas in Brazil. In a market that has been continually expanding over recent years, enabling the importation of gas from neighboring countries, this loss is strongly questioned, even more because of the waste of a non-renewable energy resource, which in addition to producing emissions, could be replacing other energy sources which are more environmentally destructive.

In this context, some goals have been established for the use of Brazilian natural gas. As part of this, Petrobras created a Zero Flaring Plan (see section 2.3) and ANP began to monitor the use of the oilfields in the country. This plan, created in 1997, has been producing results, as shown in Table 2.2.2, and demanding investments in infrastructure and new forms of distribution of production.

Table 2.2.2 - Balance for Natural Gas in Brazil

	1991	2000
	(10^3 m^3)	
Imports*	-	2,211
Production	6,291	13,328
Total Supply	**6,291**	**15,539**
Reinjection	1,141	2,729
Flaring and Losses	1,715	2,370
Domestic Supply	**3,435**	**10,440**
Self-Consumption (Petrobras)**	708	2,916
LNG***	332	743
Sales	2,395	6,572
Adjustments	-	208

Source: ANP and MME, 2001
* Refers to imports from Bolivia.
** Refers to self-consumption by Petrobras and production in the natural gas processing units - UPGN.
*** Liquefied Natural Gas Liquids - LNG. The portion of natural gas which liquefies in the UPGNs.

Although natural gas still holds a secondary position in Brazilian energy consumption and production, the rapid expansion in its production in the period 1980-2000 was only exceeded by the growth in oil production. This situation resulted in the doubling of the share of natural gas in primary energy production in the Brazil over the period in question, reaching a share of 6% in 2000. However, in terms of the domestic supply of primary energy, the share of natural gas in this year is only 3.7% of the total, even with imports of Bolivian gas. This is due to the high amount reinjected (20% of production) and also to flaring/losses (18% of production).

The penetration of natural gas in end use energy consumption, although still in the early stages, has been favored by incentive policies in different economic sectors to replace other sources, especially fossil fuels, where natural gas is presented as a more efficient and economically viable energy option. Such initiatives are guided by the current consensus around the decisive role that natural gas can have on the definition of a model of sustainable development for Brazil. Thus, the use of natural gas is intended to both reduce external dependency on oil and its products and their weight on the trade balance, and avoid the use of other more greenhouse gas intensive sources, and therefore the worsening of climatic impacts resulting from global warming.

2.2.2 Prospects for Use of Natural Gas

The prospects for use of natural gas in thermoelectric generation are promising and are attracting an increasing number of companies interested in exploiting this area of energy production. The availability of extensive reserves in the country and the establishment of facilities for importing natural gas by private enterprises — the result of the current process of liberalization of the hydrocarbon sector — increase the possibility of a natural gas supply in the domestic market in the medium term, which contributes significantly to the allocation of investment in gas-fired thermal plants.

Along with its proven reserves of natural gas, Brazil has a huge supply market in Latin America, especially in bordering countries such as Bolivia, Argentina and Venezuela. Another option for reinforcing supply of gas in Brazil is to import liquified natural gas LNG.

Thermoelectric generation gives natural gas the role of an agent of decentralization in the operation of the electrical system, as well as a force for energy integration between Brazil and the neighboring countries. An example of this is the importation of natural gas in supplying thermoelectric plants in the South and Southeast regions, as in the case of the 600 MW Uruguaiana Thermoelectric Plant, using gas from Argentina. Also, the supply of natural gas to thermoelectric plants is a fundamental factor in the financial viability of the operation of gas pipelines under construction in Brazil, ensuring minimum levels of consumption and therefore supply to the potential centers of consumption of natural gas.

The strategic role assumed by natural gas in the expansion of generating capacity of self-producers, independent producers, as well as the private sector concessionaires of the public service, also results from its advantages compared to fuel oil and other fossil fuels used in thermoelectric generation, such as its lower corrosive power, the reduction in equipment maintenance, greater control of combustion in the production process, and the elimination of fuel stockpiles.

In addition, natural gas fired thermoelectric plants and cogeneration systems will bring great benefits in terms of stability of future electrical energy supply, because of its greater capacity for adaptation of supply to demand, its modularity and the short construction time of these projects, along with the better management of the load curve of the electrical system, which reduces peak demand from the system, avoiding the installation of additional generating capacity. Another advantage is the possibility of installation near the large load centers, saving transmission costs and contributing to the reduction of levels of electricity losses and increasing operational reliability.

According to Brazilian government estimates[48], the opportunities for use of natural gas in the various sectors of the economic should raise the share of this source in the Brazilian energy matrix from the current to 2.6% to 12% in the year 2010.

On the demand side, natural gas has shown great versatility, adapting to a broad range of application, which includes the production of LPG and natural gasoline, replacement of LPG and manufactured gas in residential, commercial, industrial and other uses, use as a raw material in the petrochemical and fertilizers industry, replacement of diesel oil in bus fleets and public service utilities, and replacement of oil products in industry and generation of industrial heat.

[48] Natural Gas Committee, Administrative Directive no.9, of September 16, 1991, of the National Energy Secretariat.

However, among the main trends of penetration of gas is its use as a fuel for thermoelectric generation, which is a determining factor in reducing the risk of possible restrictions on electricity supply in periods of unfavorable hydrological conditions. This trend was institutionalized as the federal government's Priority Thermoelectric Generation Plan - PPT, developed in order to encourage thermoelectric generation.

In terms of global sustainability, the replacement of oil products and other fossil fuels by natural gas is positive, since the use of natural gas results in lower emissions of gases responsible for the greenhouse effect. This change is expected mainly in the transport and industrial sectors. But in electrical generation, where the high share of hydro energy gives Brazil favorable conditions in terms of greenhouse gas emissions, the significant increase of the share of thermoelectric generation projected for the coming years will bring new factors into play in the debate over environmental issues, related to expansion of the electricity supply, because of the significant increase in greenhouse gas emissions.

2.2.3 Greenhouse Gas Emissions from Natural Gas Fired Thermoelectric Plants *vis-à-vis* Fuel Oil Fired Thermoelectric Plants

The expansion of conventional thermoelectric generation in Brazil will introduce qualitative changes in the set of environmental externalities of the electrical sector. With the rapid increase in the number of thermoelectric plants, the focus of attention is shifting more and more to the issue of air quality control, because of emissions of pollutants.

Environmental demands from civil society are expected to increase, seeking to lessen the severity of the impacts of concentrations of these substances in the air. Among the most serious impacts are the harmful effects on the health of the population, ranging from pulmonary and cardiovascular diseases to the increased incidence of carcinogenic processes, and the emergence of new atmospheric phenomena, such as acid rain formed by the fall in pH of rainwater by means of its contamination by sulfuric or nitric acid.

However, it is the impacts on global climatic change that pose the greatest obstacles to the growth of thermoelectric generation in Brazil. Such environmental limitations will certainly be reflected in the costs and technical and economic viability of construction of conventional thermoelectric plants, and demand improvements over current technological levels. Thus, the use of natural gas to replace other fossil sources traditionally used in thermoelectric generation is presented as the most appropriate option in the full development of thermoelectric generation in Brazil, because it allows the increase in energy efficiency of generation and especially the mitigation of much of the adverse impacts caused by other sources on the environment.

The comparison of carbon emissions contained in CO_2, based only on the chemical characteristics of the fuels and on their energy contents, shows that the combustion of natural gas emits 218 mg C/kcal, allowing the reduction of 44.5% in relation to emissions from burning European coal, which has 393 mg C/kcal. Compared to heavy fuel oil, which emits 307 mg C/kcal, the reduction in emissions resulting from the adoption of natural gas is 29.0%. Compared to the use of light fuel oil (290 mg C/kcal), burning natural gas allows a reduction of 24.8% in total carbon emissions.

These results differ somewhat from the emissions estimated based on electrical energy generated, which depends also on the efficiency of the technologies used in thermoelectric plants. However, natural gas remains a real alternative in reducing the rate of growth of greenhouse gas emissions, with coefficients of emission of carbon dioxide per kWh generated lower than that of fuel oil and coal in thermoelectric generation in the main technologies used — i.e. conventional steam cycle, gas turbine and combined cycle.

Compared to burning fuel oil, the use of natural gas enables the reduction by 27% of total carbon dioxide emissions in plants equipped with conventional steam cycle generating technology. In plants with gas turbines, reductions in CO_2 obtained by using natural gas compared to fuel oil rises to 31%. For combined cycle thermoelectric generation, this change in energy source would mean a reduction in CO_2 emissions of 28%.

Another important characteristic of natural gas is the absence of sulfur dioxide (SO_2) and particulate materials resulting from inert material in the fuel, which are typically found as byproducts of burning coal and, in lesser quantities, heavy fuel oil.

However, the effectiveness of natural gas in reducing emissions of contaminants and in overcoming the barriers imposed by the environmental impacts related to the greenhouse effect depends on a rigorous control of losses. This is because methane (CH_4), the chief component of natural gas, when released to the atmosphere through leaks or incomplete combustion, also contributes to climate change to a greater degree than carbon dioxide (CO_2).

2.3 Petrobras Programs to Improve Utilization of Natural Gas in the Campos Basin

The Campos basin is Brazil's main oil producing region, with around 80% of domestic production. It extends from the coast of the State of Espírito Santo, along the entire State of Rio de Janeiro, to the State of São Paulo. Leadership in the development of the deep water production technology use in these oil fields resulted in various awards and international recognition.

Because of the increased production in this region and with the prospects for growth in the natural gas market, in 1997 Project Zero Flaring - PQZ, consisting of actions to improve the utilization of gas from the Campos basin. The objective of the project is to increase the availability of gas on the market, improve the utilization of energy resources and reduce pollution emissions[49].

With the implementation of the actions under way, the estimated reduction of gas flaring in 2001 is 6.2 million m^3/d, with a total of around 3.4 million m^3/d in 2005. This reduction of half the flaring is occurring in parallel with an increase of almost 100% in production, which will exceed 15.9 million m^3/d in 2001, increasing to 27.5 million m^3/d in 2005. Thus, the improvement in the process is in the order of 400% over this period, with the result that the indicators for gas utilization, which were already comparable to other countries such as the USA and Mexico, are approaching *benchmark* values at the global level.

[49] In 2001, the PQZ was expanded and complemented with other activities, including creation of the Gas Optimization Plan - POAG. POAG emerged in 2001 and absorbed the PQZ, since it was broader and had the same objectives. The plan included the installation of new compressors, expanding the capacity of other existing ones and changing the system for raising oil in some wells, going from gas-lift to centrifuge pumps, thus liberating compression capacity for the export of gas to the continent. Also part of POAG were activities involving review of procedures, control of stocks and personnel training. Investments in this project exceeded the 200 million dollar mark.

Huge benefits justify the implementation of the project: better use of energy from gas associated with oil production; making more gas available for electrical generation through a thermoelectric program being carried out by the federal government; contribution to the governmental goal of increasing the share of gas in the Brazilian energy matrix and reducing emissions of pollutants such as carbon monoxide and nitrogen compounds; and reducing emissions of greenhouse gases.

From the perspective of global climate change, the Zero Flaring Program is of special importance, since between 2002 and 2005 the program will prevent approximately 15 million tonnes of CO_2 from being released to the atmosphere.

2.4 Programs in the State of São Paulo for Reduction of Vehicle Emissions in Urban Transport

Since 1981, concerns with vehicle emissions have increased because of the growing concentration of CO and suspended particulates in the atmosphere. At the end of the 1980s, it became obvious that the phenomenon was linked to vehicle emissions, and that urgent measures were necessary. During the 1990s, the São Paulo Metropolitan Region - RMSP was subject of severe episodes of air pollution, especially during the winter, because of the combination of pollutant emissions and climatic conditions unfavorable to dispersion, resulting in serious problems to public health.

In 1996, the government of the State of São Paulo, by means of the State Environmental Secretariat - SMA, implemented a more aggressive policy to fight atmospheric pollution caused by mobile sources, especially passenger vehicles. A range of strategies was adopted to raise awareness of the relation between private automobile use, air pollution and human health. Seeking to improve air quality in the RMSP, more energetic measures were applied to control vehicle emissions based on the relevant legislation, and also based on the precepts in Agenda 21, especially the Precautionary Principle and the Polluter Pays Principle. The set of policies that began with the "Respira São Paulo" ("Breath São Paulo") Campaign resulted in a legislative bill (of the State Policy of Vehicle Pollution Control and Sustainable Transport), sent to the Legislative Assembly in 1997.

Operation "Rodízio", implemented from 1995 to 1998, consisted of restricting the circulation of approximately 20% of the automobile fleet in São Paulo and in another 9 municipalities in the RMSP, in the winter months, when there is poorer dispersion of atmosphere pollutants. With the withdrawal of these vehicles and the resulting fluidity of traffic flow, it is estimated that total emissions of CO from the fleet had been reduced by 19% in 1998. Another important aspect of Operation "Rodízio" was that it raised awareness of the population about the relation between air quality and transportation, along with generating pressure on authorities to invest in the expansion and improvement of the quality of public transport.

2.5 The Role of Nuclear Energy in Reduction of Greenhouse Gas Emissions in Brazil

At the end of 2000, the installed generating capacity of the country was 74,903 MW[50], with 88.5% of this total provided by hydroelectric plants. With two units in operation (Angra 1 and 2, with capacity of 675 and 1,309 MW respectively), nuclear energy accounts for 1.5% of the total installed capacity of the country. Although modest from a national perspective, these nuclear plants are important to the local supply of the State of Rio de Janeiro, which is the second most important state of the country in terms of contribution to GDP.

For 2006, the Ten Year Plan calls for an installed capacity of around 98,000 MW, with 81% in hydroelectric plants, and 3.5% in nuclear plants (Angra 1, 2 and 3[51], totaling 3,275 MW).

Nuclear energy does not directly emit greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, etc.) or any gas that causes acid rain (sulfurous anhydride, nitrogen oxides). Furthermore, it does not emit any carcinogenic, teratogenetic or mutagenic metals (arsenic, mercury, lead, cadmium, etc.). The use of nuclear energy also does not emit gases or particles that cause urban smog or the destruction of the ozone layer.

Although the third largest source of electrical generation in the world, avoiding emissions of considerable amounts of carbon dioxide and pollutants, nuclear energy has been considered by the general population more as an environmental threat than as an unlimited source of energy, as was expected at the beginning of its technological development. The environmental impact of thermonuclear plants has also been strongly emphasized in recent decades, and is a leading concern of environmental movements. Aside from the remote, but not negligible, possibility of soil, air and water contamination by radionuclides, warming of water of the receiving body from effluent discharge represents a risk to the local environment.

Along with the constant precautions in terms of safety and the high costs of disposal of the nuclear wastes, some point to economic and financial restrictions in relation to thermonuclear plants. Nuclear reactors are not compatible with the trend towards liberalized energy markets, which favors generation technologies which allow plants with lower capacity and faster and lower-cost construction.

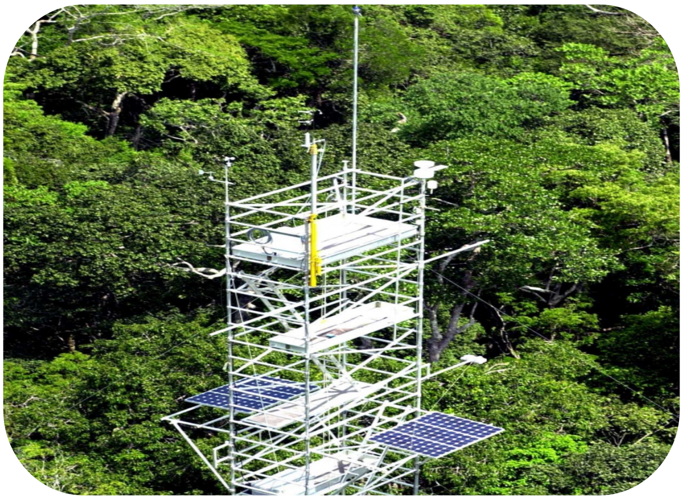
Proponents of nuclear energy argue that it is the only energy technology that treats, manages, contains and isolates its wastes to completely protect human health and the environment. Solutions for final disposal of low, medium and high-level radioactive wastes exist and are in use in various countries.

Furthermore, waste management and disposal technologies are advancing continuously, including transmutation and recycling of fuel. The implementation of these refined technologies could help to increase the public acceptance of nuclear energy. Along with this, because of the fact that nuclear energy is a highly concentrated form of energy, nuclear plants and fuel cycle facilities do not need large areas. Thus, the environmental impact of nuclear energy on land, forests and waters is minimal and does not require the displacement of large populations.

Thus, the fact is that since the start of operations in 1984 to the end of 2000, Angra 1 generated 33,000 GWh of electricity. In the period of 1984-2000, using the same assumptions as section 1.3.3 for replacement of nuclear generation, for Scenario I avoided CO_2 emissions would be in the order of 9.6 million tonnes of CO_2 and in Scenario II in the order of 24 million tonnes of CO_2. These avoided emissions would be substantially greater if the complete energy chain were taken into account, including mining/extraction to combustion, including transport.

[50] Includes 3,442 MW from self-generators.
[51] In its meeting on December 5, 2001, the National Energy Planning Council - CNPE approved the preparation of studies for the construction of Angra 3, for which part of the project is ready.

Research and Systematic Observation



3 RESEARCH AND SYSTEMATIC OBSERVATION

In accordance with article 4.1 (g) of the Convention, a variety of research projects and systematic observation related to the problem of climate change have been carried out in Brazil.

In this context, teams of Brazilian researchers are participating in an international effort in global research programs related to climate change, including the Global Climate Observing System - GCOS, the Global Ocean Observation System - GOOS, and the Pilot Research Moored Array in the Tropical Atlantic - Pirata.

Among the research initiatives led by Brazil are the Large Scale Biosphere-Atmosphere Experiment in Amazonia - LBA, which seeks to expand understanding of the climatological, ecological, biogeochemical and hydrological functions of the Amazonian region; the impact of land use changes on these functions; and the interactions between the Amazonia and the global biogeophysical system of the Earth.

The projects carried out under the Pilot Program for the Protection of Tropical Forests of Brazil - PPG7 and the development of regional climate change models are other examples of important research being carried out in Brazil. There is also research under way related to glaciology and climate change.

Finally, the chapter analyzes the “Brazilian Proposal” — the document submitted in May 1997 by Brazil titled “Proposed Elements of a Protocol to the United Nations Framework Convention on Climate Change, Presented by Brazil in Response to the Berlin Mandate”. This proposal is intended to produce a paradigm change by creating objective criteria for assessing the responsibility of each country for causing climate change, in terms of the relative and differentiated responsibility of each country in contributing historically, through anthropogenic greenhouse gas emissions, since the Industrial Revolution, to the increase in temperature of the earth's surface.

Brazil is thus undertaking and cooperating in scientific research and in systematic observations in order to clarify, reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitudes and trends over time of climate change.

3.1 World Climate Programs

Several international research initiatives are currently underway at the global level, primarily carried out under the auspices of the World Meteorological Organization - WMO and the Intergovernmental Panel on Climate Change - IPCC. Many Brazilian research institutions and researchers are participating in a global effort, through a range of international programs and projects, in order to better understand the current situation and future prospects of climate change on the planet, as presented in the following table:

Table 3.1.1 - Brazilian participation in global climate programs in 2000

International Program/ Project	Activities	Institutions/Person Responsible
	Monitoring and Collection of International Data	
Global Climate Observing System - GCOS	Ensure the acquisition of information for the monitoring and detection of climate change and responses to it; and apply this information in socio-economic development and research on better climatic understanding, modeling and prediction.	INMET (C. Athayde) INPE/CPTEC (C. Nobre)
Global Ocean Observing System - GOOS	Collect, analyze and disseminate data and information on oceans, coastal regions and enclosed and semi-enclosed seas, in order to allow reliable predictions of oceanic and atmospheric conditions, along with facilitating coastal zone management and supplying the research needs regarding changes of the global environment.	DHN - Marinha (J. Romaguera Trotte)
	Global Climate Research Program	
Global Energy and Water Cycle Experiment - GEWEX	Study atmospheric and thermodynamic processes that determine the global hydrological cycle, its equilibrium and adjustments to global changes.	INPE/CPTEC (J. Marengo) USP (P. Silva Dias e M. A. Dias)
Climatic Predictability and Variability - CLIVAR	Investigate the variability of the climatic system of the Earth and predict these variations, through monitoring of the variations of surface conditions (ocean temperature, humidity of soil and vegetation, snow and ice cover) which affect the climate.	INPE/CPTEC (J. Marengo e C. Nobre) USP (P. Silva Dias) UFPR (A. Grimm)
Stratospheric Processes and their Role in Climate - SPARC	Concentrating on the interactions of dynamic, radioactive and chemical processes, the goal is the construction of a stratospheric climatological reference and improved understanding of temperature, ozone and water vapor trends in the stratosphere.	INPE (V. Kirchoff)
Arctic Climate System Study - ACSYS	Understand variation in the Arctic Ocean and changes that include ocean-ice processes.	INPE (A. Setzer)

Continue

International Geosphere-Biosphere Program		
Global Change in Terrestrial Ecosystems - GCTE	Understand how global changes will affect terrestrial ecosystems.	INPA (N. Higuchi)
International Global Atmospheric Chemistry - IGAC	Understand how atmospheric chemistry is regulated and the role of biological processes in the production and consumption of atmospheric trace gases.	USP/Institute of Physics (P. Artaxo)
Past Global Changes - PAGES	Discover the significant climatic and environmental changes that occurred in the past and their causes.	INPE/CPTEC (J. Marengo)
Global Analysis, Interpretation and Modeling - GAIM	Develop comprehensive prognostic models of the global biogeochemical system and link these models with those of the climate system.	INPE/CPTEC (C. Nobre)
Training		
Global Change System for Analysis, Research and Training - START	Develop a system of regional networks for collaboration between scientists and institutions that carry out research on regional aspects of global change, evaluate its causes and impacts and provide information relevant to policymakers and politicians, mainly related to capacity-building in developing countries.	INPE/CPTEC (C. Nobre)
Assessments of Impacts and Adaptations to Climate Change - AIACC	Develop a regional training system for START projects involving the use of global and regional climate scenarios regarding assessment studies of vulnerability to climatic change.	INPE/CPTEC (J. Marengo)

3.2 "PIRATA" Program

The Pilot Research Moored Array in the Tropical Atlantic - Pirata is a project involving Brazilian, French and U.S. scientists, carried out through international cooperation. It is considered one of the five largest oceanographic programs in the world.

The project consists of implementing a pilot system that provides atmospheric and oceanic data in the tropical Atlantic Ocean, through launching and maintaining a dozen "Atlas" buoys between 1997 and 2000, anchored on the high sea in the middle of the Atlantic Ocean, near the Equatorial region, at a depth of up to 500 meters.

The buoys, together with the tide-gauges and meteorological stations on the Data Collection Platforms - DCPs, measure sea temperature and obtain data about meteorological conditions in the region. The data obtained are transmitted via satellite through the ARGOS and SCD services, and can be available in practically real time on the Internet.

The data obtained can assist scientists in understanding ocean-atmosphere interactions in the tropical Atlantic region, enabling the formulation of models for seasonal prediction of climate in this region and in the adjacent continental areas.

During the pilot phase of the Pirata program, from 1997 to 2000, it was intended to assess engineering, logistics and maintenance problems that could arise in the implementation of the observation system. It is expected that other countries can join in the maintenance and possible expansion of Pirata, to make it an Atlantic extension of the Global Climate Observing System - GCOS and of the Global Ocean Observing System - GOOS. In addition, the information obtained by Pirata will be a great contribution to the international research effort undertaken by the World Climate Research Program - WCRP, especially for the "post-Tropical Ocean Global Atmosphere - TOGA" activities (CLIVAR-GOALS), which carried out the monitoring of the Pacific Ocean, using the same procedures, between 1985 and 1994.

The construction of buoys, assembly of equipment and its maintenance are being financed by the National Oceanic and Atmospheric Administration - NOAA and the National Aeronautics and Space Administration - NASA, from the U.S. Brazil is responsible for the installation of seven buoys (deployed between 1998 and 1999), two tide-gauges, and meteorological stations located in the Atol das Rocas and in the São Pedro and São Paulo Archipelago, with an anticipated budget of US$ 2.5 million.

Brazil has a great interest in the extension of the Pirata program. This interest results from the fact that, from a meteorological and oceanographic point of view, there is a need from permanent monitoring of this region, including inter-hemispherical heat transport, which occurs beneath the surface of the ocean in that region. In addition, the data to be collected are indispensable in improving climate predictions, as well as for shorter term weather forecasts. Temperature anomalies end up determining extreme rainfall events in the Northeast of Brazil, which are only predictable if there is permanent monitoring of this variable.

3.3 Large Scale Biosphere-Atmosphere Experiment in Amazonia - LBA

The Large Scale Biosphere-Atmosphere Experiment in Amazonia - LBA (see http://lba.cptec.inpe.br/lba/index.html) is an international research initiative led by Brazil. The LBA was designed to generate new knowledge required for understanding climatological, ecological, biogeochemical and hydrological functions of the Amazonian region, the impact of land use changes on these functions and the interactions between the Amazonia and the global biogeophysical system of the Earth.

The LBA is centered on two main questions, which are addressed through multidisciplinary research, integrating studies in the physical, chemical, biological and human sciences:

How does the Amazonia currently function as a regional entity?

How will changes in land use and climate affect the biological, chemical and physical functioning of the Amazonia, including its sustainability and its influence on global climate?

The LBA emphasizes observation and analysis that will expand the knowledge base regarding the Amazonia in six areas: Climate Physics, Carbon Storage and Exchange, Biogeochemistry, Atmospheric Chemistry, Hydrology and Land Use, and Vegetation Cover. The program is designed to address the main issues raised in the Framework Convention on Climate Change - FCCC and will provide a knowledge base oriented to the sustainable use of land in the Amazonian region. To this end, data and analyses will be used to define the present state of the Amazonian system and its response to current perturbations, and will be complemented with model results to provide an understanding of possible changes in the future.

The LBA combines new analytic instruments and innovative and multidisciplinary experiments in a powerful synthesis that will generate new knowledge to address outstanding issues and controversies. It also provides a new understanding of the environmental controls over flows of energy, water, carbon, nutrients and trace gases between the atmosphere, hydrosphere and biosphere of the Amazonia, ensuring the scientific basis for formulating policies regarding the sustainable use of natural resources of the region. The expansion of research capacities and networks in Amazonian countries linked to the LBA stimulates training and research relevant to sustainable development.

3.4 Pilot Program for the Protection of Tropical Forests of Brazil - PPG7

At the 1990 G-7 summit (Germany, Canada, United States, France, Italy, Japan and the United Kingdom), held in Houston, Texas, the German Chancellor Helmut Kohl proposed the creation of a pilot program to prevent the increase of the rate of deforestation in the Brazilian tropical forests, which reflected the growing concern of the international community with deforestation in Brazil.

The program guidelines were outlined by representatives of the Brazilian government (Interministerial Committee), the World Bank and the European Commission, in response to the recommendations made at that meeting, which was approved by the G-7 and the European Community in December of 1991.

In 1992, the Executive Directors of the World Bank adopted Resolution no. 92-2, establishing the Rain Forest Trust Fund to finance the pilot program for the protection of tropical forests of the Brazilian Amazonia and Atlantic Forest.

After authorization from the Brazilian Senate in August of 1993, an agreement was signed on February 25, 1994 between Brazil and the World Bank to implement the pilot program. Brazil agreed to provide 10% of the total funds available for the program.

For the first phase of the program, US$ 291.1 million were approved by the G-7, by the Commission of the European Union, and by the Netherlands. Of this amount, US$ 58.2 million was allocated to the Fund, to be implemented in the period of 1995 to 2001, and US$ 232.9 was destined to bilateral assistance.

The World Bank is responsible for coordination of the program between the donors and the Brazilian government, along with administration of the Fund. The Bank started the work in 1992, on the same date the Fund was created. The first projects were approved in 1994 and implemented starting in 1995, with the Ministry of Environment - MMA serving as the Brazilian representative responsible for coordination of the program and the of the projects.

Progress on the program is the responsibility of the Brazilian Government, through the Environment Ministry - MMA, the Ministry of Justice - MJ and the Ministry of Science and Technology - MCT, and has the support of the World Bank, of the European Union - EU, and the donor country members of the G-7.

The Pilot Program for Protection of Brazilian Rainforests - PPG7 is a set of integrated activities seeking to strengthen and expand the environmental benefits from Brazilian tropical forests, in a manner compatible with the development of the country. The program has the following formal objectives:

- demonstrate the viability of harmonizing economic development and environmental protection in tropical forests;
- preserve biodiversity of tropical forests;
- reduce the contribution of tropical forests to global greenhouse gas emissions;
- provide an example of international cooperation between developed and developing countries in environmental issues of a global scale.

The PPG7 supports a broad set of integrated projects that contribute to the reduction of deforestation of tropical forests in the Amazonian region, and at the same time seek to protect biodiversity, reduce greenhouse gas emissions and use forest resources in a sustained manner. These projects are structured in four subprograms:

Natural Resource Policy Subprogram: seeks to ensure the sustainable use of natural resources and contribute to the definition and implementation of an appropriate model of integrated environmental management for the Legal Amazonia, including projects involving ecological-economic zoning, environmental monitoring and vigilance, environmental inspection and enforcement, and environmental education;

Demonstration Projects Subprogram: includes three types of demonstration projects:

- Type A Demonstration Projects - PD/A: seek to contribute to the conservation and preservation of the Amazonia, the Atlantic Forest and associated ecosystems, by supporting sustainable development through the participation and integration of local contributions;
- Environmental Education Project: with specific activities planned for the Amazonian region, possibly in the areas of influence of the Ecological Corridors Project. Its objective is to contribute to the conservation of nature, the sustainable use of natural resources and the dissemination of local knowledge;
- Indigenous Demonstration Projects - PD/I: destined exclusively to indigenous populations and lands. It is expected that by means of these projects it will be possible to finance initiatives on the part of indigenous groups that promote the sustainable management of natural resources and environmental protection on their lands, thereby contributing to maintaining the physical and cultural integrity of indigenous peoples.

Conservation Areas and Management of Natural Resources Subprogram: aimed at developing sustainable management models for Conservation Units and recovering areas that were subject to anthropogenic activities, and promoting the sustainable management of natural resources. This subprogram involves 6 projects (extractivist reserves, protection for indigenous lands and populations, support for forest management in the Amazonian region, ecological corridors, management of natural resources on floodplains, and monitoring and control of deforestation and fires).

Science and Technology Subprogram: seeks to promote production and dissemination of scientific and technological knowledge relevant to the conservation and sustainable development of the Amazonian region, through two components: directed research projects, and science center projects, completed in December of 1999. The proposal for a research network in the Amazonian region of Phase II of this subprogram is being development, and calls for, among other things, support to established and emerging scientific groups, as well as those being formed, as well as the establishment of efficient mechanisms for dissemination of results to the various sectors of society.

Other Projects: along with the projects cited above, linked directly to the subprograms, there are others (monitoring and analysis support project; marketing project; pilot program management, monitoring and policies project) that are directly responsible to the Executive Secretary of the Pilot Program.

3.5 Regional Climate Models: Long Term Simulations for South America Using the Eta Regional Model

The Eta model, used at National Center for Environmental Prediction - NCEP in the United States, was configured to run over the South American continent, with a resolution of 80 km. In Brazil it is used by INPE's Center for Weather Forecasts and Climate Studies (see section 6.3) - Eta/CPTEC. This limited area model has 38 atmospheric layers and its domain includes part of the adjacent Atlantic and Pacific Oceans. The model runs in weather prediction mode with a 6-hour forecast, and extending to 72 hours. It is currently run to make seasonal climate predictions, with horizontal resolutions of 80 and 40 km. A regional model with greater resolution could better resolve orography than General Circulation Models - GCMs. For South America, the model response to synoptic and subsynoptic systems is crucial, in particular for the south and southeast regions that are frequently swept by frontal and convective systems.

In this preliminary study, the regional Eta model was used to produce predictions of one month in South America under dry and rainy conditions (for some extreme rainfall events, in an experimental mode).

The Eta/CPTEC regional model proved capable of producing one-month climatic predictions for South America in a continuous run. The results were compared to predictions by the GCM in order to evaluate the positive contribution of regional runs. The regional predictions showed that the greater resolution could provide more details to the predictions, especially for the temperature fields near the surface. The magnitude of variables predicted was in general closer to the observations. It should be remembered that part of the quality of the regional predictions depend on the quality of the prediction of the global model. The Eta/CPTEC regional model presented good quality rain forecasts, with the best predictions obtained in the Center-South region of South America, as well as in the most northerly part of the Northeast and the north of the Amazonia.

The results of these preliminary tests are encouraging. The next steps for this work consist of preparing the model for seasonal predictions. The use of predicted ocean surface temperatures and improved treatment of water transport in the soil and atmosphere are being considered, as well as a representation of topography, vegetation and soil that more closely resembles reality. These data will presumably contribute to enabling longer term predictions of around three months with the Eta/CPTEC model over South America, thereby generating continuous and operational seasonal predictions similar to those carried out with a global climate model (see section 5.10).

In the initial phase of the project "Extended Range Simulations over South America" the Eta/CPTEC model was for the first time integrated in the "climatic mode", that is, run continuously for a greater period of time that that used to produce weather predictions (60 hours) over South America. The model was evaluated in terms of stability and quality of predictions produced for an integration of the longer period, proving capable of reproducing the climatic conditions with good spatial resolution. The next step is expected to be the completion of a climatic run of Eta/CPTEC, of at least 10 years, to represent the climatology of this model, and thus to study and determine the abilities of the model and the predictability of the climate in different regions of the country and of South America, similar to the evaluations made with CPTEC's global climate model.

Another study is being carried out at CPTEC titled "Modeling Emissions and Transport of CO_2 from Areas of Burning in Amazonia." During the dry season, fires in areas with high biomass concentrations in the central region of Brazil and in the Amazonia contribute significantly to an increase in CO_2 emissions to the atmosphere. To estimate the CO_2 balance during this season, numerical experiments with the gas transport model were conducted from August to September of 1995. This generated interest in including aerosols and smoke from burning of biomass in the radiation parameters within the Eta/CPTEC model, which will be of great importance in the modeling of climate changes resulting from increased greenhouse gases and aerosols.

3.6 Research in Glaciology under the Antarctic Program

Antarctic ice is extremely sensitive to environmental changes, and could react suddenly, in ways still not entirely understood, to climatic alterations caused by human actions. Therefore the international glaciology community is especially interested in understanding how this ice interacts with other parts of the planetary environmental system, its response to global environmental changes (mainly those resulting from human activities) and in monitoring these changes on the continent.

Scientific interest in the region is also warranted because the stratigraphy and chemistry of the polar snow and ice and of the high-altitude glaciers provide one of the best paleoclimatic techniques, allowing the reconstruction of atmospheric changes going back 440 thousand years. Recent research in Antarctica as well as in Greenland has revealed that glaciers function as a natural archive of the environmental history of the planet. Analysis of the evidence contained in ice cores extracted from great depths allows scientists to infer the environmental changes that have occurred over the historical period.

In view of the strategic importance of this region, in 1959 several countries signed the Antarctica Treaty, through which they committed to use Antarctica only for peaceful purposes, and also committed to international cooperation for the development of scientific research. Brazil became a party to this Treaty in 1975.

The Brazilian Antarctic Program - PROANTAR was created by decree no. 86,830, of January 12, 1982. The Program is developed and implemented by the Interministerial Commission for Ocean Resources - CIRM, in accordance with the international commitments assumed by Brazil under the Antarctic Treaty. The Ministry of Science and Technology - MCT, through the National Council for Scientific and Technological Development - CNPq, is responsible for the selection and tracking of scientific activities of PROANTAR.

PROANTAR involves interrelated scientific research and activities undertaken by Brazil on the Antarctic Continent. The selection of research projects for PROANTAR is based on their relevance to scientific questions involving the Antarctic environment and the scientific competence of the researcher. The scientific emphasis of PROANTAR takes into account the objectives and directives coming from the National Policy for Antarctic Issues - POLANTAR, and the scientific programs and initiatives proposed by the Scientific Committee for Antarctic Research - SCAR, an international body linked to the International Council for Science - ICSU.

Logistical support for the research projects of PROANTAR is provided by the Brazilian Navy, involving the operation of the Ary Rongel Oceanographic Support Ship, the maintenance of the Commandant Ferraz Antarctic Station, the installation and maintenance of the shelters and camps, and transportation of researchers. These latter activities are also supported by the Brazilian Air Force - FAB.

The Antarctic and Glaciology Research Laboratory - LAPAG, created in 1992, is located within the Department of Geography of the Institute of Geosciences of the Federal University of Rio Grande de Sul - UFRGS, and functions as an interdisciplinary center for Antarctic research.

The main objective of LAPAG is the introduction of glaciological science to Brazil, and is the first Brazilian group specializing in research about ice and snow. The work plan involves research activities in Antarctica and in the Andes, teaching, and advising in the Graduate Program of Geosciences and Geography. The research is carried out in cooperation with national and international institutions.

The research program of LAPAG, financed by the Brazilian Antarctic Program - PROANTAR, the National Council for Scientific and Technological Development - CNPq, and the Coordinating Foundation of Personnel Improvement for Higher Education - CAPES, focuses monitoring of the ice cover of the subpolar Antarctic islands by means of remote sensing techniques, with the objective of detecting changes in the volume of ice and establishing linkages with variations in climatic parameters; and chemical analysis of snow and ice samples to reconstruct the South American climate over the last 2000 years.

Every two years, LAPAG undertakes field expeditions in Antarctica. In the austral summer of 1997-98, this laboratory coordinated a glaciological expedition to the ice cap of the King George Island of the South Shetland Archipelago. After confirming the loss of 7% of the area covered by ice over the last 40 years, it was decided to implement a continuous monitoring program on the island to evaluate the impact of climate changes in the region.

3.7 Simplified Climate Change Model

The Brazilian document titled "Proposed Elements of a Protocol to the United Nations Framework Convention on Climate Change", submitted in May of 1997, presented two elements for discussion in relation to the Berlin Mandate process. The first element was to establish the individual responsibility of countries in terms of causes of 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. The quantification of the principle of common but differentiated responsibilities was one of the basic goals underlying the proposal.

The first problem faced in writing the proposal, in order to shift the approach from causes (emissions) to effects (global warming), was the establishment of objective criteria to measure climate change.

It thus became of paramount importance to establish the relation between net anthropogenic emissions and the resulting climate change. Recognizing that climate change must have 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 change in average temperature of the earth's surface. Other consequences of climate change that could be used as a variable, such as variations in the time rate of change in the average temperature of the earth's surface, and/or the increase in average sea level, can be obtained from the change in average temperature of the earth's surface.

This criteria is intimately linked to the physical reality of warming caused by the greenhouse effect, a property which is not applicable to absolute emissions, which are an instantaneous "snapshot" of a situation in an arbitrarily chosen year. In addition, the average temperature of the earth's surface can be used as an indicator of global warming, and the attribution of responsibility of each country can be made in terms of its relative contribution to the total temperature increase. The heart of the model corresponds to a process of double accumulation that is the essence of global warming. The accumulation of emissions increases concentrations and for each annual level of concentrations, the accumulation of energy deposited on the earth's surface increases the temperature (average over the globe's surface).

The change in temperature is also an objective measure of climate change, since it can be argued that the detrimental effects of climate change are in some direct proportion to this change.

It should be noted that remaining uncertainties in current knowledge of the absolute value of forecast temperature change do not affect the conclusions about the relative contribution of countries. This is reflected, for example, in the margin of uncertainty regarding climate sensibility (it is known that the change in temperature resulting from doubling the carbon dioxide concentration is between 1.5 and 4.5 degrees Celsius). Future improvements, to the extent that they progressively reduce the uncertainties, can be easily incorporated by updating the calibration constants of proportionality in order to improve the precision of the absolute results, without prejudice to the figures for relative contributions.

By reconstructing a 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 proportion of the total temperature increase that can be attributed to each individual country. Therefore, the estimate of relative responsibility of a given country for causing global warming can be provided, even given the current uncertainty of the absolute increase in temperature that can be attributed to the enhanced greenhouse effect alone.

Given that the Convention contains the fundamental principle of common but differentiated responsibility, the Brazilian proposal provides an objective criteria for differentiation of responsibilities, along with a means for quantifying the relative responsibility of developed countries in relation to developing countries as a result of their contribution to atmospheric concentrations of greenhouse gases at the time the Convention was negotiated[52].

Using this simplified approach, the relative responsibility of Annex I countries compared to the non-Annex I countries over the period until 2200 was assessed, taking into account the estimated concentration in 1990 attributed to both groups of countries. Published historical data about CO_2 emissions from the energy and cement sectors for each country in the period from 1950 to 1990 were used[53], together with a retroactive extrapolation to the period prior to 1950, to estimate the atmospheric concentrations in 1990.

The effect of the emissions of other greenhouse gases was not considered because of a lack of available data. However, this effect is known to be small if compared to that of carbon dioxide, according to the Second Assessment Report of the IPCC. In addition, the relatively short residence time of methane in the atmosphere tends to reduce the importance of the historical emissions of this gas. For these reasons, carbon dioxide emissions from the energy and cement sectors are likely a good proxy for the estimate of the increase in average global surface temperatures for the purposes of evaluating the relative responsibilities of Annex I and non-Annex I countries.

The conclusions demystify the relevance of the discussion about the year in which the emissions of Annex I and non-Annex I countries become equal, because in this hypothetical year the responsibility for causing global warming will still be largely attributable to the Annex I countries.

A process is being developed under the Subsidiary Body for Scientific and Technical Advice of the United Nations Framework Convention on Climate Change to consider the Brazilian proposal (see www.unfccc.int/issues/ccc.html). Various countries have also established groups of scientists to analyze the proposed new approach. However, much work still needs to be done in order to create a consensus about a measure for climate change that takes into account both equity and responsibility, and which will be accepted by all countries.

[52] The estimate of the contributions of each country to the initial concentrations in 1990 could take into consideration the differences in starting points of each Party, as mentioned in Article 4.2 (a) of the Climate Convention.
[53] These data were obtained from the Oak Ridge National Laboratory in the U.S. This is a wide-ranging and high-quality set of data. The current set of available data was improved after the submission of the Brazilian Proposal. See the Internet site http://cdiac.esd.ornl.gov/.

Education, Training end Public Awareness

4 EDUCATION, TRAINING AND PUBLIC AWARENESS

According to Article 4.1(i) of the Convention "all 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".

Since Brazil was the host country of the Earth Summit in 1992, Brazilians have a general notion about issues related to global warming and the hole in the ozone layer. But in general, people are not very aware of climate change or of the Climate Convention. This is a very complex e technical issue, difficult for non-experts to understand. Also, there is very little written material available in Portuguese. The initial attempts to mobilize institutions and experts were very difficult, because of the lack of knowledge about the Brazilian obligations in the Convention, related legislation and the costs and benefits involved for the participating institutions.

Despite these difficulties, there have been attempts to expand education, public awareness, and training regarding issues related to climate change.

Several educational programs implemented in Brazil are in accordance with the objectives of the Convention. Of special note are the National Environmental Education Program - PRONEA and the National Environmental Education Policy - PNEA, which aim at promoting a broad program of environmental education in Brazil. Also of great importance are the programs "PROCEL in Schools" and "CONPET in Schools", directed especially at children and teenagers through partnerships with teaching institutions. Their objectives are to expand the awareness of teachers and students about the importance of using electricity, oil products and natural gas in the best manner and to widely promote actions towards this end.

The Brazilian Climate Change Forum - FBMC, created in 2000 and chaired by the president of the Republic, seeks to promote the awareness and mobilization of society about global climate change.

The Brazilian Internet site on climate change of the Ministry of Science and Technology - MCT has contributed to the increase of public awareness about the issue, through making available information about the entire process of negotiation for the Convention, the main references for the climate science, and the preparation of the National Communication. Furthermore, some publications in Portuguese (such as the Portuguese version of the official text of the Convention and the Kyoto Protocol), articles from newspapers and magazines, and information about seminars and presentations have helped in generating awareness of an issue that until a short time ago was totally unheard of in Brazil.

4.1 Environmental Education

Article 225, paragraph 1, clause VI of the Brazilian Constitution states 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 (...) In order to ensure the effectiveness of this right, it is incumbent on the Government to (...) promote environmental education at all school levels and public awareness of the need to preserve the environment".

The development of the concept of environmental education raised the need to create a political instrument in Brazil for such activities. In 1994, the Ministries of Environment - MMA, Education - MEC, Culture - MINC and of Science and Technology - MCT produced the National Program of Environmental Education - PRONEA, thereby meeting a constitutional requirement, along with international commitments assumed by Brazil.

The activities of PRONEA are organized around two perspectives: the first, devoted to the deepening and systematization of Environmental Education for current and future generations, delivered through the school system; and the second oriented to good environmental management, seeking to create public awareness and the production of appropriate information throughout society. In accordance with this perspective, priority is given to reaching three publics:

- decision-makers in organizations and those with capacity to influence decisions that affect environmental issues;
- users of natural resources;
- those working in communication media and social communicators in general.

Although there is a felt need to reformulate this program, it continues in force, and should be brought into line with Law no. 9,795, from 1999, which created the National Environmental Education Policy.

Sanctioned by the president of the Republic on April 27, 1999, Law no. 9,795 "addresses environmental education, institutes the National Environmental Education Policy, and contains other provisions". The law recognizes environmental education as an important, essential and permanent component in the entire educational process, formal and non-formal, as recommended by Articles 205 and 225 of the Federal Constitution.

The National Environmental Education Policy - PNEA is a programmatic proposal for promoting environmental education in all sectors of society. In contrast with other laws, it does not establish rules or sanctions, but responsibilities and obligations.

In defining responsibilities and putting them on the agenda of the various sectors of society, the National Environmental Education Policy - PNEA institutionalizes environmental education, legalizes its principles, transforming it into an object of public policies, and provides society with an instrument for demanding the promotion of environmental education. Finally, the PNEA legalizes the requirement to address environmental issues in a transversal manner, as proposed by National Curriculum Parameters and Guidelines[54].

The Secretariat of Basic Education of MEC, through the Environmental Education Coordination Office - COEA, has the mission of formulating and proposing quality policies for basic education, supporting the state and municipal school systems, as well as promoting and expanding the possibilities for students to exercise their rights as citizens.

To achieve its mission, COEA, following the guidance of PNEA, defined two priority activity areas: environmental education projects in school life and integration of environmental issues in the basic education subjects.

[54] For one year the Environmental Education Technical Group of CONAMA, chaired by COEA/MEC, discussed proposals for regulating the law. On June 25, 2002, the Regulation of Law no. 9,795 by Decree no. 4,281 was signed by the president of the Republic.

Other initiatives

- National Curricula Parameters of the Ministry of Education: identifies the environmental dimension as a transversal theme and having and interdisciplinary approach. It emphasizes the need for creation of aware citizens, able to decide and act in the social and environmental reality with a commitment to life and the well-being of each person and of society, at the global and local level.

- Project of Capacity-Building, Support and Development of Educators in Environmental Education: under the responsibility of COEA and the National Environmental Education Program Directorate of MMA, this project is carried out under the Brazil-UNESCO Agreement, with the objective of supporting the consolidation and development of environmental education in Brazil, in formal and non-formal contexts.

- "Supporting Integrated Environmental Education Projects": carried out by the National Environmental Fund - FNMA, its objective is to support integrated projects that pursue community awareness and education, capacity-building and training in pursuit of environmental protection and conservation.

4.2 Educational Programs in Electricity Conservation and Rational Use of Oil and Natural Gas Products

4.2.1 PROCEL in Schools

Among the diverse activities developed by PROCEL (see section 1.2.2.2), one is especially directed at children and youth, by means of teaching institutions. This is called "PROCEL in Schools".

With the signing of a Technical Cooperation Agreement between the MME and the MEC in December of 1993, the guidelines were established for the activities of "PROCEL in Schools", including to:

- train teachers at the primary and secondary education levels to work with their students in all aspects of fighting waste of electricity, including the National Industrial Training Service - SENAI and National Commercial Training Service - SENAC;

- develop educational and teaching materials about energy, to be distributed free of charge to teaching staff and students;

- establish a way to involve students of technical high schools and higher education institutions in using technological resources in fighting energy waste and changing habits of energy use.

"PROCEL in Schools" is currently being expanded to cover the entire country. Initially the expansion activities were focused on public schools, because it was easier to sign technical cooperation agreements with the Secretariats of Education, at both the state and municipal levels. Private schools are also part of the target public of "PROCEL in Schools", since a technical cooperation agreement has already been signed between Eletrobrás/PROCEL and the Interstate Federation of Private Schools - FIEP. Already 24 states of the Federation and the Federal District participate in the Program.

Table 4.2.1 - Results of "PROCEL in Schools"

	Students Trained
1989-1994	800,000
1995-1997	791,375
Total	1,591,375
Total energy saved	**84 kWh/year/student***
1997	33.5 million kWh/year
1989-1997	133.67 million kWh/year

* Verified by monitoring the electricity bills of students' families for some months after conclusion of the course.

4.2.2 CONPET in Schools

"CONPET in Schools" is an education project created to provide teachers with information and knowledge about oil, its products and natural gas (vide section 1.2.2.3). The project also addresses ideas related to the rational use of these energy sources, along with expanding the universe of knowledge of students, raising awareness of the importance of issues related to society, nature and the preservation of natural resources and the environment, stimulating them to be a defender of the rational use of these resources and in particular oil products and natural gas. The program is broad and involves students from elementary and secondary schools in the public and private school systems.

The methodology, successfully used since 1992, consists of working with the teacher and not directly with students, which along with being more efficient, makes the process permanent. Thus, the professor is offered a upgrading program about oil, its products and natural gas, in order to generate awareness and engagement with the project, and to facilitate the development of the issue in the classroom. The course is offered to a specific group of teachers from each school, that participate voluntarily and are responsible for multiplying the knowledge received to the other teachers and for the interdisciplinary coordination of the issue.

Implementation of the project "CONPET in Schools" is decentralized, participative and open to all teaching institutions in the country, both public and private. The institutions interested in participating should sign an agreement for technical cooperation with CONPET. The results of the program up to 1998 are presented in the table 4.2.2 below:

Table 4.2.2 - Results of CONPET

State	Municipalities	Schools	Teachers	Students	Kits distributed
Bahia	164	724	1,927	504,800	724
Mato Grosso do Sul	10	110	178	68,100	110
Rio de Janeiro	47	381	982	243,857	381
São Paulo	7	24	63	12,000	24
TOTAL	**228**	**1,239**	**3,150**	**828,757**	**1,239**

4.3 Brazilian Climate Change Forum

Decree no. 3,515, of June 20, 2000, created the Brazilian Climate Change Forum - FBMC, which is chaired by the president of the Republic, with the objective of building awareness and mobilizing society around the issue global climate change.

Brazilian non-governmental organizations, the private sector and the academic community have expressed interest in expanding the discussion of the issue, in order to allow a greater integration of the various social actors, increase awareness of society about the challenges that the issue of climate change involves.

Thus, the objective of the FBMC is to be a public venue for debates about the issue. The FBMC seeks to build awareness and mobilize society for discussion about the problems resulting from changes to climate, as well as about the Clean Development Mechanism - CDM.

The Forum has the participation of the ministers of State; as well as figures and representatives from civil society, to be designated by the president of the Republic, with recognized knowledge, or who are agents with responsibility for climate change.

Since its creation, FBMC has organized various activities and disseminated information in various areas related to the issue of global climate change, as can be seen on the website www.forumclimabr.org.br.

4.4 Raising Awareness of Climate Change Issues in Brazil

4.4.1 Brazilian Climate Change Home Page on the Internet

The construction of a site on climate change on the World Wide Web, begun in September of 1995 in the very early days of the Internet in Brazil, was a pioneer and innovative idea that has contributed to the development of the Brazilian National Communication and to the increase in public awareness of the issue in Brazil. The site (www.mct.gov.br/clima) therefore constitutes an important tool for the implementation of the Brazilian commitments assumed under the Climate Convention.

Reflecting the entire process of preparation of the National Communication, the site brings together and makes available information generated by a wide range of institutions and experts involved in the preparation of the inventory and documents for the National Communication, including the name and contact information for each expert responsible for the preparation of each document.

The dissemination through the Internet of all this material increases the quality and reliability of the work, ensuring transparency and enabling the participation of experts not directly involved in the process, but who wish to make comments and criticisms.

Thus, the Climate Change Site on the Internet has strengthened the capacity of the coordination agency and helped to decentralize the preparation of the National Communication, enabling the total involvement of all the relevant institutions, independent of their location.

The site enables important texts to be made available throughout Brazil in Portuguese, with the full text of the Convention and the Kyoto Protocol, documents related to the negotiations under the Convention, especially decisions of the Conferences of the Parties, as well as documents, speeches and proposals that reflect the Brazilian position on the issue. Along with this, it points to information on other sites on the Internet related to climate change that is considered relevant, with levels of knowledge ranging from information for newcomers to the issue to detailed scientific data (such as the IPCC reports).

Along with being a place where information is disseminated, the home page is also a place where additional information can be obtained, because it provides information about the responsibilities of the General Coordination, indicates who is who in the office and tells how people can make requests and forward questions. The Internet has proven an effective means for putting the external public in direct contact with the General Coordination, which has responded to questions from students, journalists and professionals from other areas. Presented in three languages[55] — Portuguese, Spanish and English — the Brazilian climate change site goes beyond the Brazilian public, and has become a point of reference internationally, allowing Brazil to take part in the global debate around climate change.

By February 17th, 2000, there were around 3000 pages available in three languages, as shown in the following Table 4.4.1:

Table 4.4.1 - Number of Pages on the MCT Homepage in 2000

	Portuguese	English	Spanish	Total
Number of Pages	992	952	976	2,920
Size (KB)	4,862.5	4,800.9	4,702.8	14,366.2

In general, the use of the Internet has contributed to ensuring the quality of work and facilitating public awareness, and allowing a better dissemination of information and a greater knowledge of the Convention and its implementation in Brazil. This effort, however, has limitations, such as the availability of access to the Internet in Brazil, which is currently restricted to a part of the Brazilian society. However, the network is evolving rapidly (with an estimated 11.6 million Brazilian users in 2001, or around 8% of the population), which means the work begun in 1995 has only just begun to bear fruit.

4.4.2 Portuguese Version of the Official Documents of the United Nations Framework Convention on Climate Change and of the Intergovernmental Panel on Climate Change

As explained above, one of the greatest difficulties encountered in expanding awareness of issues related to climate change in Brazil is the scarcity of written material available in Portuguese. Obviously, overcoming this difficulty requires time and resources.

Thus, within the criteria for establishing priorities, the translation and publication in Portuguese of the official text of the Convention was a natural choice as the first step in disseminating the issue in Brazil. In 1996 the text was translated and published in Brazil by the Ministry of Science and Technology - MCT and the Ministry of Foreign Relations - MRE. With the support of the Permanent Secretariat of the Convention, the Portuguese version was published by the Information Unit on Climate Change - IUCC of the United Nations Environment Program - UNEP, with an initial print run of 3000 copies.

In the year 2000, with the creation of the Climate Change Program of the Federal Government, the text of the Kyoto Protocol was translated and published in Portuguese by MCT and MRE. With the support of the United Nations Development Program - UNDP, the text was published with an initial print run of 3,000 copies.

[55] In 2002, an agreement was signed with the Interministerial Climate Change Mission (*Mission Interministérielle de l´Effet de Serre*) of the French Government to finance the French language version of the homepage of the General Coordination on Global Changes, which is now being implemented.

Also translated and published were the report of the "Second IPCC Assessment: Climate Change 1995" and the report "Climate Change 1995 The Science of Climate Change", containing a summary for policy-makers and a technical summary of the report of the IPCC Working Group I.

The Portuguese version of these documents is available in electronic format on the site of the General Coordination on Global Climate Change (www.mct.gov.br/clima). This translated version is the key instrument in generating public awareness and understanding of the issue not only in Brazil, but also in other Portuguese-speaking countries (Portugal, Angola, Mozambique, Guinea-Bissau, Cabo Verde, São Tomé and Príncipe, and East Timor).

4.4.3 Research on Awareness about Climate Change

From March to July of 1998, the General Coordination on Global Climate Change of the MCT carried out a study to analyze and identify the particular circumstances and necessities of Brazil in terms of awareness of climate change.

The research examined the context where increased awareness of climate change should occur, what the target public should be, the most effective media or channels for reaching them, and the possible partners for a climate change awareness program.

The main issues raised and findings of the research were:

***Level of awareness about climate change**,* with an analysis of four questions:

It was revealed that there was an excellent level of awareness about climate change among the interviewees, being below only the level of awareness about climate variation/extreme events and HIV/AIDS. The high level of awareness about the Climate Change Convention was surprising, and was even higher that the level of awareness about the issue of global warming itself. The responses indicate a good level of general knowledge, despite the confusion between destruction of the ozone layer and issues related to climate change.

It was found that the four questions considered most important affecting quality of life in Brazil are the poor distribution of income, unemployment, increasing crime and violence, and illegal drug use. The research results confirm the idea that climate change is not seen as a priority issue by interviewers, in light of the greater priority given to social issues in the current situation of the country.

There is a clear political division of opinions: half of the interviewees were opposed and the other half was in favor of developing countries accepting greenhouse gas emissions reduction commitments. But both sides recognize that economic development can be achieved simultaneously with environmental protection.

For the question of who the target public should be in any awareness-raising program, it was shown that a higher priority was attributed to business leaders and government employees, followed by journalists and civic leaders. It should be noted also that school teachers had an average that was close to the groups given the highest priority. Students, whether at the university level of secondary school level, were considered as the lowest priority target public for an awareness program.

The most important issues related to climate change in Brazil are, in order of importance:

Energy Sector: all interviewees mentioned the energy sector as being one of the most important issues related to climate change, recognizing the consequences of our electricity matrix — basically hydroelectricity — for national water resources and the effects of mitigation measures on the development of the energy sector.

Forests: the importance of this question derives mainly from the Brazilian contribution to greenhouse gas emissions resulting from deforestation in the Amazonia, rather than from fossil fuel consumption. The issue of deforestation is not only of concern to many Brazilians, but also an important political issue because of external pressure through international forums.

Extreme climatic events: concerns were also raised about the effects of climate change on extreme climatic effects, especially floods and droughts. Concerns were expressed in the interviews about the effects of climate change on top of the Brazilian climatic conditions, which represent the greatest relative interannual variability in the world.

Biodiversity: it was identified as one of the most important issues, since one of the main characteristics of the country is its great diversity of natural resources. Therefore, mention was made of the need to adopt agricultural and forestry practices that do not generate negative climatic impacts and that preserve biomass and biological diversity in Brazil.

Water resources: this issue is intimately related to energy issues, since the Brazilian electricity matrix consists primarily of hydroelectricity. Along with this, there has been a growing awareness about the seriousness of the "global water crisis" and its effects of day-to-day life of all citizens. Another issue raised was the increased temperature caused by the *El Niño* phenomenon and its effects, such as increased flooding in the South of Brazil and droughts in the Northeast.

Desertification: more than 1 million km^2 of Brazilian territory is undergoing a process of desertification and another 100,000 km^2 is in serious condition. Another stated that desertification resulting from long summers and droughts could also increase in the Northeast region of Brazil.

4.4.4 Other Activities

4.4.4.1 Publications

With the objective of expanding the amount of material about climate change in Portuguese, between 1997 and 2000, the General Coordination on Global Climate Change, with the support of partners, carried out the following activities:

- publication of the results of the Workshop "Exchange of Latin American Experiences with Preparation of National Communications", held in Itaipu from September 30 to October 2, 1997;
- publication of the report "National Inventory of Methane Emissions from Waste Management", in partnership with the Government of the State of São Paulo, Environmental Secretariat, CETESB, UNDP, US Country Studies and MCT, 1998;
- publication of the Proceedings of the Workshop "Global Climate Change and Brazilian Agriculture", held in Campinas, São Paulo, 16 - 17 of June, 1999;
- publication of the book "Energy Efficiency: Integrating Uses and Reducing Waste", in partnership with the National Electrical Energy Agency - ANEEL, the

National Petroleum Agency - ANP and MCT, 1999;

- publication of the book "The State of Water in Brazil - 1999: Perspectives on Management of and Information about Water Resources", in partnership with the National Electrical Energy Agency - ANEEL, the Ministry of Mines and Energy - MME, the Ministry of Environment - MMA and the Ministry of Science and Technology - MCT, 1999;

- publication of 900 copies of the primer "The Greenhouse Effect and the Convention on Climate Change", in partnership with the National Development Bank - BNDES, 1999.

4.4.4.2 Seminars and Debates

Between 1997 and 2000, around 150 events were held in Brazil about climate change, along with two IPCC events (one on article 2 of the Convention, held in Fortaleza in 1994; and the other about "Good Practice in Inventory Preparation - Emissions from Waste", held in São Paulo, in 1999, with the support of the state government). These events were primarily held at the initiative of agencies linked to the Federal Government. However, the partnership between universities and research institutes, established in the quest to overcome the methodological difficulties found in the survey for the Brazilian inventory of emissions, has stimulated interest of these bodies in sponsoring events on the issue. Also, the process of developing rules for the Clean Development Mechanism has led to great interest on the part of business leaders and sectoral association, which have also held seminars, courses and debates on the issue.

4.4.4.3 Magazines and Newspapers

The Brazilian media has been gradually becoming more attentive to the issue of climate change, and the number of articles in newspapers and magazines on the issue has increased considerable. The national press has covered the issue more attentively since the negotiations for the Kyoto Protocol, especially as a result of the presentation by the Brazilian delegation of the Elements of a Protocol for the UNFCCC, better known as the "Brazilian Proposal", in response to the Berlin Mandate (see section 3.7). The process of developing rules for the CDM, which originated in the Brazilian Proposal, and the implications of this instrument in the Brazilian political and economic scenario, has led to increasing interest on the part of the media.

Table 4.4.2 - Number of articles in large circulation magazines and newspapers in Brazil mentioning the problem of the greenhouse effect

Year	1995	1996	1997	1998	1999	2000
No. of citations	11	20	300	240	306	473

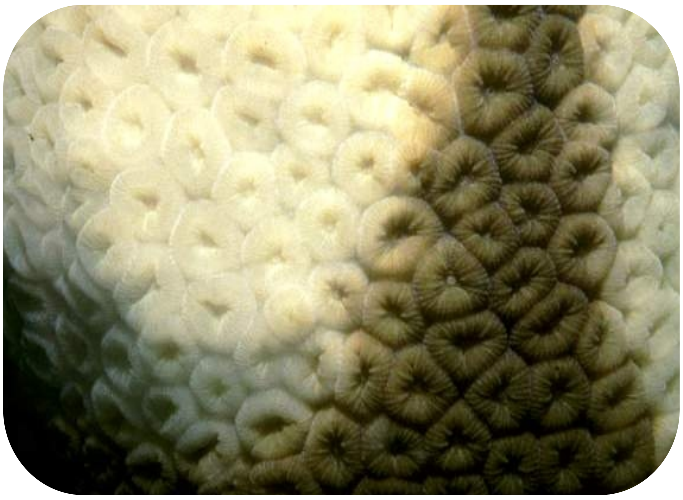
Journalists who specialize in environmental issues and the editorial space given to some Brazilian experts and scientists in the print media have helped considerably in the public awareness about climate change.

4.4.4.4 Radio, TV and Internet

Like the print media, other vehicles of communication have followed climate change related issues. Many radio stations and TV programs, both in broadcast channels and those available through subscription, have run programs covering this issue, including debates and interviews, mainly when international meetings were held, for example, Conferences of the Parties to the Climate Convention, or national events related to global changes. The CDM and its regulatory process is the leading issue related to this issue.

There is also extensive information about climate change on the Internet, with several sites specialized in this issue, run by other government agencies, environmental bodies, NGOs, and news agencies, in addition to the site of the MCT.

Effects of Global Climate Change on Marine and Terrestrial Ecosystems



5 EFFECTS OF GLOBAL CLIMATE CHANGE ON MARINE AND TERRESTRIAL ECOSYSTEMS

Because of the limited available resources, both human and financial, in the early stages of implementation of the Convention, the Brazilian government adopted the strategy of placing emphasis on the studies for the preparation of the Brazilian Inventory of Net Anthropogenic Emissions of Greenhouse Gases. The limited literature about vulnerability and adaptation to the effects of climate change in Brazil were analyzed in this document. In the year 2000, with the inclusion of the climate change issue in the Government's 2000-2003 Multi-Year Plan - PPA, studies were conducted about vulnerability to climate change, emphasizing health, agriculture and coral bleaching.

The present chapter aims at understanding the direct and indirect interactions between climate and society in Brazil. Some case studies of climate change impacts were identified and presented as examples of areas that require further research. Some studies have identified the adverse effects of drought in the Northeast, as well as in other regions of the country.

Drought, floods and frost have caused losses of millions of dollars, and have been responsible for a considerable number of deaths. The agricultural sector is of course the most directly affected by drought, but other sectors, such as hydroelectric energy generation, are also affected. Floods also represent a serious problem in various regions, including the metropolitan region of Rio de Janeiro. Frost is a source of great concern in the South and Southeast regions. Other effects can be perceived in coastal zones resulting from rising sea levels, as well as in the health area, especially related to the expansion of malaria and dengue.

Coastal vulnerability must be addressed by municipal, state and federal authorities, and it is important that a preventative approach be implemented in selecting sites for urban expansion and industrial development. An evaluation of possible mitigation measures will be important to avoid the high costs of protecting affected areas and improving coastal structures to deal with a given increase in sea level.

Transmission of various infectious diseases is particularly sensible to climatic changes, especially those transmitted by mosquitoes, such as malaria for example. In Brazil, the Amazonian region is one of the areas most vulnerable to these problems, because its natural environment is the most favorable to the increased spread of diseases in which reproduction of vectors and parasites benefit from the climatic conditions of high temperatures and humidity, as well as the great availability of water. Other health impacts could be secondary to the impacts of climate on social and ecological systems, including changes in food production, displacement of populations and economic problems.

Brazil is a vast country, with great regional differences, such as the Amazonia, the semi-arid Northeast, the Center West, the grasslands of the South, and the *Pantanal*. Each specific region could have characteristic future climates. Current knowledge of the regional dimensions of global climate change, however, is still very fragmented due to the lack of future climate scenarios in the country.

Therefore, there is a need to develop of long term climate change models with sufficient spatial resolution for regional analysis, which will enable the creation of scenarios of possible future climate change with different concentrations of carbon dioxide in the atmosphere, and analysis of the impacts of this change on Brazil.

5.1 Semi-Arid Region

5.1.1 Reduction of Negative Impacts of Extreme Events

The *El Niño* Southern Oscillation - ENSO is the dominant influence on interannual climatic variability on a planetary scale. It has a global impact, associated with the large scale dislocation of tropical circulation. Many tropical areas, including Brazil, are directly affected by the droughts and reduced rainfall linked to the warm phase of ENSO, and in an analogous manner in the cold phase. The consequences include social and environmental impacts.

In the northeast of Brazil, where many severe droughts are linked to the occurrence of ENSO, statistical and dynamic predictions are successfully used to reduce the negative impacts of these extreme events.

The government of the State of Ceará, for example, by means of actions in the agricultural and water resource sectors, has shown that it is possible to avoid a large population shift when conditions are provided for practicing reasonable subsistence agriculture, by stimulating agricultural production and selecting more drought resistant seed stock.

Clearly a well-considered strategy should be adopted for producing climatic information and making it available to users, thereby adding economic and social value to the decision-making process.

5.1.2 Salt Production

The Northeast region of Brazil is an ideal location for salt production, because of the long coastline, many hours of sun per year, rain restricted to a well-defined season, calm seas and constant winds, which combine to make it the largest salt-producing region of Brazil.

Climatic conditions have an important role in salt production. Salt production is by nature carried out in the dry periods, and provides a counter-cyclical opportunity for unskilled workers during the dry winters, and even in dry summers when the rains do not appear.

The salt industry is very sensitive to climate variations, especially in low-technology salt production operations. Two examples are the states of Rio Grande do Norte and Ceará. In Rio Grande do Norte, the production was based on capital and on a local entrepreneurial spirit, with low technology. In Ceará, on the other hand, the modernization of production was based on capital and an entrepreneurial spirit brought from outside Brazil, and there was thus a higher level of investment and technology, which created greater resilience in this industry to climatic variations.

5.2 Coastal Zone

5.2.1 Effects of Sea Level Rise

There is increasing evidence of coastline erosion in different areas of the Brazilian coast. However most of the geo-morphological studies have been limited to inherently unstable and dynamic areas, such as inlets and sand bars at the mouth of rivers, or areas affected by construction projects. These cases cannot be considered evidence of erosion due to sea level rise, because the lack of sediment supply, increased storm intensity, local tectonic movements and human interference can contribute to erosion.

The absence of measurements of sea level over a longer time horizon and of topographic and cartographic records makes it difficult to situate current changes of a coastline in a long term perspective. But at any rate, preliminary conclusions point to the need to begin a broad study of the potential impacts of an increase in sea level in Brazil.

Despite the limits of available information, Brazil has participated in the GOSS Program (see section 3.1) of the Intergovernmental Oceanographic Commission - IOC-UNESCO, coordinated locally by the Hydrography and Navigation Directorate - DHN of the Brazilian Navy and involving a range of governmental bodies, universities and private port companies. Ten marigraphs have been installed in Brazil, including three stations on oceanic islands, all linked to the national geodesic network. In addition, a network of ocean stations in ports that would support GOSS stations is being studied, and therefore more precise data about the relative sea level may be available to Brazil in the future.

5.2.1.1 Potential Consequences of Sea Level Rise

North Region

Problems of salinization have not been identified to date, but the large-scale destruction of coastal mangrove swamps has been reported in the North of Brazil, and sea cliffs in an active process of erosion have been observed.

For the entire region, rising sea levels would increase significantly the penetration of tides into the rivers. Flooding along river valleys would be laterally confined by the adjacent higher areas. Depending on the amount of sediment, low alluvial areas, such as in Marajó Island at the mouth of the Amazonas river, could be flooded. However, significant economic consequences are not expected, since population densities are generally low and periodic flooding of rivers occurs now.

Northeast Region

In many areas, rocky cliffs will restrict the limit the territorial extent of any effect of a large rise in sea level. Mangrove swamps, located in low areas of coastal plains, in estuaries, around coastal lagoons, and in agricultural areas in temporarily flooded river valleys, will be affected. More serious problems will appear in coastal cities such as Recife, Aracaju and Maceió, where urbanization has expanded to low areas and flooding already occurs, especially when strong rains coincide with spring tides. Drainage problems and flooding will affect the low areas of coastal plains around São Marcos Bay (State of Maranhão) and of Todos os Santos Bay (State of Bahia).

The flow of rivers in the region is usually very small, except during the rainy season. Most estuaries are subject only tidal currents. With a rise in sea level, flooding of the river valleys would extend the reach of the tides which would increase the capacity of these canals formed by tides to trap sediments, thus influencing the balance of sediments along the coast.

Groundwater is a common source of water for many coastal communities. The increase in population and in sea level has significant implications for this resource, possibly involving saline intrusion. Furthermore, excessive removal of groundwater can cause soil subsidence.

Southeast Region

The range of geographic formations of the coastal zone in this region (coastal mountains, small beaches, rocky shorelines, lagoons, bays, estuaries) will be affected differently by a rise in sea level. Some sites already display signs of erosion, despite having very little human interference. In other sites, intensive extraction of sand from the dunes, beaches and tidal channels has contributed to a deficit in the sediment balance, making these areas more vulnerable to rising sea levels.

South Region

Erosion and accumulation processes were verified on the coast of the State of Paraná. In the State of Santa Catarina, exposure of peat at the base of coastal cliffs, in contact with the berm of the beach, indicates a long term trend of retreat. Erosion of the shores of Lagoa dos Patos (State of Rio Grande do Sul) is interpreted as an indication of relative sea level rise.

Saline intrusion in coastal lagoons would have local impacts on fishing; in the case of Lagoa dos Patos, where water from the lagoon is used for irrigation, the problem would cause greater concerns.

Other implications

The general implications of increased sea level in mangrove swamps, ports and terminals, as well as on human occupation on the Brazilian coast, have been described above (see Part I, section 4.2).

It is crucial that detailed studies be carried out of the possible effects and responses to realistic scenarios of sea level rise along the coast of Brazil. These studies should include evaluations of the effects caused by this event, descriptions of economic activities that will likely be affected, and a careful monitoring of physical changes.

5.3 Coral Bleaching

Although coral bleaching has been observed in Brazil for some time, systemic studies about its causes were not published until an extensive bleaching phenomenon was reported, in 1993-1994, for the coral species *Mussismilia hispida* and *Madracis decactis* on the coast of the State of São Paulo, related to an abnormal increase in ocean water temperatures.

In Abrolhos (in the State of Bahia), two bleaching events connect the phenomenon to an increase in the temperature of surface waters: the first during a temperature anomaly in the summer of 1994, when 51 to 88% of the communities of the genus *Mussismilia* were affected, and the second related to the strong *El Niño* event that began at the end of 1997 in the Pacific ocean and also caused an increase in water temperature along the coast. During this event another hot spot was reported on the north coast of the State of Bahia, and in both locations the water temperature was around 1°C above the annual average for these locations. On the north coast of Bahia three species of coral, *Agaricia agaricites*, *Mussismilia hispida* and *Siderastrea stellata*, had between 20 and 80% of their communities affected. This bleaching process lasted for around six months, but after one year all the communities had recovered. During the Abrolhos event it was observed that 10 to 90% of the communities of around 9 coral species were partially or totally bleached.

Not only in Brazil, but in various parts of the world, the phenomenon of coral bleaching appears to coincide with warming of the oceans during *El Niño* events, demonstrating the small variations in surface water temperatures can cause changes in climatic patterns which directly affect tropical ecosystems, especially coral reefs.

The incidence and severity of coral bleaching will cause substantial changes in the structure of communities of the reef ecosystem, which need to be scientifically understood in order to minimize the deterioration of the state of the oceans and its implications for life on our planet.

As a result of this concern, under the Climate Change Program (see section 7.3) of the Government 2000-2003 Multi-year Plan, an agreement was signed between MCT, the Federal University of Bahia (through its Geophysics and Geology Research Center) and the Foundation for Research and Extension Support - FAPEX for conducting a study of global climate change and coral bleaching in Brazil.

Thus, a project is already under way to scientifically evaluate the effects of increased ocean water temperature — related to global climate change — on photosymbiotic organisms of coral, whose loss causes bleaching, as well as the capacity of these corals to tolerate and/or acclimatize to these sudden environmental changes.

The knowledge generated in this project will produce data that will enable a better understanding of processes responsible for the changes observed in the reef biota of Brazil, especially in coastal reef areas, which are more shallow and thus more susceptible to variations in temperature of surface water. Through this work, we intend to improve the methodology for studying coral bleaching, to support projects involving management of reefs with coral bleaching and/or with severe damage.

5.4 Floods

5.4.1 The city of Rio de Janeiro

The problem of flooding in Rio de Janeiro goes back centuries, and results from improper land use in the region, and especially from the lack of adequate environmental management. A sustainable long term strategy is necessary to significantly reduce the effects on the population of Rio de Janeiro resulting from climate change events.

Unplanned expansion of human settlements and the lack of investments in basic infrastructure, such as drainage systems, waste disposal and sewage facilities, as well as roads and constructions, are responsible for the impacts of extreme weather events. Of the original vegetation cover (Atlantic Forest), little remains today. In its original state, the dense vegetation functioned as an excellent defense against erosion and landslides.

Rio de Janeiro has a high population density and its urbanization level is one of the highest in Brazil. Only a very small part of the population (less than 5%) lives in rural areas. Most of the municipalities in the metropolitan region are completely urbanized. The rural exodus, which began in the early 20th century, resulted in a large number of poor, who because of the high cost of land and the lack of public transport, had little choice but to settle on vacant lands, in areas subject to flooding, or seek land in distant districts. The settlements on the mountainsides and on the shores of the rivers and canals are characteristic of development in the Metropolitan Region of Rio de Janeiro in recent decades. Among the unregulated forms of land use, the expansion of *favelas* is one of the most insidious. The result is the deterioration of the environment and the creation of great difficulties for governments to provide basic urban services.

5.4.2 Flooding in the *Pantanal*

In contrast with other areas, where flooding results mainly from improper land use practices, in the *Pantanal* the floods are a natural part of environmental processes, and play an important role in the ecological balance of the region.

Human actions that result in loss of natural cover, such as uncontrolled burning in the high lands of the Paraguay River watershed, cause accelerated soil erosion, depleting the soils and reducing water retention, increasing velocity of water flow in the tributaries and the flow of sediments capable of damaging the ecological balance of the region.

Alterations in the highest land of the Paraguay River watershed can have significant consequences for the *Pantanal*. According to IBAMA, the destruction of a large area of original vegetation cover can cause disturbances to physical processes (water and heat balances, climate, soil structure, winds), and also to the biosphere (destruction of various life forms).

Thus floods in the *Pantanal* are part of the daily life of the region, where ecosystems alternate constantly between terrestrial and aquatic. There are three main types of floods in the *Pantanal*:

- ordinary: minor, reaching 3-4 meters;
- intermediate or extraordinary: regular, frequent, reaching 4 to 5.5 meters; if there are areas for its discharge, they create natural reservoirs, are beneficial and do not cause economic or social problems; and
- exceptional: these floods reach 5.5 to 6 meters and are rare, with serious social and economic consequences: they submerge pasture, reduce the area of dry land and cause serious problems because of delays in drainage of water and the mechanisms of evapotranspiration.

In general, flooding in the *Pantanal* is of the intermediate type. They are responsible for the deposition in flooded areas of fertile alluvial material, which after various uses is carried to the Paraguay River. The floods are also an important factor in the renewal of plant cover, mainly in clear grasslands, depressions, inlets, savannas and edge of forests, and are responsible for the renewal of flora and fauna typical of the *Pantanal*.

While the ecosystem is rejuvenated by the floods, the economy suffers from the reduction in cattle raising, the main activity of the region, because of reduction in pasture area. Cattle collect around the flooded areas and frequently enter the flooded areas in search of forage. Thus, the highest land is converted to pasture, while other land remains flooded because of the slow drainage. As a result, there is an imbalance between the cattle herd, pasture and available dry land.

Exceptional floods (above 6 meters) always cause unpredictable economic losses, because they are generally accompanied by cold fronts that later increase the number of deaths in the herd, along with the many losses caused by damage to ranch infrastructure.

When the floods occur, much of the workforce is dispersed because there is little work to be done and the cattle owners generally face financial difficulties. Also, the population living close to the riverbanks which lives on subsistence fishing and farming is displaced by the high waters and seeks shelter in nearby cities.

5.5 Frost

5.5.1 Coffee Plantations

Coffee is a small tree which grows continually and requires a limited variation in temperature, with an average of 16ºC to 23ºC. The effect of temperatures outside this range depends on the degree and duration of the deviation, as well as other factors such as soil humidity, wind and rain.

High temperatures reduce plant growth and cause premature development and maturing of the fruit, with a resulting loss in quality. If a heat wave occurs during the flowering period of the trees, there will be a drop in yield. Under intense and direct light, photosynthesis begins to stop above 24°C and reaches zero at 34°C.

Cold weather can also considerably reduce growth of the coffee tree. Below 12°C, growth is completely inhibited, but the greatest losses occur below 3°C, the point at which the leaf tissue freezes internally. The mere presence of ice on a coffee tree does not necessarily cause serious damage, but it is the internal freezing of tissue that must be avoided at any cost, when frost affects the plantations.

The extent of the damage caused by the cold will depend only on intensity temperatures below 2°C close to the soil will block growth of stems of young trees, which normally leads to the death of affected tissue.

Thus, coffee production is affected by frost and the extent of the damage depends on the severity of the event.

5.5.2 Orange Plantations

Citric fruits originated in sub-tropical areas and are sensitive to temperature extremes, which affect the rate of growth of the plant, as well as development of the fruit. Some authors place the optimum temperatures for the development of oranges at between 22 and 23°C. Thus, as in coffee production, 12°C is the limit temperature below which the plant begins a zero growth period. At the other extreme, above 36°C plant activity begins to reduce, reaching the minimum at 42°C.

Generally, high temperatures burn leaves and fruit. The effect on leaves is caused by the destruction of chlorophyll, blocking photosynthesis and thus the metabolism and nutrition of the plant. A visible effect in equatorial regions is the discoloring of the skin of the fruit. Since there is no cold season, the fruit maintains it green color after maturing, which causes problems for the sale of fruit.

For citric fruits destined for production of juice concentrates, the main result of high temperatures is formation of sugar and alterations in the sugar/acidity ratio. In the absence of a cold season, maturing occurs at high temperatures, which favors the formation of sugar at the expense of acidity. With irrigation, citric fruits can be grown in arid or even desert regions.

Low temperatures also damage the leaves, fruits and foliage. The extent of the damage depends not only on the intensity of the winter, but also on its duration. Below 4°C, leaves and stems begin to suffer; a frost of 2°C lasting two days can cause serious consequences. Between 0.8 and 2.8°C, the fruit begins to show signs of damage. Ice causes the coagulation and impermeability of cell walls, followed by death of the cell.

Since most of the juice is exported, global market prices are another important determining factor. It is difficult to precisely identify the effects of frosts, but when they significantly reduce supply, they result in higher prices. This has never occurred in Brazil with orange production.

5.6 Health

Extreme climatic events (storms, floods, droughts.) have significant collective health impacts, through causing a rise in infectious diseases or by claiming victims through accidents.

Future scenarios related to global climate change suggest a greater instability of phenomena linked to climate variability, making prediction more difficult, and reducing the ability to protect populations.

Brazil, because of its geographic location and size, is subject to significant climatic variations, which lead to environmental changes, which favor the emergence of endemic infectious diseases that are sensitive to climate, such as malaria, dengue, cholera, leishmaniosis (tegumentary leishmaniosis and visceral leishmaniosis), leptospirosis, hantavirus. The mechanisms of action of climate variables may be direct, such as the creation of environmental humidity favorable to the development and dispersion of infectious agents and vectors, or indirect, such as human migration processes caused by drought and floods, stimulating the spatial redistribution of endemics and an increase in social vulnerability of communities. Infectious endemic diseases are responsible for the high morbidity and mortality that affect the vulnerability of populations.

Under the Climate Change Program (see section 7.3), in the Government's Multi-year Plan, coordinated by the Ministry of Science and Technology - MCT, there are provisions for studies of vulnerability and adaptation to the impacts of climate changes.

An agreement has been signed between MCT, Oswaldo Cruz Foundation - FIOCRUZ through the Program of Global Environmental Changes in Health - PMAGS, and the Brazilian Graduate Association for Collective Health - ABRASCO to analyze the vulnerability of the Brazilian population to climate change impacts.

The agreement has the general objective of conducting a retrospective study of socio-environmental vulnerability of the population when subject to extreme climatic events and to endemic diseases sensitive to climatic oscillations. An objective of the agreement is to develop a Geographic Information System - GIS, which will enable preventing critical situations that increase the risk of morbidity and mortality from diseases selected for the study.

The research being undertaken covers all of Brazil, although the large territory and the heterogeneous distribution of diseases require a study which takes into account the realities and peculiarities of each region of the country. Thus, five endemic infectious diseases were selected — malaria, dengue, cholera, leptospirosis, and leishmaniosis — being those which are considered to be most influenced by climatic events. Such diseases are also analyzed in the context of each region with a higher level of endemicity, and incidents resulting from extreme climatic events (droughts, floods, storms, and others) are being analyzed in each region where there is a historic record of their occurrence.

5.7 Electrical Sector

Quantitative predictions of hydrological effects of climatic alterations are essential to understand and resolve the potential water resource problems related to supply for domestic and industrial use, electricity generation, agriculture, transport and leisure, as well as for planning and management of water resource systems and environmental protection.

Climate change will affect the planning, construction and operations of projects involving water resources. Because of the long lifetime, these projects will be subject to climatic conditions for which they were not planned. The vulnerability of a system increases to the extent that its capacity for adaptation decreases, and when the system is not flexible. The vulnerability of socioeconomic and natural systems depends on economic circumstances and institutional infrastructure. Thus, systems are typically more vulnerable in developing countries, where economic and institutional conditions are less favorable.

In the area of energy, Brazil is highly vulnerable to climatic changes, given the importance of hydroelectricity in the country's energy matrix. Even considering the prospects for expanding Brazilian thermoelectric capacity, the country's electrical generation system will continue to be strongly dependent on water availability for the production of base-load energy, and therefore for ensuring the demand is met.

Implementing research and monitoring, through cooperation between Brazilian and international institutions, is essential to improve the climatic projections on a regional scale, and take into account the response of natural and socioeconomic systems to climatic variations and improve the knowledge of the effectiveness, costs and benefits of strategies for adapting to these changes.

In December of 1998, ANEEL, MCT and UNDP signed a Protocol of Intentions establishing technical cooperation for activities related to climate change research involving the Brazilian electrical sector, to enable activities involving the greenhouse gas emissions inventory, climatic vulnerability of the Brazilian electrical sector, mitigation measures for reducing the risks of global climate change, and public awareness of climate change.

The work involving the greenhouse gas emissions inventory seeks to improve the methodologies for measuring emissions from hydroelectric reservoirs and thermoelectric plants, and to establish a system for ongoing measurements from electrical concession-holders. This knowledge represents an important element in outlining new scenarios for the electrical sector in the face of global climatic changes and the prospects for expansion of thermal generation.

5.8 Agriculture

The agro-industrial sector represents around 7.5% of Brazil's GDP (IBGE, 2000) and employs around 18 million people (IBGE, 1996), which demonstrates the great importance of the primary sector in the absorption of rural labor. Therefore, given the social and economic relevance of agriculture, special attention is justified for studies about the effects of climate change on the agricultural sector. Although, there have been few studies in this area in Brazil, three can be cited here.

Using a General Circulation Model - GCM, one such study (SIQUEIRA *et al*, 1994), presented projections about the potential effects of climate change on Brazilian agriculture, focusing on 13 different sites in Brazil, and on wheat, corn, and soybean crops. The sites were selected based on agro-climate studies, representing the main Brazilian agricultural climate regions: subtropical, high tropical, tropical regions, semiarid and equatorial/subequatorial.

A sensitivity analysis was conducted on each site to assess the effect of gradual changes in temperature (0, +2°C and +4°C), rainfall (0, +20%, -20%) and in atmospheric concentrations level of CO_2 (550ppm) on the production and physiology of agricultural crops.

The simulators used in this study were Goddard Institute for Space Studies - GISS, Geophysical Fluid Dynamic Laboratory - GFDL; United Kingdom Meteorological Office - UKMO, and the simulators of crop growth, developed by IBSNAT: CERES-Wheat version 2.10 for wheat; CERES-Mayze for corn; and Soybean crop growth simulation model - SOYGRO for soybean.

The three GCMs used projected increased temperatures, precipitation changes and small variations in solar radiation. Sensitivity analyses were carried out later to assess the effect of climatic alterations on the crops analyzed.

Based on the results, this study estimated the effects of climatic alterations on national production of these crops, aggregating the results obtained in the regions and weighting them for the cultivated areas in each region. The impact on wheat production would be large (reductions of 33%, 18% and 34% for scenarios from the GISS, GFDL and UKMO models, respectively). Corn production in Brazil would also drop (11%, 11% and 16% GISS, GFDL and UKMO scenarios, respectively). However, Brazilian productivity estimates for soybean rose by 26%, 23%, and 18% for the GISS, GFDL, and UKMO scenarios, respectively.

Different impacts on the regions were projected in these scenarios, with the Northeast region being especially vulnerable to decreased corn production and the Central and Center South region being vulnerable to reductions in wheat production. The South region would be vulnerable to reductions of wheat and corn and the North region would be vulnerable to reductions of corn.

This same study also projected alternative scenarios, by means of the general circulation models, in order to analyze adaptation strategies based on technologies such as the use of irrigation and new cultivars, changes in planting dates, and nitrogen fertilizers. These techniques would help to mitigate the effects of climate change on the productivity of the crops affected but would not be sufficient to compensate for all the losses projected by the scenarios generated.

The projection made for a more heat-resistant cultivar presented promising results in terms of the potential for adaptation to global warming, but the prospects for practical implementation of this new cultivar still need to be tested and evaluated through genetic improvement programs. For soybean in the Northeast, increased production is foreseen with the use of irrigation and nitrogen fertilizers, to compensate for any impact of climate change.

The main limitations of the study lie in the fact that the simulators used were not validated for all regions analyzed, and that the technology and land use were treated as constants, even knowing that they will probably be modified in the future. Thus, new studies are needed to assess the real implications of the direct physiological effects of CO_2 on crop development and productivity.

Taking a different approach, other studies carried out (ALVES *et al*, 1996) estimated the impact of global climate change on Brazilian agriculture using a Ricardian model. The model evaluates the influence of variables such as production, labor, fertilizers, constructions, roads, scientific research, adoption of technology, rural extension, and variables such as climate (temperature, rainfall, solar radiation) and soil conditions (type of soil, slope, texture) on land productivity, and thus on land prices. From this it would be possible to estimate the impacts of adaptation of producers to climatic alterations on production and soil productivity. According to the authors, the net impact of climate change would be negative for Brazilian agriculture, especially for the Center West region, where the cerrado is dominant, while the South region will benefit moderately from warming.

The study carried out in 1996 (MENDELSOHN, 1996), using various climatic scenarios and projections based on a GCM, estimated that the impact of climate change on the Brazilian economy would be significant, with extensive damage to the agriculture, forestry and energy sectors. The study concluded that because the Brazilian climate is already hot and the sectors sensitive to climate alterations are predominant in the country, the Brazilian economy would be one of the most affected in the world[56].

5.9 Disaster Preparedness

The continuous monitoring of weather conditions by radar, satellites, telemetric stations and lightning detectors is essential to be able to issue alerts, involving various meteorological phenomena such as heavy rainfall, high winds and lightning. This information is valuable both to the general population and to decision-makers, and has implications for the sectors of public safety, water resources, agriculture, environment, electrical sector, oil exploration, transport, industry and commerce, civil construction, tourism, leisure and sports, health and the safety sector.

The Meteorology System of the State of Rio de Janeiro - SIMERJ, established on January 29, 1997, seeks to adopt a structure capable of offering support to authorities, society, and the private sector in decision-making, in order to minimize the harmful effects of weather and climate and to take advantage of their beneficial effects. This system provides a range of services that had not been available through existing meteorological services available in the state until then.

With implementation of the system, the State of Rio de Janeiro will be able to take preventative civil defense actions, such as issuing alerts regarding floods (see section 5.4.1), heavy rainfall, high winds, hail, lightening strikes, floods and landslides, especially in high-risk areas of metropolitan and mountainous regions.

Similar programs are being developed in the States of Paraná (Paraná Meteorological System - Simepar), Minas Gerais (Minas Gerais Meteorology and Water Resources System - Simge) and Goiás (Goiás Meteorological and Water Resources System - Simego), in which climatic monitoring supports planning of actions to minimize impacts of adverse climatic conditions (prolonged drought, extreme temperatures, and others).

5.10 Regional Modeling of Global Climate Change

In many regions of Brazil, there is still no clear signal that climate change is already occurring, especially in relation to average air temperature and precipitation patterns. However, some changes have been observed in the regional atmospheric circulation of the Atlantic sector that suggest systematic changes in precipitation in the Amazonian region and the Northeast and Southeast regions of Brazil. For example, (a) the subtropical Atlantic anticyclone has intensified, which caused increased precipitation in the North of Argentina and possibly in the South of Brazil during the last 30 years; (b) moisture transport from the tropical North Atlantic to the Amazonian basin and Brazilian Northeast regions has intensified since 1950 and led to a systematic increase (although statistically insignificant) in precipitation (IPCC, 2001). Changes such as these, mentioned as interdecadal climatic variations (generally from natural sources), have also been detected in data from rivers and in precipitation in other regions of Brazil. It is still not know of these negative long term trends are natural manifestations of climate variability or are caused by human activities.

[56] The IPCC Third Assessment Report (2001) showed some advances in relation to the climate scenarios generated by global and regional models. The IPCC predictions for Brazil showed, in general, an increase in temperature by 2080 of from 1°C (low emissions scenario) to more than 6°C for the North of Brazil. In terms of precipitation, the level of uncertainty is still higher, because the various simulations present divergent data regarding precipitation.

The projections of climate change scenarios for the 21st century were derived from various global climate models used by the IPCC and were discussed by scientists in regards to Brazil (Hulme and Sheard, 1999; Marengo, 2002). The fact that global climate models use different physical representations of processes, with a relatively low resolution grid, introduces a certain degree of uncertainty in these future climate change scenarios. This uncertainty is extremely significant in the evaluation of vulnerabilities and impacts of climate change, as well as in the implementation of adaptation and mitigation measures. For example, for the Amazonian basin, some models produced climates with higher rainfall and others relatively drier climates. For the Northeast of Brazil, the great majority of models suggest increased precipitation.

In fact, most of the uncertainties in the model projections for the climate change scenarios can be connected with the problem of spatial scale and the representation of extreme climatic events on higher spatial scales than those produced by most of the global climate models. The problem of spatial scale is also crucial, since extreme events (waves of low moisture, heat and cold waves, storms) can be identified only with daily data, and not with the monthly or seasonal data produced by most of the IPCC global models.

Of course there is also the problem of representation of the physical process by parameterization of the different models and the correct representation of the current climate by the climate models. Thus, there is a need for downscaling methods that can be applied to the climate change scenarios based on the global climate models, in order to give more detailed projections of climate, by state, valleys or regions, with a higher spatial resolution than that provided by a global climate model. This would be of great use for studies of climate change impacts on the management and operation of water resources, on natural ecosystems, on agricultural activities and even in health and transmission of diseases.

Thus, it is of fundamental importance to develop climate modeling capacity in Brazil, through analyses of global and regional climate models and for current and future climate change scenarios.

The Center for Weather Forecasts and Climate Studies - CPTEC, within the National Institute for Space Research - INPE has developed climate modeling capacity at the global and regional levels, which is currently used to forecast weather and seasonal climates. CPTEC has also developed a regional climate model (Eta/CPTEC) which could be easily applied to South America to generate detailed climatic predictions, including for climate change (see section 3.5). This activity was supported by the PPA 2000-03, under the Climate Change Program (see section 7.3).

It is intended to make regional climatic predictions available to groups from South America so that experts can develop climate change scenarios in national research centers. The regional climate models present a much higher resolution than the global climate model, and thus provide climatic information with useful local details, including realistic predictions of extreme events. The predictions made using regional climate models thus lead to substantially better assessments of vulnerability of each country in relation to climate changes and how the Brazil can adapt to them.

The different IPCC climate change scenarios are available from the Data Distribution Centre - DDC of the IPCC, currently located at the Climate Research Unit of the University of East Anglia, in Norwich, UK. This also involves the development and refinement of the regional atmospheric model Eta/CPTEC, with a horizontal resolution of up to 40 km. The work will be carried out by CPTEC, in collaboration with other research groups linked to the IPCC, such as the Tyndall Centre for Climate Research, the Hadley Centre for Climate Prediction and Research, the Center for Ecology and Hydrology and the Climate Research Unit of the University of East Anglia, all located in the United Kingdom. While CPTEC will be the main user of the model results (downscaled climate change scenarios), this activity will have the collaboration and interaction of some of the projects financed in Latin America under Scenarios Development and Application in Assessment of Impacts, Adaptation and Vulnerability of the AIACC (Assessment of Impacts and Adaptation to Climate Change).

The climate scenarios provided by the IPCC-DDC with different levels of emissions and socioeconomic development (SRES scenarios) will be used for South America. This will help to deal with the uncertainties produced by the different models in the simulation of future climates under the same forcing (SRES scenarios).

The scenarios for the 21st century provided by the different climate models (from IPCC-DDC) do not reflect the details of a watershed or a region. These models provide climate projections at a grid scale as large as 300 km of latitude and longitude, which is considerably larger than that necessary to study impacts and vulnerability, especially those that involve hydrological processes. The growing need for climate change scenarios with a greater spatial and temporal resolution demands the implementation of different methods for downscaling (dynamic, statistical)., These methods would reflect the physical mechanisms and processes of the watershed and should capture the regional aspects of large scale climate.

CPTEC's climate modeling strategy includes global climate models and regional climate models nested in a global climate model (dynamic downscaling).

For downscaling of global climate change scenarios to be developed at CPTEC, the regional model to be used is Eta/CPTEC, nested in version 3 of the Hadley Center's coupled global climate model (HadCM3H, a special version of HadCM3 with a higher horizontal resolution), developed in 1998. A 300 year run of HadCM3H is being made available at CPTEC. The preference for the Eta/CPTEC regional model over the Hadley Center's HadRM3 regional model results from the fact that CPTEC has knowledge and experience with the characteristics and structure of the Eta/CPTEC, related to the use of this regional model in studies and experiments with sensitivity, simulations and predictions.

The Eta/CPTEC model will be improved with some modifications and the adaptation of its radiative scheme, so that it can include variable levels of radiative forcing from greenhouse gases and aerosols (CO_2, CH_4, S_2O, etc.), thus preparing the system to generate regional scenarios. In addition to the concentrations of greenhouse gases in the IPCC scenarios, the model would be capable of accounting for aerosols, other particulates and gases emitted to the atmosphere from burning of biomass and forest fires in the Amazonia during the dry season, which, as documented, affects the regional energy balance and thus circulation and precipitation as well.

Testing is currently being carried on coupling of the Eta/CPTEC and HadCM3H models. It was expected that by the second half of 2002 we would have a 10-year climatology from the Eta/CPTEC regional model, using the lateral conditions of the CPTEC/COLA model.

By mid-2003, results were expected from the model for time ranges centered on 2020, 2050 and 2080, with the climate change scenarios of HadCM3H downscaled with Eta/CPTEC. The regional model will be run with horizontal resolutions of 40 to 80 km and 38 vertical levels, with a six-hour time step. The Eta/CPTEC is being improved through incorporation of a new radiative scheme that includes the effects of smoke and aerosols resulting from burning of biomass in the Amazonia. Smoke and aerosols are not currently included in the SRES.

The SRES climate change scenarios will be downscaled to 40 km with the use of both the Eta/CPTEC model and the HadCM3 global model. The regional climate change scenarios, together with any model results (paleoclimatic model runs) and various sets of observational data will be made available on the CPTEC web site and on mirror sites established by the MCT and other interested institutions. CPTEC will provide results of models and experts for the analysis of these regional level climate change scenarios, in Brazil and South America. CPTEC's analysis will be carried out in the context of climate change scenarios after downscaling, observed climatic trends and the interpretation of paleoclimatic indicators, used as analogies of what could happen in the future as a result of climate feedbacks and mechanisms. The information provided by CPTEC will be used by other sectors of government and by society to assess impacts and vulnerability and the implementation of adaptation and mitigation measures by the respective decision-makers at the executive level of state and federal governments.

Creation of National and Regional Capacity

6 CREATION OF NATIONAL AND REGIONAL CAPACITY

Brazil has special needs in terms of the institutional structure to deal with issues related to climate change. The development of human resources is one of the main objectives related to the formation of national and regional capacity, since this issue is a new area of study and there are few specialized programs on the issue in developing countries.

This chapter describes Brazilian capacity-building initiatives related to climate change (see also section 7.3), in particular activities of the Center for Weather Forecasts and Climate Studies - CPTEC/INPE, as well as the participation of Brazilian scientists in the IPCC process. At the regional level, an important initiative is the creation of the Inter-American Institute for Global Change Research - IAI, an intergovernmental organization dedicated to research.

6.1 Interamerican Institute for Global Change Research - IAI

The phenomenon of global change was identified at the United Nations Conference on Environment and Development - UNCED, held in Rio de Janeiro in 1992, as one of the greatest challenges to be faced in the near future. Since then, there has been a clear awareness that this is a trans-border issue and must be addressed scientifically as a global and regional problem, along with pursuing measures towards mitigation and alleviation at the national level.

With this concern in mind, the Interamerican Institute for Global Change Research - IAI was created on May 13, 1992, in Montevideo, Uruguay, to coordinate work throughout the Americas. The Institute is an intergovernmental organization dedicated to research, headquartered in Brazil, with the goal of developing the capacity of understanding the integrated impact of present and future global change on regional and continental environments in the Americas and to promote scientific cooperation and informed action at all levels.

Guided by the principles of scientific excellence and international cooperation, and with a broad exchange of scientific data about global change, the main objectives of the Institute are:

- to promote and facilitate regional and international cooperation for interdisciplinary research about aspects of global change;
- to carry out, on a regional scale, research that cannot be conducted by one country or institution individually;
- to prioritize study of aspects of global change with regional importance;
- to contribute to the dissemination of information, education and technical and scientific capacity;
- to promote the free exchange of scientific information.

Thus, the IAI's work is carried through four basic activities:

- contributing to the advance of scientific knowledge on the continent, through research, education and technology transfer, and defining a scientific agenda with well defined priorities;
- supporting the International Conventions and Protocols (Climate Change, Biodiversity, Ozone), contributing to clarify the scientific issues and their policy implications related to these instruments, in order to support national interests;
- supporting broad international cooperation, contributing to international climate change related programs, and promoting information policies that ensure free access to data;
- supporting the interests of IAI member countries, through providing scientific information which serves the interests of federal, state and local governments, the private sector and the public in general.

For the IAI, the great scientific challenges are climate variations, ranging from seasonal to interannual; climatic change in the coming decades; ultraviolet radiation and the reduction of stratospheric ozone; changes in land cover and in marine and terrestrial ecosystems; and the understanding of the complex behavior of the Earth System and its various components. The Institute's other challenges include the management of large amounts of data about climate change, communication of research results regarding these changes, education of a new generation of scientists from an appropriate environmental perspective, and the commitment to progressively understand the Earth System.

Training and education of future scientists are fundamental for the ongoing advance of research on global changes in the Americas. Thus, the IAI has an important role in training students to carry out research than can contribute to resolving environmental problems in their countries, and contribute to the development of the Institute's scientific agenda. The IAI offers training and education to students through scholarships and support to training and education activities.

In Brazil, the National Council for Scientific and Technological Development - CNPq offers a total of 20 scholarships for Doctorate or Post-Doctorate studies in a program for training graduate students offered in conjunction with IAI, through an institutional agreement between the Institution and CNPq. To complement this, in June 1998 IAI and CNPq signed a memorandum of understanding which specifies fields and activities of common interest which could orient future cooperation activities between the two institutions.

6.2 Intergovernmental Panel on Climate Change - IPCC

In principle, the IPCC is made up of scientists chosen from among experts in climate change throughout the world. In practice, however, most of the experts who participate in the Assessment Reports of the Panel come from developed countries.

The participating of developing country scientists is proportionally small. As a result, the participation of Brazilian scientists in the three Working Groups[57] for the Assessment Reports is also small.

[57] Working Group I assesses the scientific aspects of climate systems and climate change; Working Group II assesses the scientific, technical, environmental, economic and social aspects of vulnerability to climate change, along with the negative and positive consequences for ecological systems, socioeconomic sectors and human health; Working Group III assesses the scientific, technical, environmental, economic and social aspects of mitigating climate change and, through a multidisciplinary group, assesses the methodological aspects of crosscutting issues, and the Task Force works with the preparation of greenhouse gas inventories.

Only six Brazilian scientists participated in the IPCC First Assessment report, from 1990, with 4 in Working Group I (WG I) and 2 in WG II. For the IPCC Second Assessment Report, in 1995, 5 Brazilians participated as authors (3 in WG I and 2 in WG II), along with 6 as collaborators (1 in WG I, 2 in WG II and 3 in WG III) and 6 as reviewers (1 in WG I, 2 in WG II and 3 in WG III). For the IPCC Third Assessment Report[58], 12 Brazilians scientists contributed as authors (3 in WG I, 3 in WG II and 6 in WG III), 1 as collaborator (WG II) and 10 as reviewers (2 in WG I, 3 in WG II and 5 in WG III).

One of the objectives of the national training programs in terms of issues related to climate change is to increase the number of Brazilian scientists who can carry out research related to the issue and contribute to a better understanding of related issues. The participation of these scientists is of great importance, especially because they have a more specific understanding of processes (such as, for example, those related to the Amazonian region) and technologies (such as use of alcohol as motor vehicle fuel) important to developing countries.

6.3 Center for Weather Forecasts and Climate Studies - CPTEC/INPE

CPTEC/INPE is equipped with supercomputers SX-3/12R and SX-4/8A capable of processing up to 3.2 billion and 16 billion floating decimal point arithmetic operations per second, respectively. They have the capacity to use numeric models for the simulation of weather and climate, integrating atmospheric and oceanic information[59].

CPTEC's computing system is fed with information from METEOSAT and GOES satellites, from the WMO data network, national networks under the responsibility of the National Institute of Meteorology - INMET, under the Ministry of Agriculture, Airspace Control Department - DECEA, in the Ministry of Aeronautics, Hydrography and Navigation Directorate - DHN, in the Ministry of the Navy, state meteorology centers and other international centers. The satellites SCD-1 and 2, which collect environmental data, also play an important role in collection the information necessary to INPE's meteorological research. An observation network called meteorological and hydrological Data Collection Platforms - PCDs were implemented in 1996 throughout the country. The PCDs are operated jointly by CPTEC and ANEEL, and transmit meteorological and hydrological information in real time to a center operated by CPTEC, through SCD-1 and 2. All this information enables CPTEC to provide reliable weather forecasts for the entire country.

Along with the various activities of the institute that ensure the high quality of weather predictions, there are plans for activities and research on climate trends in Brazil and the implementation of a research group for preparing climatic scenarios, using the experience of participation of CPTEC researchers in the IPCC, as well as collaboration with researchers from the Hadley Centre, the Tyndall Centre, and the University of East Anglia in the UK. It is expected that a regional modeling capacity will be implemented at CPTEC to develop regional climatic scenarios based on the IPCC predictions, using the technique of dynamic downscaling, where the Hadley Center's HadCM3 coupled global model will be aligned with the Eta/CPTEC regional model, allowing the implementation of regional climate predictions for Brazil and South America, with a resolution of up to 40 km (see section 5.10).

[58] Released in 2001.

[59] The SX-3 model will be replaced by the new supercomputer SX-6. The SX-6 will be capable of processing up to 768 billion floating decimal point arithmetic operations per second, when the two implementation phases are completed. With this new supercomputer, CPTEC will enter a new era of research on climate and climate change, since it will be possible to run global and regional climate models to generate climatic scenarios for the 21st century.

Integration of Climate Change Issues in Medium and Long Term Planning

7 INTEGRATION OF CLIMATE CHANGE ISSUES IN MEDIUM AND LONG TERM PLANNING

Throughout Brazil's history, there was always a concern to control exploitation of the territory's natural wealth. What were once merely political and economic measures, over time came to involve issues of environmental preservation. At present, Brazil's environmental legislation is among the most advanced in the world, although there are still administrative and institutional difficulties in its implementation.

Awareness of medium and long term environment issues is essential to sustainable development, a principle that is set out in the Rio Declaration and which is one of the foundations of Agenda 21. Both documents are outcomes of the UN Conference on Environment and Development - UNCED, held in Brazil in 1992 - Rio 92. Domestically, in the process of drafting the Brazilian Agenda 21, an attempt was made to establish strategies to ensure sustainable development in Brazil, with recommendations for actions, actors, partnerships, methodologies and institutional mechanisms necessary for its implementation and monitoring.

In terms of national policies for medium and long term planning, for the first time in the 2000-2003 Government Multi-Year Plan - PPA, there is a specific program on climate change to produce scientific information related to greenhouse gas emissions and to support the development of a policy for actions in this area.

Most of the programs described in this chapter do not have the direct objective of reducing greenhouse gas emissions, but will have impacts on emissions from different sources. One of the most important factors is that not just the federal level is involved, since some initiatives also require the commitment of states and municipalities.

At the federal level, the National Air Quality Control Program - PRONAR seeks to control air quality by establishing national emission limits. The Motor Vehicle Air Pollution Control Program - PROCONVE has the same objective, but deals specifically with air pollution by automotive vehicles. Although these programs are aimed at fighting local pollution and not directly at climate change, they are described here in terms of the institutional and legislative aspects involved and could, in the future, enable the creation of similar instruments and legislation to address greenhouse gas emissions from human activities.

Another important issue addressed in this work involves the measures adopted by the Brazilian government to combat deforestation in the Amazonian region. The legal, administrative and economic measures that have been adopted, as well as the strategy for political actions, are analyzed here.

Project for Gross Deforestation Assessment in the Brazilian Legal Amazonia - PRODES is the largest forest monitoring project in the world, providing estimates of deforestation; and the Program for Prevention and Control of Burning and Forest Fires in Legal Amazonia - PROARCO is aimed at predicting and controlling burning and forest fires in the Arc of Deforestation in the Brazilian Amazonia. Also, there is a large number of conservation areas in Brazil, as will as other programs to fight fires and burning, aiming at protecting and conserving the existing flora and fauna, in accordance with Article 4.1 (d) of the UN Framework Convention on Climate Change.

Finally, financial and fiscal measures (Green Protocol, Ecological ICMS tax, and others) are analyzed, which have begun to show significant results for the reduction of environmental degradation and the promotion of sustainable development.

7.1 Brazilian Environmental Legislation

Since colonial times, Brazil has had specific regulations governing the territory and its wealth. The oldest Brazilian legal document addressing natural resources is the Waters Code (Decree no. 24,643, of July 10, 1934), which defined the right of ownership and exploitation of water resources for public supply, irrigation, navigation, industrial uses and energy generation. Thus, since the 1930s there have been various legal instruments which establish the rights and duties of society in relation to specific environmental areas.

A very important law in the history of Brazilian environmental legislation is no. 4,771, from September 15, 1965, known as the Forestry Code, which recognized existing forests on Brazilian territory and other forms of vegetation as public goods, imposing limits on the right to property. It also established minimum criteria for the permanent preservation of areas and for the creation of parks and biological reserves.

Since the United Nations Conference on the Human Environment, held in Stockholm in 1972, there has been growing concern in Brazil with issues related to environmental protection.

In 1973, a Special Environmental Secretariat - SEMA was created under the Ministry of the Interior, which was the first official Brazilian body devoted to the rational use of natural resources and environmental preservation. With the creation of this body, legal regulations were expanded significantly.

Law no. 6,803, from 1980, which defines the basic rules for industrial zoning in critical pollution areas, introduced the idea of Environmental Impact Assessment - EIA. One of the elements of the environmental impact assessment process is the Environmental Impact Study - EIS, for which regulations were introduced later. This involves carrying out technical and scientific work aimed at analyzing the consequences of implanting a project in the environment, through EIA methods and techniques for predicting the environmental impacts. The result of the study is the Environmental Impact Report, which is accessible to the public and funded by the project proponent.

In 1981, the first generic law was created to systematize the existing specific laws, with the publication of Law no. 6,938, which provides for a National Environmental Policy, its objectives and mechanisms of formulation and application. This law, which establishes environmental licensing as an instrument of this policy, addresses connections between economic development and environmental preservation. The law also created the National Environmental System - Sisnama and the National Environmental Council - Conama, whose responsibilities include establishing regulations and standards related to the control of environmental quality.

Another important advance related to protection of the "diffuse rights" involves Law no. 7,347, of 1985, which governs public civil actions involving responsibility for damage caused to the environment.

The Federal Constitution, promulgated in 1988, represents a significant advance for the environmental area, in that it dedicates a special chapter to the environment and includes its defense among the principles of the economic order, seeking to reconcile promotion of socio-economic growth with the need for environmental protection and preservation.

Thus, Article 225 of Chapter VI, dealing with the environment, establishes that: "All have the right to an ecologically balanced environment, a good of common use of the people and essential to a healthy quality of life, imposing on the public authorities and the collective the duty to defend and preserve it for the present and future generations." Therefore, the environment is characterized as an inherent right of each individual and of all of society, with the public authorities and the collective, without distinction, having the duty of preserving it and ensuring environmental balance.

Along with the measures and provisions which are the responsibility of the public authorities, the 1988 Federal Constitution imposes behavior on those who can directly or indirectly cause damage to the environment. Furthermore, Paragraph 4 of the same article of the Constitution declares the Brazilian Amazonian Forest, the Atlantic Forest, the *Serra do Mar*, the *Pantanal* and the coastal zone to be national heritage areas, with their use being subject to the law, under conditions that ensure environmental preservation.

Although the Constitution gives special attention to preventative activities, it also makes reference to punitive measures. Paragraph 3 of Article 225 provides for penal and administrative sanctions for offenders, be they individuals or legal entities, whose conduct or activities are considered harmful to the environment, without prejudice to the obligation to repair the damages caused.

In 1989, Law no. 7,735, of February 22, created the Brazilian Institute for the Environment and Renewable Natural Resources - IBAMA, to implement and enforce national policies for environment, and to preserve, conserve and ensure the rational use, monitoring, support and control of natural resources.

In 1996, there was an important amendment to the Forestry Code, through Provisional Measure no. 1,511, of July 26, which revises Article 44 of Law no. 4,771, of September 15, 1965, providing for the prohibition of increase in conversion of forested areas to agricultural areas in the North region and the northern part of the Center West region. The new text of Article 44 of the Forestry Code provides that in these regions clearing is only allowable if tree cover remains on at least 50% of the area of each property. Furthermore, according to the provisional measure, in the properties where the tree cover consists of forest physiognomy, clearing will not be permitted in at least 80% of these forest typologies (see section 7.6.2.1). The provisional measure has since been rewritten[60].

Another important legal advance is the law passed on February 12, 1998, no. 9,605, the Environmental Crimes Law, which represents a change in the system of sanctions in the current legislation. Until then, the legal arrangement had only established monetary sanctions for crimes against flora. This law provides for penal and administrative sanctions for conduct and activities which damage the environment, as well as consolidates environmental legislation, with typification of environmental crimes and infractions and with their respective penalties duly stipulated.

In 2000, the project of the National System of Conservation Units was approved by the Senate, received presidential sanction and became Law no. 9985, which brought the concept of conservation unit up to date, introducing social issues and uses for other ends. The importance of the establishment of a National System of Conservation Units (see section 7.8) is in the definition, standardization and consolidation of criteria for the establishment and management of these units, thereby enabling a better management of Brazilian environmental heritage.

Brazilian legislation addressing defense of the environment is made of numerous dispersed laws. This phenomenon, as in almost all areas of law, results from, among other factors, the different political and institutional contexts that have characterized the recent history of Brazil.

In summary, it is recognized that the Brazilian environmental legislation is one of the most advanced in the world, with clear legal guidelines for pursuing sustainable development, in spite of the institutional and administrative difficulties posed to its broad implementation.

7.2 Brazilian Agenda 21

Given the importance of each society establishing their own development priorities, the signatory countries to the agreements emerging from the United Nations Conference on Environment and Development, known also as Rio 92, assumed the commitment to development and implement their respective national programs for Agenda 21.

At the beginning of 1997, a new national committee was created in Brazil for sustainable development, linked to the Chamber of Natural Resource Policies of the Government Council. This new institutional arrangement had the goal of bringing together, under the president of the Republic, the coordination of various bodies and governmental agencies committed directly to preparation of the Brazilian Agenda 21.

Thus, through a Decree of February 26, 1997, a Sustainable Development and National Agenda 21 Policies Commission - CPDS was created under the Chamber of Natural Resource Policies. The purpose of the Commission is to propose strategies for sustainable development, and the coordination, development and implementation of Agenda 21.

The CPDS is chaired by a representative of the MMA and consists of one representative of each of the bodies of the different sectoral activities of the government: Ministry of Planning and Budget, Ministry of Foreign Affairs, Ministry of Science and Technology, the then Secretariat of Strategic Issues of the Presidency of the Republic - SAE, and the Secretariat of the Chamber of Sectoral Policies. Along with the government bodies it is intended that the CPDS have parity, with five representatives of organized civil society.

An intensive discussion process provided important inputs to CPDS in establishing a methodology for developing the Brazilian Agenda 21, defining the assumptions and priority issues for the country.

On June 8, 2000, during Environment Week, CPDS presented to the president of the Republic the results of the work carried out, described in the document "Brazilian Agenda 21 - Bases for Discussion". At that time, the continuation of the process of developing the agenda through holding state-level debates was announced. Upon completion of the state-level discussions, a regional meeting was held in each region of the country, where the reports from the states were analyzed with the objective of preparing a document that expresses the outcomes for the region.

[60] Provisional Measure no. 2,166-67, of August 24, 2001, also significantly amended Articles 1, 4, 14, 16 and 44, and expands on provisions of Law no. 4,771, of September 15, 1965, which created the Forestry Code, as well as amends Article 10 of Law no. 9,393, of December 19, 1996, which covered the Rural Property Tax - ITR, and contains other provisions. This provisional measure provides that forests and other forms of native vegetation, except those located in areas of permanent preservation, along with those not subject to the regime of limited use or is an object of specific legislation, are subject to removal, as long as a legal reserve of at least 80% is maintained of the rural property located in a forested area of the Legal Amazon (for the other regions th percentage of area to be maintained is also determined). The vegetation of the legal reserve cannot be removed, but can only be used under a regime of sustainable forestry management, in accordance with principles and technical and scientific criteria established in the legislation in force. The provisional measure also regulates the conduct of owners or holders of rural properties with an area of native, natural, original or regenerated forest.

The process of developing the Brazilian Agenda 21 and its results can be followed on the homepage of the Ministry of Environment (see http://www.mma.gov.br)[61].

7.3 Brazilian Climate Change Research Program - Ministry of Science and Technology - MCT

An example of the increasing importance of issues related to climate change was the inclusion of a Climate Change Program in the Federal Government's 2000-2003 Multi-year Plan - PPA, with the allocation of federal budgetary resources. The program's objective is to produce scientific information related to greenhouse gas emissions to support the definition of a policy for activities related to climate change. The indicator selected for achieving that objective is the increase in the number of institutions with the capacity to address the climate change issue. When the program began, there were 27 institutions directly involved with the issue, and it is expected that at the end of the PPA, 49 institutions with the appropriate capacity will be directly involved.

The Climate Change Program of the PPA included 6 activities:

Action 1 - Development of studies on vulnerability and adaptation to the impacts of climate change: the objective is to begin a process of studying vulnerability and adaptation to climate change impacts in the areas of agriculture, fields, forests, water resources, costal resources, human health, species of flora and fauna, and fish.

Action 2 - Development of forecasting models to monitor climatic changes: seeks to begin a process of scientific research and study through systematic observation and the development of climate information systems, with the goal of reducing uncertainties about the causes, effects, magnitude and changes over time of climatic changes and the economic and social consequences of various response strategies.

Action 3 - Preparation of the National Inventory of Anthropogenic Greenhouse Gas Emissions: the object is to contribute to the periodic preparation of the national inventory of greenhouse gas emissions, and to carry out studies on emission factors and activity levels in the sectors of energy, industry, solvent use, agriculture, land-use change and forestry, and waste treatment.

Action 4 - Implementation of a monitoring system for greenhouse gas emissions: seeks to begin a process of establishing permanent systems for monitoring greenhouse gas emissions.

Action 5 - Greenhouse effect information system: the goal is to maintain and improve existing information systems about the issue of greenhouse gases and government actions devoted to their control, as well as the implementation of education, awareness and information campaigns on the issue.

Action 6 - Development of studies on climate change mitigation: this activity offers support for conducting assessment studies for the creation of a national climate change mitigation plan, containing measures and policies in the sectors of energy, industry, agriculture, forests and waste treatment, in order to implement a national strategy for assessing the best opportunities in terms of a cost-benefit analysis.

Information about the projects developed within the Climate Change Program and their outcomes can be found at the site of the General Coordination on Global Changes of the MCT (see http://www.mct.gov.br/clima).

7.4 National Air Quality Control Program - PRONAR

In recent decades, the levels of atmospheric pollution in urban areas of Brazil increased considerably, along with the economic and industrial growth of the country. There is thus an awareness of the importance of the creation of a national program that addresses the fixed sources of atmospheric pollution. Given that most states do not provide local source emission standards, there was a need to set standards and establish atmospheric monitoring activities.

Thus, through Conama Resolution no. 5, of June 15, 1989, the National Air Quality Control Program - PRONAR was created, in order to provide guidance and control for atmospheric pollution in Brazil, involving regulatory strategies such as the establishment of national standards for air quality and source emissions, the implementation of a policy for prevention of the deterioration of air quality, the implementation of a national air monitoring network, and the development of inventories of priority sources and atmospheric pollutants.

The basic strategy of PRONAR, according to this resolution, is to establish national limits for emissions, by type of source and priority pollutants, with the use of air quality standards held in reserve as a complementary control action. In order to implement this, short, medium and long term goals were established as a basis for the allocation of resources and decisions about actions.

The first legal provision under PRONAR was Conama Resolution no. 3, of June 28, 1990, which established new national air quality standards:

[61] The launch of the Brazilian Agenda 21 took place in July of 2002, finalizing the preparation phase and marking the beginning of the implementation phase. The Brazilian Agenda 21 consists of two documents: "Agenda 21 Brasileira - Ações Prioritárias" (Brazilian Agenda 21 - Priority Actions), which established the preferential paths to the construction of Brazilian sustainability, and "Agenda 21 Brasileira - Resultado da Consulta Nacional" (Brazilian Agenda 21 - Result of the National Consultation), product of the discussions held throughout Brazil.

Table 7.4.1 - National Air Quality Standards - Conama Resolution no. 3, of June 28, 1990

Pollutant	Duration of Sampling	Primary Standard (µg/m³)	Secondary Standard (µg/m³)	Measurement Method
Total Suspended Particulates (TSP)	24 hours*	240	150	High Volume Sampler
	AGM	80	60	
Smoke	24 hours*	150	100	Reflectance
	AAM	60	40	
Inhalable Particulates	24 hours*	150	150	Inertial Separation/ Filtration
	AAM	50	50	
Sulfur dioxide	24 hours*	365	100	Pararosalinic
	AAM	80	40	
Carbon monoxide	1 hour*	40,000 (35 ppm)	40,000 (35 ppm)	Non-dispersive Infrared
	8 hours*	10,000 (9 ppm)	10,000 (9 ppm)	
Ozone	1 hour*	160	160	Chemiluminescence
Nitrogen Dioxide	1 hour	320	190	Chemiluminescence
	AAM	100	100	

(*) Should not be exceeded more than once per year.
Annual Geometric Mean - AGM.
Annual Arithmetic Mean - AAM.

Another advance in this resolution was the establishment, at the national level, of criteria for preparation of an emergency plan for severe air pollution incidents, which previously existed only in the State of São Paulo.

However, the State Air Pollution Control Programs were not developed and implemented as planned. This fact, along with some administrative characteristics of the program, rendered unviable the medium term goals such as implementation of the national air quality monitoring network and production of a national inventory of sources and emissions. Currently, IBAMA has plans to reactivate this program.

It is also expected that the Law of Environmental Crimes (Law no. 9,605, of February 12, 1998), which should provide greater agility in punishing offenders, will give the program new strength. Section III of the chapter on environmental crimes of Law no. 9,605 specifies crimes related to pollution and other environmental crimes.

The implementation of mechanisms for the control of environmental quality, such as ISO 14,000, can also significantly support air quality control, with the direct involvement of the private sector. What is important, however, is to strengthen the institutional structure and implement the provisions of PRONAR so that this program becomes an effective instrument for the control of environmental pollution.

7.5 Motor Vehicle Air Pollution Control Program - Proconve

In Brazil, highway transportation accounts for 96.1% of passenger transport. Growing urban population, deficiencies in public policies regarding mass transport and the recovery of economic growth have led to a dramatic increase in private transportation. The national fleet of automobiles and light duty vehicles increased from 10,325,000 in 1990 to 12,726,000 in 1995[62], resulting, in principle, in increased pollutant emissions from motor vehicles.

On May 6, 1986, Resolution no. 18 of Conama created the Motor Vehicle Air Pollution Control Program - Proconve with the purpose of mitigating pollutant emission levels from motor vehicles, improving the technical characteristics of liquid fuels used by the national fleet of motor vehicles and reducing atmospheric emissions. This resolution established the basic guidelines of the program and stipulated the first emission limits. On October 28, 1993, Law no. 8,723 reaffirmed the obligation to take the necessary steps to reduce vehicle pollution emission levels.

The Brazilian Institute for the Environment and Renewable Natural Resources - IBAMA is responsible for the national coordination of the program. CETESB is co-responsible for its implementation, operation and technical updating, through an agreement to provide technical advice and support.

The technical aspect of the program is very important, since its main objective is to reduce atmospheric contamination by establishing maximum emission limits, inducing technological advances on the part of manufacturers and requiring that both vehicles and engines comply with the maximum limits established. Proconve also calls for certification of prototypes and keeping of statistics of production vehicles; authorization from IBAMA for the use of alternative fuels; the impounding or repair of vehicles and engines that are found not to be in accordance with production or design standards; prohibition of sale of vehicle models that have not been approved; and establishment of "Inspection and Maintenance Programs for Vehicles in Use", called "I/M Programs".

[62] The scrappage rate is already calculated (FERNANDES, 2002).

To implement the program, vehicles were classified in three categories, each with a specific timetable: light passenger vehicles, with a total mass of up to 3,856 kg (automobiles); light commercial vehicles, which are divided into vehicles with a test mass of up to 1,700 kg and over 1,700 kg (pickups and vans); and heavy vehicles, with a total mass of above 3,856 kg (buses and trucks).

Elimination of Tetraethyl Lead

At the beginning of Proconve, to be able to achieve the specified emission levels, it was seen as necessary to use catalytic converters on automobile exhaust systems and electronic fuel injection to replace carburetors. Since the tetraethyl lead added to gasoline rendered catalyzers inoperative in a short time, this additive was clearly incompatible with the new technological resources for emissions reductions. Thus, efforts of Petrobras resulted in the elimination of tetraethyl lead in gasoline in 1989, and Brazil became the first country in the world to completely eliminate this toxic additive from its fuel matrix. The additive used to replace tetraethyl lead was anhydrous alcohol, which has significant advantages (see section 1.1), especially in terms of the environment.

With regard to light passenger cars, emission control was divided into three phases, according to the provisions of Conama Resolution no. 18/1986, with the first two already implemented. Phase I, from 1988 to 1991, focused on the improvement of model designs that were already being produced when the program was established, as well as initiating the control of evaporative emissions. Phase II, based on the limits established in 1992, focused on emission reduction, with the application of new technologies such as electronic injection, electronically-controlled carburetors and catalytic converters. Phase III, under way since 1997, involves inducing the manufacturer/importer to employ state-of-the-art technologies available for mixture formation and electronic control of the engine, establishing emission limits (Table 7.5.1).

Table 7.5.1 - Light Passenger Vehicles - from 01/01/1997

POLLUTANTS	LIMITS
Carbon monoxide (CO g/km)	2.0
Hydrocarbons (HC g/km)	0.3
Nitrogen Oxides (NO_x g/km)	0.6
Particulate material (PM** g/km)	0.05
Aldehydes (CHO* g/km)	0.03
Evaporative emission (g/test)	6.0
Crankcase gas emissions	None

* except for vehicles with diesel engines.
** except for vehicles with Otto cycle engines.

Conama Resolution no. 15 of December 13, 1995, is concerned with light commercial vehicles, including vans and pick-ups. With the significant increase in the number of such vehicles in Brazil, maximum emission limits have also been set for them (Table 7.5.2).

Table 7.5.2 - Emission Limits for Light Commercial Vehicles - from 01/01/1998

POLLUTANTS	LIMITS (g/km): Vehicles with specific mass of up to 1,700 kg	LIMITS (g/km): Vehicles with specific mass of above 1,700 kg
Carbon monoxide (CO)	2.0	6.2
Hydrocarbons (HC)	0.3	0.5
Nitrogen Oxides (NOx)	0.6	1.4
Particulate material (PM**)	0.128	0.16
Aldehydes (CHO*)	0.03	0.06

* except for vehicles with diesel engines.
** except for vehicles with Otto cycle engines.

Heavy vehicles have been a constant concern, as they are the main emitters of particulate matter and nitrogen oxides in the main traffic corridors of large urban centers.

Conama Resolution no. 18/1986 took the first steps to control diesel vehicle emissions. In 1993, by means of Resolution no. 8 of August 31, which updated Proconve to include heavy vehicles manufactured and sold in Brazil, regardless of the type of fuel used, as presented in Table 7.5.3.

Table 7.5.3 - Emission Limits for Heavy Vehicles

	CO	HC (g/kWh)	NO_x	Smoke (k)*	Particulates (g/kWh)*
PHASE I	—	—	—	2.5	—
PHASE II	11.2	2.45	14.4	2.5	—
PHASE III	4.9	1.23	9.0	2.5	0.7/0.4**
PHASE IV	4.0	1.1	7.0	—	0.15

* applicable only to diesel engines.
** 0.7 g/kWh, for engines of up to 85 kW and 0.4 g/kWh for engines of more than 85 kW.

Similar to Otto cycle vehicles, a progressive scale was established so that diesel powered vehicle categories would fall within the emission limits. It was established that as of March 1, 1994, all diesel engines produced for the models chosen by their manufacturer as those representing at least 80% of its production must meet the Phase II limits, with the remaining models meeting Phase I limits, as set out in Table 7.5.3. As of January 1, 1996, the same applies to Phase III, with the remaining models required to meet the Phase II limits, and the same principle would be applied as of January 1, 2000 for Phase IV, with the remaining models meeting Phase III limits. Only from January 1, 2002 onwards will all heavy vehicle engines be required to meet the Phase IV limits. For urban buses the dates established for Phases III and IV were moved up by two years.

As of 2002 there have been two types of diesel oil authorized in Brazil: common and metropolitan, the latter being distributed in the large metropolitan areas as defined by Conama/IBAMA. Thus diesel oils are thus classified as types A and B in metropolitan areas and types C and D in other cities: diesel oil A having 0.10% sulfur, diesel B 0.20%, diesel C 0.35% and diesel D 0.50%. Changes are planned for the years 2005 and 2009.

Having made important achievements, the objective of Proconve is to administer and where appropriate update the existing legislation[63]. Discussions to this end are under way with the sectoral trade associations, in order to by 2005 update emission limits both to light vehicles and heavy vehicles.

The success of the program can be seen by comparing the limits imposed in Tables 7.5.1 and the results achieved in Table 7.5.4, which shows, thanks mainly to Proconve, a dramatic reduction of average emission factors for light passenger vehicles from 1980 to 2000.

Since the schedule established by Conama resolutions related to Proconve are being strictly followed, at almost no cost to the government, and is achieving its targets satisfactorily, the program is considered, even abroad, one of the best programs for controlling emissions from mobile sources in developing countries. Moreover, it is certainly one of the most successful environmental programs ever implemented in the country, and has since been adopted by Mercosul.

Table 7.5.4 - Average Emission Factors for Light Passenger Cars

YEAR/ MODEL	FUEL	POLLUTANT* CO (g/km)	HC (g/km)	NO_x (g/km)	CHO (g/km)	Evaporative Emissions from Fuel (g/test)
Pre-1980	Gasoline	54	4.7	1.2	0.05	Na
1980-83	Gasoline C	33	3	1.4	0.05	Na
	Ethanol	18	1.6	1	0.16	Na
1984-85	Gasoline C	28	2.4	1.6	0.05	23
	Ethanol	16.9	1.6	1.2	0.18	10
1986-87	Gasoline C	22	2	1.9	0.04	23
	Ethanol	16	1.6	1.8	0.11	10
1988	Gasoline C	18.5	1.7	1.8	0.04	23
	Ethanol	13.3	1.7	1.4	0.11	10
1989	Gasoline C	15.2	1.6	1.6	0.04	23
	Ethanol	12.8	1.6	1.1	0.11	10
1990	Gasoline C	13.3	1.4	1.4	0.04	2.7
	Ethanol	10.8	1.3	1.2	0.11	1.8
1991	Gasoline C	11.5	1.3	1.3	0.04	2.7
	Ethanol	8.4	1.1	1	0.11	1.8
1992	Gasoline C	6.2	0.6	0.6	0.013	2
	Ethanol	3.6	0.6	0.5	0.035	0.9
1993	Gasoline C	6.3	0.6	0.8	0.022	1.7
	Ethanol	4.2	0.7	0.6	0.040	1.1
1994	Gasoline C	6	0.6	0.7	0.036	1.6
	Ethanol	4.6	0.7	0.7	0.042	0.9
1995	Gasoline C	4.7	0.6	0.6	0.025	1.6
	Ethanol	4.6	0.7	0.7	0.042	0.9
1996	Gasoline C	3.8	0.4	0.5	0.019	1.2
	Ethanol	3.9	0.6	0.7	0.040	0.8
1997	Gasoline C	1.2	0.2	0.3	0.007	1
	Ethanol	0.9	0.3	0.3	0.0012	1.1
1998	Gasoline C	0.79	0.14	0.23	0.004	0.81
	Ethanol	0.67	0.19	0.24	0.0014	1.33
1999	Gasoline C	0.74	0.14	0.23	0.004	0.79
	Ethanol	0.6	0.17	0.22	0.013	1.64
2000	Gasoline C	0.73	0.13	0.21	0.004	0.73
	Ethanol	0.63	0.18	0.21	0.014	1.35

Source: CETESB, 2001.
*Weighted averages for each model-year by volume of production
na - not available.
Gasoline C - 78% gasoline plus 22% anhydrous alcohol (v/v)
RCHO - formaldehyde+acetylide

Other Considerations

Sulfur Content

Conama Resolution no. 226, of August 20, 1997, addresses technical specifications for commercial diesel oil. This resolution establishes a schedule for the reduction of sulfur content in diesel fuel.

In light of the above considerations, and the number of vehicles circulating in different regions of the country and their environmental necessities, different sulfur contents were stipulated for diesel sold in the metropolitan regions of large cities (set out in that resolution) and in the rest of the country.

Since January of 1998, the maximum sulfur content in Brazilian diesel fuel is 0.5%. Starting in January 2000, diesel fuel sold in metropolitan regions of large cities (São Paulo, Santos, Cubatão,

[63] In addition, it is worthwhile citing Conama Resolution no. 297, of February 26, 2002, which establishes gas emission limits for motorcycles and similar vehicles, starting in January 1, 2003. Conama Resolution no. 291, of October 25, 2001, regulates the elements for conversion of vehicles to natural gas; and Resolution no. 282, of September 12, 2001, establishes the requirements for catalytic converters for the replacement parts market.

Rio de Janeiro, Salvador, Aracaju, Recife, Fortaleza, Porto Alegre, Curitiba, São José dos Campos, Campinas, Belo Horizonte and Belém) has a maximum sulfur content of 0.2% in accordance with a diesel fuel improvement program.

Conama's proposal is that, starting in January of 2005, common and metropolitan automotive diesel oil, respectively, have the following minimum specifications: sulfur content (max.) of 500 ppm and 2000 ppm; T 85% - 360°C for common, T 90% - 360°C for metropolitan; density - 0.82 to 0.86 and 0.82 to 0.87; cetane number - 45 and 42. Starting in January 1, 2009, metropolitan and common automotive diesel oil should have the following minimum specifications: sulfur content (max.) of 50 ppm and 500 ppm respectively.

Vehicle Maintenance and Inspection

The maximum emission limits stipulated in the Conama resolutions must be guaranteed in writing by manufacturers, for at least 80,000 km for Otto Cycle[64] engines and 160,000 km for diesel engines, or for five years of use, whichever comes first. In order to maintain this guarantee, the owner must be able to prove that the preventive maintenance recommended in the vehicle owner manual has been properly carried out.

However, the implementation of Proconve led to the conclusion that it was no use imposing rigid pollution and noise limits on manufacturers, if after being sold the vehicle did not undergo the proper maintenance to ensure the continuity and durability of the stated emission levels. Thus emerged the need to implement programs for inspection of vehicles in use, as a way to ensure that their owner carries out at least the maintenance procedures called for by the manufacturer and within the periods set by the regulators for these inspections.

In 1993, Conama created and passed regulations for “Inspection and Maintenance Programs for Vehicles in Use”, called “I/M Programs”. These programs were to be implemented by the State and Municipal Environmental Executive Agencies - OEMA, according to the general guidelines and regulations established at the federal level, in light of the real necessities and special characteristics of each state.

There was, however, no compulsory linkage between these programs and the annual vehicle licensing, which is the responsibility of the State Traffic Departments - Detrans, and was seen as the only way to ensure that the vehicle in circulation undergoes a pollution emission inspection. It was then that, in 1995, the National Traffic Council - Contran created this linkage through regulation, as well as created the vehicle safety inspection, through Resolution no. 908/1995, to be implemented as of 1998.

The approval of the new Brazilian Traffic Code - CTB (Law no. 9,503 of September 23, 1997) established this linkage in law, with its application mandatory for all Detrans in the annual vehicle licensing process, where the inspection of pollutant gas emission and noise had already been implemented.

But what is really important, and this should be the only objective of inspections, is to ensure that the owner understands the concept of correct maintenance of their vehicle, on which depends their safety and that of others, and on which also depends the quality of the air that all breath. Thus the inspection services should be cheap, efficient and high quality.

The I/M Programs, although addressing local pollution, could prepare the population to be concerned about greenhouse gases in the future.

7.6 Measures to Combat Deforestation in the Amazonian Region

7.6.1 Main Causes of Deforestation

7.6.1.1 Large-scale Development Projects

Social, economic, and political inequalities between the different regions of Brazil, along with the stratification of Brazilian society, led to the implementation, especially between the 1960s and the 1980s, of development projects in frontier regions, whose goals were more focused on the country's necessities than on meeting the legitimate development interests of these frontier areas.

Low land prices and the resulting expectation of future gains, facilitated access to natural resources, the perception that resources are inexhaustible, as well as the provision of tax and credit incentives by governments, were factors that attracted the private sector, with no concern for bringing improved technologies that could ensure the competitiveness and sustainability of resource exploitation (EGLER, 1998).

The deforestation in the Brazilian Amazonia caused by the above mentioned factors started in the 1970s, with the introduction of programs for agricultural settlement in the North region, supported by the National Integration Program - PIN, the Program for Land Redistribution and Agro-industry Incentives for the North and Northeast - PROTERRA[65] and the Programs for Agriculture, Livestock, and Agro-mineral Poles in the Amazonia - POLAMAZONIA[66].

In general, the objectives of large development projects in the Amazonia focus on the increase in intensive production and extraction of natural resources, mainly minerals and timber, the creation of an industrial center devoted to assembly of electronic equipment and cutting of precious stones, support for agricultural activities, and the occupation of remote areas to ensure sovereignty over the territory. Over the past three decades, there has been little investment in attracting private companies capable of creating competitive and innovative productive structures for technologies in the Northern region.

The large cattle ranches, agricultural settlement projects and the majority of development mega-projects supported by the Federal Government in the region have proven unsustainable in the medium term, and have provided very low levels of social benefits and high environmental impacts.

The existence of credit policies that used to offer lower real interest rates for loans for agricultural activities than for non-agricultural sectors, guaranteed minimum prices for agricultural producers, flexible rules for land title rights for squatters, low property taxes, and fiscal incentives for investments in approved undertakings in the region, had a great impact on deforestation in the region. It is worth

[64] For which should be determined the Emissions Deterioration Factors, through tests on accumulation of mileage, according to Resolution no. 14, of December 13, 1995.

[65] PIN and PROTERRA were part of the national integration policy of the North and Northeast regions, established in the First National Development Plan (1972-1974). PIN involves mainly the construction of the TransAmazon highway (a transversal, east-west route interconnecting with the Northeast and a longitudinal, north-south route connecting with the Center and South of the country). It also involved settlement of the adjoining region in association with the private sector, through construction of residential centers. PROTERRA, through land title reform of these regions, called for breaking up the large latifundios and expansion of properties that were too small for economically viable activities, in order to stimulate medium-sized rural companies to change the traditional production systems through appropriate use of land, credit and modern technologies to raise the productivity of the sector.

[66] POLAMAZÔNIA aimed at promoting the integrated use of the potential for agriculture, forestry and mining in projects located in 15 selected areas, distributed throughout the Legal Amazon.

noting that many of these policies have been scaled back or eliminated in recent years.

Even generation and distribution of electricity in the region, which are essential to enable development projects, have been a factor in regional imbalances. The main objective in the construction of hydroelectric projects in the North region has been to supply some urban centers and to promote energy intensive economic activities through providing electricity at subsidized prices.

Highly centralized decision-making between 1960 and 1990, including with the participation of the Amazonia Development Superintendency - SUDAM, about infrastructure and development projects by the Federal Government, in the name of "actions for development and integration of the Northern region", did not take into account the environmental, cultural, and socioeconomic realities of the regions.

This period in fact contributed little to the development of the region, due to the low technological level of the main activities in the Amazonia and its low level of social development. During the 1990's the share of the North region in Brazil's GDP remained at less than 5%.

7.6.1.2 Characteristics of Economic Activities in the Amazonia

There is a competition between primary resource extraction and forests in the Amazonian region, because of the need for land area for production. Since 1970 there has been a great expansion of agriculture in the Amazonia, which could be related to deforestation rates. This expansion was driven by the growing population pressure in the region. In the North region the population grew from 5.9 million in 1980 to around 10 million in 1991, and to around 12.9 million in the year 2000. This population pressure is also one of the factors that could be related to conversion of forests into agricultural lands.

The agricultural activities in the Amazonian region, including growing crops (manioc, sugar cane, corn, potatoes, tobacco, rice, soybean, wheat, and others) and cattle ranching, require large areas of land. Thus expansion of agriculture and ranching, along with being a factor in deforestation in the region, can result in the degradation and abandonment of areas with low soil quality.

For transportation of people and products, in recent decades a large number of roads have been built, which is directly related to population density, to agricultural and economic activities, and thus to deforestation.

In the Amazonian region the direct effects of mining on deforestation has been very limited, but the massive investments in the mining development poles have lead to a development *boom* that has brought more wide-ranging impacts on the region.

Another important economic activity in the Amazonia is timber extraction, which is not a recent activity, having been carried out for more than 300 years. However, in the past logging was done on a small scale, with the extraction of a few species, without causing significant damage to the forest ecosystem. Wood was a byproduct of clearing land for agricultural purposes. Over the last two decades, however, there has been a much more intensive and destructive system of timber extraction, involving clear-cutting, with the use of machinery that allows the extraction of a great number of plant species in a short time period, in an unsustainable manner, weakening the entire forest ecosystem.

Brazil is the world's largest producer of tropical wood, and is also a great consumer. To meet the demand for tropical wood, across the Amazonian region there are 3000 timber companies, both Brazilian and foreign-owned. These companies extract more than 30 million cubic meters of logs from the region per year. Much of this total involves the unsustainable exploitation of native forests. This results in impacts such as erosion and depletion of species of higher commercial value.

Another factor that should be considered in assessing the economic activities of the Amazonia is that wood, as well as other extractivist forest products (nuts and rubber), has a low market value. Thus, its destructive extraction practices, along with depleting the natural resources of the region, have not contributed to improving the incomes of the local population, establishing a vicious circle between poverty and environmental degradation.

It is understood that the sustainability of forests, including their environmental, economic and social aspects, is essential to the region. It is thus necessary to establish criteria and methods for the exploitation of forest resources based on an equilibrium between regeneration and production. Sustainable forest management could be a viable alternative for achieving this goal, and national legislation has sought to strengthen this option.

Sustainable forest management is defined in Article 2 of Decree no. 1,282, of October 19, 1994, as "the forest administration to obtain economic and social benefits, while respecting the maintenance mechanisms of the ecosystem that is the object of management."[67] It was thus perceived that the forest management plans should be guided by concern for conservation of natural resources and forest structure and functions, maintenance of biological diversity and the socioeconomic development of the region.

Article 1 of this same decree also stipulates that "exploitation of original forests of the Amazonian basin addressed by Article 15 of Law no. 4,771, of September 15, 1965 (Forestry Code), and other forms of natural arboreal vegetation, will only be permitted in the form of sustainable forest management, according to the general principles and technical underpinnings established in this decree."

It was thus intended to regulate exploitation of forests and other forms of arboreal vegetation for alternative land use in the Amazonia. This decree further established forest restocking as a requirement, following specific technical criteria, by the individual or company that exploits, uses, transforms or consumes forestry raw material.

The main restraints on sustainable forest management are economic, social, technical and institutional. The greatest problems identified are the low profitability of forest management, in some cases due primarily to competition from wood extracted illegally, and the trend towards conversion of natural forest areas into areas for agricultural production.

In addition, although the country has broad experience with silviculture and biotechnology techniques with subtropical plantations, such innovative management techniques are restricted to the South and Southeast. There are also few

[67] This Article conforms to Article. 4.1(d) of the UN Framework Convention on Climate Change, which calls for all Parties, in accordance with their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, to "promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems."

technical training centers and qualified workers for such activities in the region.

One of the main problems of implementation of forestry management in tropical areas is the great diversity of tree species (sp). While management plans in temperate areas are designed to support 30 sp/ha, in moist tropical forests they must be designed to support around 400 sp/ha. This species diversity implies a lower density of individuals of a given species, which means that forestry management is less productive than if it were designed for a few species.

The inefficient use of forest resources in the Brazilian Amazonia has two essential causes: market failures related to the lack of definition of property rights that, combined with the abundance of land, forests, mineral resources, among others, lead to their underutilization; and institutional failures and difficulties in regulating property rights, with the need to strengthen the institutional structure of the region, that is, increase the technical and administrative capacity for research, regulation and monitoring, and to enforce laws at the local and national levels.

7.6.1.3 Land Title Distribution and Macroeconomic Issues

Directly related to the problem of primary activities in the Amazonia is the problem of land title distribution. Large properties with more than 10,000 hectares represent more than 40% of productive land. Because of this unequal distribution, thousands of families lack access to land, which in recent decades has led to enormous political pressure to carry out Agrarian Reform, resulting in the search for new frontiers for agricultural expansion.

The relative weight of properties with an area of 10,000 ha or greater is much higher in the Northern region. The percentage of rural property in holdings with 10,000 ha or more was 36% in the North region in 1966, climbing to 56% in 1978, and 47% in 1992 (INCRA, 1996).

The 1988 Federal Constitution sought to establish the foundations for changing this pattern. The Constitution establishes that property must serve its social function (Article 5, clause XXIII) and further provides in Article 184 that "It is within the power of the Union to expropriate on account of social interest, for purposes of agrarian reform, the rural property that is not performing its social function". Although the rule containing the principle of the social function of property came into force immediately, the issue still raises questions. Article 188 of the Constitution further provides that "the destination given to public and unoccupied lands shall be made compatible with the agricultural policy and the national agrarian reform plan".

Thus, in the Amazonian region, especially in the 1980s and early 1990s, there was a policy of awarding of land title and privatization of public land with forest cover. In addition, the fact of having a large forested area on a private property facilitated its classification as unproductive for the purposes of agrarian reform. Although this distortion has been under review in recent years, 80% of the lands destined for agrarian reform are located in the region of the Legal Amazonia.

This evaluation is necessary to understand the relation between the rate of deforestation in the region, the structure of land ownership, and macroeconomic issues. In Brazil, the rate of deforestation is influenced by a range of factors, among them population pressures, economic crises, and political instability.

In Brazil these factors have resulted in an increase in the rate of deforestation to a historic record in the 1994-1995 period: 29,130 km^2 of the Amazonian Forest was cut down in only one year. This is an increase of 38% over the average annual gross deforestation rate observed in the period 1978-1989, which was 21,130 km^2. According to INPE, the greatest deforestation rates are consistently observed in the States of Pará, Mato Grosso and Rondônia, accounting for more than half the average rate of gross deforestation each year in the Legal Amazonia.

In addition, illegal activities involving extraction of high-value timber in the Amazonia accounted for 80% of the sector's total profit in Brazil[68]. The illegal operation[69] of foreign-owned sawmills occurs because of the lack of capacity of IBAMA to supervise the implementation of forest management plans and carry out appropriate inspection of an area of 2.3 million km^2.

7.6.2 Measures to Combat Deforestation

7.6.2.1 Legal Measures

A report prepared by the then Secretariat of Strategic Issues - SAE[70] and the gross annual deforestation rate published by INPE (see section 7.7) provided data that created awareness in government and compelled it to adopt actions to reverse this trend[71]. In July of 1996, the government established the "Amazonia Package", which called for two emergency actions.

The first emergency action was established through Presidential Decree no. 1,963, of July 25, 1996, which suspended new authorizations for forest exploitation and established a two year moratorium on issuance of licenses for exploitation of two species: mahogany (*Swietenia macrophylla*) and virola (*Virola surinamensis).* In June of 1998, the government renewed the moratorium for another two years[72]. This issue is also being addressed in discussions under the Amazonia Cooperation Treaty - ACT, in the context of the objectives of the regional policy for mahogany. The second action was Provisional Measure no. 1,511, of July 26, 1996, which, among other measures, revises Article 44 of Law no. 4,771[73] of September 15, 1965 (see section 7.1). In addition, three basic activities were established to reduce the rate of deforestation: prohibition on new conversions of forested areas to agricultural systems; provision that the use of forest areas on the Legal Amazonia will only be permitted when implemented through a process of sustainable forest management; and subjecting the implementation of economic activities to the recommendations in the Ecological-Economic Zoning, in any area where the zoning has been concluded at a scale of at least 1:250,000. The provisional measure has been rewritten since them.

Another important legal instrument for controlling deforestation is the Law of Environmental Crimes, no. 9,605, sanctioned on February 12, 1998, addressed above (see section 7.1). This law consolidates environmental

[68] According to the official report prepared and published by the then Secretariat of Strategic Issues - SAE in mid-1997. The report prepared by SAE/Presidency of the Republic was useful in quantifying a situation that had already been diagnosed by IBAMA and NGOs such as the Worldwide Fund for Nature - WWF.
[69] The illegal operation was discovered because 22 foreign-owned sawmills declared that they had 508,000 hectares and that they were exploiting only 186,000 hectares. However, with this data, ecologists calculated that they could only extract 6 million cubic meters of high-value wood, while in fact they were declaring production of 30 million cubic meters. A more rigorous inspection carried out by SAE (see previous footnote) showed that just 8 sawmills had 1.9 million hectares of forest, which is four times greater than the total area declared by the 22 companies together.
[70] See footnote 68.
[71] The report prepared by the Secretary for Strategic Issues was published in 1997, but the research, described above, served to support legal actions in 1996.
[72] This moratorium was extended to 2001 for logging of mahogany.
[73] Provisional Measure no. 2,166-67, from August 24, 2001, also significantly amended Articles. 1, 4, 14, 16 and 44, and expands on provisions of Law no. 4771, from September 15, 1965. See footnote 60.

legislation, with typification of environmental crimes and infractions and with their respective penalties duly stipulated. Thus, compliance with the Forest Code is not restricted to economic aspects; it will have more serious consequences for individuals and companies.

7.6.2.2 Administrative Measures

Despite the importance of these emergency measures, the effectiveness of the "Amazonia Package" and the success in implementing the Environmental Crimes Law are dependent on improvements in the system of capacity-building, monitoring and enforcement in the Amazonian region.

It is fundamental to develop a more effective system of enforcement for deforestation in the Amazonian region that involve actions seeking to guide the exploitation and use of natural resources towards a basis of legality. Enforcement is an important tool for preservation, with the goal of coordinating, executing and bringing about the execution of government decisions and regulations.

A new scheme for enforcement based on audits in large sawmills has been implemented by IBAMA, which is thought to be more effective that an increase in the number of on-site IBAMA officials. The previous scheme proved to be inefficient over the long term. The isolation of government officials working in the middle of the forest has been an obstacle to effective action. The auditing approach may not be totally effective, but it appears to be the only operational alternative for the immense and uninhabited area of the Amazonian region.

Another important element in combating environmental degradation is the growing technological capacity of the country. Monitoring of the Amazonian Forest carried out by INPE allows IBAMA to implement a system of identification and monitoring of the dynamics of deforestation that expands the effectiveness of the use of the various legal instruments available to control human activities in the region.

The quality of IBAMA's inspection and enforcement activities increases with the use of new technologies such as remote sensing, satellite images, georeferenced localization and aero transported sensors, since now actions are planned ahead of time and directed to the sites of unauthorized deforestation.

The annual publication of deforestation (see section 7.7) data and its availability on the Internet, starting in February of 1999, are crucial measures in guiding the planning of political actions and are important instruments available to the Federal Government and to Brazilian society.

The Experience of the State of Mato Grosso

The State of Mato Grosso is part of what is called the "Legal Amazonia". It has an area of 906,068.078 km^2, with three distinct eco-regions: forest (52%), *cerrado* (savanna) (41%) and *Pantanal* (floodplain) (7%). In the 1990s, the state had high rates of illegal deforestation, which led the state authorities to seek creative solutions.

In 1998, discussions began to allow the State Environmental Foundation - FEMA, the body responsible for environmental policy in the State of Mato Grosso, to work in partnership with IBAMA to control deforestation and burning in Mato Grosso. To prepare for taking on these responsibilities, FEMA created the Forest Resources Directorate in 1999, prior to the signing of the "federative agreement" in 2000. The "Federative Pact for Decentralized and Shared Environmental Management" established guidelines for the activities of the various bodies involved — the Ministry of Environment, IBAMA and the government of the state of Mato Grosso, represented by FEMA — aiming at a system of technical and administrative cooperation for exercising the constitutional powers for protection of the environment and renewable natural resources.

FEMA made controlling deforestation the main objective of its activities, with civil society as a participant in the process, mobilizing rural landowners, and giving them orientation in making better use of their land, in accordance with the environmental legislation in force. Thus the Environmental Control System for Rural Properties was created and implemented, which has achieved an significant reduction in deforested areas, by using traditional instruments of inspection, licensing and monitoring, supported by information technology[74].

The rural properties of Mato Grosso are required to have a Single Environmental License - LAU. To obtain it, the owner delivers to FEMA a CD-Rom with a satellite map of the property, which must indicate the part to be exploited, the legal reserve, and the areas of permanent preservation. By overlaying the map received with satellite images, the agency can check whether the landowner deforested unauthorized areas. A farm receives a license only if the owner presents a basic environmental plan, and if irregularities are detected the owner is responsible and must follow a restoration plan for the area.

The licensing is renewed each year and the areas are monitored by FEMA. The data are collected and updated by the Geographic Information System - GIS developed by the agency, which constitutes a portrait of the rural zone of the state. Currently, the Single Environmental License - LAU of rural properties in the state has been generating a considerable increase in revenue for the institution, which invests in maintenance of the model implemented[75].

The result has been a reduction in the areas deforested and burned, through precise control of what is taking place on rural properties. In one year, there was a reduction of 32% in deforestation and 53% in the number of fires.

[74] This environmental control process is dynamic and interactive. During the inspection campaigns, the environmental agent notifies the landowner that a license is required for activities carried out on the property. During the licensing process the project is analyzed and the information in digital form are registered in the state map database, allowing the monitoring of activities through geoprocessing. Outstanding issues and irregularities are forwarded for legal action, with the landowner being held responsible for compliance.

[75] The amount of resources obtained through this type of licensing - LAU was not significant until the year 2000, and was below the amount obtained through other modes of licensing. In the year 2001, with the intensification of fieldwork, there was a significant increase in the amount collected from this category of license, totaling R$1.97 million. This amount exceeded all the other types of collections from licenses and fines issued by FEMA.

7.6.2.3 Economic Measures

The objective of all these regulations, monitoring measures, programs and technological innovations is to pursue a paradigm change in the model of economic exploitation of the Amazonian Forest.

Among the economic measures that could improve the implementation of the "Amazonia Package" is the Green Protocol (see section 7.11.2) and the incentives for sustainable management in special protected areas for indirect use, known as National Forests - FLONAs.

The Green Protocol is a declaration of principles signed by the Brazilian public banks to ensure that the development projects financed by public investments are environmentally sustainable and in accordance with environmental legislation.

The introduction and paragraphs II and III of Article 14 of Law no. 6,938 of 1981, which addresses National Environmental Policy, state that notwithstanding the penalties set out in federal, state and municipal legislation, the non-compliance with measures necessary to the preservation or correction of inconveniences and damages from degradation of environmental quality will subject the transgressors to the loss or restriction of fiscal incentives and benefits offered by the State, and to the loss or suspension of access to lines of credit in official lending agencies.

The former system of public financing has been one of the contributing factors to environmental degradation and unsustainable conversion of natural habitats. Thus, changes to financial policies and practices is a fundamental step towards promoting development and environmental conservation. The impacts of the Green Protocol should be clearly assessed, but if environmental concerns were truly institutionalized in financial practices, Brazilian financial institutions could be an effective instrument in bringing about compliance with the legislation and environmental programs. This strategy has achieved relative success in international financial institutions such as the World Bank, which has incorporated environmental concerns into its lines of credit and has created administrative bodies to deal with environmental issues.

Finally, an initiative that brings together relevant concerns with economic incentives and improvement in inspection are the FLONAs' projects. According to Decree no. 1,289, of October 27, 1994, national forests are areas under the public domain, inalienable and cannot be occupied, in part or in whole, constituting goods of the Union, with native or planted vegetation cover. The basic objective is to increase the area of the Amazonian region under the control of the State, reserving it for forestry purposes and ensuring that it is used in a sustainable manner.

The project of FLONAs represent, on the one hand, an attraction to logging companies, who are given the possibility of exploiting resources that are not on their private properties, and can thus delay exploitation of the highest-value wood on their own land. On the other hand, the FLONAs can become areas for research on new forestry management techniques that research institutes and NGOs have developed, but which cannot be easily disseminated or implemented by companies that resist changing their traditional methods unless they are required to or receive economic benefits for this.

The cancellation of forestry concessions that IBAMA had already awarded, together with provisions ensuring that only sustainable forestry activities will be permitted in the future (Article 3 of Provisional Measure no. 1,511-16), and progress in the creation of FLONAs, should represent a first initiative in the effective implementation of the "Amazonia Package".

According to IBAMA, there are 59 National Forests, covering more than 16 million hectares. In these areas, the government will be able to conduct better supervision and will be able to allow development of sustainable forestry systems and extractivist activities.

Another important step taken in the process of development and review of forestry management regulations and instruments that have an economic base is Law no. 9,393, of December 19, 1996, which regulates the Rural Property Tax - ITR (see section 7.11.6.) The ITR, calculated on an annual basis, is levied on property, dominium utile or possession of a contiguous area, formed by one or more parcels of land, located in rural areas.

This decision encourages important initiatives such as the creation of legal reserves and permanent preservation areas, the adoption of forestry management and the expansion of areas considered in the specific program of Private Natural Heritage Reserves - RPPNs (see section 7.8).

7.6.3 Political Action Strategy

The formulation and implementation of an action strategy with a national scope and a social dimension requires an innovative approach from the Federal Government involving the creation of positive agendas: they must listen to all the groups involved with the problem, identify proposals and negotiate solutions in search of consensus.

The development of a positive agenda presupposes that problems such as deforestation and burning will not be resolved only by monitoring and enforcement, but rather through a coordinated effort by all the diverse actors of society, presenting alternatives that generate employment and income, in a sustainable manner, contributing to solutions to economic and environmental crises based on policy guidelines.

In this regard, in 1999 the Environment Ministry created five directives for combating deforestation in the Amazonia[76].

- improve forest monitoring through identification of the economic and social causes that give rise to deforestation and ensure resources to IBAMA and the state environmental bodies, to carry out relevant enforcement actions;
- strengthen innovative agro-forestry projects under way in the form of pilot projects in the Amazonia, and incorporate the positive results into policies for the region;
- reorient credit mechanisms towards projects for the sustainable use of the region's natural resources;
- reconvert degraded areas (around 100 million hectares) to small and medium scale agroforestry activities, avoiding the encroachment of economic activities into the native forest;
- strengthen and expand those economic and social projects that ensure the sustainable use of biodiversity and the permanence of populations traditionally adapted to the tropical environment.

Thus a work program was developed, coordinated by the Secretariat for the Amazonia of the Ministry of Environment - MMA, which has the general objective of pursuing environmental management and the sustainable development of the Amazonian region. This work program

[76] According to the inaugural speech of Minister José Sarney Filho upon assuming the position in early 1999.

has the specific objectives of promoting decentralized environmental management, implementing sustainable development activities as an alternative to deforestation, and recognizing the value of environmental services provided by the Amazonian forest and by extractivist populations.

The traditional populations of the Amazonian region, consisting of indians, riverside dwellers and extractivists, have coexisted with the forest for decades, gaining their livelihoods with very low environmental impacts. This situation has been constantly threatened by the various forms of destructive occupation of the region, often resulting in the exodus of populations to the periphery of cities and/or replacement of forested areas by degraded areas, resulting in high environmental impacts. It is thus necessary to ensure the sustainability of the way of life of the traditional populations that coexist with the forest.

There is thus an attempt to reverse the process of deforestation, based on the pursuit of endogenous solutions for the region. In accordance with this philosophy, a work plan was established by the Secretariat of Amazonia, under MMA, for the period 1999-2003 involving the following programs: Program for the Development of Ecotourism in the Legal Amazonia (Green Tourism - Proecotur); Brazilian Program of Molecular Ecology for the Sustainable Use of Biodiversity (Probem/Amazonia); Expansion and Consolidation of a System of Protected Areas; and the Amazonia Solidarity Program. Also deserving of mention is the National Forests Program.

National Forests Program

Created by Decree no. 3,420, of April 20, 2000, the National Forests Program has the mission of promoting sustainable forestry development, reconciling exploitation with ecosystem protection, and making forestry policy compatible with other public policies, in order to promote the expansion of internal and external markets and the institutional development of the sector. The lines of action and respective goals of the National Forests Program are presented in the Table 7.6.1.

For all the activities, partnerships are expected to be established with the private sector represented by the pulp and paper industries, and the timber, steel and charcoal industry, which consumes forestry raw materials research and teaching institutions, professionals from the sector, state and municipal governments, other Ministries and federal bodies, international bodies, and environmental and social NGOs.

Table 7.6.1 - Lines of Action and Respective Goals of the National Forests Program

Lines of Action	Goals
Expansion of the planted forest base	- 630,000 hectares/year of plantations.
Expansion and strengthening of native forest management in public areas	- expand the area of National Forests - FLONAs in the Legal Amazonia by 50 million hectares by the year 2010, and by 10 million hectares by 2003; - ensure that current and future FLONAs can supply at least 10% of the demand for sawlogs coming from the Amazonia by 2003; - increase the area of FLONAS and state and municipal forests in the Northeast to 1.5 million hectares by 2010, in order to meet the supply for firewood, non-wood products and for rural use in the region. - expand the areas of extractivist reserves and equivalent areas.
Management of native forests on private land	- incorporate into the sustainable production regime 20 million hectares in the Amazonia and 560,000 hectares in the Northeast, by the year 2010.
Monitoring and inspection	- expand monitoring of natural resource use throughout Brazil; - reduce burning, forest fires and the destructive extraction of timber and non-timber products; - revise the regulatory instruments that give authorization for deforestation; - support processes of decentralization of monitoring, inspection and enforcement activities.
Traditional and indigenous populations	- expand the implementation of programs, projects and activities involving the federal, state and municipal governments, NGOs and other economic and social sectors, which recognize the value of traditional and indigenous populations.
Forestry education, science and technology	- increase productivity in small and medium size forested properties by 50%, over 10 years; - create viable operational techniques for reducing costs of restoring altered areas and areas of permanent preservation; - support projects and activities for using wastes from timber industries. - reduce wood waste in sawmills by 30%.
Environmental services of forests	- restore 100,000 hectares/year of forests for permanent preservation, in priority areas of selected watersheds; - create mechanisms for obtaining domestic and external financial resources for the protection, recovery and restoration of areas for permanent preservation.
Institutional strengthening and forestry extension	- conduct research in order to support the process of improving forest management; - create a forestry development fund, with a budget of R$ 100 million/year; - offer professional upgrading courses and improve the physical infrastructure of forestry institutions; - create or strengthen forestry extension programs in the states, the Federal District and the municipalities; - institute a program to promote and strengthen sustainable forest management;
Modernize forest-based industries	- increase efficiency of processing sawlogs by around 50% to 60%, by 2003; - add value to 40% of the timber produced by 2003; - train around 10% of the work force used by the forestry industry by 2003.
Market and commerce in forestry products	- increase wood exports from sustainable origins from the current level of less than 5% to at least 30% by 2010; - increased the share of higher value added forestry products and byproducts (processed products and furniture) to 30% of total Brazilian exports by 2010; - maintain the leadership position of the pulp and paper sector in domestic and international markets.

7.7 Projet for Gross Deforestation Assessment in the Brazilian Legal Amazonia - PRODES

The Project for Gross Deforestation Assessment in the Brazilian Legal Amazonia - PRODES (see http://www.obt.inpe.br/prodes/) is the largest forest monitoring project in the world using satellite remote sensing techniques. For many years INPE has been analyzing Landsat satellite images to monitor gross deforestation rates in the Amazonian region. Publication of the data shows the continuing commitment of the Federal Government to treat this information with transparency.

The Brazilian Amazonia includes the States of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Tocantins and part of the States of Mato Grosso and Maranhão, covering a total area of approximately 5 million km^2. Of this total, forest vegetation classes cover around 4 million km^2.

Satellite images in colored compositions at a scale of 1:250,000, permit identification of alteration in forest areas down to 6.25 hectares. The Amazonian region is covered by 229 of these images that provide the limits between the area of original forest and other vegetation types. Each survey identifies the newly deforested areas, which are copied onto overlays, and undergo a rigorous analysis. When approved, the overlays are digitalized, and the size and location of each deforested area are computed with the use of a Geographic Information System.

The methodology developed by INPE enabled the creation of "PRODES Digital", whose objective is to automate the project's operations, creating a reliable georeferenced database which is easily manipulated by the user.

PRODES, along with providing estimates of the size and rate of gross deforestation, also indicates the geographic location of the most critical areas. For example, in 1999 more than 78% of the gross deforestation in the Amazonian region was concentrated in 44 of the 229 Landsat satellite images. In addition, the PRODES data are overlaid on the vegetation map (RADAM) of the Brazilian Geography and Statistics Institute - IBGE to identify the forest types that are undergoing alterations. The distribution of newly deforested areas by size class, also provided in this study, is used by IBAMA as an indicator of the possible causes of deforestation in the Amazonia.

The information provided by INPE permits IBAMA and the state environmental agencies to carry out surveys of the causes, dynamics and consequences of the process of deforestation in the Amazonian region.

The integrated monitoring strategy carried out by IBAMA is based on the following elements:

- intensive use of airplane based sensors to identify selective cutting of timber;
- adoption of satellite communication systems installed in IBAMA's inspection vehicles for consulting registries, enabling the verification of documentation and the existence of irregularities;
- identification, diffusion and application of technologies for sustainable forest use, seeking to replace environmentally destructive agricultural and forestry practices.

As a result, control is possible through the emission of tax assessment notices, authorizations for transportation of forestry products and inspection reports, along with allowing monitoring of the work of inspectors.

7.7.1 Data Obtained by PRODES

Deforestation is understood as the conversion of areas of primary forest types by human actions for agricultural, forestry and ranching activities, detected through orbital platforms. The term gross deforestation indicates that the areas in a process of secondary succession or forest regrowth were not included in the calculation of the size and rate of deforestation.

Table 7.7.1 - Average rate of gross deforestation from 1978 to 1999 (km^2/year)

States in the Brazilian Amazonia*	77/88*	88/89	89/90	90/91	91/92	92/94**	94/95	95/96	96/97	97/98	98/99
	(km²/year)										
ACRE	620	540	550	380	400	482	1208	433	358	536	441
AMAPÁ	60	130	250	410	36	-	9	-	18	30	-
AMAZONAS	1510	1180	520	980	799	370	2114	1023	589	670	720
MARANHÃO	2450	1420	1100	670	1135	372	1745	1061	409	1012	1230
MATO GROSSO	5140	5960	4020	2840	4674	6220	10391	6543	5271	6466	6963
PARÁ	6990	5750	4890	3780	3787	4284	7845	6135	4139	5829	5111
RONDÔNIA	2340	1430	1670	1110	2265	2595	4730	2432	1986	2041	2358
RORAIMA	290	630	150	420	281	240	220	214	184	223	220
TOCANTINS	1650	730	580	440	409	333	797	320	273	576	216
TOTAL AMAZONIA	21130	17860	13810	11130	13786	14896	29059	18161	13227	17383	17259

Source: INPE, 2001.
* average for decade.
** two-year average.

In the period of 1995 to 1997, the deforestation rate increased and later decreased. In 1995, deforestation reached its highest level, at 29,059 km^2, in contrast with the decade's lowest level, in 1991, of 11,130 km^2. In 1997, the deforestation level registered was 13,037 km^2, the second lowest rate ever registered, confirming a trend towards decrease begun in 1996, when the rate fell by around 40%. However, the deforestation rate increased again in the period of 1998-1999.

Table 7.7.2 - Average rate of gross deforestation from 1978 to 1999 (%)

States in the Brazilian Amazonia*	77/88*	88/89	89/90	90/91	91/92	92/94**	94/95	95/96	96/97	97/98	98/99
						(%)					
ACRE	0.42	0.39	0.39	0.28	0.29	0.35	0.86	0.31	0.26	0.40	0.33
AMAPÁ	0.06	0.12	0.23	0.37	0.03	-	0.01	-	0.02	0.03	-
AMAZONAS	0.10	0.08	0.04	0.07	0.06	0.03	0.14	0.07	0.04	0.05	0.05
MARANHÃO	1.79	1.30	1.03	0.63	1.07	0.35	3.21	2.01	0.40	0.99	1.21
MATO GROSSO	1.01	1.31	0.90	0.64	1.05	1.40	2.43	1.56	1.25	1.56	1.71
PARÁ	0.62	0.55	0.47	0.37	0.37	0.42	0.78	0.62	0.41	0.58	0.51
RONDÔNIA	1.11	0.78	0.91	0.62	1.27	1.46	2.75	1.45	1.18	1.23	1.44
RORAIMA	0.18	0.39	0.10	0.27	0.18	0.15	0.14	0.14	0.11	0.14	0.14
TOCANTINS	2.97	2.00	1.61	1.61	1.17	0.95	2.29	0.94	0.81	1.73	0.66
TOTAL AMAZONIA	**0.54**	**0.48**	**0.37**	**0.30**	**0.37**	**0.40**	**0.81**	**0.51**	**0.37**	**0.48**	**0.48**

Source: INPE, 2001.
Gross deforestation relative to the remaining forest area.
* average for decade.
** two-year average.

the advance of the agricultural frontier, mainly in the States of Mato Grosso, Rondônia and Maranhão, Pará and Tocantins. The area of gross deforestation in the Amazonian region in 1999 was 569.269 km^2.

Deforestation occurs mainly in a belt called the "arc of deforestation". This arc starts in the northeast of the State of Pará, extending south to the western part of the State of Maranhão, then northwest to the State of Tocantins, crossing the north of the State of Mato Grosso in the direction of the State of Rondônia, crossing this state completely in an east-west direction and reaching the east of State of Acre.

Overlaying the deforestation maps on vegetation maps of areas that are undergoing a process of undesired occupation shows clearly that the advance of deforestation is occurring in a region of vegetation in transition, which corresponds to

Figure 7.1 - Deforestation observed in 1999

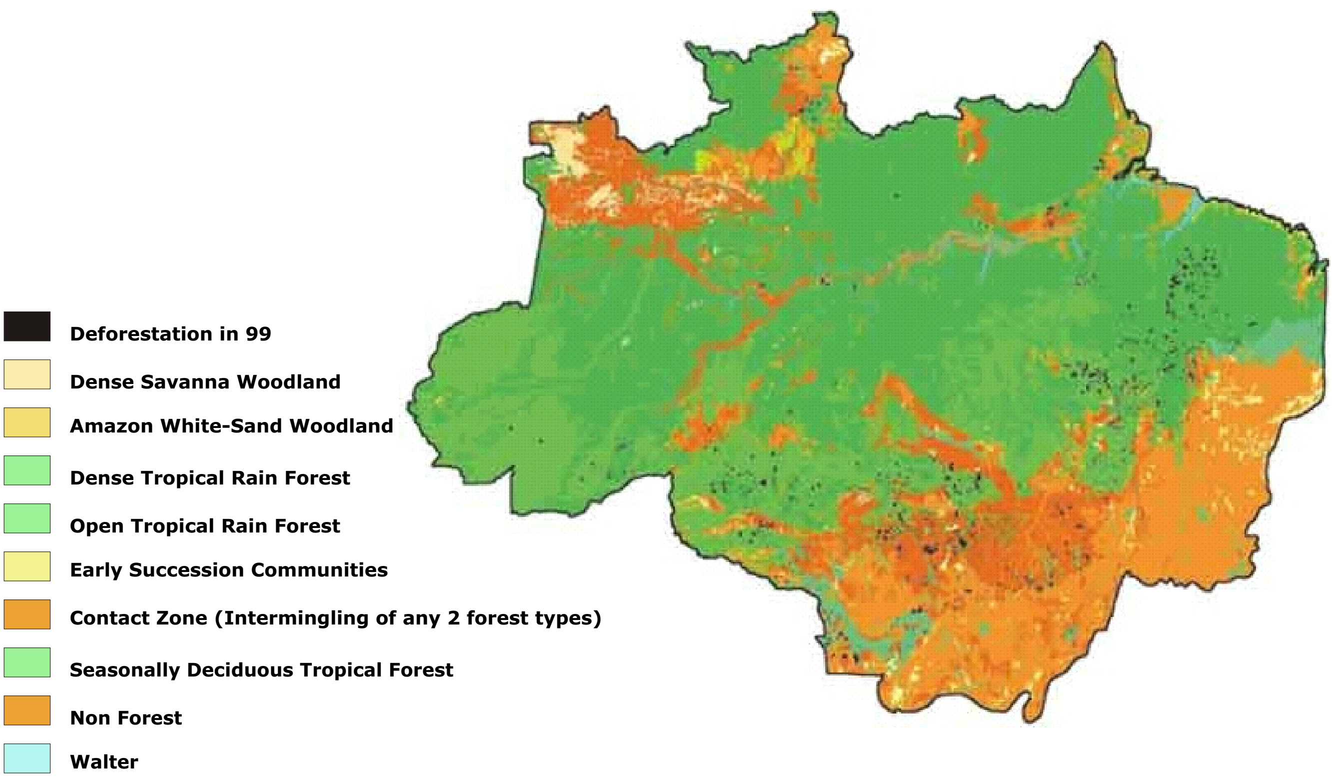


Table 7.7.3 - Area of gross deforestation from January of 1978 to August of 1999

States in the Brazilian Amazonia	jan/78	abr/88	ago/89	ago/90	ago/91	ago/92	ago/94	ago/95	ago/96	ago/97	ago/98	ago/99
						(km²)						
Acre	2500	8900	9800	10300	10700	11100	12064	13306	13742	14203	14714	15136
Amapá	200	800	1000	1300	1700	1736	1736	1782	1782	1846	1962	1963
Amazonas	1700	19700	21700	22200	23200	23999	24739	26629	27434	28140	28866	29616
Maranhão	63900	90800	92300	93400	94100	95235	95979	97761	99338	99789	100590	102326
Mato Grosso	20000	71500	79600	83600	86500	91174	103614	112150	119141	125023	131808	137610
Pará	56400	131500	139300	144200	148000	151787	160355	169007	176138	181225	188372	194619
Rondônia	4200	30000	31800	33500	34600	36865	42055	46152	48648	50529	53275	55274
Roraima	100	2700	3600	3800	4200	4481	4961	5124	5361	5563	5791	6112
Tocantins	3200	21600	22300	22900	23400	23809	24475	25142	25483	25768	26404	26613
TOTAL AMAZÔNIA*	**152200**	**377500**	**401400**	**415200**	**426400**	**440186**	**469978**	**497055**	**517069**	**532086**	**551782**	**569269**

Source: INPE, 2001.
* including old deforestation.

7.8 The National System of Conservation Units - SNUC

Brazil is one of the richest countries in the world in environmental terms: its territory contains approximately 1/3 of the remaining tropical forests and the largest river system on the planet. It also contains the world's largest floodplain — the *Pantanal*, the savanna with the richest biological diversity — the Cerrado, and more mangroves than any other country. The Brazilian flora represents 22% of the world's flora, with many species of flora and fauna that only exist in Brazil.

But although Brazil has one of the most advanced environmental legislation in the world (see section 7.1), there have been many difficulties in combating the destruction of Brazilian flora and fauna in many areas. For this reason, "conservation units" were created, which are spaces devoted specifically to the protection and conservation of samples of each type of existing flora and fauna. The legislation related to the conservation units was fragmented. On July 18, 2000, after a long legislative process, Law no. 9985 was approved, which consolidates and creates the National System of Conservation Units - SNUC, formed by the entire set of federal, state and municipal conservation units. Conservation units can be understood as the "territorial space and its environmental resources, including jurisdictional waters, with relevant natural characteristics, legally instituted by the State, with objectives of conservation and defined boundaries, under a special regime of administration, to which suitable guarantees of protection apply."

The SNUC has the following objectives:

- contribute to the maintenance of biological diversity and genetic resources in national territory and jurisdictional waters;
- protect species threatened with extinction at the regional and national levels;
- contribute to the preservation and restoration of diversity of natural ecosystems;
- promote sustainable development starting from natural resources;
- promote the use of principles and practices of nature conservation in the development process;
- protect natural and little altered landscapes of remarkable scenic beauty;
- protect the relevant characteristics of a geological, geomorphological, speleological, archeological, paleological and cultural nature;
- protect and restore water and soil-related resources;
- recover or restore degraded ecosystems;
- provide means and incentives to activities of scientific research, studies environmental monitoring;
- recognize the economic and social value of biological diversity;
- provide means and support for environmental education and interpretation, recreation in contact with nature, and ecological tourism;
- protect natural resources necessary to the subsistence of traditional populations, respecting and recognizing their knowledge and culture, and providing economic and social support.

Brazil has a large number of conservation units. The general policy approaches to the creation, recognition and use of conservation units are outlined by Conama, and having as executing bodies IBAMA and the responsible state and municipal bodies.

The conservation units forming part of SNUC are divided into two groups, with specific characteristics: fully protected areas and areas of sustainable use. The basic objective of the fully protected areas is preservation of nature, with only indirect use of their natural resources permitted, with exceptions set out in the law. The group of fully protected areas consists of Ecological Stations - ESECs, Biological Reserves - REBIOs, National Parks - PARNAs, Natural Monuments and Wildlife Refuges. The areas of sustainable use have the basic objective of making conservation of nature compatible with the sustainable use of part of its natural resources. The Environmental Protection Areas - APAs, Areas of Relevant Ecological Interest - ARIEs, National Forests - FLONAs, Extractive Reserves - RESEXs, Fauna Reserves, Sustainable Development Reserves and Private Natural Heritage Reserves - RPPNs, make up the group of areas of sustainable use.

Not including the indigenous reserves[77], there are a total of 226 federal conservation units, with a total area of 44,835,960.84 hectares, or 448.35 thousand km², covering 5.25% of Brazilian territory.

Table 7.8.1 - Federal Conservation Units by category

Category		No.	Total Area * (ha)	Country** (%)
Full Protection	National Parks	47	11,669,883.78	1.37
	Biological Reserves	24	2,984,401.23	0.35
	Ecological Stations	28	3,694,311.67	0.43
Subtotal	Full Protection	99	18,348,596.68	2.15
Sustainable Use	Environmental Protection Areas - APAs	28	6,473,193.04	0.76
	National Forests - FLONAs	59	16,075,244.67	1.88
	Areas of Significant Ecological Interest	17	32,371.24	0.0
	Extractive Reserves	23	3,906,555.22	0.46
Subtotal	Sustainable Use	**127**	**26,487,364.17**	**3.10**
Total	**Federal Conservation Areas**	**226**	**44,835,960.84**	**5.25**

Source: IBAMA, 1997 (updated by IBAMA-DIREC in 2002).
* the overlap between conservation units were processed by including them in the category of the greatest use restriction.
** based on the digital municipal network of 1996, provided by IBGE; the continental area of Brazil, not including the oceanic islands.

There are a large number of conservation units administered by the states (451 units, in 1997), protecting a total area of more than 29.8 million hectares. Some of these units are very large, such as the Amanã Sustainable Development Reserve in the State of Amazonas, covering 2.35 million hectares. This reserve is linked to the Sustainable Development Reserve of Mamirauá, the Jaú National Park, the Anavilhanas Ecological Station, the Rio Negro State Park and together with these areas, forms a continuous corridor in the State of Amazonas of 8,567,908 ha.

Table 7.8.2 - State Conservation Units in Brazil by Unit of the Federation

State/ Region*	CUs - full protection Area (ha)	CUs - full protection Number	CUs - sustainable use Area (ha)	CUs - sustainable use Number
Center West	**590,448**	**25**	**391,958**	**9**
DF	15,737	7	71,256	4
GO	32,158	5	3,244	2
MS	765	3	-	0
MT	541,788	10	317,458	3
Northeast	**778,474**	**62**	**7,040,692**	**53**
AL	892	2	19,700	2
BA	17,105	9	489,074	21
CE	59	1	33,119	4
MA	748,312	3	6,321,569	7
PB	2,647	4	-	0
PE	8,287	41	24,195	14
RN	1,172	2	1,880	1
SE	-	0	54,413	3
PI	-	0	96,742	1
North	**3,293,759**	**16**	**13,081,345**	**41**
AC	-	0	-	0
AM	2,320,012	4	5,831,191	7
AP	5,811	2	23,000	1
PA	24,897	1	6,009,711	3
RO	942,739	8	1,062,607	27
RR	-	0	-	0
TO	300	1	154,836	3
Southeast	**1,052,135**	**107**	**2,125,792**	**53**
ES	10,334	10	26,729	6
MG	113,765	27	186,897	5
RJ	89,873	14	87,217	10
SP	838,163	56	1,824,949	32
South	**254,327**	**57**	**1,156,402**	**28**
RS	87,645	20	54,058	4
SC	108,524	7	1,100	1
PR	58,158	30	1,101,244	23
TOTAL	**5,969,143**	**267**	**23,796,189**	**184**

Source: Marino, 1997.
* Brazilian States and Regions.

[77] With a total of 586 areas, indigenous lands cover a total area of 105,091,977 ha, representing 12.3% of the continental area of Brazil (IBAMA, 2002).

A study by the National Environmental Fund - FNMA, including federal, state and some municipal conservation units, showed that in terms of ecosystems, the Amazonian region contains the greatest protected area, although in percentage terms it is the Coastal Zone that has the greatest proportion of its biome included in conservation units.

Table 7.8.3 - Federal Conservation Units by Biome

Brazilian Biomes	Area of Biome* (ha)	% of total	Full Protection** (ha)	% of total	Sustainable Use** (ha)	% of total
Amazonia	368,896,022.37	43.17	13,568,629.85	3.68	19,846,195.37	5.38
Caatinga	73,683,115.53	8.62	504,938.65	0.69	1,597,553.44	2.17
Southern Plains	17,137,704.54	2.01	50,992.75	0.30	317,015.82	1.85
Cerrado	196,776,092.28	23.03	2,638,266.86	1.34	1,467,786.66	0.75
Coast	5,056,768.47	0.59	322,675.01	6.38	316,060.62	6.25
Caatinga-Amazonia Ecotones	14,458,259.63	1.69	6,659.04	0.05	1,064,640.06	7.36
Cerrado-Amazonia Ecotones	41,400,717.92	4.84	5,678.78	0.01	36,127.02	0.09
Cerrado-Caatinga Ecotones	11,510,813.00	1.35	383,732.97	3.33	15,527.72	0.13
Atlantic Forest	110,626,617.41	12.95	790,857.21	0.71	1,823,262.27	1.65
Pantanal	13,684,530.26	1.60	75,494.59	0.55		
Area not mapped	1,310,194.36	0.15				
Totals	**854,540,835.77**	**100**	**18,347,925.72**	**2.15**	**26,484,168.98**	**3.10**

Source: Marino, 1997 (updated by IBAMA - DIREC in 2002).
* according to mapping carried out by IBAMA/WWF at a scale of 1:5,000,000,000, considering only the continental area.
* the overlap between CUs were processed by including them

of these areas, resulting in the need for international cooperation programs and co-management with non-governmental organizations.

A study carried out by WWF, in 1999, revealed that of the 86 conservation units analyzed, 47 were in a precarious situation, 32 were considered minimally implemented, and only 7 units were classified as reasonably implemented.

In the municipalities there are also organized systems of protected areas, generally linked to the respective Secretaries of Environment and with allotments in the respective budgets. In addition, many universities and research institutes establish and protect significant areas of ecological/forestry reserves for scientific/experimental purposes, along with conservation.

Some private organizations administer protected areas with the goal of conservation, and with many of them linked to ecological tourism. Mining, energy and forestry companies, especially in the pulp area, also have important reserves created as environmental compensation or devoted to the development of management techniques. Pulp and paper companies, for example, maintain more than one million hectares protected in the region of the Atlantic Forest alone. Also, various conservation NGOs maintain important private reserves or ecological sanctuaries.

Another advance in recent years has been the creation of marine Extractive Reserves - RESEXs along the Brazilian coast. These reserves cover only the aquatic aspect, and do not require resolution of the land title problems on the coastal zone (protected by ordinary legislation). Besides these RESEXs, there are federal conservation units consisting of coastal and oceanic islands, as well as others protecting beaches, dunes, coral reefs, marine feeding grounds, bays, estuaries, saltwater lagoons, salt marshes, mangrove swamps, coastal sandy soil vegetation (*restinga*) and *marismas*[78]. Despite the existence of these RESEXs, conservation of the biological diversity of the marine and coastal zones is still fragile.

Although there is a large number of conservation units, it should be recognized that simply creating them, with the objective of protecting biodiversity, is no guarantee that this will in fact occur. In Brazil, many of these areas face problems of implementation that makes achievement of their purpose inviable. This is a consequence of the insufficiency of resources provided by the government for the maintenance

The main problem faced by the strategy of protection of the fully protected conservation areas, then classified as for indirect use, has been the small number of IBAMA staff per area an average of one staff member for each 27,560 hectares. Other limiting factors are the inaccessibility of the areas, and the lack of means of transport and equipment. In strategic points, support has been obtained from the Army, state and federal police, municipalities and non-governmental organizations. In the RESEXs and Sustainable Development Reserves, "collaborating inspectors" have been mobilized, and leaders from the communities themselves have been trained and accredited by IBAMA. Inspection of coastal and marine areas has been made more difficult in Brazil because of the lack of a coast guard active in the environmental area. However, the Brazilian Navy has often cooperated with IBAMA in this area.

Another problem identified is that deforestation and occupation of land around parks for real estate speculation and agricultural activities convert large areas of these parks into "green islands" under constant external pressure, disrespecting the legislation that calls for a 10 km buffer zone around the conservation areas. Within this buffer zone, defined in a Conama resolution, human occupation and economic activities must be compatible with the role of preservation of the unit, and must pose no risk to its integrity.

It is expected that Law no. 9,985/2000, in bringing up to date and consolidating the principles and directives that guide the implementation of public policies related to conservation of *in situ* biological diversity, replacing the existing legislation in the area, will contribute to improving the administration of conservation units.

According to this law, the bodies responsible for the administration of the conservation units can receive resources, including visitor fees and donations of any nature, from domestic or international sources, with or without charges, from private or public organizations or individuals that wish to contribute. Furthermore, the management body for the conservation unit is responsible for administration of the resources obtained, and these are to be used exclusively in its implementation, management and maintenance. This new development in terms of direct management of

[78] Swampy land along the coast or river shore.

resources by the administrators of conservation areas was well received by environmentalists.

Another major advance in biodiversity conservation in Brazil has been the implementation of Private Natural Heritage Reserves - RPPNs. These are private areas set aside in perpetuity with the objective of biological conservation, regulated by Federal Decree no. 98,914, of January 31, 1990, which expanded significantly after 1992, and were consolidated by Law no. 9,985, of July 18, 2000.

Since 1990, the areas considered RPPNs cannot be deforested and the removal of extractivist products is forbidden, so that the area maintains the characteristics of a genetic bank, with full and permanent protection. Decree no. 1,922, of June 5, 1996, established rules for recognition of RPPNs. By 1998, 150 of them had been created throughout Brazil, with areas of between 1,000 and 104,000 hectares, with a total of 341,057.34 ha.

The landowner can transform the entire area into an RPPN, or only part of it. To be classified as a RPPN, an area must be important for protection of biodiversity, contain landscape features of great beauty, or have characteristics that justify environmental recovery activities that would preserve fragile or threatened ecosystems. RPPN owners, whether individuals or companies, enjoy some advantages: they do not pay the Rural Property Tax - ITR on the part of their property classified as a RPPN; they have priority in obtaining resources from the National Environment Fund - FNMA; and they have protection against fires, hunting or deforestation.

Table 7.8.4 - RPPNs by State

State/Region	No. of RPPNs	Area (ha)
Amapá	1	46.75
Amazonas	5	104,222.96
Pará	1	2,000.00
Rondônia	1	623.24
Roraima	1	109.59
Tocantins	1	745
Total North Region	**10**	**107,747.54**
Alagoas	3	180.5
Bahia	15	9,821.59
Ceará	3	3,124.33
Maranhão	5	1,054.04
Paraíba	4	5,580.65
Pernambuco	1	1,485.00
Piauí	1	27,458.00
Rio Grande do Norte	2	910.24
Total Northeast Region	**34**	**49,614.35**
Distrito Federal	1	1.00
Goiás	15	13,306.60
Mato Grosso	6	82,040.79
Mato Grosso do Sul	9	49,533.35
Total Center West Region	**31**	**144,881.74**
Minas Gerais	30	21,841.60
Rio de Janeiro	16	3,037.78
São Paulo	10	346.19
Total Southeast Region	**56**	**25,225.57**
Paraná	4	2,272.35
Rio Grande do Sul	9	3,175.68
Santa Catarina	6	8,140.11
Total South Region	**19**	**13,588.14**
Total Brazil	**150**	**341,057.34**

Source: IBAMA-DIREC, 1998 (updated by IBAMA-DIREC, 2002).

In Brazil, indigenous areas are designated by the Federal Government for the exclusive use of the indigenous communities that inhabit them. According to Article 17 of Law no. 6001 of December 19, 1973 (Indian Statute), indigenous lands are those areas set aside (indigenous reserve, indigenous park and indigenous agricultural settlement) and the lands under the dominion of indigenous communities or those living in the wild. Concomitantly, Administrative Directive no. 1060, of December 5, 1994, of the National Indian Foundation - FUNAI stipulates the name of "indigenous land" for any and all territory occupied by indigenous people.

Given this classification, Brazil has 105,091,977 hectares of indigenous land[79], covering 12.3% of Brazilian territory. There are 586 indigenous lands, classified as registered, declared, demarcated, delimited and identified. The greatest number are in the Legal Amazonia region (IBAMA, 2002).

These areas are not considered conservation units, since their primary management objective is not the protection of biological diversity. However, because of the size of these areas, they are very important in terms of protection of the biological wealth of the country.

Adding indigenous lands to federal and state conservation units, the percentage of protected areas, including the different degrees of protection, rises to 20.78% of the Brazilian territory, with around 94% of this land concentrated in the Legal Amazonia Region (IBAMA, 2002).

7.9 Prevention of Fires and Burning

7.9.1 National System of Forest Fire Prevention and Control - PREVFOGO

On April 10, 1989, Federal Government, by means of the Decree no. 97,635, created the National System of Forest Fire Prevention and Control - PREVFOGO, which made IBAMA responsible for coordinating the actions necessary for the organization, implementation and operationalization of activities related to education, research, prevention, control and fighting of forest fires[80] and burning[81].

In 1990, the first year of PREVFOGO, two different lines of activities, one short term and the other medium term, were defined.

The first had the basic objective of establishing emergency mechanisms for fire protection in the Federal Conservation Units with the greatest risk of fires. To this end efforts were made to provide them with infrastructure and means of forest fire prevention and control, as well as human resources trained for this task. To provide for this training, IBAMA signed agreements with the Fire Departments of the States of Rio de Janeiro, the Federal District and Goiás. In 1991, these activities were expanded, and each year new protected areas and other states are being served by the program.

[79] See footnote 77.
[80] This is all uncontrolled fires affecting any form of vegetation, which could be caused by humans (intentional or negligence) or have natural causes (lightning).
[81] These are agricultural/ranching or forestry practices, where controlled burning is used as a factor of production.

The second activity is aimed at designing the form of organization and operation of the system.

The decree that created Prevfogo was revoked by Federal Decree no. 2,661, of July 8, 1998, which regulated the Sole Paragraph of Article 27 of Law no. 4,771, of September 15, 1965 (Forestry Code), through the establishment of precautionary standards related to the use of fire in agricultural and forestry practices, and provides for other measures. However, Prevfogo was maintained by this new decree, with the mandate to develop and disseminate controlled burning techniques, train human resources for disseminating the respective techniques and to raise awareness among the population of the risks of inappropriate use of fire. According to this new legal instrument, forest fire is understood as any uncontrolled fire in a forest or any other kind of vegetation.

The decree also prohibits the use of fire in forests and other forms of vegetation — as well as for simply burning wood chips, forestry residues and woody material, when its reuse is economically viable — in belts defined around certain areas, such as electricity transmission and distribution lines and substations, conservation areas, highways, urban areas, etc.

Given the observation of certain legal rules and conditions, it is permitted to use fire in agricultural and forestry practices, through “controlled burning”, which requires obtaining prior authorization. Controlled burning and use of fire is considered to be a factor of production and management in agricultural and forestry activities, and for the purposes of scientific and technological research, in areas with previously defined physical boundaries.

7.9.2 Program for Prevention and Control of Burning and Forest Fires in Legal Amazonia - PROARCO

Over the 1980s, deforestation in the Amazonia consumed an average of 21,000 km^2/year of forests. In the wake of this deforestation, the largest fires and burned over areas in the region were identified. In this context, the combination of an excessive number of fires in deforested areas of the Amazonia with the adverse effects *El Niño* could increase the susceptibility of the region's vegetation cover to fire, especially in the areas closer to the border, corresponding to the “Arc of Deforestation”.

After the forest fire episode which occurred in the State of Roraima, the Federal Government recognized its limitations in dealing with such problems in isolation, without recourse to other governmental and non-governmental organizations and agencies. In general, the episode showed that the governmental institutions with responsibility for controlling burning and forest fires did not have adequate equipment or capacity to effectively monitor and control these processes.

The response to this search for alternatives was the Program for Prevention and Control of Burning and Forest Fires in Legal Amazonia - PROARCO launched by IBAMA in May of 1998.

The broad goal of PROARCO (see http://www2.ibama.gov.br/proarco/) is to prevent and combat forest fires on a large scale in the Legal Amazonia, especially in the Arc of Deforestation.

Thus, the program intends to encourage the integration of the agencies of different levels of government and society in carrying out actions of prevention, inspection and control of burning and fighting forest fires in the region, decentralizing the execution of actions and defining the responsibilities of the federal government, states and municipalities.

7.9.3 Prohibition of Burning in Sugar Cane Harvest

Federal Decree no. 2,661, of July 8, 1998, analyzed in section 7.9.1, also provides for the gradual reduction of the use of fire as a deleafing method and preparation for harvest of sugar cane in fields of greater than 150 hectares, where mechanical harvesting can be used. The reduction cannot be lower than one quarter of the mechanizable area of each agro-industrial unit or property not linked to the agro-industrial unit, in each five year period, starting on the data of publication of the decree.

Each five years, starting on the date of publication of this decree, competent agencies will assess the socioeconomic consequences of the prohibition of the use of fire as the basis for making the modifications necessary to the measures imposed, in light of the technical progress in sugar cane harvest.

In the state of São Paulo, it was attempted through state legislation to establish still shorter terms for the reduction of burning in sugar cane harvest, including in non-mechanizable areas. The State of São Paulo is the largest and most modern sugar cane producer in Brazil, with around 3 million hectares of its territory dedicated to this crop, accounting for almost half of the area planted with sugar cane in Brazil.

However, deleafing of sugar cane through burning is currently practiced in the State of São Paulo, as in other states. Nevertheless, this practice has been contested by members of the state Public Attorney's Office through court actions and by the actions of communities concerned about the effects of this agricultural practice on health, safety, the environment and quality of life in the urban areas near the plantations. The practice has also been questioned by government staff because of the environmental damage, especially air pollution and risks of fires and deforestation.

However, mechanical harvest of sugar cane has been growing in recent years, with some environmental benefits. In the mechanical collection system, the straw is not burned, which avoids emissions of atmospheric pollutants, and the dry leaves, tips, and green leaves that are cut off are spread on the soil surface, forming a layer of material that, when it degrades, provides a source of nutrients to the soil and to the sugar cane crop, or used to generate energy. However, plant owners have applied considerable pressure, alleging economic obstacles to adoption of this technology, as well as rural unemployment.

In 1998, the State Secretariats of Agriculture and Supply and of Environment issued the joint Resolution no. 01/1998, regulating the gradual elimination of burning of sugar cane straw, and requiring the presentation of plans, criteria, deadlines and reports for the elimination of burning, among other measures.

Later, in 1999, the discussions under the Chamber of the Sugar and Alcohol Sector of the State of São Paulo were resumed, seeking new negotiations of the regulations in 1997 State Decree no. 42,056, which failed to meet a range of demands.

In the year 2000, the São Paulo State Legislative Assembly approved the Law no. 10,547, of May 2, that defined procedures, prohibitions, rules for implementation, and precautionary measures to be obeyed when using fire in agricultural, ranching and forestry practices. The law known as the “Burning Law” did not establish a clear timetable for the elimination of burning from these practices, nor did it define penalties for those who fail to comply. Thus, new legal measures are being undertaken to regulate the process of prohibition of burning of sugar cane in the state[82].

7.10 Cities for Climate Protection

The Cities for Climate Protection - CCP campaign is an initiative of the International Council for Local Environmental Initiatives - ICLEI launched in June of 1991. This is an international campaign to mobilize local government actions to reduce greenhouse gas emissions and support the international collective effort of municipal governments *vis-à-vis* national governments and the UN Framework Convention on Climate Change.

One of the objectives of the campaign is to coordinate initiatives and provide technical support, and educational material, to municipalities for the development of local capacity to understand the problem and implement the "Local Action Plans" for reduction of greenhouse gas emissions. To this end, the campaign seeks to develop and maintain a structure that encourages its participants to monitor, quantify and report their results to ICLEI and to their national governments.

By June 30, 1997, CCP has already recruited 174 local governments, representing a population of 100 million people throughout the world. Urban CO_2 emissions from these cities contribute around 5% of total global emissions.

While developing countries have no commitments for greenhouse gas reduction targets, according to the Kyoto Protocol, cities of these countries can and are invited to join this campaign and take initiatives to reduce their emissions.

In Brazil, six cities with a combined total of approximately 9.3 million inhabitants have joined this campaign: Rio de Janeiro - RJ; Volta Redonda - RJ; Niterói - RJ; Betim - MG; Goiânia - GO; and Porto Alegre - RS. These cities have all formalized their participation in the campaign through a resolution signed by the municipal government, committing it to follow the basic guidelines established by ICLEI for participation, aimed at reduction of greenhouse gas emissions.

For example, the city of Rio de Janeiro, through its Environment Secretariat, has been contributing to the initiative by carrying out the following activities and programs: development of criteria for land use and occupation and management plans in conservation units; systematic monitoring and control of activities that modify the environment; registry of potentially polluting activities; efficient energy consumption; development and investment in alternative transport; cycle path program; appropriate waste treatment and recycling; air quality control; preservation and recovery of vegetation cover; establishment of environmental information system; public awareness and commitment to environmental issues.

[82] Law no. 10,547 was regulated by Decree no. 45,869, from June 22, 2001, which among other things provides that: "the use of fire as a deleafing method and to facilitate the sugar cane harvest, should be eliminated gradually, with the reduction in each five-year period being no less than 25% of the area of each agro-industrial unit or property not linked to the agro-industrial unit (...)". The Decree establishes that starting in 2001, burning of sugar cane crops will not be conducted on 25% of the areas suitable for mechanical harvest, and 13.35% of the areas which cannot be harvested mechanically. Complying with these provisions, along with various others, was considered difficult by sugar cane producers. A new draft bill, for which compliance is considered more feasible by rural producers, while meeting the demands of environmental agencies, is before the State Legislative Assembly. On September 19, 2002, State Law no. 11,241 was promulgated, which called for the gradual elimination of burning of sugar cane leaves and provides for related measures.

Other urban environmental initiatives

Other Brazilian cities are carrying out environmental activities and programs, although outside the CCP.

The city of São Paulo, through its Environment Secretariat - SMMA is also in negotiations to join the CCP campaign, and its Strategic Planning and Management System already presents a range of plans, programs and projects for the improvement, preservation and conservation of environmental quality. Examples include the Inspection and Maintenance Program for Vehicles in Use (I/M-SP); the Natural Gas Program; the One Million Trees Program; and the Implantation of the Cycle Paths Program.

Curitiba (in the State of Paraná) has traditionally demonstrated a concern with the regulation of urban space, which is reflected in general environmental issues. The Collective Transport System is experimenting with biodiesel, which involves a composition of traditional fuels with non-polluting components and ethanol, used as an alternative fuel in some transport lines. The city also has a policy of creation of spaces as alternatives to automobile use, such as cycle paths; air quality monitoring; land use and zoning legislation; solid wastes disposal policies; waste separation projects; and environmental education programs.

Various small and mid-sized cities throughout Brazil have shown their commitment to environmental preservation, and many have developed action plans, such as Local Agenda 21, to this end.

7.11 Financial and Taxation Measures

7.11.1 An Evaluation of the Fiscal Incentives for Forestation/Reforestation - FISET-F/R

Since the mid-1960s, resources for the Brazilian forestry policy have been concentrated in reforestation activities and silviculture industry, to the detriment of the other areas under the responsibility of the Brazilian Institute for Forestry Development - IBDF, created in 1967.

On September 2, 1966, Law no. 5,106 introduced fiscal incentives for forestation and reforestation, benefiting individuals and companies who chose to allocate part of their income taxes to reforestation activities. In the first case, individuals could deduct from their gross income all the investments made in this activity, to a limit of 50% of their income, and companies could deduct the amount of their expenses from their taxes payable, to a limit of 50% of the taxes.

According to Decree-Law no. 1,134 of November 16, 1970, a company could, instead of deducting the expenses made from the amount of taxes owing, discount up to 50% of this tax for the application (in the following fiscal year) in forestry projects that have been previously approved by IBDF. Thus, Decree-Law no. 1,376, of December 12, 1974, created a new modality of managing those resources, through the establishment of Funds not only for reforestation, but also for other activities such as fishing and tourism.

With the creation of the fiscal incentive fund for forestation/reforestation - FISET-F/R, the IBDF came to assume greater responsibility for the administration of incentives and their application. The incentives were not based on resources generated by the projects themselves, since they were on the initial phase, which made them attractive to potential reforestation companies.

After twenty years of activity, FISET-F/R was phased out by Law no. 7,714 of December 29, 1988. The IBDF and its responsibilities were assumed by IBAMA. Despite all the distortions in the implementation of FISET-F/R, the program's operations resulted in some positive outcomes:

- 7.2 million hectares were planted, even though 15% of this total was lost because of using unsuitable areas or lack of a market;
- 1.6 million direct fixed jobs were created;
- wealth in the order of 4.7% of the GDP was generated;
- the country became the fourth largest paper exporter and the third largest pulp exporter (according to 1998 data);
- a level of US$ 13 billion in exports per year was reached;
- 2.3 million hectares of native forest were conserved, constituting the largest ecological corridor in the Atlantic Forest;
- US$ 4.5 billion in taxes were collected;
- technology to stimulate companies from the farmland reforestation sector was developed.

Despite this relative success, which includes import substitution, contribution to exports and advances in the area of biotechnology, the program was criticized because of the social costs involved.

Information provided by reports by IBDF itself indicated great disparities were found between the effective (market) cost of implementation and maintenance of the forestry projects receiving incentives and the cost paid by IBDF, which was evidence of the inefficiency in the procedures adopted in project approvals and in the payment of project costs.

Nowadays an incentive like FISET would not likely be considered by the Brazilian government, since it was based on tax refunds and during the 20 years that the incentive was offered, US$ 6 billion was spent to stimulate forestation activities.

7.11.2 Green Protocol

In 1995, the Federal Government launched the "Green Protocol" program, with the goal of incorporating environmental variables as an essential criteria of sustainable development, in the process of analysis for offering official credit and tax benefits.

The two original objectives of the Protocol are to give priority in the allocation of public resources through credit operations or tax benefits to projects with the greatest potential for social and environmental self-sustainability; and avoiding the use of such resources in projects that contribute to greater environmental damage in Brazil.

The Decree of May 29, 1995 created the Working Group that developed the lines of activity of the Green Protocol, culminating in the signing of the "Sustainable Development Charter of Principles"[83], by the five federal banks (Brazilian Development Bank - BNDES, Banco do Brasil, Caixa Econômica Federal, Banco do Nordeste do Brasil and the Banco da Amazônia).

In compliance with the Charter, the signatory federal banks, along with the Ministries of Environment, of Finance, of Planning and Budget, and of Agriculture and Supply, as well as the Central Bank, became members of a Working Group coordinated by the Chamber of Natural Resources of the Civil House of the Presidency of the Republic, with FINEP joining later.

The greatest difficulties found in addressing the priorities identified, especially in effectively incorporating the proposals of the Green Protocol in the day to day credit operations of the federal banks, resulted from the need to challenge some structural factors related to the form of production and the type of consumption in our society, as well as change procedures and positions of the State and its financial institutions. However, these new forms of operating are increasingly justifiable, since environmental issues are becoming treated less as externalities in the economic and financial system and are becoming more important, both in government projects and in private undertakings and trade relations (see section 7.11.3).

The Green Protocol has achieved results, mainly in terms of building awareness and capacity in the federal financial institutions involved; institutional adaptation of licensing mechanisms; the effort to identify external private resources directed to the environment; design of projects and programs in conjunction with the banks, oriented to sustainable development and to mitigation of environmental impacts; and in particular, the rationalization of use of pesticides.

7.11.3 Environmental Responsibility of Banks

As mentioned above, Article 225 of the 1988 Federal Constitution attributes to the State and the collective the duty to preserve the ecologically balanced environment for present and future generations.

In this regard, in Brazil there are various legal provisions that seek to provide guidelines for public and private banks for their activities that affect the environment.

Articles 3, 12 and 14 of the National Environmental Policy Law have provisions that, applied to financial institutions, in a broad sense, raise financing and credit to the level of environmental control instruments. Financing, especially involving government incentives (see section 7.11.2), must incorporate the environmental component in lending decisions, based on environmental impact studies prior to project analysis and awarding of credit, as has been occurring with the World Bank.

Financing agencies include not only traditional banks, but also cooperatives, autonomous state agencies, private and public joint stock companies, multi-service and investment banks and even pension funds — that is, all those institutions that can, in a broad sense, fit under the description "entities or bodies that provide financing or government incentives". Thus, banks have the duty to pay compensation for environmental damage caused (ADAMI, 1993).

The Law of Environmental Crimes has various provisions with a direct impact on the environmental responsibility of banks, especially Articles 2, 3 and 4. This law establishes the

[83] This "Charter", in listing the General Principles of Sustainable Development, calls for the banking sector to increasingly provide financing to projects that are not damaging to the environment or that meet the characteristics of sustainability; that environmental risks should be taken into account in the analyses and conditions for financing, and that environmental management requires the adoption of practices that anticipate and prevent environmental degradation.

penal responsibility of legal entities, and holds that legal entities will have administrative, civil and penal responsibility in cases where an infraction is committed by a decision of its legal or contractual representative, or of its collegiate body, in the interest or benefit of its entity. The responsibility of legal entities does not exclude that of individuals who are responsible or co-responsible for, or participants in, the same act.

7.11.4 The Ecological ICMS Tax and Application of the "Protector-Receives" and "Non-Polluter-Receives" Principles in Environmental Management

The Tax on the Circulation of Goods and Services - ICMS accounts for a significant part of the revenue of Brazilian states and is also an important source of resources for municipalities. Article 158 of the Federal Constitution stipulates that 25% of the resources from the ICMS in each State be forwarded to the municipalities; of this 25%, 75% must be distributed according the aggregate value generated by each municipality and the remaining 25% according to criteria established by the States themselves.

In recent years, the distribution of this later 25% incorporated a new category, in some States, which stimulates municipalities to maintain conservation areas and develop appropriate environmental practices, such as waste and sewage treatment.

This category has been widely known as the "Ecological ICMS" and is aimed at compensating those municipalities that give up the right to generate products and services so that society can enjoy the environmental resources and services on its territory.

According to the WWF, which carried out a wide-ranging study of the issue, the adoption of the Ecological ICMS is the first experience of including environmental criteria in the redistribution of taxes. Some Brazilian States already use the Ecological ICMS very successfully, while others are still developing the legal instruments for its application.

The State of Paraná is a pioneer in the application of the Ecological ICMS, followed by the States of São Paulo, Mato Grosso do Sul, Minas Gerais, Rondônia, and Rio Grande do Sul. Each state establishes its own criteria for distribution according to the specific characteristics of the region, which contributes to legitimating the application of the Ecological ICMS in areas with different environmental characteristics.

Environmental management in countries with abundant resources generally apply the principle of "user-polluter-pays", which is still not common in countries with severe financial limitations. In situations of poverty, it is more effective to invert this concept and apply the principle of "protector-receives", since in these countries the disposition to receive is much greater than the disposition to pay (RIBEIRO, 1999).

The adoption of this "protector-receives" system depends on the existence of a government committed to reducing inequalities between poor and rich cities, as well as the demographic pressure on large cities, interested in promoting small and medium-sized cities, and environmentally sensitive to the "ecologization" of public policies.

In this context, the Ecological ICMS represents a mechanism for transferring resources to municipalities which "invest" in environmental conservation through maintenance of environmental reserves or headwaters on their territory, following the "protector-receives" principle, as well as to municipalities that undertake environmentally healthy activities such as sanitation, following the "non-polluter-receives" principle.

The "protector-receives" principle rewards those who preserve a resource of collective and public interest. This principle is analogous to that adopted to reward owners of real estate of historical value, which are protected as cultural heritage. If such rewards were not adopted, the intention to protect could generate the opposite phenomenon: acceleration of destruction of the nature feature that it is desired to protect.

The Ecological ICMS stimulates local governments to invest in actions that will produce environmentally significant results, which is more effective than simply penalizing. This is thus a positive incentive and a non-coercive form of regulation.

7.11.5 Emissions Reductions Resulting from Tax Incentives for Vehicles with 1,000 Cubic Centimeters Engines in Brazil

In 1993, a tax incentive was introduced in Brazil to stimulate production of automobiles with small engines (≤1,000 cubic centimeters[84]). The objective of the reduction in the Industrial Products Tax - IPI was to encourage the production of more efficient automobiles that would be accessible to the lower-income population. By the year 2000, around 64% of domestic sales of new automobiles consisted of those with small engines, as shown in Table 7.11.1.

Table 7.11.1 - Sales, Fuel Economy and IPI on Automobiles in Brazil

Year	1,000 cc.			All Others			
	Sales (number of vehicles)	Fuel economy (km/l)	IPI (%)	Sales (number of vehicles)	Fuel economy (km/l)	IPI (%)	Share of 1000cc in total (%)
1992	92,573	8	14.0	504,391	8	31.0	15.5
1993	241,964	9	0.1	661,864	8	25.0	26.8
1994	447,867	10	0.1	679,806	8	25.0	39.7
1995	595,845	10	8.0	811,228	8	25.0	42.3
1996	701,440	10	8.0	704,105	8	25.0	49.9
1997	871,873	10	13.0	697,854	8	30.0	55.5
1998	702,927	12	8.0	508,958	8	25.0	58.0
1999	605,635	12	7.0	406,212	9	20.0	59.9
2000	754,419	12	10.0	422,355	9	25.0	64.1

Source: Database provided by ANFAVEA (2001), GEIPOT internet site (2001) and Carsale internet site (2001).

[84] Vehicles with 1.0 liter or 1,000 cubic centimeter (cc) engines.

Since automobiles with engines smaller than 1,000 cubic centimeters have a lower specific consumption than the average for vehicles with more powerful engines, the reduction of the IPI also resulted in reductions of carbon emissions. In this analysis, it is assumed that in the absence of this fiscal incentive, the renewal of the fleet would be based on cars with fuel consumption equivalent to the average of more powerful automobiles, which is the same as assuming that cars with 1,000 cubic centimeters engines in Brazil were purchased by a portion of the population that previously had acquired more powerful automobiles. In other words, it is assumed that the fiscal incentives did not stimulate car purchases; it only changed the type of automobile acquired.

The estimate of avoided CO_2 emissions in the period of 1993 to 2000, resulting from the measures analyzed here, was based on the total number of automobiles with 1,000 cubic centimeters engines sold since 1993, the average distance traveled by the vehicles and their different fuel economies, defined as shown in Table 7.11.1, with the last parameters changing according to the year the car was manufactured. Thus, the total estimated avoided emissions for the period between 1993 and 2000 is 22.3 millions t CO_2[85].

7.11.6 Rural Credit: Restrictions on Environmental Offenders

The rural sector needs to interact with the productive and financial sectors because of the risks of agricultural activity, which is easily influenced by external factors, by absolutely unpredictable weather events, and by price fluctuations on the domestic and international markets (WILDMANN, 2001).

Brazilian legislation calls for, as the main form of compensating the structural problems of agricultural activity, a specific credit policy for the sector, with lines of credit tied to resources coming from institutional allocations[86], or from resources from the treasury.

Article 2 of Law no. 4829, from 1967, defines Rural Credit as "(...) provision of financial resources by public agencies and establishment of private lines of credit for rural producers or their cooperatives, for the exclusive application in activities that fit und the objectives of the legislation in force."

A very important factor, especially in an activity of very high environmental impact[87] such as agriculture, is creating compatibility between the rural activity of the proponent/beneficiary and the environmental demands coming from the law and from the competent authorities. Environmental offenders cannot be allowed to benefit from loans from the National Rural Credit System.

Thus, Article 14 of Law no. 6,938 from 1981, which addresses national environmental policy and its objectives and mechanisms of formulation and application, provides that without prejudice to the penalties established by federal, state, and municipal legislation, non-compliance with the measures necessary to the preservation or correction of inconveniences and damages caused by the degradation of environmental quality will subject the transgressors to: "(...) II - the loss or restriction of the fiscal incentives and benefits conceded by the State; III - the loss or suspension of participation in lines of financing in official credit establishments; IV - to suspension of their activity."

In terms of taxation measures that favor forest management and restocking in the rural sector, which include forest policy mechanisms in the calculation of landed property tax, consideration should also be given to Law no. 9,393, from December 19, 1996, which regulates the Rural Property Tax- ITR, analyzed above

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[85] Adopting an average of 22% of anhydrous alcohol mixed with gasoline.

[86] Such resources are classified as: mandatory funds, as a percentage of the mandatory bank deposit, paid by the Central Bank for use in Rural Credit; tied funds, which come from rural operations, including fines, interest and payments from Rural Credit operations; funds from rural savings accounts, an institute created by the legislator for raising resources for supporting rural programs; resources from funds, programs and specific lines, and free resources from financial institutions. All the allocations, however, are established in legislation or set by the National Monetary Council.

[87] Non-Governmental Organizations have concluded that agricultural and ranching activities, which uses almost exclusively clearcutting and insists on using burning practices, is potentially more damaging than logging activities, since this activity is concentrated on the extraction of specific plant types of a minimum size, which tends to spare smaller specimens.

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